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An Empirical Investigation of Reputation Loan Size Dynamics in Rural Credit Markets in Honduras

By

Reka Sundaram-Stukel and Bradford L. Barham

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Abstract: This paper examines the role of two types of reputation - borrower credit history and productivity - in disequilibrium supply and demand models of loan size dynamics in formal and informal credit markets. Using panel data on Honduran households, full- and partial-information regime switching econometric models yield four principal findings: (1) credit contracts in the formal sector are largely collateral driven and not reputation driven; (2) the informal sector credit contracts are borrower reputation based; (3) the informal sector utilizes positive/negative credit histories in both markets to credibly reward/punish borrowers; and (4) technical efficiency has a positive impact in determining loan size in both sectors on the demand and supply side of the market.

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I. Introduction

Economists have worked long and hard to understand the basic logic of rural credit market imperfections and their potential impacts on efficiency, equity, and poverty outcomes. Much attention has been focused on the theoretical and empirical determinants of credit market (non-price) rationing which excludes certain classes of borrowers, usually the asset-poor, from securing formal sector and to a lesser extent informal sector loans (Bell et. al. (1997), Carter (1988), Hoff and Stiglitz (1993), Jaffee and Russell (1976), Kochar (1997a,b)). Recent research and policy experiments are exploring how reforms (such as credit bureaus and information exchange among micro-enterprise lenders) aimed at sharing information on borrower reputation might help to broaden and hasten credit market access (Bannerjee and Duflo (2000), Padilla and Pagano (2000), Pagano and Japelli (1993), McIntosh and Wydick (2005), Louto et. al (2007)) and thus the productivity and welfare of rural producers.

This article attacks a distinct but related question by examining the role of borrower reputation in shaping loan size outcomes in rural Honduras, where reputation is considered to have two potentially observable features. One is credit repayment history, and the other is technical efficiency. Using disequilibrium models of loan supply and demand for the formal sector and the informal sector, the econometric analysis explores the role of reputation in loan size dynamics while controlling for the other factors often incorporated into analyses of credit market outcomes. The intention is to identify whether improving information flows about reputation might serve as a substitute and/or complement to the recent policy initiatives that have emphasized land market and titling reforms as a way to help improve credit market outcomes (Boucher et al. 2006).

Several recent theoretical forays have considered how the provision of dynamic incentives by lenders might be used to manage credit market risk (Diamond, 1989; Ghosh and Ray, 1996, 2001; Mookherjee and Ray, 2003; McIntosh and Wydick, 2005 and Vercammen, 1995). This class of models provides a rationale for explaining the persistence of long-term relationships that may or may not attain first-best outcomes, but do allow borrowers to build a reputation through good repayment habits that help to secure continued access to credit, generally on progressively better terms. Lenders, in turn, reduce their risk of default (and other costs) by actively gathering information about the borrowers' abilities to supplement their experience regarding repayment history. The model that we develop focuses precisely on the tenuous balance that can arise between a borrower's credit history and the lender's knowledge about their productivity. The balance is critical to attain the so-called *disciplining effect* of providing the borrower both positive incentives and potential penalties that make their good reputation worth maintaining.

One fundamental question is whether these dynamic incentive approaches apply in some segments of rural credit markets and not in others. Specifically, we develop two competing ways of viewing lender-borrower relationships. The first is a pure reputation model that we believe provides a useful structure for understanding informal credit markets. The second is a collateral-leveraging hypothesis that in a parallel fashion seems to provide a useful structure for understanding formal credit markets. The empirical analysis essentially attempts to identify the degree to which the predictions of the two models fit the observed outcomes for rural Honduran households in informal and formal credit markets using panel data from 1994 and 2001. Because of the major differences in the lending institutions, the contractual design and terms of loans, and often the characteristics of borrowers who are active in the two markets, we treat the two as distinct markets. We also have different information sets about them from the household surveys that were done on credit market experiences. In the case of the formal sector, we have sufficient data to estimate a full-information disequilibrium analysis, while in the case of the informal

sector we only have data sufficient to support a partial information disequilibrium analysis. The characteristics of data are more fully detailed in section IV and in the data appendix.

The nature of the data is also one of the reasons the econometric models of the formal sector and informal sector are examined as separate markets. Bell et al., (1997) and Carter and Olinto, (2003) assumed households that are rationed (perhaps for lack of collateral) in the formal credit market "spillover" into the informal sector where they get otherwise inferior loan contracts, ones with higher interest rates, shorter terms, and smaller amounts. Kochar (1997b), on the other hand, assumes that borrowers may choose to transact in the formal or informal credit sector depending on which is the low cost sector for them. This paper makes a more agnostic assumption of simply separating the credit markets and examining them for how loan sizes evolve based on normal factors that would condition credit market outcomes (titled land, education) as well as on reputation. While it would certainly be more robust to develop a joint estimation framework for outcomes in the two sectors, the dimensionality curse of our disequilibrium models of supply and demand make joint estimation intractable. Because we are focusing more on the loan size dynamics of borrowers in these markets rather than on their participation choices, the dimensionality constraint that demands separate analyses is not as troublesome as it might otherwise be. The estimations are done using maximum likelihood methods, and we run both restricted and unrestricted models, with the restricted ones including only the reputation and/or collateral effects appropriate to that sector.

The main results of the estimations are that reputation, both in terms of repayment history and revealed technical efficiency, shape loan size outcomes in informal credit markets. By contrast, borrower reputation has relatively little impact on formal sector lending outcomes, whereas physical and human capital assets play a more pivotal role. Titled land, in particular, proves to be essential in both securing loans and in the size of the loans offered. Information flows on borrower history do matter across sectors, but perhaps in the reverse direction from what policy makers might hope. Credit history in the formal sector does shape informal sector lending

outcomes but not visa versa. Overall, these findings also underscore the apparent segmentation of credit markets in Honduras that like elsewhere in Latin America limit poorer households to informal sector lending options (Guirkinger and Boucher, forthcoming; Barham et al., 1996; Carter and Olinto, 2003). The good news is that those informal options appear to provide some potential for capitalizing on reputation with larger and better loan terms over time. The bad news is that the information and institutional structures do not yet provide asset-poor farmers a clear path to formal sector loan opportunities based on reputation.

This rest of the paper is organized as follows: Section 2 presents the theoretical framework of loan size dynamics based on reputation and collateral leveraging. Section 3 motivates the disequilibrium, separate sector approach, and then explains the estimation strategy for the disequilibrium sectoral loan supply and demand equations. Section 4 presents pertinent descriptive statistics, and results of the estimation. Section 5 concludes.

II. Theoretical Framework

The purpose of this section is to develop two models of the dynamics of loan size that capture the pertinent differences of informal and formal lending markets in rural areas and to help motivate the empirical disequilibrium model of loan size dynamics. The models are stylized representations of the two sectors. For example, the informal lending market is assumed to have no collateral provision and to pivot entirely on dynamic reputation incentives to ensure borrower good behavior. In contrast, the formal market is assumed to center on collateral provision and allow only repayment history as a form of reputation that can be used to increase the degree of leverage provided by the collateral. The purpose of these models is to develop a consistent representation of how loan size dynamics might evolve for different classes of borrowers in these sectors, but the actual econometric examinations will consider the full roles of reputation and collateral leveraging in both sectors to test whether the logic of these markets is as distinct as portrayed here.

i. Pure Reputation Hypothesis

The theoretical framework outlined in this sub-section summarizes a multi-period model developed in Sundaram-Stukel, 2005. The existence of informal sector supply schedules hinge on three main assumptions: (i) credit is extended without collateral; (ii) all qualifying incumbent borrowers are extended trial loans; and (iii) there are no legal mechanisms in place to enforce these credit contracts. We assume that the informal sector consists of a large number of borrowers and finite number of informal lenders. Thus, repayment is achieved through incentives of future access and contract terms. Lending can be profitable only if loan contracts are designed in such a way as to induce good borrowers to repay.

All borrowers are identical expect with respect to their productivity η (innate ability). Access to credit depends on borrowers' productivity (or business know how). Adverse selection exists because lenders cannot discern this productivity parameter (η) for incumbent borrowers. However, through repeated interaction lenders are able to indirectly estimate a borrower's productivity parameter. In this environment we define borrower reputation as follows: credit history R, which includes repayment, defaults and arrears and an expected borrower productivity parameter $E(\eta)$. Each period lenders revise their prior expectationof the borrowers' productivity (η) through Bayesian updating[1]. We start by assuming the existence of a decision rule employed by lenders to determine the size of a loan advanced $Q(\eta, R)$, where future loan sizes are thus a function of repayment and expected productivity.

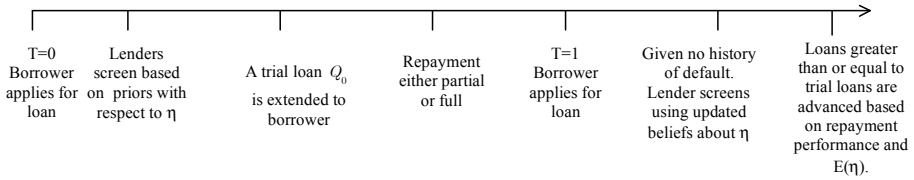
The precise decision rule defines a threshold level of expected productivity parameter $E_t(\eta) = \underline{\eta}$ below which lenders will not find it profitable to lend at period t=0. Since at the

[1] Informal lenders excluding moneylenders are often privy to detailed information such as output either through direct or indirect monitoring. For example, if the primary source of credit for a rural farmer is coffee exporters then this type of credit is often tied to the sale of coffee to exporter. The coffee exporter thus has detailed information regarding the output stream (or productive capacity) of the borrower. The theoretical model shows that lenders use the output streams to estimate the productivity parameter.

beginning of a credit relationship lenders do not know η well, the decisions are based on the lenders priors on a borrowers' productivity. For the sake of expositional ease, let us assume Q_0 is the trial loan size for a new borrower who is eligible with $E_0(\eta) = \underline{\eta}$. Mathematically we can restate the above condition as:

$$S_0^I = \begin{cases} = Q_0 & \text{if } E(\eta) > \underline{\eta} \\ = 0 & \text{if } E(\eta) < \underline{\eta} \end{cases} \quad (1)$$

As can be seen from equation 1 only those borrowers with prior η above the threshold value of $\underline{\eta}$ will qualify for trial loans. Outright default during trial phase results in no future access to credit in the informal market. Benefits to reputation depend critically on good behavior, thus we lay out the sequencing of loans explicitly as follows:



The evolution of loan sizes and underlined reputation effects are summarized in the following cases of interest:

Case 1. Incumbent Borrower with Bad Reputation

A household with a negative history at $t = 0$, will be rationed and face a zero supply of credit ($Q = 0$) in all $t > 0$. The reason for this is that a bad history in the beginning of the relationship should credibly exclude a potential borrower from participating in the credit market.

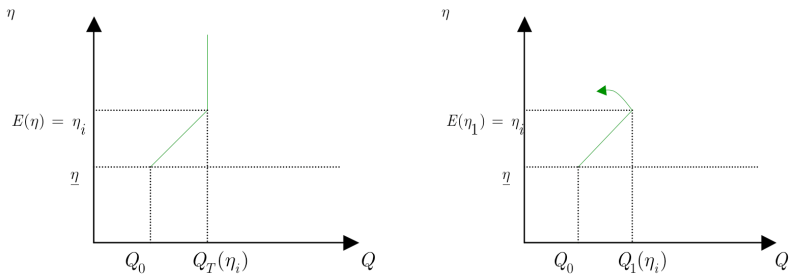
Case 2. Perfect Reputation with Perfect Repayment Performance

A household with a positive reputation history will face a supply of credit $Q \in [Q_0, Q_i(\eta_i)]$ and belongs to the non-rationed regime (Figure 1.1). This is the case where the borrowers reputation is favorable and thus the borrower is rewarded with higher loan in period t=2 based on the lenders

estimate of productivity parameter η. Note with repeated interactions the lender will be able to get a precise estimate of the borrowers' productivity and thus, tailor a loan amount to exactly match the borrowers' capacity to repay. That is at period t=T the borrower will receive a loan amount exactly consistent with his productive capacity, $Q \equiv Q_T(\eta_i)$

Case 3. Perfect Reputation at Entry with Fluctuating Repayment Performance

A household with a positive reputation history will face a supply of credit in period t=2, after trial at t=0, of $Q_2 = [Q_0, Q_1)$ (Figure 1). This corresponds to the case where the lender's prior indicated that the borrower was credit worthy but a bad performance, in period t=2, triggered either a revision of the estimate of borrower productivity or a punishment strategy, such that the borrower received a loan less than or equal to the loan at period t=1. Note the lender will re-estimate the borrower productivity parameter each period until s/he has a precise estimate. If the prior belief about the borrowers' credit worthiness was wrong, then future bad performances will result in no future credit access to the borrower.



(a) **(b)**

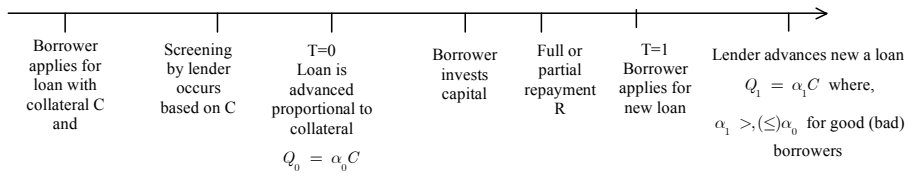
Figure 1: Productivity-effort Supply Trajectories

Overall, then, there will be borrowers who are rationed in informal sectors because of low productivity and/or bad repayment history. Other borrowers will be rewarded with increases in

informal lending based on their reputation, with the largest loan sizes going to those borrowers who combine both strong repayment records with high productivity.

ii. Collateral Leveraging Hypothesis

Now let us consider the case where repeated interaction does not reveal information about the borrower's productivity. In this case, lenders rely on *indirect mechanisms* (i.e. the terms of the credit contract like collateral requirement and repayment history) to mitigate default risk (Hoff and Stiglitz (1993))[2]. Based on a survey of lenders in Honduras, we found that bank loans are heavily collateralized, with little variation in interest rates, and are tied to collateral, with new borrowers receiving loan sizes equal to a lower percentage of their collateral compared to borrowers with an established relationship with a lender.[3] Indeed, the vast majority of surveyed lenders in Honduras indicated that first time and delinquent borrowers receive loan amounts of no more than 50% of collateral value whereas previous borrowers with clean histories received loan amounts of up to 80% of their collateral value. The framework developed here relies heavily on the theoretical model developed in Vercammen (1995). While Vercammen argues that reputation effects increase borrower welfare through the lowering of interest rates, we postulate here that positive reputation effects provide higher leveraging power on collateral assets. Again the timing of benefits to borrowers' reputation is crucial, so we lay it out explicitly as the following:



[2] While interest rates could potentially be lower for borrowers with good reputations. In the Honduran context, the data reveals very little interest rate variation. However, the theoretical arguments provided in (McIntosh and Wydick, 2005 and Vercammen, 1995) can be extended to model quantity as well. Furthermore, Hoff and Stiglitz (1993) offers a thorough discussion of the policy implications of both the direct and indirect screening mechanisms.

[3] See Sundaram-Stukel (2005) for more details on this survey of lenders.

Thus, we assume that collateral is the preferred indirect mechanism for reducing information problems, and that a good repayment history enables borrowers to increase the leverage on their collateral. In order to explore the notional supply trajectories of loan contracts in the formal market, we need to first identify which class of households could potentially benefit from dynamic incentives. There are three distinct regimes to consider:

Regime 1: $C > \bar{C}$

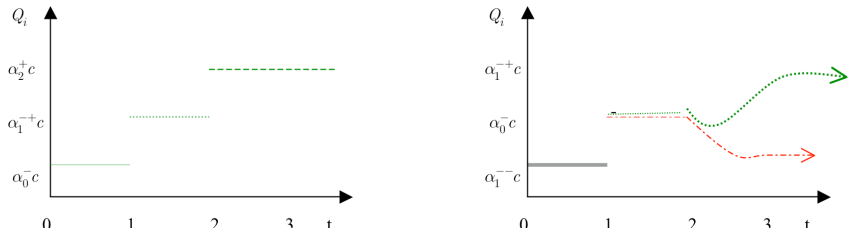
This corresponds to the case where households have enough collateral assets to leverage the full amount of loan they might want, and are therefore not on the short side of the credit market (Stiglitz & Weiss (1981), Hoff and Stiglitz (1993), Kochar (1997a), Conning (1999)). Thus, these households do not benefit from the leveraging of collateral and do not need dynamic incentives.

Regime 2: $C < \underline{C}$

This class of household is either rationed and faces a zero supply $Q = 0$ or face a positive supply that is proportional to the level of collateral assets but is not worth the transactions cost of securing the loan. If they face a zero supply, it need not mean that they have a negative history in period $t = 0$; it could be due to a variety of reasons such as the formal or informal sector having lower limits on the loan amounts they consider profitable. The body of work on why poor households are more vulnerable to rationing is enormous, and we refer the interested reader to Hoff et al. (1993) and Ghosh et al. (2000) for a good review. While households in this class might benefit most from dynamic incentives, they do not have enough collateral to secure viable entry to the market. For these households the pure reputation driven contracts would be most beneficial.

Regime 3: $C \in [\underline{C}, \bar{C}]$

This class of households can benefit most from collateral leveraging because they have sufficient collateral to access the market, but cannot secure the full loan they might want with an initial loan.



(a) (b)

Figure 2: Collateral Leveraged Supply Trajectories

Figure 2 diagrammatically presents the possible trajectories of the evolution of loan sizes for households in this class with negative priors or seeking their first loan. Unlike the borrower reputation driven case, where a history includes both the repayment history and an expected productivity parameter of the borrower, here reputation solely reflects the repayment history of a borrower. Thus, a negative history denotes either non-repayment or arrears, and no history is equated to a negative history.

Since households generally do not exhibit large variations in collateral assets from year to year, we assume that a household has the same level of collateral in all three periods. The horizontal axis represents time and the vertical axis denotes the loan amount as a percent of collateral. Let us consider an example of the possible trajectory for a household with an initial negative prior. That is, at period t=0 the lender is not convinced of the borrowers creditworthiness. In this case, the lender advances a loan amount equal to α_0^- of the collateral value (for example $\alpha_0 = 40\%$). If this borrower proves to be creditworthy, then s/he receives up to $\alpha_2^+ (> \alpha_0^-)$ of collateral value in period t=2 (dashed line in Figure 2a; where α_2 could equal 80% of collateral value). However, if this borrower has negative repayment history in period t=1 then, their capacity to leverage collateral will depend greatly on the extent of the negative

experience. That scenario is depicted in Figure 2b with the loan size heading down to α_1^{--} of collateral or heading back up over time (dotted line in Figure 2b).

For borrowers who have a positive initial prior, or a positive history, then they might start in period t=0 with a loan amount $Q_0 = \alpha_0 C$ (for example, 60% of collateral) value and may end with loans up to $Q_1 = \alpha_1 C$ where $\alpha_1 > \alpha_0$ (maybe 80% of collateral value) in the next period, that is t=1. In this sense, positive priors combined with positive repayment allow borrowers to leverage collateral more efficiently than borrowers with checkered histories.

barham 7/12/07 2:54 PM
Comment: Where is this portrayed in Figure 1.2?

Again, there will be borrowers who are fully constrained, partially constrained, and unconstrained. For the partially constrained, collateral leveraging ratios will depend positively on repayment history but will be expected to be less than one regardless.

III. Estimation of Disequilibrium Models of Formal and Informal Credit Markets

We begin this section with a graphical portrayal of the range of credit market outcomes that are possible for borrowers in the formal and informal sectors. The portrayal takes into account the potential for full to partial to no supply side constraints and variations in demand for both formal and informal sectors, which combined give rise to a wide range of possible disequilibrium configurations. This "spaceship" of credit market outcomes provides the basic motivation for the disequilibrium S-D approach to estimation and the dimensionality rationale for the segmentation of the two lending markets. Next we lay out the basic D-S disequilibrium model. Then we tailor this model to the full-information context of the formal market (where we elicited full information from survey respondents about their experience in the credit market) and to the partial information context of the informal market (where our surveys did not elicit full rationing information). The direct elicitation methodology is now common in credit market studies

(citations), but is more fully discussed in the data appendix. Finally, we discuss the unrestricted and restricted versions of the models that we run to examine the role of reputation and collateral-leveraging in the different loan markets.

i. Empirical Motivation for the Disequilibrium, Segmented Modeling Approach

With two supply and demand schedules for lending outcomes in the formal and informal sector, the number of distinct market outcomes is of the magnitude 2^4, or 16 distinct observational outcomes. Figure 3 represents 12 of these possibilities starting at the top with the demand side and then following down the supply side possibilities, which allow for unconstrained, partially constrained, and fully constrained outcomes.[4] The partially constrained outcome captures the situation of a borrower who receives a loan but for a lower quantity than they would have preferred at the going terms.

Many of the outcomes in Figure 3 are "disequilibrium" outcomes (i.e., ones where supply does not meet demand). Case 3, for example is one where the borrower has demand for formal credit but the lender will not supply a loan, while in Case 4 the borrower has demand for formal and informal credit but only receives informal credit. Including the partial constraint outcomes, Figure 3 has 6 cases of disequilibrium outcomes including 3 where borrowers are partially constrained in credit markets (cases 10, 11, 12).

The actual joint estimation of a model with 16 or 12 distinct regimes, although theoretically straightforward, poses severe computational problems because of the need to consider two notional demands and two notional supplies. This implies that the distribution functions involved are quadrivariate normal distributions. The computational time required for such an estimation approach makes it impractical. Moreover, the possibility of convergence to "false maxima" due

[4] Four possibilities are not mapped. Three would go below case 1 and would map out three supply possibilities associated with zero demand. Case 5 captures two in one with no supply from either sector.

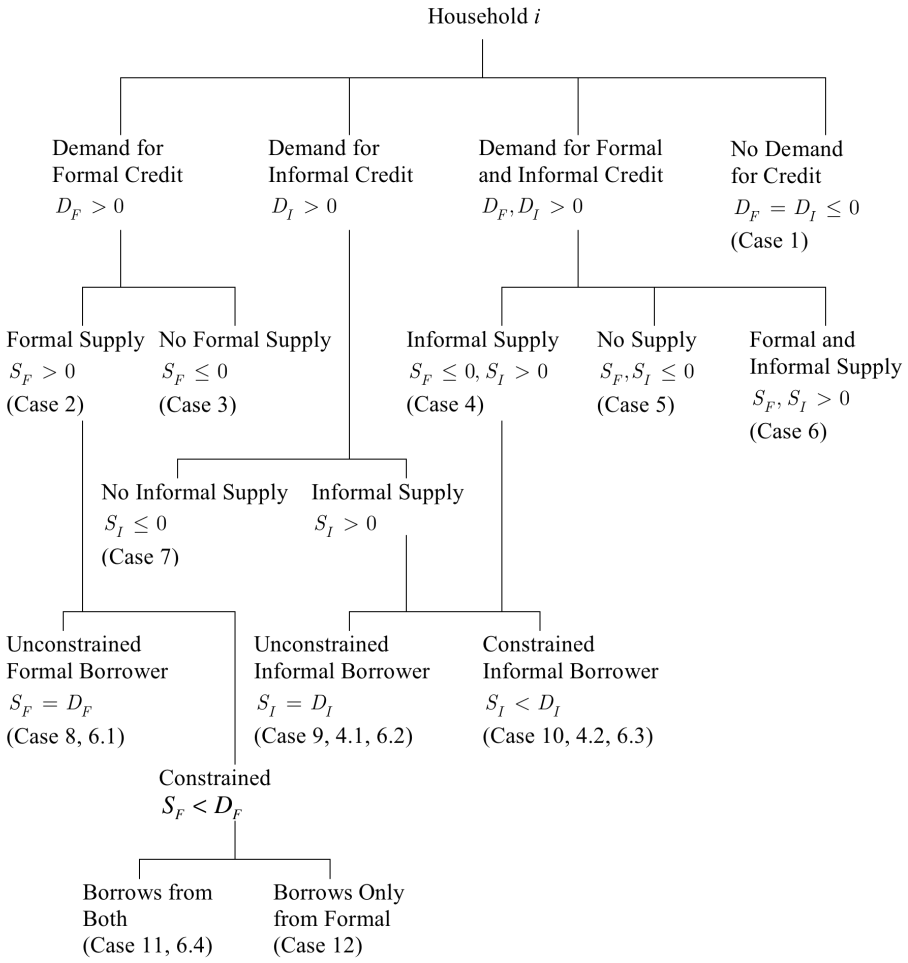


Figure 2.1: Spaceship: Credit Market Participation Outcomes

to non-zero covariance structure of the error terms is also cited in the literature as a potential problem (Maddala (1983), Goldfeld and Quandt (1978)). This problem arises because at certain parameter values, the likelihood may be maximized at the boundary of the parameter space with a correlation coefficient of ± 1. This results in a singular covariance matrix.

In order to keep the estimation tractable, we estimate the notional demands and supplies for the formal and informal lending sectors, separately. The limitation of this approach is that we lose the ability to discuss the impact of borrower reputation on associated spillover demand, a topic explored in Sundarem-Stukel (2005). However, here our primary goal is to understand the effect of borrower reputation on loan size, and so we abstract away from spillover demand.

ii. The Basic Demand-Supply Disequilbrium Approach

The demand schedule for agricultural credit can be derived by solving the optimization problem for the *ith* household.[5] For the present purposes we assume a household's demand schedule for credit is denoted by $D(r^i : X_i, \gamma_i, \eta_i, \beta_d, u_1)$, where r^i denotes the effective interest rate faced by a household for a given loan size; X_i is a vector of observable household characteristics such as farm size, education etc; γ_i represents credit market experience; η_i represents the contribution of productivity to the household's notional demand for credit; u_1 is a demand shifter that captures household characteristics unobservable to the econometrician (for example, managerial skill and/or risk aversion); and β_d is the vector of demand parameters.

We have two supply schedules that are available to households depending on their choice of credit sector. Solving the lender's maximization problem yields the notional supply schedule[6]. The notional supply schedules faced by household *i*, are represented by $S_{ji}(r^j : Z_i^j, \gamma_i^j, \eta_i^j, \beta_s^j, u_2^j)$, where $j = F, I$. This schedule specifies all the (r^j, S_{ji}) pairs offered to the *ith* household, where S_{ji} is the maximum loan amount offered to the *ith* household from sector *j* at interest rate r^j based on the household characteristics. Here, Z_{ji} is the vector of household characteristics observed by the lender, γ_i^j is the vector characterizing the borrowers'

[5] We refer the readers to Bell et. al. (1997) for the derivation of the supply and demand schedules.

[6] We refer interested readers to Bell et. al. (1997), Kochar (1997b), and Sundaram-Stukel (2005) for a derivation of the notional supply schedules.

participation history in the credit market, and η_i^j captures the borrowers' productivity parameter inferred by the lender. As lenders observe only some borrower characteristics, the vector Z_{ji} may not include all the elements in X_i. Further, the vector of household characteristics observed by the informal sector may differ from that of the formal i.e., $Z_{Fi} \neq Z_{Ii}$.

In the absence of rationing and with perfect price adjustment the equilibrium is characterized by supply and demand equality in each of the lending sectors. Mathematically we can represent this condition by:

$$Q_{ij} = S_{ij} = D_{ij}, j = F, I \tag{2}$$

where Q_{ij} is the equilibrium quantity transacted in the credit sector j by household i. In the presence of credit market imperfections, however, the quantity transacted in the loan sector may not be an equilibrium outcome. As discussed above, lenders may condition loan amounts based on the household's collateral assets, borrower reputation and other observable household specific characteristics; thus, loan supply can be lower than the desired amounts. Mathematically we restate the aforementioned condition as:

$$Q_{ij} = \min\{S_{ij}, D_{ij}\} \tag{3}$$

This model implies that if the household is rationed in sector j then, $S_{ij} = Q_{ij} < D_{ij}$ where, Q_{ij} is generated by the supply function. On the other hand, if the household is not rationed, then $Q_{ij} = D_{ij}$, and the resulting quantity Q_{ij} are generated by the demand curve N.

For the purpose of the estimation of the disequilibrium model, consider the linear approximations of the household demand and sectoral supply schedules specified as:

$$\begin{aligned} D_i^j &= \max\{0, X_1\beta_1 + \gamma_i\beta_{1\gamma}^j + \eta_i\beta_{1p}^j + u_1\} = \max\{0, D_i^{*j}\} \\ S_i^j &= \max\{0, Z_i^j\beta_2^j + \gamma_i^j\beta_{2\gamma}^j + \eta_i\beta_{2p}^j + u_2\} = \max\{0, S_i^{*j}\} \end{aligned} \tag{4}$$

where $j = F, I$ and D_i^{*j} and S_i^{*j} are, respectively, the latent notional household demand and supply in the formal and informal sector. The parameters β_k, $k = 1,2$ capture the marginal effects of household characteristics, X_i's and Z_i^j's; the $\beta_{k\gamma}^j$'s capture the marginal effect of credit market experience; the $\beta_{k\eta}^j$'s are the marginal effect of a borrower's productivity on loan supply and demand, and the u_k's are the error terms accounting for household-specific omitted variables. We assume that within a given sector *(j = F, I)*, the error terms are distributed bivariate normal with a mean of zero and the variance covariance matrix given by:

$$\Sigma = \begin{bmatrix} \sigma_{Dj}^2 & \rho_j \\ \rho_j & \sigma_{Sj}^2 \end{bmatrix} \tag{5}$$

Thus we are assuming that the error terms are correlated with each other. Given the above specification, the observed loan amount for household *i* in each sector is given by:

$$Q_i^j = Min[D_i^{*j}, Max[0, S_i^{*j}]], \; j = F, I \tag{6}$$

We use this structure to recover the demand and supply parameters, where $f(D_i^{*j}, S_i^{*j})$ represents the joint density of S_i^{*j}, D_i^{*j} conditional on X_i's and Z_i^j's. Based on the rationing and observed loan supply and demand information obtained from the Honduras dataset, we estimate both a full-information and a partial-information regime switching model in the formal and informal sectors, respectively. In the subsequent section we discuss the different regimes that arise in the two sectors.

iii. Estimation of the Formal Sector

In the formal sector, both the level of rationing and the sample separation are known; thus, we can estimate a full information maximum likelihood model. Both a household's demand and supply have a positive probability of being zero, so we need to incorporate the possibility that the quantity transacted can be censored at zero. Given data on sample separation, inferred through

ancillary perceived rationing information, identifying observations that correspond to a point on a demand curve or supply curve becomes relatively straightforward. The sorting of households is explained diagrammatically in Figure 4 The full-observability structure used to estimate the formal credit supply and demand parameters, where $f(D_i^{*j}, S_i^{*j})$ is the joint density of the latent notional formal sector demand and supply, is discussed in detail below. Using information on formal loan amounts and the perceived rationing status, each observation can be placed uniquely in one of five cases.

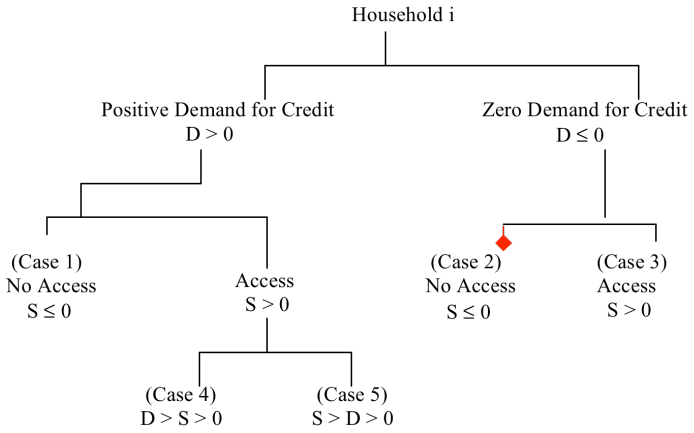


Figure 4: Observed Regimes in the Formal Sector

In case 1 the households have an observed loan quantity of zero, however, they have indicated a positive demand for formal credit and reported that they were rationed from the formal sector either because they did not possess sufficient collateral or were not willing to risk their collateral, that is $D^{*F} > 0$ *and* $S^{*F} \leq 0$. Thus their contribution to the likelihood function is given by the probability that $P(D_i^* > 0, S_i^* \leq 0 \mid X_i, Z_i)$. In case 2, as in the former case, the

observed quantity transacted is zero. The households in this class, however, report a zero demand for credit because they perceive themselves to be rationed from the formal sector, that is $D^{*F} \leq 0$ *and* $S^{*F} \leq 0$. The contribution to the likelihood is the probability $P(D_i^{*F} \leq 0, S_i^{*F} \leq 0 \mid X_i, Z_i^F)$. The final case of zero observed quantity (case 3 in figure 4) results from households that reported they did have access to formal sector credit, but voluntarily opted out of this market. The contribution to the likelihood is the probability $P(D_i^{*F} \leq 0, S_i^{*F} > 0 \mid X_i, Z_i^F)$. Households with positive observed supply fall in two distinct cases. First, in case 4, the quantity transacted in this case is exactly equal to the household's demand for credit. These households reported that they were happy with the amount they received. Second, this class (case 5 in figure 4) of borrowers has constrained access to formal credit. Since we have data both on the loan amount transacted and the amount of excess demand, in this case we can estimate both the corresponding supply and demand points. The contribution to the likelihood function is the joint density of both supply and demand. The likelihood function estimated for the formal sector is simply the sum of all the 5 associated cases. The full derivation of the log likelihood function is presented in Appendix A.

iv. Estimation of Informal Sector

Estimation of the disequilibrium model in the informal sector is not as straightforward as the formal sector because, unlike in the formal sector, we cannot sort households into the observationally distinct regimes. This poses a problem, particularly for the non-participating households. In the formal sector model we were able to sort the non-participating households into three distinct regimes. In the informal sector, however, since we do not have information about the households' perceived rationing status, we need to use a partial-observability framework and jointly estimate the likelihood of being a non-participant. On the other hand, we can sort households with observed positive loan amounts in the informal sector, into two observationally

distinct regimes: those with excess demand (constrained borrowers), and those with no excess demand (unconstrained borrowers). The resulting partial observable likelihood function to be estimated is the sum of three distinct cases.

The first group corresponds to the case where households have zero observed loan amount. There are three indistinguishable sub-cases. The first sub-case corresponds to the situation where households report zero demand because they perceive themselves to be rationed, that is $D_i^{*I} \leq 0, S_i^{*I} \leq 0$. The second sub-case concerns households who report zero demand and do not perceive themselves to be rationed from the informal sector, that is $D_i^{*I} \leq 0, S_i^{*I} > 0$. The last sub-case is one where households report having a positive demand for informal credit but find themselves rationed from the sector, that is $D_i^{*I} > 0, S_i^{*I} \leq 0$. Thus, the contribution to the likelihood of these observations is the probability $P(D_i^{*I} \leq 0, S_i^{*I} > 0 \mid X_i, Z_i^I)$ and $P(D_i^{*I} > 0, S_i^{*I} \leq 0 \mid X_i, Z_i^I)$. The second group consists of households with quantity transacted exactly equal to the household's demand for credit. These households did not report any excess demand at the going interest rate. The final group consists of borrowers with constrained access to informal credit. Since we have data both on the loan amount transacted and the amount of excess demand, in this case we can estimate both the corresponding supply and demand points. Collecting all the likelihood terms from the three cases in the informal sector, we can write the cumulative log-likelihood which is presented in Appendix B. The estimation of both formal and informal sector likelihood functions requires that there exist sufficient variation between the vector of individual characteristics X_i and Z_i^j, $j = Formal, Informal$.

v. Unrestricted and Restricted Specifications of the Models

We estimate five disequilibrium supply and demand models of loan size outcomes (including rationed borrowers), specifically two estimations for the informal sector and three for the formal sector. We run an unrestricted and a restricted version of a pure reputation model for the informal

sector that is consistent with the conceptual model presented in section II. The unrestricted model includes supply side information on titled and untitled wealth holdings, while the restricted model uses only "reputation" information related to borrowing and repayment history and borrower technical efficiency outcomes. It is our hypothesis that for the informal sector, the restricted model should perform as well as the unrestricted model, because the reputation information should be the main driver of loan size outcomes rather than collateral wealth.

For the formal sector, we first examine an unrestricted version of the pure reputation model that is identical to the one we run for the informal sector. For the formal sector, we expect that a primary driver of loan outcomes will be the supply side information on collateral wealth rather than pure reputation. Next, we drop all of the reputation information from that specification except for a term that captures the interaction of previous formal loans with a technical efficiency parameter. Our second hypothesis is that this restricted version of the collateral leveraging model should perform as well as the unrestricted version of the pure reputation model, because the formal sector relies primarily on the collateral wealth conditions and only secondarily on the borrower's productivity reputation. Finally, we run a fuller version of the collateral leveraging hypothesis model that includes some additional information on loan history repayment which is more fully consistent with the conceptual discussion in section II. Overall, the results demonstrate the distinctive roles that reputation plays in the informal and formal credit markets, the primary role of collateral in the formal sector, and more generally the factors that shape demand and supply outcomes for loan size in both markets.

IV. Data and Estimation Results

i. Description of Pertinent Variables

The data come from a sample of 850 households who were surveyed in 2001 from six departments in Honduras. One of the survey modules was dedicated to credit access, and included detailed information on the household's credit market experience, existing credit

contracts, and their perceptions of their ability to access formal and semi-formal credit. Table 1 uses those questions to show the prevalence of seven categories of borrowers (four in the formal and three in the informal sector), the use of the informal sector by formal sector borrower categories, and to compare their total owned and total titled land.

Notice first that 45% of the respondents reported being fully constrained in the formal sector, while another 12% reported being partially constrained. Both of those groups were also active in the informal sector with about 25% of the fully constrained and 46% of the partially constrained formal sector borrowers securing loans in the informal sector. These estimates underscore the degree to which the informal sector may serve to capture spillover demand from the formal sector. In terms of collateral, the median titled land for those who report being fully constrained was zero manzanas of land, compared to 1.90 for those who were partially constrained. By contrast, the unconstrained formal sector borrowers reported a median total of 7.4 manzanas of titled land. These differences in titled land across the credit constraint regimes suggest the decisive role of collateral wealth in shaping rationing regimes in the formal sector. Similar wealth levels are evident in Table 1 for the informal sector borrower categories, though we do not put the same emphasis on those, because we expect other factors, such as reputation, to play a more central role in shaping supply outcomes in that market

Table 1: Spillover Demand and Collateral Assets of Borrowers by Rationing Status

Regime	Househol	Informal	Total	Titled
			Median	Median
Formal Sector				
Constrained Non-	380 (45%)	26.56%	1.92	0
Constrained Borrowers	103 (12%)	45.63%	6.5	1.90
Unconstrained Non-	212 (25%)	22.40%	6.12	2
Unconstrained Borrowers	138 (17%)	0.0%	11.88	7.38
Informal Sector				
Non Borrowers	586 (70%)	-	3.06	0.06
Constrained Borrowers	75 (10%)	-	6.04	2.50
Unconstrained Borrowers	172 (20%)	-	10.63	6.0

Table 2 summarizes the rest of the data used in the analysis. The amount borrowed in the formal sector is simply the value of loans taken from banks and government programs. The amount borrowed from the informal sector is similarly defined. Informal sources of credit include moneylenders, merchant/traders, agricultural input stores and friends and family. If households borrowed from multiple sources within a sector the interest rate was computed as the weighted (by loan value) average. The household's assets are disaggregated as follows. In the formal sector estimation we distinguish between the titled land and untitled land whereas in the informal sector we do not make this distinction. We justify this distinction on the grounds that collateral especially in the form of titled land is central to formal banking, whereas interviews with informal lenders (with the exception of moneylenders) suggest that very little emphasis is placed on titled land as a form of collateral. In both the formal and informal sector, we include the value of non-agricultural land assets as a separate variable.

The credit experience variables used throughout the econometric analysis are composite measures based on the previous decade of loan experience for households. This is the main way that the panel nature of the data is exploited in the paper. These credit experience variables are constructed as indicator variables that identify households as having had positive or negative credit market repayment records based on their own reporting. We keep the positive and negative credit experience sector-specific so as to determine the extent of information flow between the two sectors. Households have a positive record when they have fully repaid previous loans without arrears, and negative ones when they have had loans in a sector which were in arrears. The negative credit experience variable includes only information on arrears because we do not have default information. Because this is a weaker form of negative history than default, evidence that being in arrears on a loan matters would suggest even stronger results for more negative credit market behavior. When we test the collateral leverage hypothesis, we interact assets, both land and non-land, with credit history indicator variables to capture the idea

developed in Figure 2b in section II that the leveraging of collateral is related to previous repayment behavior.

We use the household's technical efficiency index to proxy for borrower productivity. The technical efficiency index was calculated by comparing the input-output bundle for each farm household, within a department, with a nonparametric representation of the frontier technology using Data Envelope Analysis. The efficiency indices were calculated at the department level so as to condition on regional differences in the frontier technology. Inputs include total agricultural area owned, total wealth, number of permanent workers, number of potential household agricultural labor force, total cost of variable inputs, and distance to the market. The output bundle includes output from permanent crops (measured by an output index for all permanent crops), annual crops, vegetables produced for home consumption, salaried income and livestock earnings. It may be noted that the estimates of technical efficiency are biased downward due to the recent coffee crisis, which resulted in negative income shocks for coffee growing households.

Table 2: List of Variables and Descriptive Statistics

VARIABLE	UNIT	MEAN	STD	MINIMUM	MAXIMUM
Borrower					
Titled Area in Mz.	manzana	0.85	1.92	0.00	14.39
Untitled Area in Mz.	manzana	0.56	1.33	0.00	12.45
Age Household Head	years	5.21	1.61	1.80	9.50
Titled Area Squared	square	4.40	18.42	0.00	207.07
Past Loan size as % of	percent	0.03	0.09	0.00	1.24
Number of Dependents	number	8.48	3.36	1.00	14.00
Distance to Formal Bank	kilometers	1.19	1.44	0.00	25.00
Education Household	years	2.99	3.31	0.00	20.00
Employed Household	number	0.88	1.10	0.00	6.00
Formal Interest Rate	percent	26.95	5.15	0.00	43.00
Informal Interest Rate*	percent	26.15	5.24	0.00	63.00
Non Agricultural Land	millions of	0.05	0.12	0.00	2.09
Experience	years	25.65	15.82	0.00	83.00
Technical Efficiency		0.48	0.19	0.01	1.00
Credit Experience					
Dummy for Formal sector		0.03	0.16	0.00	1.00
Dummy for Previous		0.19	0.40	0.00	1.00

Dummy for Informal	0.02	0.13	0.00	1.00
Dummy for Previous	0.09	0.28	0.00	1.00

* Note the interest rates are a weighted average of combined loans from a given sector.

Number of dependents, education of household head, number of household members employed, distance to formal bank, farm experience and age of household head are the main other control variables in the regression. We include the farm experience variable, education, and age in the supply equation. Education also is assumed to affect the relative demand for formal sector credit, in part because households with less education may find the process of securing formal sector credit challenging. Similarly, the number of dependents, and distance to the bank affects the households demand for credit but has no place in the lending decisions. Household members with outside employment should decrease the need for credit, since each working member can earn wages to finance the households' productive needs and thus, enters the demand equation. It also enters the supply decisions because more family paid workers could potentially signal less repayment risk.

ii. Estimation Results

The estimates of our unrestricted and restricted, disequilibrium models of loan demand and supply for the informal and formal lending sectors are provided in Tables 3 - 5. Before presenting the specific results from these different models, we preview two general results that are common to loan outcomes in both sectors. First, a household's demand for loans is significantly and positively related with the index of technical efficiency. Likewise, this measure also plays a significant and positive role in shaping lenders loan supply decisions though in somewhat distinctive fashions in the two sectors. Second, in all five models the demand variances are substantially larger than the supply variances. For example, for the unrestricted versions of the pure reputation models (Tables 3 and 4), the demand variances are

$\sigma_D^I = 195.7, \sigma_D^F = 131.3,$ while the supply variances are $\sigma_S^I = 45.4, \sigma_S^F = 4.9$.[7] This large difference in variances suggests that the information observed by the econometrician is more closely aligned to the information possessed by banks when making lending decisions than it is to the borrowers' information and preferences. In addition, the consistently lower estimates of supply variance in the formal sector (relative to the informal sector) suggest that our estimations do a better job of characterizing formal sector credit decisions than informal sector lending decisions. This may be explained by the weaker quality of data available on the informal sector where we are forced to combine borrowers with no loans into one category rather than the three in the full information estimation for the formal sector.

A close look at the regression estimates in Table 3 provides a revealing picture of the factors influencing loan size outcomes in the informal sector. Starting with the broad role of reputation versus collateralized wealth, the coefficient estimates related to previous loan experience, loan repayment history, and (again) borrower technical efficiency are all statistically significant in loan size outcomes, whereas in the unrestricted model none of the coefficients on collateral or non-collateral wealth are statistically significant. This result is reinforced by the likelihood ratio test results between the unrestricted and restricted models of the informal sector which show no significant difference between the two, when the restricted model drops all of the supply-side wealth measures from the demand-supply estimation. It is worth highlighting that demand for loans in the informal sector is positively and significantly related to the land and asset situation of the borrower in both the unrestricted and restricted models. That outcome seems consistent with the notion that wealthier households are more likely to pursue larger projects.

The role of reputation in shaping loan size outcomes in the informal sector is worth detailing. First, the positive and significant coefficient estimates on informal and formal history

[7] Overall, the variance terms suggest that our model provides a more precise prediction of the supply decisions. Besides omitted variables, the high demand variances could be due to the homoskedastic error structure. Thus, large variations in the sample may contribute to higher variances in the demand equations.

show that borrowers with a previous history of loans are more likely to demand and receive a larger loan in the informal sector. Those results are consistent with a sector that relies on reputation. Second, the negative and significant coefficients on borrowers with a history of loan arrears in either sector demonstrate the impact of negative reputation in either sector on borrowers' capacity to secure loans. It seems logical that this negative effect of arrears is much stronger for arrears in the informal sector than for arrears in the formal sector which could reflect the lack of full transparency across lending sectors or the higher degree of sanctions for arrears in a sector that relies more on reputation than collateral. Again, the positive role of technical efficiency in shaping demand and supply for loans in this sector underscores the broader conception of reputation developed in the pure reputation model of section II.

The unrestricted pure reputation model of formal sector loan size is shown in the first two columns of Table 4. It provides a stark contrast to the informal sector results using a similar model in Table 3. In the formal sector, the only supply side coefficient estimates that are statistically significant in their effect on loan size outcomes are those related to physical and human capital holdings. Specifically, titled land holdings, non-land assets, and education of the borrower are all positively and significantly related to loan supply outcomes (though the positive effect of titled land holdings is diminishing given the negative and significant coefficient on the quadratic term). None of the supply side reputation effects that play such a central role in the informal sector models in Table 3 prove to be statistically significant in the formal sector estimation. Their lack of importance is further demonstrated in Table 4 by the results in the restricted formal sector model which excludes all of the information terms except for one discussed shortly. Again, a likelihood ratio test between the two models in Table 4 reveals that they are not significantly different, so that no explanatory power is lost by excluding the reputation information variables in the formal sector demand and supply model.

The one reputation term that is included in the formal sector restricted model is the interaction term between a previous loan with the formal lender and the technical efficiency of

the borrower. That term was part of the conceptual model in section II, and reflects the prospect that a formal lender might learn about the productivity of borrowers through repeated interactions. As mentioned above, that term is positive and significant in the restricted model.

On the demand side of the restricted formal sector model, we note the following outcomes depicted in Table 4. First, as would be expected, the interest rate (price) is negatively and significantly related to loan size outcomes. Second, age is negatively and significantly related to loan demand, a result that is consistent with a life-cycle view of rural households. There are also some less intuitive results. One is that total land holdings are not statistically significant in shaping demand for loans, though this outcome may be consistent with a sector where many households are supply constrained. Another is that other asset holdings are negatively and significantly related to demand for loans which could be explained by the possibility that non-land assets serve as a substitute source of financing for productive activities. Finally, distance from lender is positively related to the demand for loan size. That seems somewhat counter-intuitive, though one might interpret it in the following fashion. For those who are less proximate to other sources of lending where reputation and information play a central role, formal sector lending that relies on collateral wealth might be a better bet.

The last set of econometric results on the formal sector is presented in Table 5. This specification provides a more complete portrayal of credit history variables with lenders decisions than the restricted model in Table 4. In particular, the notion of collateral leveraging is more fully explored by including an interaction between previous loans and titled land to capture the potential dynamics portrayed in Figure 2 in section II. Overall, the results of this collateral leveraging model are consistent with the restricted model in Table 4 (and a log-likelihood test shows them not to be statistically different in fit). However, the additional credit repayment history variables tighten the fit of the model and several of them are statistically significant. Perhaps most important is the finding that the formal sector tends to use collateral leveraging to punish delinquent borrowers. That is evident in the negative and significant coefficient estimate

on the interaction of arrears with titled land and non-land assets in Table 5, which is consistent with Figure 2b's portrayal of how loan size is shaped by loan repayment history.

Table 3: Informal Sector Pure Reputation Parameter Estimates

	Unrestricted Model I		**Restricted Model II**	
	Demand	Supply	Demand	Supply
Constant	-45.85***	-87.04***	-55.32***	-66.73***
	(5.35)	(5.52)	(5.28)	(3.561)
Interest	0.69	0.75*	0.72	0.62*
	(1.21)	(0.41)	(1.24)	(0.35)
Total Land Owned (Mz.)	7.94	5.57	9.89*	
	(4.86)	(4.86)	(5.29)	
Total Land Squared		-0.47		
		(0.54)		
Non Land Asset	34.36***	1.66	40.13***	
	(3.16)	(4.49)	(3.55)	
Dependents	6.73*		6.76	
	(3.89)		(4.64)	
Age (Household Head)	-2.09*		-2.06	
	(0.81)		(0.94)	
Education (Household Head)	2.01		1.14	
	(0.81)		(4.45)	
Farming Experience (years)		0.33		0.29
		(0.26)		(0.27)
Distance to Bank	0.15		0.07	
	(0.68)		(0.70)	
Technical Efficiency	14.84***	42.60***	12.81***	29.52***
	(2.58)	(3.72)	(4.35)	(3.75)
Informal History	18.50***	32.47***	20.31***	28.13***
	(5.91)	(7.84)	(5.57)	(7.09)
Formal History	50.05***	55.53***	51.25***	53.48***
	(8.09)	(6.79)	(4.38)	(7.32)
Informal Arrears		-61.00***		-84.37***
		(8.85)		(8.092)
Formal Arrears		-26.14***		-12.62
		(7.29)		(8.05)
Variance Terms				
σ	195.52***	46.38***	198.57***	47.44***
	(4.73)	(3.27)	(2.96)	(0.097)
η	-0.25***	-0.25***	-0.32***	-0.32***
	(0.09)	(0.09)	(0.10)	(0.10)
Log of Likelihood	-1707.93		-1708.48	

Standard errors in parentheses

*Significant at 10% ** Significant at 5%; *** Significant at 1%

Table 4: Formal Sector Pure Reputation Parameter Estimates

	Unrestricted Model I		Restricted Model II	
	Demand	Supply	Demand	Supply
Constant	36.74	-1.94	27.67***	-1.61
	(13.47)	(1.44)	(3.91)	(1.45)
Interest	-20.79***	-0.56	-18.27***	-0.66
	(5.92)	(0.42)	(6.23)	(0.42)
Titled Land (Mz.)		1.29***		1.31***
		(0.32)		(0.30)
Titled Squared		-0.11*		-0.11***
		(0.03)		(0.03)
Total Land (Mz.)	-0.51		0.04	
	(2.45)		(2.41)	
Non-Land Asset	-33.53	13.03***	-66.17***	13.92***
	(21.49)	(2.63)	(23.64)	(2.64)
Dependents	2.01		2.26	
	(1.75)		(1.62)	
Age (Household Head)	-7.93**	0.18	-7.12**	0.17
	(3.54)	(0.16)	(3.14)	(0.15)
Education (Household Head)	0.87	0.15*	1.28	0.15*
	(1.68)	(0.085)	(1.63)	(0.08)
Distance to Bank (km)	6.32**		6.22**	
	(3.21)		(3.18)	
Permanent Employees	-0.68	-0.08	-0.41	
	(4.97)	(0.21)	(4.93)	
Technical Efficiency	47.50**		35.93***	
	(21.97)		(11.27)	
Interaction History (Tech. Eff.)		2.55		4.23***
		(2.00)		(0.98)
Informal History	-4.46***	0.43	-2.73	
	(1.23)	(1.07)	(6.85)	
Formal History	-3.09	1.25	0.31	
	(13.01)	(1.10)	(10.36)	
Informal Arrears		-1.06		
		1.81		
Formal Arrears		-0.87		
		(1.48)		
Variance Terms				
σ	131.25***	4.92***	130.97***	4.94***
	(8.30)	(0.38)	(7.75)	(0.37)
ρ	-0.59***	-0.60***	-0.59***	-0.54***
	(0.06)	(0.06)	(0.06)	(0.02)
Log of Likelihood	-2213.20		-2213.91	

Standard errors in parentheses

*Significant at 10% ** Significant at 5%; *** Significant at 1%

Table 5: Formal Sector Collateral Leveraging Parameter Estimates.

	Demand	Supply
Constant	20.77	-1.59
	(27.16)	(1.34)
Interest	-16.69**	-0.64
	(7.60)	(0.40)
Titled Land (Mz.)		0.97***
		(0.28)
Titled Squared		-0.05*
		(0.03)
Total Land (Mz.)	-0.72	
	(2.50)	
Non-Land Asset	-54.73	21.99***
	(42.10)	(3.16)
Dependents	2.46	
	(1.81)	
Age (Household Head)	-6.64*	0.15
	(3.76)	(0.14)
Education (Household Head)	1.44	0.14
	(1.82)	(0.08)
Distance to Bank (km)	5.30	
	(3.27)	
Permanent Employees	-0.59	
	(5.04)	
Technical Efficiency	35.13	
	(26.36)	
Interaction History (Tech. Eff.)		5.25***
		(1.03)
Interaction History (Titled Land)		0.28
		(0.32)
Interaction Arrears (Titled Land)		-0.88**
		(0.42)
Interaction History (Non-Land Asset)		-20.61***
		(4.58)
Informal History		
Formal History		
Variance Terms		
σ	130.54***	4.55***
	(8.359)	(0.35)
ρ	-0.59***	-0.59***
	(0.06)	(0.06)
Log of Likelihood	--2201.0186	

Standard errors in parentheses

* Significant at 10%; ** Significant at 5% ***Significant at 1%

V. Conclusion

This article presents an empirical investigation of the impact of borrower reputation and collateral leveraging on the notional supply and demand for loans by rural Honduran households in the informal and formal sectors. In section II, we conjectured with the help of two conceptual models that the evolution of loan size depends on the lenders information context and approach. If loans are reputation-driven, then loan sizes depend on a good repayment history and revealed productivity. If they are collateral driven, then loan sizes depend on wealth holdings and repayment history in the sense that the collateral will leverage larger or smaller loans based on the repayment history (and information about the productivity of the borrower). We undertook an econometric estimation of structural disequilibrium models of credit supply and demand for the informal and formal sectors using different informational structures - pure reputation as the benchmark for the informal sector and collateral wealth leveraging as the benchmark for the formal sector - to examine which types of models fit the individual sectors better. We used directly elicited information from borrowers to help identify their credit demand and supply constraints that may be limiting their access to credit. Our estimation approach belongs to a class of models that incorporate endogenous and exogenous switching models with partially and fully known sample separation. The specifications included a range of models that spanned the purer reputation to collateral leveraging approaches with some restricted comparisons to help test whether collateral mattered in informal markets and broad reputation measures mattered in the formal sector. The main findings from the estimated models can be interpreted as follows.

We have shown that borrower reputation is the dominant factor shaping loan size outcomes in the informal sector. For example, previous credit market experience decreases the likelihood of being rationed by 20% for households at the lowest end of the wealth continuum. The threat of severing future credit due to delinquent repayment behavior also appears to be more credible in the informal sector, as positive and negative repayment histories are rewarded accordingly, and do not depend on direct experience with the particular lender. It is also interesting to note that

technical efficiency (our proxy for productivity) has a strong and significant impact on informal sector lending decisions and can have one but only given previous lending experience with the borrower in the formal sector as well. These findings are consistent with our conceptual models that shows credit market experience and borrower productivity jointly determine future loan sizes, though in different ways in the two sectors. In addition, we find that the informal sector utilizes borrower credit history from both sectors. Thus, while credit market experience is transferable from the formal to the informal sector. However, the reverse is not true.

In the formal sector, the lack of titled land significantly increases the likelihood of a borrower being rationed, and the size of formal loans is directly related to the collateral wealth holdings of the borrower. Meanwhile, general borrower reputation measures have relatively little impact on formal sector loan size decisions compared to collateral wealth, and the most significant impacts of "reputation" are revealed in the interactions of previous formal credit market experience with collateral holdings. Direct interviews with formal bank officials corroborate this finding that lending decisions are linked to collateral and leveraged up based on direct repayment performance of the borrower. Furthermore, there seems to be no transferability of credit experience from informal to formal sectors.

Our results bode poorly for efforts to bridge the informal and formal sector markets without clear attention to what kind of borrower credit repayment history would be considered valuable to formal lenders. In all likelihood, any effort to increase the use of reputation in the formal sector would require contracts similar to informal sector arrangements, which start small and then allow the rural poor to build good credit histories, thereby reducing the dependence on collateral assets. But, even this suggestion begs a key question regarding whether information, reputation, and future loan access are all that the really informal sector lenders "hold over" their borrowers. If their repayment pressures are more implicit (or extra-legal), then it might be difficult to reduce the pronounced emphasis on collateral in the formal sector where similar pressures might not be feasible. Put differently, the stark differences we see in the fundamental roles of reputation and

collateral in the informal and formal sector markets raise deeper questions about whether merely improving information flows will be sufficient to generate broader and deeper access of borrowers to loans in the formal sector.

Appendix A: Likelihood Function for the Formal Sector

All five observable regimes have distinct components that are as follows:

$$P(D_i^* > 0, S_i^* \le 0 \mid X_i, Z_i)$$
$$= \int_{-\infty}^{X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F-(Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)} \int_{-\infty} f(u_2,u_1)du_2du_1 \qquad (i)$$
$$= \Phi_2(X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F/\sigma_D, -(Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)/\sigma_S, \rho)$$

$$P(D_i^{*F} \le 0, S_i^{*F} \le 0 \mid X_i, Z_i^F)$$
$$= \int_{-\infty}^{-(X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F)-(Z_i^F\tilde{\beta}_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)} \int_{-\infty} f(u_2,u_1)du_2du_1 \qquad (ii)$$
$$= \Phi_2(-(X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F)/\sigma_D, -(Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)/\sigma_S, \rho)$$

$$P(D_i^{*F} \le 0, S_i^{*F} > 0 \mid X_i, Z_i^F)$$
$$= \int_{-\infty}^{-(X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F)} \int_{-\infty}^{Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F} f(u_2,u_1)du_2du_1 \qquad (iii)$$
$$= \Phi_2(-(X_1\beta_1+\gamma_i\beta_{1\gamma}^F+p_i\beta_{1p}^F)/\sigma_D, (Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)/\sigma_S, -\rho)$$

$$P(S_i^{*F} \ge D_i^{*F} > 0 \mid X_i, Z_i^F)$$
$$= \int_{D^*-(Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)}^{\infty} f(u_1,u_2)du_2 \qquad (iv)$$
$$= \phi(u_1)\times\Phi\left[\frac{-D^{*F}+Z_i^F\beta_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F-\rho(\sigma_S/\sigma_D)(u_1)}{\sigma_S^2(1-\rho^2)}\right]$$
$$P(D_i^{*F} > S_i^{*F} > 0 \mid X_i, Z_i^F) = \phi_2(u_1,u_2) \qquad (v)$$

Collecting all the likelihood terms from the five cases we can write the cumulative log-likelihood as:

$$\ln[L(u_1,u_2 \mid p_i,\gamma_2^F,\beta_2^F,\beta_1)] =$$
$$\sum_{i\in Case\,1}\ln[P(D_i^{*F}>0,S_i^{*F}\le 0\mid X_i,Z_i^F)] + \sum_{i\in Case\,2}\ln[P(D_i^{*F}\le 0,S_i^{*F}\le 0\mid X_i,Z_i^F)]$$
$$+\sum_{i\in Case\,3}\ln[P(D_i^{*F}\le 0,S_i^{*F}>0\mid X_i,Z_i^F)] \qquad (7)$$
$$+\sum_{i\in Case\,4}\ln\Big[\int_{D^*-(Z_i^F\tilde{\beta}_2^F+\gamma_i^j\beta_{2\gamma}^F+p_i\beta_{2p}^F)}^{\infty} f(u_1,u_2)du_2\Big] + \sum_{i\in Case\,5}\ln[\phi_2(u_1,u_2)]$$

Appendix B: Likelihood Function for the Informal Sector

The likelihood function has three distinct components: those with observed zero demand, constrained borrowers and unconstrained borrowers. The cumulative likelihood function is given by:

$$\begin{aligned}
&\ln[L(u_1,u_2 \mid p_i,\gamma_2^I,\beta_2^I,\beta_1)] = \\
&\sum_{i\in Case\,1} \ln[P(D_i^* > 0, S_i^* \le 0 \mid X_i, Z_i) + \\
&\quad P(D_i^* \le 0, S_i^* \le 0 \mid X_i, Z_i) + P(D_i^* \le 0, S_i^* > 0 \mid X_i, Z_i)] \\
&+ \sum_{i\in Case\,2} \ln[\int_{D^* - (Z_i^I\beta_2^I + \gamma_i^I\beta_{2\gamma}^I + p_i\beta_{2p}^I)}^{\infty} f(u_1,u_2)du_2] + \sum_{i\in Case\,3} \ln[\phi_2(u_1,u_2)]
\end{aligned} \tag{8}$$

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