

Will More Credit Increase Interest Rates in Rural Nepal?*

by

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Abstract:

We test two alternative models of interest rates determination in informal rural credit markets, using data from a cross-sectional national household survey from Nepal. We find strong support for a full information, capacity-constrained and repeated oligopoly model with third-degree price discrimination. We find only marginal support for an asymmetric information cost-pricing monopolistic competition model. Price discrimination depends on the observable characteristics; caste, installment period and geographical region. The interest rates decrease as village lending capacity increases up to a certain level of capacity. Interest rates do not depend on risk related variables such as land value and loan size.

JEL-classification: D43, O16, Q14.

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1. Introduction

In his discussion of informal rural credit markets in less developed countries, Basu (1990) describes the markets as fragmented oligopolies. A fragmented oligopoly is a market structure between monopoly and competitive markets. Due to lack of legal enforcement mechanisms and lack of traditional collateral, lenders only lend to people with whom they have repeated social and economic interaction. As a consequence, borrowers can have loans only from a few lenders, and the set of lenders will typically differ between borrowers, explaining the term fragmented oligopoly. Such markets can be modeled as in Basu and Bell (1991), where two lenders have monopoly power in their respective segments, and play a Cournot game in a third segment. Floro and Ray (1997) have a similar model where two lenders exercise monopoly power in their respective segments, as long as they find it profitable not to compete in the other lender's segment. When the lenders are sufficiently patient, the collusive solution is sustainable in a repeated game. Floro and Ray argue that expansion of formal credit may affect the incentives for collusion and might worsen the credit terms for the informal borrowers. The present paper discusses a hypothesis of this kind, but the model have more detailed predictions for the equilibrium interest rate. The market structure is also different. Floro and Ray study informal lenders (rice millers) that are geographically separated, and they thus apply a Hotelling type location model.

We model fragmented oligopolies, in the sense that every segment is a separate oligopoly. This is to focus on a more complex model of price determination within the segments. In line with Floro and Ray (1997) we model a repeated game, but we apply a model of collusive pricing that explicitly determines the effect of larger lending capacity on the equilibrium price. That is, we apply the Brock and Scheinkman (1985) model of a capacity constrained and price-setting oligopoly. Furthermore, we test the predictions of the model on data from a

household survey. In the empirical analysis we compare the model with models of cost-pricing, such as an asymmetric information model with monopolistic competition. We do not believe that any model will fully describe real informal rural credit markets. Our model is useful in explaining the relative high interest rates in segments of the rural credit markets with very low default rates. The low default rates are due to nearly perfect information and high degree of economic and social control.

The high rural interest rates seem to be a major obstacle to rural development. Some poor farmers are in a vicious circle, where they every year take the same consumption loan, which is repaid with e.g. a 50% real interest rate. In this sense the high interest rates affect the distribution of wealth. Furthermore, farmers are not able to make productive investments due to the high interest rates. Credit programs have become a popular policy instrument to reduce rural poverty. In addition to the income effect of loans with interest rates below the informal market rate, these programs are also meant to increase competition in the rural credit markets, and thereby lower the market interest rates. Also the modernization of the economies, leading to more commercial credit in the rural sector, will increase lending capacities, and possibly increase competition. Chowdury and Garcia (1993), at p. 22, report an increase in formal credit supply in rural Nepal, from NR 806 million in 1986 to NR 1480 million in 1990. A major part of this supply is credit programs, as the Intensive Banking Program involving commercial banks, and the Small Farmers' Development Program implemented by the Agricultural Development Bank (ADB).

Formal lending institutions in the rural sector will typically require collateral from the borrowers. In Nepal this is also the case for credit programs, as reported by Nepal Rastra Bank (1994), at p. 21, on the loan policies of the ADB: *"Also, the loans to small and marginal farmers and the other poor are collateral-based although according to policy, they*

had to be made on group guarantee basis (without collateral)." It is reasonable to assume, as we do in the present paper, that only net-lenders in the informal market have sufficient collateral to borrow in the formal sector. Consequently, credit programs as well as more commercial credit will increase the lending capacity in the informal market. This may in turn affect the equilibrium interest rate in the informal market. However, there is no direct competition, since net informal borrowers are not allowed (additional) loans from the formal sector.

Brock and Scheinkmans' (1985) repeated Bertrand-Edgeworth model is a model of tacit collusion. Tacit collusion seems to be a realistic representation of the informal credit market in Nepal. When we asked people why they did not reduce the interest rate to get a higher share of the market, lenders told us that no one has ever done that.

Brock and Scheinkman (1985) focus on entry of lenders. In our model it is not realistic to have entry of lenders. It takes a long time to establish economic and social relations with borrowers. Such relations are necessary for lenders that need sufficient information to screen the borrowers and sufficient power to enforce the loan contracts. As an aspect of enforcement, these informal lenders are able to accept non-marketable collateral, as discussed by Bhaduri (1977). Collateral as standing crops, future labor services and revision of tenurial conditions, are only valuable for lenders with permanent economic relations with the borrowers. We thus focus on changes in individual capacities.

We demonstrate that increasing individual lending capacities, holding the number of lenders constant, will have the same effect on the collusive price as increasing the number of lenders, although the economic explanation is not the same. So we can apply a general formulation of

the Brock and Scheinkman model, where the collusive price is a function of aggregate capacity within the village.

A main contribution of the present paper is to formulate a proxy for aggregate lending capacity at the village level. We apply land value above a certain critical value, identified at the national level, as an indicator of individual lending capacity. The village capacity is measured as the average of individual capacities. The proxy can thus be considered as exogenous to individual interest rates. This proxy for village lending capacity contributes significantly to the variance in interest rates between villages.

The Brock and Scheinkman (1985) model predicts a uniform price at the village level. However, this is not in line with stylized facts for informal rural credit markets. In a separate paper, Hatlebakk (2000), we generalize the model to allow for third-degree price discrimination. This means that lenders apply their common knowledge about household characteristics to categorize borrowers into separate segments. To keep the theoretical model in the present paper simple, we will not present the full model of price discrimination. However, the empirical analysis captures the full model in the sense that we include household characteristics as explanatory variables. For a certain (village) lending capacity, the household characteristics as represented by a set of significant dummy variables, describe a vector of prices as predicted by the full model of price discrimination.

As we shall see below, the Brock and Scheinkman (1985) model predicts that interest rates will increase in aggregate lending capacity for a certain interval of the capacity. Hatlebakk (2000) demonstrates that this counter-intuitive result is less likely to happen when we allow for many segments and price discrimination. Furthermore, that paper demonstrates that the counter-intuitive interval is small even for the one-segment case. Therefore it is not surprising

that we are unable to identify a significantly increasing part of the price function in the present paper. When we divide the price function into two linear parts, we find a significantly decreasing part for low village capacity, and a non-significant increasing part for larger village capacity.

The non-significant increasing part may be interpreted as support for the repeated game model of monopoly pricing, or it might be interpreted as support for competitive marginal cost-pricing. However, as we demonstrate in Hatlebakk (2000), price discrimination cannot be sustained in the competitive equilibrium. The price discrimination we identify in the present paper indicates that we can reject the competitive model, and we can interpret the non-significant increasing part of the price-function as unconstrained monopoly pricing.

This is an important result, since alternative explanations of high informal interest rates, are based on competitive cost-pricing. The literature points to a risk premium in the informal market, or to screening costs. Hoff and Stiglitz (1997) present a model of monopolistic competition and enforcement costs. In their model a credit subsidy will lead to entry, and thus higher average costs due to loss of scale economies or negative externalities among lenders. In Bose (1998) lenders and borrowers are heterogeneous, and a decrease in the formal interest rate will increase lending from the well informed informal lenders to the less risky borrowers. Consequently, the residual borrowers will have a higher default rate in equilibrium, which implies higher interest rates. Aleem (1990) explains the high interest rates by screening costs.

If lending costs determine the interest rates, then we should be able to identify variables that determine these costs, and thus the interest rates. The risk-premium hypothesis implies that interest rates increase in the lender's cost of default. The cost of default is in turn likely to be smaller the higher is the borrower's wealth, as measured by land value. Similarly, the cost of

default is likely to increase in the loan size. On the other hand, the average screening costs are likely to be smaller the larger is the loan. The total effect might be a U-shaped relation between loan size and interest rates, as modeled by Bell (1990). However, when adjusting for endogeneity, we find no significant effect of loan size on the equilibrium interest rates. Furthermore, we find no significant effect of land value on the interest rates.

So we conclude that the high interest rates in rural Nepal are not due to lending costs. We will emphasize that this conclusion is due to the fact that we have been able to identify important explanatory variables, such as lending capacity and indicators of price discrimination. If we omit these variables, then interest rates appear to depend on borrowers' land value¹.

A competitive model that we are not able to test, is the model by Gupta and Chaudhuri (1997) where the informal interest rate equals the effective formal rate, including a bribe on formal loans. They demonstrate that if formal and informal loans are complementary in the production process, a reduction in the formal rate can lead to an increase in the bribe and therefore in the informal interest rate.

In Brock and Scheinkman (1985) so called trigger strategies are applied to maintain collusion. If one lender deviates from the collusive price, then all lenders will play the stage-game Nash equilibrium infinitely. An alternative to these strategies is so called stick and carrot strategies, where the deviator is punished maximally for some periods, and then the players return to collusion. Applying results by Lambson (1987) to our case of linear demand, we demonstrate

¹ Yadav and Pederson (1996) have an analysis like this for rural Nepal. They use data from 190 households in four villages in the lowlands of Nepal and estimate a linear model, incorporating variables reflecting default risk and access to formal credit. They find that interest rates decrease with farm size, non-land assets and the ratio of irrigation, which can all reduce the default risk. They find that interest rates are lower for borrowers having formal loans and easy access to formal credit institutions, indicating that competition will reduce the

that stick and carrot strategies will lead to the same non-linear relation between the collusive price and lending capacity as the Brock and Scheinkman model². However, we have not checked whether this property holds for the general model of price discrimination.

Section 2 presents the theoretical model. In Proposition 1 equilibrium prices are stated as a function of aggregate lending capacity in the local market. Section 3 presents the econometric specification of the price function. Section 4 discusses alternative interpretations of the explanatory variables by introducing the cost-pricing hypotheses. Section 5 presents the econometric methodology. Section 6 presents the data, the proxy for lending capacity, and descriptive statistics. Section 7 presents the results. Section 8 concludes and discusses policy implications.

2. The model

We study an oligopoly with N lenders, where every lender has the same constant lending capacity k . Any change in k is exogenous and not anticipated by the lenders. There is a fixed marginal cost c of lending up to k . Lenders take part in an infinitely discounted supergame. We apply a Bertrand-Edgeworth model analyzed by Brock and Scheinkman (1985). We present the maximum price that can be sustained by collusion as a function of capacity. Brock and Scheinkman derive the price, as a function of number of firms (lenders) N . We write the model on the general form, where the price is a function of aggregate capacity, $K = Nk$. However, as argued in the introduction, increases in the individual capacities k are more likely in informal rural credit markets than entry of informal lenders and thus increases in N .

interest rate. They also find lower interest rates for loans from relatives and friends. Siamwalla et al. (1990) have a similar study from Thailand, where there is no significant effect of for example land holdings.

² Brock and Scheinkman (1985) apply a linear demand curve. Vives (1986) describes the equilibrium of the stage game for a general demand curve. However, in calculating equilibrium profits in the repeated game for even a simple non-linear demand curve described by a constant elasticity of demand, we got very messy

The empirical analysis in the present paper requires a general version of the model, where price discrimination is an option. We prove in a separate paper, see Hatlebakk (2000), that the equilibrium price functions for the general model have the same structure as the uniform price function. To keep the theoretical model in the present paper simple, we apply the uniform price model. Price discrimination is taken into account when we formulate the empirical specification of the price function.

Lenders will only lend to borrowers they know well from repeated social and economic interactions. This implies that lenders have full information about borrowers and they are fully able to enforce repayments. Demand is thus measured as effective demand, that is, demand that will actually be repaid. Aggregate demand at a uniform price p is $q = a - p$, with $a > c$. Lenders set prices simultaneously and independently at p_1, \dots, p_N , with $p_i \leq a$ for all lenders $i = 1, \dots, N$. Borrowers first choose the lowest priced offer. We apply the same rationing rule as in Brock and Scheinkman³. If m lenders charge prices below p_j , and n lenders charge exactly p_j , then lender j when he charges p_j , faces the demand

$$d(p_j | p_1, \dots, p_{j-1}, p_{j+1}, \dots, p_N) = \max(0, (a - p_j - mk)/n). \quad (1)$$

We assume that lenders are risk neutral, and consequently maximize expected profit.

expressions.

³ The lender with the lowest price has to decide on how to ration his supply. As argued by Osborne and Pitchik (1986), it is reasonable to assume that the firm chooses a rationing scheme which minimizes the profit of the other firms, as long as its own profit is not affected (the strategy can be profitable in the long run). This can be done by either selling the same amount to every customer, or by selling all to the customers with the highest reservation prices. The latter interpretation is the most realistic in a fragmented market. This rationing scheme was first applied by Levitan and Shubik (1972) and later in Kreps and Scheinkman (1983) and Brock and Scheinkman (1985).

We will now present the Nash equilibrium of the one-shot stage game. The equilibrium is the same as in Proposition 1 in Brock and Scheinkman (1985), which in turn builds on Kreps and Scheinkman (1983). The equilibrium outcome depends on aggregate capacity. For large capacity, which is case a) below, we have the normal Bertrand case. For small capacity, which is case b) below, we have capacity constrained pricing. Case c) is the intermediate case where there is no equilibrium in pure strategies. We will present the intuition behind the equilibrium in more detail below.

The equilibrium outcome of the stage game (Proposition 1 in Brock and Scheinkman (1985)):

- a) *If $K - k \geq (a-c)$, then an equilibrium is given by $p = c$, leading to $\pi^n = 0$.*
- b) *If $K + k \leq (a-c)$, then the equilibrium is given by $p = a-Nk$, leading to $\pi^n = (a - K - c) k$.*
- c) *If $K - k < (a-c) < K + k$, then the expected profit in the mixed strategy equilibrium is given by $\pi^n = (a - c - K + k)^2/4$.*

Note that we can alternatively characterize the three cases by a) $K \geq (a - c)N/(N - 1) = K_5$, b) $K \leq K_4 = (a - c)N/(N + 1)$, and c) $K_4 < K < K_5$, where K_4 and K_5 are the critical values for K that connect the special cases a) to c). More critical values will be defined below. Also note that π^n is a continuous function of K , with $\pi^n = k^2$ at $K = K_4$, and $\pi^n = 0$ at $K = K_5$. Note that for $p = c$, we can identify the maximal demand as $(a - c)$. For K sufficiently larger than $(a - c)$ we have the normal Bertrand case, for K sufficiently smaller than $(a - c)$ we have the capacity constrained case. We will not provide a complete discussion of the equilibrium, but give some economic intuition. Brock and Scheinkman (1985) refers to a proof in Kreps and Scheinkman (1983).

Case a), where $K \geq (a - c)N/(N - 1)$, is the excess capacity (normal Bertrand) case, where any set of $(N - 1)$ lenders can satisfy the full demand. Thus, only the lender that charges the lowest price can sell at full capacity. As a consequence, lenders will under-cut any price above c to sell their full capacity, and $p = c$ is the only Nash equilibrium.

Case b), where $K \leq (a - c)N/(N + 1)$, is the capacity-constrained case, where profit will always be positive, even when all lenders supply their full capacities. When they lend at full capacity, price-cuts will not be profitable. A lender j who increases the price will meet the residual demand, leading to the profit $(a - p_j - (N-1)k)(p_j - c)$, and consequently the optimal price $p_j = (a + c - (N-1)k)/2$, which is not higher than the equilibrium price $p = a - Nk$, since $k \leq (a - c)/(N+1)$ for this case. Consequently, the price that equalizes total demand and total capacity, is always the Nash equilibrium.

Case c) is the intermediate case. At a low price it is profitable to raise the price and meet the residual demand, in contrast to case b). If every lender is charging a high price there will be an incentive to under-cut the price as discussed for case a). As a consequence, in this interval there is no equilibrium in pure strategies. There is an equilibrium in mixed strategies that implies the same expected profit as if the lender meets the residual demand. We know from case b) that this price is $p_j = (a + c - (N-1)k)/2$, leading to the profit, $((a + c - (N-1)k)/2 - c)(a - (a + c - (N-1)k)/2 - (N-1)k) = (a - c - K + k)^2/4$, which is the expected profit from mixed strategies.

The profit levels in cases a) to c) are the non-cooperative profits of the lenders. When lenders collude, we assume that they will share the collusive profit, as described by

$$\pi^c = (p-c)(a-p)/N. \quad (2)$$

In case the other lenders collude, one lender may obtain the deviation profit

$$\pi^d = (p-c) k, \quad (3)$$

by charging a price infinitesimal below p .

We assume that lenders are playing trigger strategies⁴, which means that in case anyone deviates, no lender will collude in any following period. Applying such strategies, Friedman (1971) proved that it is a subgame perfect Nash equilibrium to collude as long as the discounted value of collusion, evaluated at discount factor δ , is not less than the discounted value of deviating in period $t = 0$, and playing the one-shot Nash equilibrium in all remaining periods:

$$\sum_{t=0}^{\infty} \delta^t \pi^c \geq \pi^d + \sum_{t=1}^{\infty} \delta^t \pi^n \Leftrightarrow$$

$$\frac{1}{1-\delta} \pi^c \geq \pi^d + \frac{\delta}{1-\delta} \pi^n \Leftrightarrow$$

$$\pi^c \geq (1-\delta)\pi^d + \delta\pi^n. \quad (4)$$

⁴ However, the results hold for certain stick and carrot strategies as well, see the appendix.

A whole set of prices will typically be sustainable under this incentive constraint. We assume that lenders choose a collusive price p that maximize π^c subject to the constraint $\pi^c \geq (1 - \delta)\pi^d + \delta\pi^n$. Proposition 1 describes the collusive price as a function of K .

In the proof we study successively cases a) to c), inserting for π^n from the stage game equilibrium described above. For case b) we need $K_1 = (a-c)/2$, which is the optimal monopoly quantity. The K_i -s refer to Figure 1. The proposition also holds for stick and carrot strategies, as is demonstrated in the appendix. As will be discussed below, similar results are to be found at p. 378 in Brock and Scheinkman (1985), although they do not formulate a proposition with a proof. The proposition with a similar proof is also to be found as an illustration of the multi-segment case in Hatlebakk (2000).

Figure 1 about here.

Proposition 1.

The equilibrium price equals:

$$p = a - K, \quad \text{if } K \leq (a-c)/(1+\delta) = K_2$$

$$p = c + \delta K, \quad \text{if } K_2 \leq K \leq (a - c)/2\delta = K_3$$

$$p = (a + c)/2, \quad \text{if } K_3 \leq K \leq (a - c)/2(1 - \delta) = K_6, \text{ and } \delta \text{ is sufficiently large.}$$

$$p = a - (1 - \delta)K, \quad \text{if } K_6 \leq K \leq (a - c)/(1 - \delta) = K_7$$

$$p = c, \quad \text{if } K_7 \leq K.$$

Proof: As described, we need to identify the price p that maximizes π^c s.t. $\pi^c \geq (1 - \delta)\pi^d + \delta\pi^n$. The proof is done separately for cases a) to c), since π^n differ between the cases as described for the stage game equilibrium. To simplify the proof of c) we assume a sufficiently large δ , as described by $\delta \geq (N+1)/2N$. The assumption implies that the monopoly price $p = (a + c)/2$ is sustainable for this case.

Case a): $K \geq K_5 = (a - c)N/(N - 1)$: The equilibrium price solves the optimization problem:
 $\max \pi^c = (p-c)(a-p)/N$ s.t.

$$(p - c)(a - p) / N \geq (1 - \delta)(p - c)k , \quad (5)$$

where the constraint can be simplified to become

$$p \leq a - (1 - \delta)K . \quad (6)$$

In an unconstrained optimum, we have $p = (a+c)/2$. Inserting this price into (6), we find that the monopoly price is sustainable as long as $(a + c) / 2 \leq a - (1 - \delta)K \Rightarrow K \leq (a - c) / 2(1 - \delta) = K_6$. So, if $K_5 \leq K \leq K_6$, then $p = (a+c)/2$. In case $K \geq K_6$, the constraint is binding as long as $p \geq c \Rightarrow K \leq (a - c) / 2(1 - \delta) = K_7$. So, if $K_6 \leq K \leq K_7$, we have $p = a - (1 - \delta)K$, and if $K \geq K_7$, we have $p = c$.

Case b): $K \leq K_4 = (a - c)N/(N + 1)$: First, we study the case $K \leq K_1$. In this interval aggregate capacity is less than or equal to $(a-c)/2$, which is the optimal monopoly quantity, and consequently π^c is maximized when everyone lend at full capacity. The equilibrium price will be determined on the demand side by the inverse demand function $p = a - K$, which is the

same as the Bertrand price in the stage game. Next, we study the interval $K_1 \leq K \leq K_4$ where lenders maximize $\pi^c = (p-c)(a-p)/N$ s.t.

$$(p - c)(a - p) / N \geq \delta(a - c - Nk)k + (1 - \delta)(p - c)k. \quad (7)$$

In an unconstrained optimum we have $p = (a+c)/2$, which is sustainable when $(a - c)^2 / 4N \geq -N\delta k^2 + (\delta(a - c) + (1 - \delta)(a - c) / 2)k \Rightarrow (a - c) / 2\delta = K_3 \leq K$. Consequently $p = (a+c)/2$ is sustainable in the interval $K_3 \leq K \leq K_4$. In the interval $K_1 \leq K \leq K_3$ the constraint is binding, i.e. $(p - c)(a - p) \geq \delta(a - c - K)K + (1 - \delta)(p - c)K \Leftrightarrow (K - a + p)(\delta K + c - p) = 0$, i.e. we have either $p = c + \delta K$, $p = a - K$, or both cases. In the first case only the deviation constraint binds. In the second case the capacity constraint binds, and consequently the deviation constraint binds in a trivial way, that is, the collusive price equals the competitive price. The third case is the turning-point where $c + \delta K = a - K \Leftrightarrow K = (a - c) / (1 + \delta) = K_2$.

Case c): $K_4 \leq K \leq K_5$: Lenders maximize $\pi^c = (p-c)(a-p)/N$ s.t. $(p - c)(a - p) / N \geq \delta(a - (N - 1)k - c)^2 / 4 + (1 - \delta)(p - c)k$. In an unconstrained optimum we have $p = (a+c)/2$, which is sustainable when

$$D = (a - c)^2 / 4N - \delta(a - (N - 1)k - c)^2 / 4 - (1 - \delta)(a - c)k / 2 \geq 0. \quad (8)$$

We have $K_4 = (a - c)N / (N + 1) \geq K_3 = (a - c) / 2\delta \Leftrightarrow \delta \geq (N + 1) / 2N$, and $K_5 = (a - c)N / (N - 1) \leq K_6 = (a - c) / 2(1 - \delta) \Leftrightarrow \delta \geq (N + 1) / 2N$, which is true by assumption. From case a) we know that the unconstrained price is sustainable for $K < K_6$, and will thus be sustainable for

K_5 . From case b) we know that the unconstrained price is sustainable for $K > K_3$, and will thus be sustainable for K_4 . We write the deviation constraint as $D = (a - c)^2 / 4 - \delta(a - (N - 1)K / N - c)^2 N / 4 - (1 - \delta)(a - c)K / 2 \geq 0$, and consequently we have $\partial D / \partial K = [\delta((a - c)(N - 1) - K(N - 1)^2 / N) - (1 - \delta)(a - c)] / 2$, and $\partial^2 D / \partial K^2 = -K(N - 1)^2 / 2N$, that is, D is concave, which in turn implies $D > 0$ for the full interval. \parallel

Note that the unconstrained collusive price, $p = (a + c) / 2$, is the optimal monopoly price. Also note that production will always be constrained by the demand curve. So for any $K > K_2$, the equilibrium demand is smaller than capacity, and borrowers are rationed in equilibrium.

Now we can sum up the results as illustrated in Figure 1. At low aggregate capacity, $K \leq K_1$, the collusive price equals the non-collusive price, which in turn is determined from the demand side. For the interval from K_1 to K_2 the deviation constraint binds in a trivial sense, that is, any price above the non-collusive price will be under-cut. For the interval K_2 to K_3 , the punishment (non-collusive) profit is so small that a collusive price can be sustained without leading to deviation. As K increases in this interval the punishment (non-collusive) profit decreases faster than the deviation profit increases, and consequently a higher price can be sustained in collusion. For $K \geq K_3$ even the monopoly price is sustainable. For $K \geq K_5$, the punishment profit becomes zero, and the deviation profit is increasing in K . For a certain $K = K_6$ the deviation constraint will again bind. As K increases in the interval $K > K_6$, the deviation profit increases, and the collusive price has to decrease to counteract the incentive for deviation. The collusive price decreases until it equals the marginal cost (the non-collusive price) for $K \geq K_7$.

The proposition identifies the equilibrium price in the repeated game as a function of $K = Nk$, and is illustrated in Figure 1. Figure 3 in Brock and Scheinkman (1985) illustrates the same results as a function of the number of firms N . Brock and Scheinkman do not discuss the similarity between a change in the number of firms and a change in individual capacities. This is due to their focus on entry. In contrast, our focus is on informal rural credit markets where, as discussed in the introduction, it is reasonable to assume that the number of firms is fixed, while the capacities may change. Although the effect on price is symmetric, the economic explanations differ, as can be seen from inequality (1). An increase in N decreases each lender's portion of aggregate collusive profit (the left hand side), while an increase in k increases each lender's profit from deviating (the right hand side). From (7) we see that in addition to the effects discussed for (1), both N and k will affect profit in the punishment phase. Below we formulate a proxy for aggregate lending capacity K , and estimate the price function that is illustrated in Figure 1.

3. Econometric specification.

Our main hypothesis is that lending capacity affects rural informal interest rates in line with Proposition 1, and illustrated in Figure 1. Note that this is the prediction for a uniform interest rate within a local rural credit market such as a village. We test the hypothesis using cross-sectional data. Below we specify a proxy for the aggregate lending capacity K_j in village j . In line with the figure, lending capacity is modeled as a partial-linear function, using the spline-function, $p = \beta_0 + \beta_1 K_j + \beta_2 d_2 (K_j - K_2)$, where $d_2 = 1$ if K_j is larger than the critical value K_2 from Figure 1, and $d_2 = 0$ otherwise. It turns out that it is sufficient to specify two linear parts, as illustrated by this spline function.

In line with the general version of the model, see Hatlebakk (2000), we allow the interest rate p_i paid by household i to vary according to observable household characteristics \mathbf{x}_i . This means that for a certain village j with aggregate lending capacity K_j , the interest rates paid by the households within that village are not necessarily uniform. In terms of the empirical model this is a simple generalization, while the generalization of the theoretical model is complex. This explains that we have not included the general theoretical model in the present paper. We also allow a dummy y_j to denote geographical region. Consequently, we specify the following econometric model,

$$p_i = \beta_0 + \beta_1 K_j + \beta_2 d_2(K_j - K_2) + \beta_3 x_i + \beta_4 y_j + \varepsilon_i, \quad (9)$$

The characteristics in \mathbf{x}_i are indicators of price discrimination and include a dummy indicating the length of the installment period. This indicator is not a household characteristic, but is applied in the same manner for price discrimination.

The theoretical model is formulated for the aggregate demand curve $q = a - p$. For the empirical analysis we normalize quantity over villages by dividing the proxy for K by a proxy for $(a - c)$, where $(a - c)$ is the demand at $p = c$. This in turn means that every village will have normalized demand equal to 1 for $p = c$. We allow the maximum willingness to pay to vary according to the regional dummy. This means that for $q = 0$, the price may vary over regions. The normalization implies that Figure 1 will represent the demand structure of any village.

There is no exact measure for aggregate informal lending capacity, and we apply a proxy for K_j that we denote L_j , and also a proxy for $(a - c)_j$ that we denote B_j . Since these are proxies, we specify the linear functions, $(a - c)_j = \alpha_b B_j$ and $K_j = \alpha_l L_j$. The normalized lending capacity

is the ratio $\hat{K}_j = K_j / (a - c)_j = \alpha_l L_j / \alpha_b B_j = \alpha L_j / B_j$. Note that the critical values in Figure 1 are also normalized, such that $\hat{K}_2 = 1 / (1 + \delta)$. In estimating (9), the ratio L_j / B_j will be the explanatory variable that represents lending capacity in the spline-function. By repeated regressions we identify the best fitted value for \hat{K}_2 , as measured in terms of L_j / B_j . Since the theoretical value is $\hat{K}_2 = 1 / (1 + \delta)$, we will indirectly have an estimate for the parameter α .

We need to specify the proxies L_j and B_j . We specify $L_j = \text{mean}_j[\max(0, V_i - \hat{V})]$, and $B_j = \text{mean}_j[\max(0, \hat{V} - V_i)]$. That is, we specify a cutoff \hat{V} for land value V that determines whether a household has positive lending capacity or is a potential net-borrower. Any household i within village j with land value $V_i > \hat{V}$, will contribute to the measure L_j of the lending capacity for village j . In the same way any household i within village j , which has land value $V_i < \hat{V}$, will contribute to the measure B_j of potential borrowing within village j . The explanatory variable L_j / B_j is denoted *prop* in the reported regressions.

Thus we apply land value as an indicator of a household's credit position, which means that we expect net-lending to be a positive function of land value, with net-lending shifting from being negative to being positive at the cutoff \hat{V} . The rationale is that land is the major asset in poor rural economies. So land is an indicator of credit needs (if below the cutoff) and supply of credit (if above the cutoff). Furthermore, land is a major collateral for banks, and can thus be applied to raise formal loans that in turn can be supplied in the informal market. The actual cutoff applied, NR 152 000, is identified as the critical value for V that maximizes the difference in proportion of net-lenders and net-borrowers that have land value above the cutoff. We describe the identification of the cutoff in more detail in section 6.

Equation (9) specifies a spline function for lending capacity with one knot. Figure 1 indicates that we may have four knots. However, repeated regressions for grids of one or two knots (and a grid of two knots with a third knot added at a reasonable distance from the second), demonstrate that the best fit in terms of R-squared for the two-knots case is very similar to the best fit for the one-knot case. So in the final specification, we only apply one knot⁵. The identification of the knot is described in further detail in section 5.

Note that the one-knot specification is in line with the stage-game model in section 2, that is the horizontal (non-significantly increasing) part of the price function might be interpreted as the marginal cost of lending. However, the horizontal part may as well be interpreted as the monopoly price p^* in Figure 1. As argued in Hatlebakk (2000) the interval between K_1 and K_3 is so small that we cannot expect to identify a significantly increasing part of the price function. Furthermore, price discrimination is not possible in the stage-game model, and thus the horizontal part is most likely representing monopoly prices. In the next section we will present additional tests that can discriminate between these two interpretations of the estimated price function.

4. Alternative hypotheses

The model in section 2, which is specified as an empirical model in section 3, predicts a gap between formal and informal rural interest rates. In that model the formal interest rate is the marginal cost of lending in the informal market. Depending on the aggregate lending capacity, either a capacity constraint or monopolistic pricing explains the price gap.

⁵ We do not need to specify α but the estimated knot in terms of the variable *prop* equals 2, and from the theoretical model we have $K_2 = 1/(1 + \delta)$, and thus we have $2\alpha = 1/(1 + \delta)$, or $\alpha = 1/2(1 + \delta)$.

According to alternative hypotheses, the high informal interest rates are due to additional costs of informal lending. Borrowers have private information about their own type and behavior. Lenders can become better informed by costly screening efforts, as modeled by Aleem (1990), or they can accept the expected costs of defaults. In the first case the interest rate has to cover the average cost of screening. In the second case the interest rate has to cover a risk-premium, or more precisely the equilibrium costs of default.

The screening hypothesis is highly in contrast to our model in section 2. We believe that lenders are well informed about their borrowers from repeated social and economic interactions over a long period, which may last for generations. The additional costs of screening will thus be minimal. When it comes to the risk-hypothesis, note that it requires defaults in equilibrium. We do not know about studies of defaults in the informal rural credit market of Nepal, but it is our impression that defaults are very rare.

We will represent the screening and risk-premium hypotheses in a simple model of a lender-borrower interaction. Similar models can be found in Basu (1997) and Bell (1990). The model allows lending costs and thus the interest rate to vary with household and loan characteristics. The borrower repays a loan with a probability $P(S)$, where S is screening activities at the cost $C(S)$, with $P'(S) > 0$, $P''(S) < 0$, $C'(S) > 0$ and $C''(S) > 0$. If the borrower defaults, he repays the collateral $F(V)$, where V is land value and $F'(V) > 0$. The lender chooses an optimal level of screening according to the first-order condition, $P'(S)(L(1 + p) - F(V)) = C'(S)$, and in equilibrium the interest rate will cover the average-cost of lending, as implicitly described by

$$P(S)L(1 + p) + (1 - P(S))F(V) = L(1 + c) + C(S). \quad (10)$$

The borrower is not fully liable for the loan, that is, $F(V) < L(1 + p)$. This kind of average-cost-pricing is usually modeled as the equilibrium of a model of monopolistic competition, see Hoff and Stiglitz (1997).

The model reduces to the unconstrained stage game model from section 2, when $P = 1$ for $S = 0$, leading to $p = c$. The model reduces to a pure risk premium model if P is independent of S , that is (10) reduces to

$$P(1 + p) + (1 - P)F(V)/L = (1 + c), \quad (11)$$

where $F(V)/L < (1 + p)$. The equality is only possible for $p > c$, i.e. the informal interest rate has to cover a risk premium. If the collateral $F(V)$ equals zero, then the risk premium is determined by $1 + p = (1 + c)/P$. For positive collateral, the risk premium is decreasing with V , and at full liability, i.e. $F(V) = L(1 + p)$, we will have $p = c$. For positive collateral, the risk premium is increasing with L . So the risk-premium and thus the equilibrium interest rate will decrease in V and increase in L .

The model reduces to a pure screening model if the collateral has no effect on the interest rate. In that case we can write $F(V) = 0$, and (10) reduces to

$$P(S)L(1 + p) = L(1 + c) + C(S), \quad (12)$$

which is equivalent to $P(S)(1 + p) = (1 + c) + C(S)/L$. In this case the equilibrium interest rate will increase in the average screening cost, $C(S)/L$, and thus decrease in L .

In the general case the effect of L depends on whether the risk-premium or the screening cost dominates. This is illustrated by

$$P(S)(1 + p) + [(1 - P(S))F(V) - C(S)]/L = (1 + c), \quad (10')$$

where the screening cost dominates if $C(S) > (1 - P(S))F(V)$, where the latter is the expected value of confiscated collateral. The model converges to the screening model as $F(V)$ converges towards zero, and the model converges to the risk-premium model, as the screening cost converges towards zero in equilibrium.

For this general model it may be reasonable to add the following assumption. As L increases the probability that borrowers will repay the loan decreases, that is we can replace the $P(S)$ function by $P(S, L)$ with $P'_L < 0$. In this case, the risk-premium effect on the interest rate will increase in L , and will eventually dominate the screening cost. We will thus have a U-shaped relation between loan size and the interest rate as modeled by Bell (1990)⁶. Consequently, we have the following hypotheses.

Pure risk-premium model: $dp/dV < 0, dp/dL > 0$.

Pure screening model: $dp/dL < 0$.

Full model of risk: $dp/dV < 0, dp/dL < 0$ for small L and $dp/dL > 0$ for large L .

Note that the sign of dp/dL determines whether the risk-premium or the screening part of the model is dominating. This implies the following sequence of empirical hypotheses,

- if $dp/dL > 0$, then we have support for the risk premium model,
- if $dp/dL < 0$, then we have support for the screening model,
- if dp/dL is not significantly different from zero, then we cannot reject
the full information model in section 2.
- if $dp/dV < 0$, then we have support for the risk premium hypothesis.
- if dp/dV is not significant different from zero, then we cannot reject
the full information model in section 2.

By adding (second-degree polynomials of) loan size and land value to the \mathbf{x} -vector in the regression model in (9), we can test these hypotheses. Note that at the individual level we may have special cases of the cost-pricing model where loan size and land value have no effect on the interest rate, that is if the collateral $F(V) = 0$, or if $C(S) = (1 - P(S))F(V)$. However, for a cross-section of households with large variation in land value, we would expect cost-pricing (if present) to depend on land value.

⁶ In Bell (1990) the relation is represented by U-shaped iso-profit curves for the lenders, and he thus also models the monopoly case where the monopolist select the optimal contract along the borrowers reservation-curve in the p - L space.

5. Econometric methodology

We estimate (9) using weighted OLS, with White-corrected robust standard errors⁷. The robust standard errors take into account the possibility that the residuals are not homogeneously distributed over observations, and may be dependent within clusters (villages)⁸. While robust estimation affects (usually increases) the standard errors, the probability weights affect the parameters. We apply probability weights that reflect the households probability of being selected, which in turn is a result of the survey design⁹.

The models from section 2 and 4 have different predictions when it comes to loan size. This has implications for the econometric methodology. The model from section 4 is a single equation model in the sense that the interest rates are fully determined by the equilibrium zero-profit equation (10), that is, as a function of loan size and land value.

In the model from section 2, individual loan size has no influence on the equilibrium interest rate. This is because the interest rate is determined at the aggregate level as a function of

⁷ That is, we apply the *regress* command in STATA with the cluster option, see StataCorp. (1999). An alternative would be to apply the survey commands in STATA allowing for stratification of clusters. The standard errors turn out as approximately the same, and we apply the more transparent technique where stratification is not taken into account.

⁸ The adjustment for within cluster dependency means to replace the estimated residuals for the observations within a cluster, with the mean of the estimated residuals within the cluster, before the sum of squared residuals is calculated. Thus taking the mean before the residual is squared decreases every element in the sum of squares, but also reduces the number of elements. The two effects counteract, but usually the standard errors for the parameters will increase when this dependency is taken into account. For details see the "regress" command in the STATA manual.

⁹ Rural Nepal was stratified into three strata. Villages within strata were selected with probability according to the number of households in a national census. Next, a household rooster was made for every selected village, and a (self-weighted) random sample of 12 households was selected for every village. In the remote Far-Western region the sample was increased to 16 households. The household roosters turned out to be different from the national census, and the probability weights were corrected for the difference. In addition, the factors are corrected for different probabilities between strata and regions. The probability weights were provided by the survey institution, the Central Bureau of Statistics, Nepal. The average of the adjustment factors equals 746 in the mountains, 1349 in the hills and 1374 in terai. The number of households in the samples from these strata were respectively 424, 1136 and 1224, leading to estimates for total numbers of households of 316 000 in the mountains, 1 532 000 in the hills and 1 682 000 in terai, which are in line with official census data. For terai the strata covers some urban households, which will not be included in our analysis.

lending capacity and the aggregate demand curve. Individual loan sizes will be determined recursively, as a function of the equilibrium interest rate.

Ex-ante, we need a specification that covers both models. If the model from section 2 is correct, then we might still allow loan size as an additional explanatory variable, but only if we take into account that loan size will be endogenous. Loan size is endogenous, because it is a function of the interest rate. If the model from section 4 is correct, then we have a single equation model, and we would not expect loan size to be endogenous. The model from section 2 thus predicts that we should not expect loan size to be significant if we estimate (9) using 2SLS. The model from section 4 predicts that loan size is significant, and OLS and 2SLS should give the same unbiased (but less efficient for 2SLS) parameters.

Loan size is not significant in the 2SLS estimation, while the parameters are larger and highly significant in the OLS regression¹⁰. These results indicate that the model from section 2 is appropriate. Loan size has no significant separate effect on (lending costs and thus on) interest rates. While the (apparently biased) OLS regression captures the recursive effect of the interest rate on loan sizes.

However, instrumental variable regressions are less efficient than OLS, and we cannot necessarily reject the model from section 4. The non-significant parameters from the 2SLS regression indicate that the interest rate is a U-shaped function of loan size as predicted by the model in section 4. The (biased) OLS regression indicates the same U-shaped function. So,

¹⁰As instruments for loan size we apply variables that affect the loan size and not the interest rate. These are dummy variables for the reported purpose of the loan and for potential credit needs. None of the variables are significant if they replace loan size in the price function. Loan size is not significant as a second-order polynomial (U-shaped relation) or as a linear function (pure risk model). The same conclusion can be drawn if we replace loan size by total informal borrowing (which is relevant for borrowers having additional loans from the same lender). The conclusion is independent of whether we include the lending capacity variable or not.

there seems to be a minor U-shaped effect of loan size on average lending cost and thus on the interest rate.

For a proper estimation of the model from section 2, we omit loan size. Consequently, we can apply the more efficient OLS estimator. As we will see in Table 4 this has only minor effects on the other parameters. We still include land value, which is likely to be an exogenous variable¹¹.

In the next section we present the explanatory variables, including our proxy *prop* for lending capacity. It turns out that as many as 23 out of 199 villages have zero lending capacity. This indicates no (few) commercial informal moneylenders in the village. If there is not a professional moneylender in a village, we do not expect the model from section 2 to apply, and we represent these villages by a dummy for zero lending capacity.

For positive lending capacity, we will estimate a function that approximates Figure 1. As a first approximation we apply a third-degree polynomial for the lending capacity variable *prop*, where all parameters are significant. The local minimum can be interpreted as K_2 , and with this interpretation it turns out that 12 villages have lending capacity larger than K_2 .

The third-degree polynomial indicates that we do not need the full set of four thresholds in a partial linear representation of Figure 1. To identify the knots for the partial-linear spline function, we repeat the regression first for a two-dimensional grid of knots. Then we repeat the regression for a new two-dimensional grid, where a third knot is added at a reasonable distance from the second knot. Finally we repeat the regression for a one-knot grid. In all

¹¹We apply a second-degree polynomial for land value, which fits better than a linear function.

three cases the best fit in terms of R-squared is a downward-sloping part of the curve for capacities below the knot, $prop = 2$, and then a non-significant increasing part for higher values. In the two-knots case, we actually have a non-significant increasing part for very small capacities, which is in line with the smaller interest rates for the dummy representing zero capacity. In section 7 we only report the one-knot case, since the effect of low capacity is covered by the dummy.

The estimated single knot of $prop = 2$ has the interpretation of K_2 in Figure 1. There are (as mentioned) 23 villages with zero capacity. Next, there are 128 villages along the decreasing part of the price function from zero to K_2 (which may be replaced by 48 villages along the mentioned non-significant increasing part and then 80 villages along the decreasing part). Finally, there are 48 villages along the non-significant increasing part, to the right of K_2 .

Potentially there is a selection problem in the data. Households reporting informal loans of the type we will define in section 6 are not a completely random sample. We control for selection bias using a Heckman model. We apply identifying variables that may reflect the need for credit, without having a significant effect on the interest rate¹². We cannot reject the hypothesis of selection bias, but the differences in estimated parameters and standard errors for the price function are marginal.

6. Data and descriptive statistics

We apply the Nepal Living Standard Survey (NLSS) conducted by the Central Bureau of Statistics (1996), Nepal (CBS), during the period June 25, 1995 to June 15, 1996. CBS interview-

¹²Some of the variables are the same as the instrument variables applied to adjust for endogeneity, but we cannot use all these variables, since some are only reported for actual loans.

wed 2657 rural households in 215 wards¹³. In most wards 12 households were interviewed¹⁴. The wards were sorted into three strata or ecological belts, the mountains, hills and terai. Within every strata, wards were selected with probabilities proportional to the number of households in the ward. Then the households were randomly selected within each ward¹⁵.

There are 68 pages of questions in the NLSS questionnaire, including questions on demography, housing, facilities, migration, expenditures, production, education, health, incomes, land contracts, credit and assets. The large questionnaire will potentially reduce the quality of the data. After some hours answering questions, we expect people to try to save time by giving shorter answers. The bias adds to other potential biases of data collection, such as strategic answers, "yes-saying" and respondents need for privacy.

However, the survey seems to have been professionally conducted. Each survey team consisted of one supervisor, three interviewers and a data entry operator. According to the detailed interviewer manual, the supervisor or some member of the core management team, should observe each interviewer once a week. Data were entered in the field, and checked for mistakes, missing data and mismatch between different parts of the interview. In case of problems or errors, the interviewer returned to the household to correct the information. According to the manual, the interview should be conducted in private.

¹³In Nepal every village is divided into nine administrative zones, called wards.

¹⁴In the remote Far-Western region 16 households were interviewed in every village, to increase the number of respondents. Including the urban sector it was planned to interview 3388 households in 275 wards. A ward in the remote Dolpa district in the mountains was not visited. In addition, three households are missing in another mountain ward.

¹⁵Approximately 12% of the initial sample were replaced by another random household, because the household was not found or not at home.

To control the quality of the data, the author and a field assistant visited four of the villages during February 1997, and asked the same respondents some of the same questions as CBS¹⁶. In addition, we had informal conversations about credit contracts and strategies applied in the credit market. For example, we asked why people do not under-cut the high interest rates to get a larger portion of the market and thus earn larger profits. This was a follow up question when people responded that the default rate was very low. One lender answered: "This is really a good idea, but no lender do it that way". This type of informal conversations strengthened our belief that tacit collusion is a reasonable representation of the rural informal credit market.

We have compared the answers on interest rates, number of loans and land values for the four villages. The interest rates are in the same range as in the CBS data. However, respondents reported fewer loans to CBS than to us. The explanation might be that the questions on borrowing activities started on page 62 in the CBS questionnaire. We believe that the respondents were tired at that time of the interview. Respondents in one of the hill villages reported larger land values to us than to CBS. This might be due to tax aversion, although the land tax is quite low in Nepal. In terai, land is typically more recently registered by governmental officials, and therefore probably more correct. Non-systematic misreports would lead to smaller explained variation in the regressions. Systematic misreports would lead to biased results. Misreports on land value and interest rates might for example be correlated. Since only a few households seem to misreport land values in our relatively small sample from the four villages, we cannot draw any valid conclusion about systematic misreports.

¹⁶We had to identify the sample ourselves by asking in the village for the households that had been interviewed a year ago. After the interviews, we compared the household characteristics to match the observations.

We have borrowers as the primary observation units. Every borrower may report more than one loan. In the analysis we have selected only one loan to represent each borrower. We use the marginal loan, which we define as the loan having the highest interest rate, because this is probably the loan that the borrowers would first repay¹⁷. In some cases the interest rate is not reported directly, and we have estimated the interest rate using information on loan size, length of installment period, and amount to be repaid.

Some informal loans, recorded with zero or low interest rates, are obviously part of more complex social and economic transactions. In case the lenders offer informal loans at or below the formal interest rate, the subsidy is some kind of payment. The payment can be part of a labor or land contract, mark-up in the shop or a gift or repayment between friends or relatives. We do not intend to analyze such interlinked contracts, and have excluded loans at or below the normal formal interest rate, which is 18%. For analysis of interlinkages, see Bardhan (1984), Basu (1997) or Bell (1988). This type of interlinked contracts can possibly also explain the lower estimated interest rates in wards having zero lending capacity.

We need to specify the cutoff \hat{V} that is applied in the empirical specification in section 3 to identify net-lenders and net-borrowers, and thus the normalized lending capacity variable *prop*. The cutoff is identified using data on households' land values and their lending and borrowing activities. Table 1 describes the credit positions for the non-weighted sample.

Table 1 about here.

¹⁷In case there are more than one loan having the highest interest rate, we have chosen the largest of these two,

As we can see, a large group of households (857) report no credit activity. The largest group of households (1124) have only informal loans. Very few households report informal lending, and they apparently raise the funds from their own savings and not from formal borrowing. The majority of formal borrowers have apparently either no activity in the informal market or they are borrowers. However, we cannot believe in these reports due to obvious misreports of lending activities. This is demonstrated by the non-weighted reports of borrowing and lending in Table 2.

Table 2 about here.

As we can see, the respondents borrow 3.67 times what they lend in the informal credit market. Adjusted by the probability weights, the ratio of misreport is 3.55. It is likely that even borrowers misreport, but in relative terms the misreports are 3.55 times larger for lenders.

To identify net-borrowers and net-lenders, we apply a simple adjustment to make sure that weighted total borrowing equals total lending. It is likely that both the number of lenders and the average amount of lending should be adjusted. However, we do not know the true adjustment rule. We thus apply a simple rule, where we adjust reported borrowing downwards by a factor of 3.55, such that aggregate net-lending equals zero. With respect to the credit-position, the adjustment will only affect households reporting both lending and borrowing

and in case there are more than one loan having the same size, we have chosen the first recorded in the data file.

activities. From Table 1 we know that this is a sub-sample of 155 households. Among these, 60 households (2% of the total sample) will thus change the position from net-borrowers to net-lenders. The final number of net-lenders is 252, while the number of net-borrowers is 1338. Obviously the ad hoc adjustment is not perfect. Some of the 60 households may actually be net-borrowers, some net-borrowers may actually be net-lenders and some of the 1066 households with zero activities are likely to be net-lenders.

After the adjustment, we identify the cutoff \hat{V} for land value that maximizes the proportion of net-lenders having land value above the cutoff. The cutoff is thus an indicator of credit-position. If we draw the density functions for land value for net-lenders and for households that are not net-lenders, the cutoff will be where the density-functions intersect. It is likely that the biased reports of lending is correlated with land value¹⁸. In that case the true density function for net-lenders will be further to the right, and we will have a downward bias for \hat{V} . This in turn implies that the identified cutoff of Nepalese rupees 152 000 is likely to be a lower bound for the true cutoff.

We have no information on the magnitude of the bias, and we decide to apply this lower bound. Increasing the cutoff would imply more villages with zero lending capacity. In the sample, 27% of the respondents have land value above the cutoff, and 73% have land value below. This indicates on average 3.17 borrowers per lender, which in turn also indicates that the cutoff is a lower bound. The weighted mean land value in the sample is 202 000, while the weighted median is 64 000, which implies that the cutoff is more than the double of the land value of the median household.

¹⁸Net-lenders have an average land value of NR 294 000, net-borrowers have an average of NR 144 000, while those with zero activities have an average of NR 253 000. Due to the large land values we believe that the latter group are more likely net-lenders than net-borrowers.

In case there is a linear relation between land value and net-lending, the appropriate cutoff would be the mean value of 202 000. This cutoff would add another 6% to the 73% having land value below the cutoff. We have tested the sensitivity of the regression to the choice of cutoff, by using the mean as a cutoff¹⁹. The higher cutoff implies smaller values for the proxy for lending capacity *prop*, and the parameters cannot be compared directly. But if we calculate the estimated interest rates as a function of the new capacity variable, and plot the interest rates against the original capacity variable, then the price function is very similar. So the results are not sensitive to a reasonable change in the cutoff.

To give an impression of the burden of informal loans for the poor, we report the weighted mean of total borrowing and land values for the households having land value below the median of NR 64 000. These households have on average NR 7 800 (approximately \$150) of informal loans and on average NR 23 000 of land value, implying a relative burden of 34%. From our own interviews we find borrowing more likely to be misreported than land value. The burden of 34% is thus likely to be a lower bound. For these households with land value below the median, total borrowing is relatively independent of land value, and the burden is thus decreasing with land value. The relatively few landless households have on average NR 8 400 of informal loans.

As reported above, we only include informal loans with interest rates above 18% (the inflation was about 7% at the time of the survey). As mentioned, for every household we pick the (marginal) loan having the highest interest rate (i.e. the loan the borrower would like to repay first). In Table 3 we report the weighted average of these interest rates for subgroups

¹⁹This is only done for the third-degree polynomial approximation to Figure 1, see the previous section.

that are categorized according to the explanatory variables applied in the regressions. The critical values applied for land value and loan size are the weighted medians for the variables. The respective values of Nepalese rupees 64 000 and 4 000 were approximately \$1 200 and \$75 at the time of the survey.

Table 3 about here.

From the primary data we would like to report that 72% of the reported interest rates correspond to a system of monthly interest rates, with $5\% \times 12 = 60\%$ being most common in terai, and $3\% \times 12 = 36\%$ being most common in the hills and the mountains.

Except for loan size, which is discussed in the previous section, the included explanatory variables are likely to be exogenous. We have not included variables that are likely to be endogenous. The omitted variables include the insignificant variables; reported purpose of the loan and indicators of credit needs for fertilizers and irrigation. An indicator of less than adequate income is also omitted for the same reason, although it is significant at the 10% level. Omitting the variables have only minor effects on the other parameters.

For the same reasons we have omitted an insignificant indicator of lenders' type. We would still like to report that professional moneylenders charge on average 44.5% while relatives and friends charge 37.7%. So borrowers cannot expect very soft terms from their peers.

Potentially, distance to a bank can affect the interest rates. However, most households have a bank in the nearest market area, and the variable has no significant effect on interest rates. So we have omitted the variable from the regressions²⁰.

For lending capacity, the descriptive data reported in Table 3 is in line with the estimated price function reported in Table 4. That is, the interest rates are at the maximum for small but positive lending capacities. The apparent effect of land value in Table 3 vanishes in the regressions. The installment period is important also in the regressions, and the non-significant effect of being a migrant is captured by the descriptive statistics. The descriptive statistics indicate that the ethnic groups categorized as Baishya pay higher interest rates than the occupational castes categorized as Shudras. When we adjust for other explanatory variables in the regressions this is not the case. The regional difference is captured by the descriptive statistics. The descriptive statistics indicate that interest rates are smaller the larger is the loan sizes. As discussed in the previous section, this is likely due to the fact that individual loan size is a downward sloping function of the equilibrium interest rate.

7. Results

The main results are reported in Table 4. The two first regressions include the empirically problematic loan size variable, while the variable is omitted in the three other regressions. As we can see from the table, omitting loan size has only minor effects on the other parameters. We can thus discuss the effect of loan size independently of the other variables.

²⁰Even a dummy for distance of more than one day of travel (11% of the villages) is not significant. We measure the distance as the median reported distance for formal loans within the village, and apply the maximum for the villages in the same district in case of no reports. The median of the distance for the 199 villages is 2.5 hours. We include the Agricultural Development Bank and commercial banks, such as Nepal Bank Ltd. Omitting the variable has only minor effects on the other parameters.

The descriptive statistics indicate a negative relation between loan size and interest rate. However, this does not mean that individual loan size has a direct effect on the equilibrium interest rate. In the model from section 2, loan size will not influence the equilibrium interest rate, but rather be a (downward sloping) function of the equilibrium interest rate. According to the model from section 4, the individual interest rate is determined by loan size (and land value) along an average cost function.

If the model from section 2 is true, then it would introduce endogeneity to apply loan size as an explanatory variable in the price function, see section 5. This is not the case for the model from section 4. Comparing the second (2SLS) regression and the first (potentially biased OLS) regression in Table 4, the parameters for loan size are very different, and only significant for the OLS regression. If there is no endogeneity, then the 2SLS estimates are still unbiased but not efficient. If there is endogeneity, then the OLS estimates will be biased. Since one of the models predict endogeneity, we will apply the unbiased (but not efficient) 2SLS parameters.

According to the model from section 2, we should not expect a significant effect of loan size on the interest rate. According to the model from section 4 we should expect average lending costs and thus interest rates, to be a U-shaped function of loan size. The main conclusion is thus that the insignificant parameters from the 2SLS regression imply support for the model from section 2. It is still noticeable that the insignificant parameters for loan size indicate a U-shaped function in line with the cost-pricing model. However, if we calculate the predicted function, it will be increasing only for very large loan sizes and the predicted variation in interest rates is marginal²¹.

²¹The 2SLS parameters indicate that the average cost of lending will have the smallest value for a loan size of Nepalese rupees (NR) 40 000. Compared to the weighted median loan size of NR 4 000, the average cost is

In case of endogeneity, the OLS estimates will be biased and reflect the endogeneity. This means that the apparently negative effect of loan size on interest rates reflects the descriptive statistics in Table 3, which in turn reflects the downward sloping effect of the interest rate on loan size²². However, also the OLS estimation captures the minor effect on average-cost, which implies that the U-shaped function is increasing for very large loan sizes. We thus conclude that the negative relation between loan sizes and interest rates for the most part is due to the fact that borrowers demand larger loans when the equilibrium interest rate declines. There is at best a minor effect of loan size on the average cost of lending and thus on the equilibrium interest rates.

We will now report the effect of the other (exogenous) explanatory variables. By omitting loan size we can apply OLS estimation. As mentioned, omitting loan size has only minor effects on the other parameters.

The minor support for the cost-pricing hypothesis is confirmed by the insignificant effect of land value on the equilibrium interest rates. To illustrate the minor support, we apply the insignificant parameters to calculate the predicted effect of land value on the average cost of lending and thus on the interest rates. The average cost of lending to landless households is 0.5 larger than the cost of lending to a household having the median land value of NR 64 000 and 1.4 larger than the cost of lending to the household having the mean land value of NR 202 000. Thus, if a landless household pays an interest rate of 30% then the predicted interest rate

reduced by 1.4, which can be compared to the estimated constant term of 29.6. At NR 80 000 the average cost will be the same as for the median loan size. Only 4% of the loans are larger than NR 40 000, while 1% are larger than NR 80 000.

²²The function has its minimum at NR 90 000, where the interest rate is 7.7 below the predicted value for the median loan size. The difference is in the same range as the descriptive statistics in Table 3.

for a household having the mean land value, will be 28.6%. To summarize, none of the risk-related variables have significant effect on the equilibrium interest rates.

The regression in the first column of Table 4 illustrates a general impression from "naive" regressions. If we do not include lending capacity and indicators of price discrimination, then risk-related variables like loan size and land value will appear to be significant. This is also true for regressions where we omit loan size. In a non-reported regression having only land value, installment period and geographical region as explanatory variables, land value is highly significant. This result is reported as a warning. Important explanatory variables are correlated with land value, and if these are omitted from empirical studies, one might draw biased conclusions about the effect of land value on the informal interest rates.

We now turn to the estimates of the model of capacity constrained oligopolies from section 2. The results are in the three last columns of Table 4.

Table 4 about here.

The third regression in the table is the third-degree polynomial approximation to Figure 1. The fourth regression is the partial linear representation of Figure 1, where the threshold for K_2 is identified as the best fit in repeated regressions. The last column presents a Heckman regression of the partial linear model. As we can see from the table, the estimated parameters differ only marginally between the regressions²³.

²³The exception is the third-degree polynomial representation of lending capacity. This approximation was applied to indicate the structure of the partial-linear representation, but it is less flexible. The third-degree

The predicted interest rates as a function of the (positive) lending capacity variable *prop* are drawn in Figure 2 for the partial linear regression in the fourth column.

Figure 2 about here.

The 1068 respondents live in 199 villages. The 199 villages are distributed along the *prop* axes, where 11.6% of the villages have zero lending capacity, and a predicted interest rate of 23. The significantly decreasing interval covers 64.3% of the villages, with the interest rate decreasing from 29.9 to 23.6. The non-significant increasing part covers 28.1% of the villages (4% are outside the range of the figure), with the interest rate increasing to 25.8 (for *prop* = 9). The predicted values in the figure are calculated by inserting zero for the other explanatory variables. The figure is thus representing a theoretical segment of borrowers having the following characteristics; land-less, non-migrant, Brahmins who live in the mountains, and do not report on installment period.

For any realistic segment the curve will shift (usually upwards). The segment of non-migrant Brahmins living in the hills and having longer term loans (49 respondents) will shift the curve upwards by 2.24. The segment of non-migrant Baishya living in the terai and having longer terms loans (108 respondents) will shift the curve upwards by 25.6. The worst possible case is the latter segment having short term loans (15 respondents), leading to an upward shift of 50.2.

polynomial implies a higher K_2 than the partial-linear representation of Figure 1. This is likely because the third-degree polynomial is fitted to cover some very high capacity levels. The results reported below refers to

Installment period identifies separate "products" that are likely to have separate demand curves. As expected, the interest rates are larger for short term loans²⁴. Except for installment period, caste is the main indicator applied for price discrimination. It is likely that demand differs according to norms and preferences for savings between castes, and we interpret this as a support for the demand-led model of price discrimination from section 2. If lenders are from specific castes, then price discrimination might alternatively be due to smaller costs of lending within caste. Since both explanations are valid, we are not able to discriminate between the two models, based on price discrimination between castes.

We cannot imagine any cost-explanation for the regional difference in prices, and believe that these differences are due to demand-side factors. In a model of monopolistic competition where moneylenders can screen borrowers or cover a risk-premium, we would expect professional moneylenders from the hills (or India) to enter the informal credit markets of terai to benefit from the 17% price gap. Since there seems to be no arbitrage, we rather conclude that the regional price-differences are due to higher willingness to pay for informal loans in terai.

8. Conclusions

The general version of the capacity-constrained oligopoly model in section 2 predicts a partial-linear relation between village lending capacity and a vector of interest rates. The present paper formulates a proxy for lending capacity that has a significant effect on equilibrium interest rates. The majority of Nepalese villages have lending capacity along a

the partial linear OLS regression.

decreasing part of the price function, while the other villages have capacity along a non-significant increasing part.

We also test alternative hypotheses of cost-pricing behavior. In case of cost-pricing, we would expect land value and loan size to affect equilibrium interest rates, as described in section 4. Adjusting for endogenous loan size, these variables have no significant effect on interest rates. Furthermore, the model in section 4 implies that new lenders can enter the local credit market at a certain cost. The large regional differences in interest rates between the hills and terai are not compatible with this model, and is more likely due to regional differences in willingness to pay for credit.

Another noticeable result is price discrimination according to caste. This can be explained within the cost-pricing model, if lenders are from specific castes and the cost of lending is smaller within caste. However, price discrimination is a major implication of the general version of the oligopoly model in section 2, where lenders tacitly collude on monopolistic price discrimination. At any level of lending capacity, lenders are likely to sustain price discrimination between observable segments of the local credit market. We are not able to discriminate between the cost-pricing and demand-led explanations of price discrimination according to caste. Furthermore, we are not able to discriminate between these explanations when it comes to price discrimination according to installment period. This might be due to extra costs of raising short term credit, but is more likely due to higher willingness to pay for short term (emergency) loans.

²⁴Basu (1989) describes a model where equilibrium interest rates may depend on the length of the installment period.

The only available support for the cost-pricing model from the empirical analysis, is price discrimination. Lending costs might vary between caste or according to installment period. However, these forms of price discrimination are not the main predictions of the cost-pricing model in section 4. There is no support for the predictions that interest rates depend on the risk-related variables, land value and loan size. On the contrary we find support for the predictions from the oligopoly model in section 2. Note that a naive empirical analysis supports the cost-pricing model. This is an important lesson for empirical specifications of models of informal rural credit markets.

To conclude, the informal rural credit markets of Nepal seem to be characterized by an aggregate credit constraint at the village level, and oligopolistic collusion on price discrimination. Entries of new lenders are likely to be rare, due to a high initial information cost. Lenders need to interact with the borrowers for a long period to be able to screen the borrowers and enforce repayments.

Interest rates decrease with village lending capacity up to a certain threshold. However, this effect is not substantial compared to the price-differentials within the villages. This result has implications for the design of credit programs. Credit to informal lenders (that implies a positive shift in supply) or informal borrowers (that implies a negative shift in demand) will have the same minor effect on equilibrium interest rates. However, credit programs may have a direct effect on distribution. A credit program that is able to target the poor or the higher priced segments, will redistribute net income due to a reduction in interest payments, and thus smaller expenses for borrowers and smaller profit for informal lenders.

Although it is reasonable to target poor households, the analysis indicates that one may as well target the higher priced segments. The analysis thus supports credit programs that target

low-status castes. Examples from Nepal are programs that target ethnic groups living in terai. These households pay real interest rates that are almost the double of the rates paid by the high castes living in the hills.

Appendix

As an alternative to trigger strategies, the lenders can apply so called stick and carrot strategies. We will prove that Proposition 1 holds also in this case, applying Lambson (1987). He demonstrates that the calculations in Brock and Scheinkman (1985) of mixed strategies equilibria are not necessary in our symmetric case of equal costs, discount rates and capacities.

Proof: Cases a) and b): Lambson demonstrates, see p. 390, that if there exists a Bertrand price in pure strategies in the stage game, this price should be applied in an infinite punishment phase. This is the same (trigger) strategy, as discussed in the main part of this paper. Consequently, also the collusive price will be the same when there exists a Bertrand equilibrium in the stage game, i.e. if $k \leq k_4$ and $k \geq k_5$.

Case c): In this case there is no Bertrand price in pure strategies. Lambson, see p. 393, demonstrates that there is no need to calculate mixed strategies Nash equilibria, as in Brock and Scheinkman (1985)²⁵. Instead the deviator can be punished as hard as possible by the other firms for m periods, and then all firms collude in the remaining periods. During the punishment phase, the deviator will choose a price p_i to maximize his profit π_i . We write P_i as the price charged by the other firms to punish the deviator. Applying the linear model and the rationing rule discussed above, we have

$$\pi_i = \begin{cases} \pi_1 = (P_i - c)(a - P_i) / N, & \text{if } p_i = P_i \\ \pi_2 = (p_i - c)(a - p_i - (N - 1)k), & \text{if } p_i > P_i \\ \pi_3 = (p_i - c)k, & \text{if } p_i < P_i \end{cases} \quad (\text{A1})$$

²⁵This result is not restricted to the case of linear demand, but the rationing rule assumed by Brock and

representing the deviator's profit from three different strategies.

In case 2 and 3, p_i has to be optimized, leading to the following profits,

$$\pi_2^* = \begin{cases} (a - (N - 1)k - c)^2 / 4, & \text{if } P_i \leq (a - (N - 1)k + c) / 2 = \hat{P} \\ (P_i - c)(a - P_i - (N - 1)k) & \text{if } P_i > (a - (N - 1)k + c) / 2 = \hat{P} \end{cases} \quad (\text{A2})$$

$$\pi_3^* = (P_i - c)k. \quad (\text{A3})$$

We see that the deviator's profit depends on the price chosen by the other firms. The other firms will set P_i to minimize π_i . Suppose $P_i \leq \hat{P}$ and that the deviator chooses strategy 1 or 3, then the other firms minimize π_i by charging $P_i = c$, leading to zero profit for the deviator. Consequently, strategy 2 is the optimal choice for the deviator, leading to the profit $\pi_i = (a - (N - 1)k - c)^2 / 4$.

Next, suppose $P_i > \hat{P}$. Also suppose $\pi_1 \geq \pi_3^*$ and $\pi_2^* \geq \pi_3^*$, where both statements leads to $P_i \leq a - Nk$. Then, using $\hat{P} = (a - (N - 1)k + c)/2$, we get $(a - (N - 1)k + c)/2 < a - Nk$, which leads to $k < (a - c) / (N + 1)$, which is not true in regime c). Thereby π_3^* is the maximum profit for the deviator when $P_i > \hat{P}$. The other firms have this information, and to punish the deviator as severely as possible, they set P_i marginally above \hat{P} , to minimize the deviator's profit. Thereby he sets the price at \hat{P} , leading to $\pi_i = ((a - (N - 1)k + c) / 2 - c)k = (a - (N - 1)k - c)k / 2$. However, the other firms would like to punish the deviator as severely as possible. Suppose that the profit for the deviator in this case is less than the profit in the

Scheinkman is needed.

above case, then $(a - (N - 1)k - c)k / 2 < (a - (N - 1)k - c)^2 / 4$, leading to $k < (a - c) / (N + 1)$, which is not true in regime c). Thereby the most severe punishment leads to profit $\pi_i = (a - (N - 1)k - c)^2 / 4$, which results from $P_i \leq \hat{P}$.

Note that the profit to the deviator during the punishment phase when stick and carrot strategies are applied, equals the expected profit during the punishment phase in mixed strategies when trigger strategies are applied. With respect to the length of the punishment phase we apply inequality (3.3) in Lambson (1987). In the limit case where $k = (a - c) / (N - 1)$, we have that $m = \infty$ and $\hat{P} = c$, which is a Bertrand price and thereby in line with the comment by Lambson that the price being a Bertrand price is a necessary and sufficient condition for $m = \infty$. For lower values of k , the punishment phase will be shorter. This means that it will be relatively more profitable to deviate compared to mixed strategies equilibria, and thereby the monopoly price in regime c) is only sustainable at larger discount factors than in the Brock and Scheinkman model. ||

So, we have that in every regime the profit during the punishment phase is the same in each period for trigger strategies and stick and carrot strategies. However in regime c), where mixed strategies are applied in trigger strategies, the punishment phase in stick and carrot strategies are typically shorter. Applying this result, we still have that for a sufficiently large discount factor there will be an unconstrained collusive price in this regime, and thereby Proposition 1 holds also for stick and carrot strategies.



Figure 1. The collusive price as a function of aggregate lending capacity.

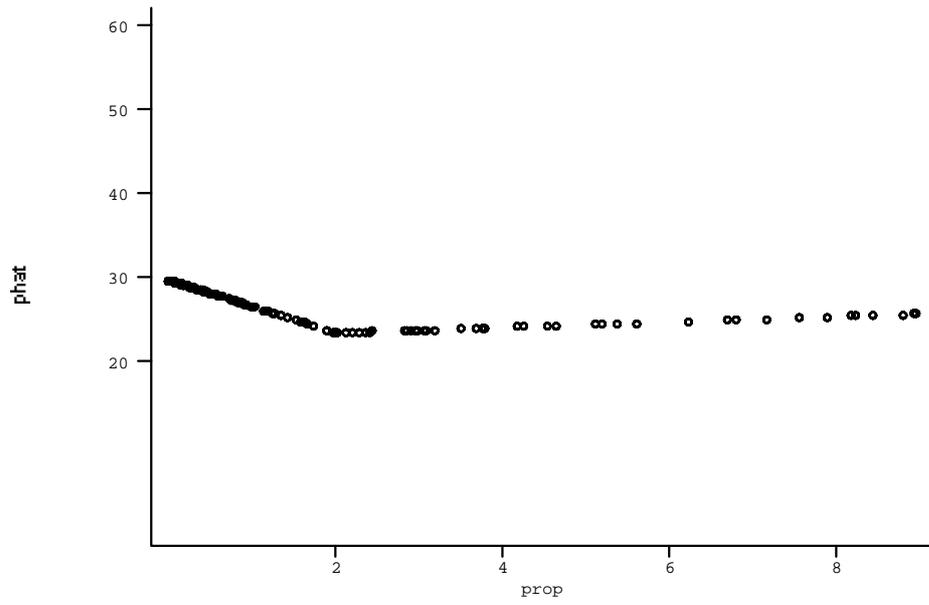


Figure 2. The predicted price as a function of aggregate lending capacity.

Table 1. Formal and informal credit activities

<i>Formal market</i>	<i>Informal market</i>			
	No informal loan	Informal borrowing	Informal borrowing and lending	Informal lending
Borrow from bank	140	121	25	13
Borrow only from programs	69	48	12	3
No formal loan	857	1124	118	126
N=2656	1066	1293	155	142

Table 2. Amounts borrowed and lent.

Nepalese rupees	Informal borrowing	Informal lending	Bank loans	Other loans
Mean	11 093	14 727	20 100	10 253
No. of respondents	1 448	297	299	147
Total	16 062 012	4 373 839	6 009 876	1 507 140

Table 3. Descriptive statistics.

Categories	N	Mean interest rate
All households	1068	41.4
<u>Lending capacity:</u>		
Prop0 = 1	125	35.6
0 < prop ≤ 1	586	43.4
1 < prop ≤ 2	129	40.2
Prop > 2	228	39.9
<u>Land value:</u>		
Value < 64 000	570	42.9
Value ≥ 64 000	498	39.8
<u>Installment period:</u>		
Period ≤ 3 months	39	67.5
Period > 3 months	531	39.8
Missing (base)	498	40.9
<u>Migrant:</u>		
Yes	156	42.3
No	912	41.3
<u>Castes:</u>		
Shudra (occ.caste)	117	38.7
Baishya (ethnic. gr.)	572	46.7
Missing	13	40.0
Chettri	205	34.7
Brahmin (base)	161	31.3
<u>Climatic belt:</u>		
Terai (lowlands)	401	50.9
Hills	495	34.7
Mountains (base)	172	33.4
<u>Loan size:</u>		
Size ≤ 4 000	532	44.5
Size > 4 000	536	38.2

Table 4. Regressions

Depend. var: Inter. rates	Naive regression	2SLS****	Third-degree polynomial	Partial linear	Heckman
Prop0		-6.908** (2.737)	-6.295** (2.616)	-6.878** (2.754)	-6.932** (2.720)
Prop		-3.196*** (1.183)	-1.943*** (0.568)	-3.139*** (1.204)	-3.150*** (1.197)
Prop+prol		0.326 (Prob>F=0.2392)		0.319 (Prob>F=0.2356)	0.321 (Prob>chi2=0.2310)
Prop ²			0.137*** (0.047)		
Prop ³			-0.002*** (0.001)		
Value ('00 000)	-0.550 (0.598)	-0.718 (0.795)	-0.661 (0.591)	-0.748 (0.567)	-0.633 (0.552)
Value ²	0.030 (0.025)	0.035 (0.035)	0.030 (0.026)	0.039 (0.024)	0.037 (0.024)
Short term	24.431*** (8.578)	24.857*** (8.597)	25.016*** (8.719)	24.860*** (8.655)	24.820*** (8.593)
Long term	0.327 (1.079)	0.358 (1.081)	0.515 (0.990)	0.267 (1.037)	0.222 (1.032)
Migrant	-3.508 (2.214)	-3.125 (2.054)	-3.500 (2.135)	-3.066 (2.095)	-2.664 (2.074)
Shudra	5.729*** (1.884)	6.788*** (2.474)	6.816*** (1.983)	7.062*** (2.022)	6.992*** (2.011)
Baishya	8.114*** (1.724)	8.267*** (2.116)	8.104*** (1.645)	8.556*** (1.764)	8.499*** (1.751)
Missing	8.466** (4.087)	6.985* (3.935)	7.319* (3.835)	7.359* (3.861)	7.556** (3.833)
Chettri	3.432** (1.645)	4.103 (2.545)	4.833*** (1.707)	4.694*** (1.706)	4.638*** (1.691)
Terai	16.378*** (2.495)	16.754*** (2.710)	17.119*** (2.680)	16.822*** (2.683)	16.774*** (2.666)
Hills	2.363 (1.984)	1.831 (2.157)	1.917 (2.122)	1.971 (2.110)	1.882 (2.092)
Constant	28.796*** (2.365)	30.627*** (3.624)	29.181*** (2.523)	29.864*** (2.607)	32.628*** (2.830)
Loansize ('0 000)	-1.909*** (0.528)	-0.768 (2.546)			
Loansize ²	0.107*** (0.036)	0.089 (0.219)			
					Selection:
Value ('00 000)					-0.026*** (0.008)
Migrant					-0.228** (0.109)
Fert.credit					0.497*** (0.109)
Tubewell					-0.204 (0.137)
Oth.irrig.					-0.019 (0.073)
Non-adeq. income					0.479*** (0.066)
Constant					-0.512*** (0.085)
Mills ratio					-3.084*** (1.166)
R ²	0.2634	0.2813	0.2850	0.2791	
N	1068	1068	1068	1068	1068/2656

Robust standard errors in parentheses.

*** Significant at the 1% level

** Significant at 5% level

* Significant at 10% level

**** Instruments for loan size: Purpose of loan, fertilizers on credit, irrigation in use, distance to bank. Loan size is non-significant also for a linear function.

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