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Access to capital in rural Thailand: An estimated model of formal vs. informal credit ☆

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ABSTRACT

This paper analyzes the mechanism underlying access to credit, focusing on two important aspects of rural credit markets. First, moneylenders and other informal lenders coexist with formal lending institutions such as government or commercial banks, and, more recently, micro-lending institutions. Second, potential borrowers presumably face sizable transaction costs in obtaining external credit. We develop and estimate a model based on limited enforcement and transaction costs that provides a unified view of these facts. Based on data from Thailand, the results show that the limited ability of banks to enforce contracts, more than transaction costs, is crucial in understanding the observed diversity of lenders.

1. Introduction

Most productive activities entail a lag between the time when inputs are acquired and the time when output is obtained. For this reason, when self-financing is not possible, the inputs must be purchased using credit from financial institutions or informal sources. The financial contracts available in rural areas vary substantially depending on the characteristics of the borrowers and lenders and the type of input being financed. Typical examples include small collateral-free and interest-free loans between friends and relatives, collateralized loans from commercial banks, and loans from moneylenders with no collateral requirements but relatively high interest rates.

This last form of lending has traditionally been viewed as unfair by policymakers and development practitioners, who argue that lenders take advantage of their position to exploit the poorer borrowers. This view is at the heart of the policy interventions of several governments and non-governmental organizations (NGOs) in developing countries. These interventions devote considerable resources to helping supply credit to poor farmers and entrepreneurs who are otherwise denied formal credit.

From the experience of countries in Asia, Africa, and Latin America, several case studies have come to challenge this view of informal finance and have questioned the effectiveness of such policies. Siamwalla et al. (1993), using data from Thailand, and Bell (1993), from India, have shown that, despite the injection of formal credit, informal finance is still used and the interest rates charged have not been affected by the increased presence of formal credit.[1] In addition, two often neglected pieces of evidence seem to render this traditional view overly simplistic. First, borrowing businesses and farms with assets that can be used as collateral tend to be more active in the formal credit market.[2] Second, borrowers are often customers in both the formal and informal credit markets.[3]

Implicit in this discussion is the notion that impediments to trade or fixed transaction costs may be important. Indeed, in villages without formal credit institutions, potential clients spend time and money every time they travel to the closest branch. Sometimes, it takes several trips before the loan is granted. In addition, formal lenders spend considerable resources in assessing the repayment capacity of prospective borrowers. In contrast, moneylenders usually

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[1] On this point, see also the collection of articles in Von Pischke et al. (1983) and Bottomley (1975), Braverman and Guasch (1986, 1993), Hoff and Stiglitz (1993), Besley (1994), and the book by Armendáriz de Aghion and Morduch (2005).

[2] This point was also developed in the context of Thailand by Feder et al. (1988) and Feder (1993). They find that farmers with titled land have greater access to institutional credit. The land title enables the owner to sell, transfer, and legally mortgage the land, and it is used as collateral.

[3] Evidence of the coexistence of formal and informal lenders in rural areas is given for example by Siamwalla et al. (1993) in Thailand; Walker and Ryan (1990) and Bell (1993) for agriculture and Platteau et al. (1985) for small-scale fishing in India; Zeller and Sharma (1998) and Jain and Mansuri (2003) in Bangladesh; Collins et al. (2009) in Bangladesh, India, and South Africa; and Bond and Townsend (1997) and Huck et al. (1999) in the very different context of small business start-ups among minorities in two Chicago neighborhoods.

live in the same village and will often themselves visit their clients, thereby becoming more accessible and gaining first-hand knowledge of their creditworthiness.

In this paper, we develop a contract theory model that provides a unified view of the coexistence of formal and informal credit and whose tractability allows a structural estimation. The model is based on two key features. First, in the spirit of Townsend (1978, 1983) and Greenwood and Jovanovic (1990), access to credit is modeled explicitly by assuming that a fixed cost must be paid in order to obtain external credit. Second, we assume that banks have limited ability to enforce credit contracts. Suppose that a productive project requires an investment in both *fixed* and *working* capital. The difference between both types of capital is that fixed capital remains after production has taken place and thus can be used as collateral, while working capital is fungible and transformed into output.[4] In addition, suppose that bank clients have the option to default on the contract before producing, keeping the working capital but losing all savings deposited at the bank and the fixed capital, which is seized. This imperfect enforceability effectively imposes a maximum on the amount of working capital that the bank is willing to lend.

In this scenario, some borrowers may find it profitable to seek an informal lender for additional working capital. If entrepreneurs differ in the ratio of working and fixed capital to produce output, banks will tend to finance entrepreneurs whose technology is intensive in fixed capital, whereas entrepreneurs that require relatively more working capital will be financed primarily by informal lenders.

In addition, if there are large fixed transaction costs of accessing formal finance, households that need little credit will tend to rely on informal lenders, whereas those with large credit needs will be better off incurring the fixed costs in order to have access to a lower cost of capital.[5]

In sum, the model is able to generate all four possible financial choices—self-financing, borrowing from either a formal or informal source, and borrowing simultaneously from both sources. Notably, both ingredients of the model are needed. If fixed transaction costs were zero, then no household would borrow exclusively from an informal source as it would always pay to first borrow from a bank. Likewise, if enforcement was perfect, no household would be constrained and there would be no need to borrow simultaneously from both sources.

In modeling the coexistence of formal and informal lenders, the literature has taken two distinct approaches. The first assumes that only informal lenders have access to institutional credit who then re-lend to poorer borrowers. Hoff and Stiglitz (1997), Bose (1998), Floro and Ray (1997), and Mansuri (2007) follow this approach.[6] The second, more in line with our paper, considers formal institutions competing directly with informal lenders. In this strand, several related theoretical explanations have been offered to explain why some households decide to resort to multiple creditors. Bell et al. (1997) argue that an imposed limit on the amount of credit that formal institutions can grant may trigger some constrained borrowers to turn to the informal sector for additional credit. For the particular case of India, Kochar (1997) evaluates the empirical plausibility of this argument and finds little evidence of credit constraints. Jain (1999) and Conning (2001, 2005) postulate that if informal lenders have an informational advantage, formal lenders will screen borrowers by partially financing the project, thus forcing the borrower to resort to an informal lender. In this way, banks ensure that the project will be monitored.

This paper is also related to Paulson et al. (2006) as they try to understand the underlying credit market imperfections in rural Thailand. Using the same data, Paulson et al. (2006) estimate an occupational choice model with limited liability and compare it with a moral hazard version of the same occupational model. Their focus is thus on the decision to set-up a business, possibly borrowing from a single lender, rather than the choice of lenders.

The paper is also related to two strands of the literature in finance. The first studies the role of trade credit provided by input suppliers as an alternative to formal credit (for example, Petersen and Rajan, 1997; Biais and Gollier, 1997; and Cuñat, 2007). The second tries to understand why firms use more than one source of credit (Bizer and DeMarzo, 1992; Petersen and Rajan, 1994; Detriache et al., 2000; and the review by Ongena and Smith, 2000).

The identification strategy we follow differs from that of Bell et al. (1997), Kochar (1997), and Conning (2001) and resembles Key (1997) and Paulson et al. (2006) in that we estimate the likelihood of borrowing from each source and obtaining a given expected income as dictated by the structure of the model. In particular, the maximum likelihood algorithm searches over household-specific fixed costs and other parameters to maximize the likelihood that a given individual makes the reported financial choice and obtains the reported expected income. Thus, the problem of unobserved heterogeneity and endogenous matching of borrowers and lenders is solved by the structure of the model.[7] More importantly, the estimation can be used to assess how relevant enforcement problems are vis-à-vis transaction costs.

The data used come from a cross-section survey conducted in Thailand in 1997, an interesting country because despite the growth episode experienced in the 1980s, formal credit is still limited in rural areas.[8]

The estimation reveals several interesting results. First, there are disparities in the cost of accessing different lenders: while the estimated cost of accessing a formal institution is on average US$30, the cost of accessing an informal source is negligible. Second, the cost of accessing formal finance depends on the characteristics of the household, such as proximity to a bank or whether the household has a savings account. Third, roughly 86% of households that resort to a bank are predicted to be constrained. Thus, most households receive a lower credit amount because they would default if the bank were to advance to them more capital.

All these facts taken together indicate that the presence of enforcement problems, more than fixed transaction costs, is crucial in explaining why formal credit is not accessible to everyone. Indeed, if we compare the estimated set-up with one without fixed transaction costs, average income would only increase by 0.1 or 0.4%, depending on the specification. But if we compare it with one with perfect enforcement, average income would increase by roughly 20% in both specifications. These numbers suggest that there is much to be gained from designing successful policy interventions that try to improve the enforcement of credit contracts.

To this end, we use the model to assess the impact of specific policies that have been typically used in developing countries (including Thailand) to foster rural financial development. In support of recent Thai government policies, we show that focusing on improving the enforcement of private contracts and the registration of property is most effective in improving access to formal credit.

[4] We could also think of fixed capital as assets with relatively high scrap value, perhaps due to a well-functioning secondary market.

[5] This point is also made in Braverman and Guasch (1986, 1993), Hoff and Stiglitz (1993), Besley (1994), Key (1997), and more generally in Banerjee (2003).

[6] Another model related to this approach is presented in Ghosh and Ray (1999). They focus on loan enforceability when credit histories are not available to (informal) lenders.

[7] See Chiappori and Salanié (2003) for a survey on empirical studies of contract theory, and Key (1997) and Banerjee and Duflo (2003) for a review of the econometric issues in credit market studies. Keane (2010) provides a nice overview of the differences between the structural approach taken here and the "experimentalist" approach which relies on "natural experiments" or imposed randomization to identify causal relationships.

[8] See Giné and Townsend (2004) for a welfare evaluation of the credit liberalization that took place in Thailand from 1975 to 1997.

The rest of the paper is organized as follows. Section 2 describes the model. Section 3 focuses on the core of the model given by a financial choice diagram. Section 4 presents the data used and describes its salient features. Section 5 turns to the maximum likelihood estimation of the underlying parameters of the model. Section 6 presents the estimation results and provides a quantitative assessment of government policies used in rural development. Finally, Section 7 concludes.

2. The model

The model is static and deterministic. Agents are income maximizers and differ in wealth b, entrepreneurial ability z, and the type of project (K, η) where K is the maximum scale at which the project can be operated and η measures the ability of lenders' to seize capital invested in the project as elaborated below. Thus, there are four sources of heterogeneity. Each entrepreneur decides how to finance the project by resorting to a formal or informal institution, borrowing from both sources, or simply choosing to self-finance. In addition, all agents can deposit their wealth in the formal institution or bank at no cost.

A formal credit institution, in this paper, is a profit-maximizing intermediation entity that relies exclusively on the existing legal system to enforce contracts. By contrast, informal lenders may resort to other mechanisms.[9] Informal lenders lend out of their own wealth and may resort to a formal institution for additional funds to re-lend, while formal institutions lend out of the collected deposits. Because of limited wealth or because they may borrow from the bank, the opportunity cost of funds is typically higher for the moneylender.[10] Hence, there is a tradeoff between both sources of credit: while banks have access to a lower cost of funds, moneylenders can prevent their clients from "running away" with the borrowed capital.

The time-line of events is given in Fig. 1. The enforcement problem is modeled by allowing bank clients to default on the contract by keeping the working capital *before* production takes place.

There is no uncertainty, so agents will simply seek to maximize end-of-period net income. Each entrepreneur has access to the following technology:

$$f(z, k; K, \eta) = zk + \tilde{\delta}(1-\eta)k, \quad \text{s.t.} \quad k \le K, \tag{1}$$

where k denotes total capital invested. The term $\tilde{\delta}(1-\eta)k$ captures the value of the fixed capital once production has taken place. The parameter $\tilde{\delta}$ may be interpreted as the fraction of non-depreciated capital and η denotes the fraction of working capital relative to total capital used in production: if the ratio η is one, only working capital is used and the project has no scrap value, whereas if the ratio η is zero, all capital used is fixed and will remain after production has taken place.[11] We can simplify notation by letting $\delta = \tilde{\delta}(1-\eta)$, where parameter δ is now individual specific through its dependency on η.

Throughout the paper, we define a *constrained* household as one that invests a level of capital below its maximum capacity, so that $k < K$. Similarly, an *unconstrained* household invests the full amount $k = K$.

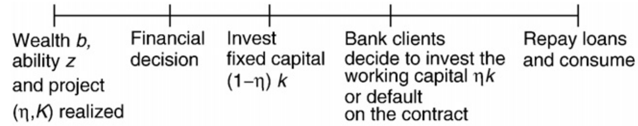

Fig. 1. Time-line of the model.

We use a linear production function because—as will become clear in the next section—it simplifies the computation of the likelihood function substantially. The cost of tractability is that the optimal level of capital K for an unconstrained entrepreneur does not explicitly depend on ability z. Rather, we will estimate the joint distribution of (z, K) allowing the data to dictate their relationship.[12] Giné (2010a) compares the financing maps obtained with linear technology and concave technology in capital of the form $f(z, k; \alpha, \eta) = zk^{\alpha} + \tilde{\delta}(1-\eta)k$ and shows that the financing maps are qualitatively similar, so the choice of the linear function does not seem too restrictive.

We now proceed to compute the net income obtained from each financial choice. Net income Y depends explicitly on household ability z, wealth b, and the type of project (K, η). It is also subscripted by the financial choice: self-finance (S), bank (B), moneylender (M), and bank and moneylender (BM).

If the entrepreneur decides to self-finance (S), she will obtain a net income of

$$Y_S(z, b; K, \eta) = \max_k \; zk + \delta k + (b-k)r_D \;\text{s.t.}\quad k \le b, \quad k \le K; \tag{2}$$

where r_D denotes the interest rate on deposits. Because the technology is linear, we can write the optimal choice of capital as

$$k_S(z; K, \eta) = \begin{cases} K & \text{if } z \ge r_D - \delta \quad \text{and} \quad b \ge K, \\ b & \text{if } z \ge r_D - \delta \quad \text{and} \quad b < K, \\ 0 & \text{if } z < r_D - \delta. \end{cases} \tag{3}$$

In words, she will invest K if it is profitable and she has enough wealth; she will invest her total wealth b if the maximum scale K is larger than her wealth; and she will not invest at all if the return on the investment is lower than the bank's deposit rate.

If she goes to the bank (B), she will borrow an amount $l_B = k - b$ (i.e., the difference between total capital invested k and wealth b), and will not deposit anything at the bank because we assume that $r_B > r_D$ since intermediation is costly. We can write the agent's net income as:

$$Y_B(z, b; K, \eta) = \max_k \; zk - (k-b)r_B + \delta k - \Gamma_B \tag{4}$$
$$\text{s.t.} \quad k \le K \quad \text{and} \quad zk - (k-b)r_B + \delta k \ge \eta k.$$

The interest rate r_B denotes the cost of borrowing and the parameter Γ_B captures the fixed transaction cost of dealing with the bank. This cost parameter captures all expenses related to obtaining the loan: trips to the bank, bank fees, and due diligence to assess the repayment capacity of the borrower. By having the borrower pay Γ_B, the bank learns the borrower's characteristics (z, b, K, η). The last constraint captures the enforcement disadvantage that banks have in dealing with the (ex-ante) moral hazard problem of the agents. Before producing, bank clients can "run away" with the working capital advanced, at the cost of losing all their deposited wealth as well as the fixed capital scrap value, which will be seized by the bank. Implicitly, we assume that although banks may fully observe their borrowers' actions, they have no legal means to prevent a borrower from "consuming" the working capital.

[9] The idea behind this assumption is that informal lenders can terminate a credit relationship or exert psychological pressure or harm their clients if they do not repay their loans. Quoting Aryeetey (1997), "To discourage default informal lenders go to the homes of their clients to deliver verbal warnings." Similarly, Aleem (1993) finds evidence of large switching costs between informal lenders, suggesting that reputation is important.

[10] One could also assume no formal intermediation costs, and because of no uncertainty, the bank's lending and deposit rate would be the same. In this case, the rate charged by the moneylender would be bounded below by the bank's lending (and deposit) rate, since the moneylender can always deposit funds at the bank.

[11] In other words, capital k is the sum of fixed capital k^F and working capital k^W. Then, $\eta = \frac{k^W}{k^W + k^F}$.

[12] One could think of production requiring non-tradable inputs (other than ability z), which would limit capacity K.

Implicit in the agent's problem stated in Eq. (4) is the notion that banks operate in a competitive setting with free entry. Therefore, banks will offer contracts that maximize their clients' income.

The optimal choice of capital for the entrepreneur depends on whether the enforcement constraint is binding. If it binds, the maximum amount of capital that the bank is willing to lend is given by:

$$k^c = \frac{br_B}{\eta - (z + \delta - r_B)}. \tag{5}$$

The above expression is found using the enforcement constraint at equality and solving for k. Notice that the constraint is less likely to bind if the project is more productive (ability z is high), the entrepreneur is richer, or she operates a technology with relatively more fixed assets (lower η).[13]

If the constraint does not bind, the entrepreneur earns net income $Y_{Bu} = (z + \delta - r_B)K + r_B b - \Gamma_B$, while if it binds, she earns $Y_{Bc} = \eta k^c - \Gamma_B$.

Now suppose that the agent resorts to a moneylender. The amount borrowed is $l_M = k - b$ and her net income becomes:

$$Y_M(z, b; K, \eta) = \max_k \; zk - (k - b)r_M + \delta k - \Gamma_M \quad \text{s.t.} \, k \le K, \tag{6}$$

where Γ_M is the fixed transaction cost of dealing with a moneylender and r_M denotes the interest rate charged by the moneylender. It is assumed that $r_M > r_B$. The moneylender is not subject to enforcement problems and will therefore advance $l_M = K - b$ so that the entrepreneur operates the project at maximum capacity.[14]

Finally, the entrepreneur may find it in her interest to resort to both a bank and a moneylender (BM). This case will arise if the bank offers too little capital due to enforcement problems: the project may be intensive in working capital (high η) or the entrepreneur may not be talented enough to convince the bank that she will not default on the loan contract and run away with the working capital. Since the interest rate charged by the moneylender is higher than that of the bank, the agent borrows from the bank as much as the bank is willing to lend her $l_B = k^c - b$ and will then turn to the moneylender to finance $l_M = K - k^c$, the remaining capital requirement.[15]

Net income can be written as total revenues from investing the maximum scale $(z + \delta)K$ minus loan repayments and fixed costs. More formally,

$$\begin{aligned} Y_{BM}(z, b; K, \eta) &= zK - (k^c - b)r_B - (K - k^c)r_M + \delta K - \Gamma_B - \Gamma_M \quad \text{or} \\ Y_{BM}(z, b; K, \eta) &= Y_M(z, b; K, \eta) + (k^c - b)(r_M - r_B) - \Gamma_B \\ &= Y_{Bc}(z, b; K, \eta) + (K - k^c)(z + \delta - r_M) - \Gamma_M \end{aligned} \tag{7}$$

where $Y_{Bc}(z, b; K, \eta)$ denotes net earnings from dealing with the bank when capital is constrained.

In sum, the model posits that an entrepreneur with wealth b and fraction of working to total capital η, facing interest rates r_B, r_M and fixed costs Γ_B, Γ_M, will decide how to finance her project based on her maximum scale K and entrepreneurial ability z, by choosing the lender that offers the credit contract yielding the highest net income. In the next section, we construct a diagram that explains this financing choice given the entrepreneur and project characteristics.

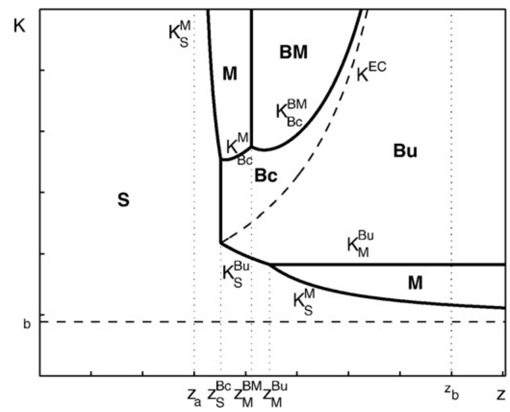

Fig. 2. Financial choice map. The solid thick lines mark the different financial choices, **S, M,B,BM**. The horizontal dashed line indicates the level of wealth b. The cutoff values of ability z displayed are defined in Appendix B.

3. The financial choice diagram

The goal is to construct a diagram that determines the optimal financial choice for any point in the ability-scale space (z,K). This space is chosen because ability z and scale K are unobserved to the econometrician. The observed variables such as wealth b, the fraction η, interest rates (r_D, r_B and r_M), and fixed transaction costs (Γ_B and Γ_M) are fixed in the background and determine the curves in the diagram. The idea is simply to obtain cutoff scale values K as a function of ability z that leave an agent indifferent between any two lending choices. The notation for all critical cutoff scales in Fig. 2 except $K^{EC}(z)$ is such that $K_S^M(z)$, say, is found by equating net incomes $Y_S = Y_M$. The cutoff scale $K^{EC}(z)$ is simply Eq. (5). These critical levels depend on the variables (b,η) and parameters $(r_B, r_M, \Gamma_B, \Gamma_M)$.[16] For example, if the fixed cost of accessing the bank Γ_B declines, the cutoff curves will move, enlarging the region where the agent is better off resorting to the bank. Since agents are summarized by the vector (z, b, K, η) and may face different parameters, the diagram that each faces will have regions of different sizes. In fact, as stated in Proposition 1 below, some regions that appear in Fig. 2 may not exist for some agents. We now provide some intuition why these regions arise where they do; Appendix B shows how these different cutoff curves are obtained analytically. Giné (2010a) contains a 3-dimensional version of Fig. 2 with net income on the z-axis.

3.1. Region S (self-finance)

If the agent has a scale K below $K_S^M(z)$ or $K_S^{Bu}(z)$, she will self-finance (Region **S**). For a given capacity constraint K, the higher the entrepreneur's ability z, the more likely she is to look for outside funds. Intuitively, if the entrepreneur is not very talented, it does not pay to incur the fixed costs and interest rates in order to expand capacity.

3.2. Region M (moneylender only)

When the entrepreneur decides to finance the project externally, Region **M** becomes relevant if the scale K is lower than $K_M^{Bu}(z)$ or higher than $K_{Bc}^M(z)$. In the first case, the amount of credit needed is small (the scale K is close to wealth b) and so saving on bank interest payment does not compensate its higher fixed cost. In the latter case, since wealth b is fixed in Fig. 2, the amount of credit needed (loan size) increases with capacity constraint K. However, given her relatively

[13] The expression in Eq. (5) written as $k^c \equiv \lambda(z,\eta)b$ can be seen as a generalization of the parameter λ in Evans and Jovanovic (1989). In their paper, λ measures the amount that can be borrowed from a bank as a proportion of wealth. Here, as in Banerjee (2003), it depends explicitly on the agent's characteristics.

[14] The problem in Eq. (6) assumes that moneylenders behave competitively. Banerjee (2003), Aleem (1993), and other studies present evidence suggesting that informal lenders earn on average relatively low profit margins, a finding consistent with competition.

[15] Bell et al. (1997) provide direct evidence of this sequential structure in which households first approach a formal institution and then resort to informal sources for additional funds.

[16] Fig. 2 is drawn assuming that $\Gamma_B > \Gamma_M$ and $r_M > r_B$ as supported by the data. In particular, we set $r_D = 1$, $r_B = 1.1$, $r_M = 1.3$, $\Gamma_B = 650$, $\Gamma_M = 275$, $\eta = 0.7$, $K = 12000$ and $b = 1775$.

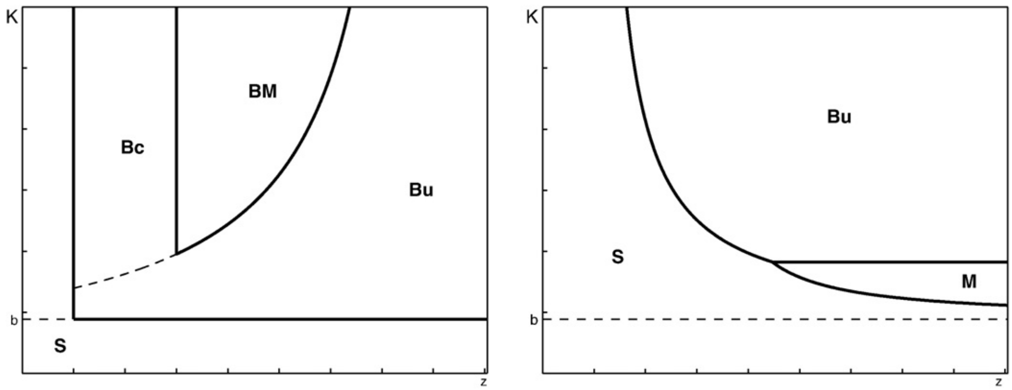

Fig. 3. Financial choice without fixed transaction costs (left) or perfect enforcement (right).

low ability z, the bank is not willing to advance enough capital to make savings on interest payment worthwhile, and so the entrepreneur is better off resorting to the moneylender only.

3.3. Region BM (bank and moneylender)

If the scale K is higher than the cutoff $K_{Bc}^{BM}(z)$, the entrepreneur will resort to both the bank and the moneylender (Region **BM**). The constrained amount k^c that the bank is willing to lend is increasing in ability z (see Eq. (5)). Thus, for a given ability-scale pair (z,K) in the upper Region **M**, if we fix the scale K and increase the ability z, we reach a point where the entrepreneur will find it profitable to incur the fixed cost Γ_B and reduce the total interest payment by borrowing less from the moneylender.

3.4. Region Bc and Bu (Bank Only, Constrained and Unconstrained)

If the scale K falls between the cutoffs $K_M^{Bu}(z)$ and $K^{EC}(z)$, the entrepreneur will borrow from the bank and be unconstrained (Region **Bu**), earning income Y_{Bu}, whereas if it falls between the cutoffs $K^{EC}(z)$ and $K_{Bc}^{M}(z)$ or $K_{Bc}^{BM}(z)$, the entrepreneur will still borrow from the bank but be constrained (Region **Bc**) and earn income Y_{Bc}. For low ability levels, the bank will limit the amount of lending because the entrepreneur is tempted to "run away" with the working capital if she was granted the maximum capacity K.

The following proposition describes the conditions that the variables (b,η) and parameters $(r_B,r_M,\Gamma_B,\Gamma_M)$ must satisfy to generate a particular finance map. The proof is relegated to Appendix B.1.[17]

Proposition 1. *There exist wealth levels $\hat{b}$ and $\tilde{b}$, $\hat{b}<\tilde{b}$ such that:*

- **i)** *If $0\leq b<\hat{b}$ then wealth b is so low that the separate regions **M** in Fig. 2 merge.*
- **ii)** *If $\hat{b}\leq b<\tilde{b}$ and $\eta>r_M-r_B$ we obtain Fig. 2.*
- **iii)** *If $b\geq\tilde{b}$ and $\eta>r_M-r_B$, the top region **M** disappears because wealth b is so high that even if the agent is constrained, it is always profitable to at least borrow from the bank.*
- **iv)** *If $\eta<r_M-r_B$ the ratio of working to total capital η is so low that banks have no problem in advancing funds. The top region **M** and region **BM** disappear.*

In order to explain the financial choices observed in the data, both elements of the model—limited enforceability and transaction costs—are needed. To see this, the left panel of Fig. 3 displays Fig. 2 again but setting the fixed costs $\Gamma_B=\Gamma_M=0$. In the absence of fixed transaction costs, all agents that require financing first borrow from the bank, and only those that are constrained and have enough ability z also borrow from the moneylender. Thus, Region **M** disappears as it never pays to resort only to the moneylender. When banks are able to enforce credit contracts perfectly, they advance funds up to the maximum scale K and the choice between bank and moneylender is driven solely by the magnitude of the fixed costs and the loan size. In this scenario, Region **BM** disappears because the entrepreneur is never constrained. This is shown in the right panel of Fig. 3, still drawn using the variable and parameter values of Fig. 2, which are described in footnote 3.

Since households in the data report using all four financial choices, namely **S**, **B**, **M**, and **BM**, *both* elements of the model are relevant.

Clearly, for a given entrepreneur and financial choice, one feature, say the cost of accessing formal credit, may be more relevant than another. Thus the diagram faced by this household will differ from that of other households. The point is that some regions are relevant for certain households and thus the model must be flexible to accommodate them. The spirit of the estimation in Section 5 is precisely to search over fixed costs and parameters of the (z,K) joint probability function so as to maximize the likelihood that a household obtains the reported expected net income from its financial choice in the particular diagram it faces.

4. The data

The data used in this paper are from the Townsend-Thai data set and come from a specialized but substantial cross-section survey conducted in two provinces in the Northeast and two in the Central region of Thailand in May 1997. It contains a wealth of pre-crisis socio-economic and financial data on 2535 households.[18] The survey instruments collected current and retrospective information on wealth (household, agricultural, business, and financial) and access and use of a wide variety of formal and informal financial institutions (commercial banks, agricultural banks, village lending institutions, moneylenders, as well as friends, family, and business associates). The data also provide detailed information on household demographics, education, and other characteristics.

Because these data provide rich and detailed information about households and financial intermediaries, they are particularly well suited for the present study. Appendix A describes how the variables are constructed from the original data. We now turn to a brief description of some of the salient features of the data and the constructed variables.

[17] Giné (2010a) contains graphs of all possible maps described in Proposition 1.

[18] See Townsend et al. (1997) for more details on the sampling methodology and the data. Although the original data contain 2880 households, we dropped those with missing information in any of the variables used in the analysis.

Table 1
Loan characteristics by lender.
Source: Townsend-Thai data.

	Obs.	L	$\sigma(L)$	Duration	r	r_c	Collat.	Z. Int.
Com. Bank	118	196	246	54	1.2208	1.2326	83.1	5.1
BAAC	1293	41	80	20	1.2232	1.2239	29.4	0.3
Individual	380	75	130	30	1.1273	1.1273	100.0	0.0
Group	913	27	37	16	1.2631	1.2643	0.0	0.5
Ag. Coop	353	43	69	18	1.1373	1.1385	36.3	0.9
Vil. Inst.	174	47	103	32	1.1036	1.1639	9.2	36.8
Informal P	553	51	157	21	1.4203	1.5176	20.1	18.8
Informal R	820	20	44	17	1.2736	1.5499	4.9	50.2
Formal	1928	51	106	23	1.1948	1.2041	31.9	4.6
Informal	1373	33	106	18	1.3327	1.533	11.0	37.6

Note: Each loan is an observation. Com. Bank includes finance and insurance companies. Village-level Institutions include loans from village funds, rice banks, buffalo banks and production and credit groups. “Informal P” includes moneylenders, store owners, landlords and traders. “Informal R” includes friends and relatives. Column L reports the average loan size and column $\sigma(L)$ its standard deviation, both in 1000 baht. The exchange rate at the time of the survey was 25 baht to the dollar. The loan duration is in months. The interest rates r and r_c are gross and compounded yearly. Column “Collat.” reports the percentage of loans that required collateral. Finally, column “Z. Int.” reports the percentage of loans given interest-free.

4.1. Features of the data

The survey reveals that households are very active in the credit market as roughly half of the sample has between one and two loans and only about a third of the households have no outstanding loans.

Table 1 displays the characteristics of loans given by different lenders. The formal sector, especially through the Banc for Agriculture and Agricultural Cooperatives (BAAC), does the bulk of the lending (69% of the total volume of lending).[19] BAAC loans, which account for 36.5% of volume, are divided into individual loans, which are backed by collateral, and group loans, which only require guarantors. When we consider the number of loans, the formal sector still dominates the informal sector giving out 59% of the total number of loans.[20] Although the standard deviations are also high, the hypothesis that the average amounts are equal across different sources of lending can be rejected at a 5% significance level.

Table 1 also reports two gross interest rates, r, computed using all loans, and r_c, computed only using loans bearing a positive interest rate. As expected, informal lenders tend to charge a higher interest rate. Among formal loans, the institutions that require collateral charge lower interest rates. Given that these institutions tend to disburse larger amounts, this may reflect lower costs of funds or lower intermediation costs. We also report the fraction of loans that required collateral. As expected, loans from commercial banks and, by construction, individual BAAC loans, are mostly backed by assets.

Table 2 reports the variables by source of credit that will be used in the estimation. From the sample of 2535 households, 34% self-finance, 36% borrow from a formal institution, 17% borrow from an informal lender only, and 13% borrow from both a formal and an informal lender. These numbers are large compared with those of Aryeetey (1997), in which only 16% of all households interviewed in the Ghana Living Standards Measurement Survey reported borrowing from the formal sector.

Observed borrowings k–b are largest for clients of a formal institution that requires collateral and for those households that resort to both a formal and informal lender. This fits well with the prediction of the model that institutions with higher fixed costs should cater to households with higher financing requirements. A test that the mean capital requirements across lending choices are equal is easily rejected by the data.

Those who borrow from a formal institution are also wealthier than those who borrow from an informal source or both sources. Those who self-finance are, on average, wealthier than informal borrowers but the high standard deviation suggests that there is more dispersion. The model can also rationalize these facts. Holding the ratio η and ability z constant, wealthier households will rely on formal institutions for additional funds because they are in a better position to put up collateral. In addition, wealthy households that decide to self-finance can be interpreted as having a low-scale project or not being very talented (low z). The top panels of Fig. 4 complement Table 2 by displaying the distribution of the log of wealth b and loan size k–b.

Table 2 and the lower panels of Fig. 4 report the average working-to-total capital ratio η and the constructed measure of expected income y. The lower right panel of Fig. 4 plots the cumulative distribution of the log of ratio η. Indeed, the mean ratio η behaves as the model predicts: clients of banks that require collateral have the lowest average ratio η, households that borrow from both have on average a higher ratio, whereas those who borrow from informal lenders only have the highest ratio. Despite the large standard deviation, the hypothesis of equal means across borrowing choices is rejected at all significance levels.

The lower left panel shows the distribution of log expected income y. Together with the top panels, one can estimate the profitability in each lending choice. It seems that “Informal” has higher profitability on average than “Both” or “Formal C”. The model can explain the relatively high profitability of informal borrowers as they operate on a small-scale and decide not to incur the fixed cost of formal finance.

Table 2 also shows the fraction of households that report being credit constrained.[21] Again, a test of equal means is rejected at all significance levels. Households that borrow exclusively from the formal sector and those that are forced to resort to both sources are more likely to be credit constrained, consistent with the predictions of the model.

Finally, Table 2 reports several household characteristics that could affect the fixed costs Γ_B, Γ_M and the value of default on a bank contract $v=\eta k^c$.

Following Guiso et al. (2004), among others, we consider measures of the household's social capital and its ties with lenders. We proxy for social capital using data on household membership in the village committee. Membership may capture social characteristics such as sense of duty, trustworthiness, and popularity among fellow villagers.[22]

We use several measures that characterize the ties that households have with the different lenders. First, we record whether the household has previously borrowed from the lender. If the borrower is an old client, the lender will have more accurate information and will be keen on extending credit and possibly lowering the cost of capital.[23] Second, we measure the strength of the relationship by

[19] BAAC is a government development bank and a major credit institution in the rural areas of Thailand. Since 1977, BAAC has been providing direct loans to farmers with collateral requirements for loans exceeding US$2400, loans to farmer groups through agricultural cooperatives, and saving services.

[20] This significant presence of the formal sector is in contrast with the findings of Udry (1993) and Aryeetey (1997) in rural Africa, where formal credit remains small.

[21] Households were specifically asked the following question in the survey: If you could increase the size of your *enterprise*, do you think it would be more profitable? If a household responded affirmatively to the question, it is considered credit constrained.

[22] For our purposes, being respected and well-known in the community may result in greater access to funds. However, in the case where membership in these committees grants power to divert funds for private, non-productive purposes, then membership may be correlated with greater risk of default on the bank loan and if so we would expect members to face the enforcement constraint more often.

[23] The observed correlation between past and current borrowing from a particular borrower can be explained by two distinct scenarios. First, as a consequence of having borrowed in the past, the cost of accessing the lender is now lower and thus it is more likely that the household will borrow again. However, some unobserved characteristic inherent to the household may place it in a better position to borrow, say because a relative is a credit officer in the formal institution. Since this unobserved characteristic is correlated through time, it may appear that having borrowed in the past is a good predictor for current behavior when in fact it just happens to be a good proxy for the unobserved characteristic that is responsible for the observed behavior. This so-called “state dependence” problem is pointed out by Heckman (1981). We therefore instrument past membership using how long formal institutions have been in the village.

Table 2
Summary of model variables.
Source: Townsend-Thai Data.

	Own	Formal C	Formal NC	Informal	Both
Loan size					
Mean		114	36	34	127
Std. Dev.		188	56	99	259
Wealth					
Mean	1700	1899	1209	896	1195
Std. Dev.	6146	5935	4530	3692	5138
Income					
Mean	1930	2230	1442	1109	1476
Std. Dev.	6352	6294	4779	3847	5480
Working-to-total capital ratio					
Mean	0.645	0.510	0.707	0.751	0.683
Std. Dev.	0.331	0.318	0.317	0.296	0.330
Credit constraints					
Mean	0.386	0.570	0.669	0.522	0.654
Std. Dev.	0.487	0.496	0.471	0.500	0.476
Mean household characteristics					
Formal inst. present in village	0.285	0.788	0.761	0.448	0.763
Past client of formal inst.	0.334	0.965	0.944	0.268	0.947
Past client of informal inst.	0.065	0.093	0.105	0.427	0.447
Member of a village committee	0.057	0.126	0.142	0.076	0.121
Head of household is male	0.698	0.786	0.852	0.776	0.831
Years of education	3.889	4.209	4.383	3.804	4.447
Savings in formal institution	0.505	0.816	0.835	0.316	0.805
Observations	848	430	486	433	338

Note: The category "Own" includes households that do not have outstanding loans. "Formal C" includes institutions that require collateral: commercial banks, finance and insurance companies and BAAC individual loans. "Formal NC" includes BAAC group loans, loans from agricultural cooperatives and loans from village-level institutions. "Informal P" and "Informal R" are merged into Informal. "Both" includes households that actively borrowed from both formal and informal sources. Loan size is the sum of all loans by the households and along with wealth and income is reported in 1000 baht. The exchange rate at the time of the survey was 25 baht to the dollar.

looking at whether households have savings deposits with a formal institution. The argument here is that these non-loan services can be used by the creditor to monitor the household or obtain additional information, thereby reducing the expected cost of such loans.

Finally, we use the presence of a formal institution in the village to proxy for distance. Because this variable may also be endogenous, we instrument it using population size and year of village formation.

5. Estimation of the model

We estimate the model in two ways; first using only financing choice as dependent variable, and second, using both financing choice and expected income. In this latter case, we assume that the log of ability z and the log of maximum scale K follow a bivariate normal distribution

$$(\zeta,\kappa) \sim BVN\left(\mu_\zeta, \mu_\kappa, \sigma_\zeta^2, \sigma_\kappa^2, \rho\right), \tag{8}$$

where $\zeta = \log(z - \underline{z})$ and $\kappa = \log(K)$. Notice that ability has a lower bound at $\underline{z} = r_D - \delta$ because it has to be worthwhile to undertake the investment.[24]

When only the financing choice is used, the distribution parameters cannot be identified. To see this, consider the likelihood that a household borrows from a given source, say M, which is the integral of the joint distribution of (ζ,κ) over the relevant region M. The algorithm estimates simultaneously the parameters of the joint distribution and the limits of integration (also a function of other parameters to be estimated). As a result, they cannot be jointly estimated, because the same value of the likelihood can be achieved by increasing (decreasing) the density and reducing (enlarging) the region over which the integration takes place. However, when we also use expected net income, then all the parameters are identified because we are placing more restrictions in the estimation.

We consider two specifications of the fixed costs and the value of default. First, each household faces the same fixed costs Γ_B and Γ_M, and is subject to the same enforcement constraint. Alternatively we allow these fixed costs and the value of default to vary among households. In particular, we assume that $\Gamma_{Bi} = \exp(x_{Bi}{'}\gamma_B)$ and $\Gamma_{Mi} = \exp(x_{Mi}{'}\gamma_M)$, where x_{ji} is the column vector of characteristics of household i that influence the fixed cost Γ_j. In addition, it is possible that households differ in their ability to use working capital for their private benefit. In this case, the value of defaulting on a bank contract would be household-specific. More formally, we can write this value $v = \eta k$ in Eq. (4) as $v(x_\eta) = \exp(x_{\eta i}{'}\gamma_\eta)\eta k$ where, again, $x_{\eta i}$ is a column vector of characteristics of household i.

We now derive the likelihood dictated by the model under both estimation strategies. Since ability z and the maximum scale K are not observable, the likelihood can be determined entirely from the cutoff curves $K_j^i, i,j = \{S,B,M,BM\}$ in the maps described in Proposition 1 and the joint distribution of ability z and scale K. In addition, when expected income is also used, Eqs. (2),(5),(7), and (8) in Section 2 describe the net income from each financing choice.

Now let $\theta = (\gamma_B, \gamma_M, \gamma_\eta)$ and $\theta_y = (\gamma_B, \gamma_M, \gamma_\eta, \mu_\zeta, \mu_\kappa, \sigma_\zeta, \sigma_\kappa, \rho)$ denote, respectively, the vector of parameters of the model depending on whether expected income is used, and let $\nu_i = (b_i, \eta_i, x_{Bi}, x_{Mi}, x_{\eta i})$ denote the vector of variables.[25] Suppose we have a sample of n households and let $l_i = \{S,B,M,BM\}$ denote the financing decision taken and y_i the income derived from that choice. Then, the likelihood that a household with characteristics ν_i facing parameters θ will choose l_i and derive net income y_i, can be written as[26] as $L_n(\theta) = \sum_{i=1}^n f(y_i|\nu_i,\theta)$ when expected income is not used and

$$L_n\left(\theta_y\right) = \sum_{i=1}^{n} f\left(y_i, l_i \,|\, \nu_i, \theta_y\right) \tag{9}$$

24 As the expected inflation rate in Thailand was around 4% in 1997, we take the interest rate on deposits to be 1% in real terms. See Fitchett (1999) for details.

25 The parameter $\tilde{\delta}$ cannot be estimated because there is too little variation in δ to estimate it separately from the mean of ability z. Intuitively, the assumed linearity of the technology allows only estimation of the gross return $z + \delta$. Essentially then only one constant is identified and we therefore fix $\tilde{\delta} = 1$.

26 Appendix C derives explicitly the form of the likelihoods $f(y_i|\nu_i,\theta)$ and $f(y_i,l_i|\nu_i,\theta_y)$.

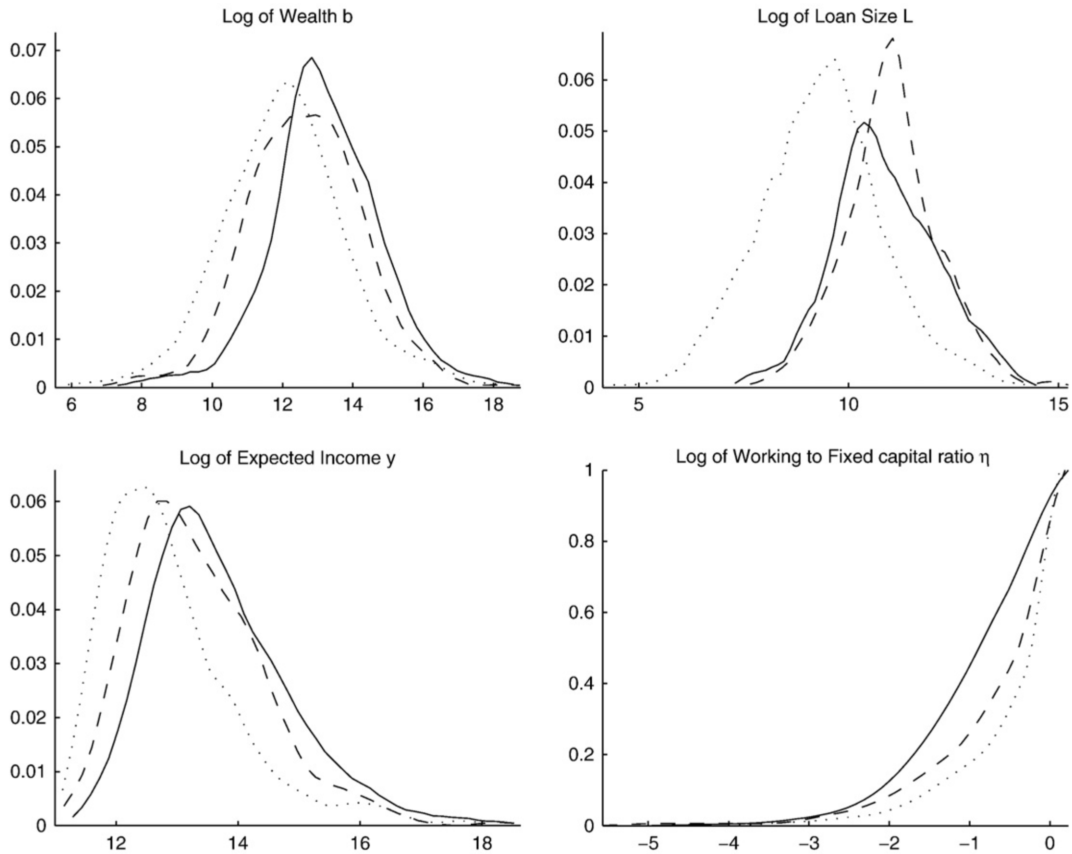

Fig. 4. Kernel density estimations. Legend: Formal C "-", Informal "…" Both "- -".

when expected income is used in the estimation. Both likelihood functions can be maximized numerically using a standard maximization routine.[27]

5.1. Estimation issues

The model imposes some preliminary restrictions on the data. First, according to Proposition 1.iv, the model assigns zero probability to households that report borrowing from both sources with $\eta < r_M - r_B$. These only account for 0.55% of the sample. When expected income is used, 5.44% of the sample is dropped because expected income was not reported, and another 6.29% of the sample is also dropped because the constructed income is too low for the model to rationalize the choice of lender.[28] Since the model is deterministic (but the income data are not), we use *expected* rather than *realized* income.[29]

Finally, the estimation requires prices r_B and r_M. Given the geographical dispersion in interest rates, we use the sample village-level gross interest rate charged by formal and informal lenders, respectively.[30] Notice then that the cost of capital is taken to be uniform within a given village. Although formal institutions do have rigid rules for setting the interest rate, informal lenders could in principle tailor them to borrower characteristics. Informal interest rates, as Banerjee (2003) suggests, can be decomposed into default rate, opportunity cost, monitoring cost, and monopoly rents. In the model here, there is no default and no monopoly rents as moneylenders are assumed to be competitive; thus, informal interest rates are determined by monitoring and opportunity costs. Given the low dispersion found in the reported informal interest rates within a village, the data suggest that both monitoring and opportunity costs are village specific.

6. Results

We combine each estimation strategy with either restricting the cost and value of default to be common or unique to each household. We thus obtain four different estimations.

6.1. Parameter estimates

Table 3 reports the estimates and standard errors of the underlying parameters of the model.[31] The first two columns only use the lending choice as dependent variable, while the last two columns use the lending choice as well as expected income. The odd columns in Table 3 restrict all households to face the same fixed cost and value of default (Common), while even columns allow the fixed cost and value of default to be household-specific (Different).

The distributional parameters are only estimated when expected income is also used in the estimation. In the first two columns, the

[27] In particular, we used the MATLAB routine `fmincon` starting from a variety of predetermined guesses.

[28] The model assigns zero probability to households that $l_i = B$ and $y_i < r_B b$ and $l_i = M$ or $l_i = BM$ and $y_i < r_M b$. We check whether selection is a concern by running two sets of regressions using first all the sample and then the selected sample, for each estimation—with and without income. The first set of regressions uses a logit and borrowing from an outside source as the dependent variable, against all the variables used in the MLE estimation. The second set uses a multinomial logit where the dependent variable is the choice of lender. We find that the coefficients do not change much and they never flip signs. In fact, none of the coefficients are statistically different from each other except for wealth and income in the multinomial logit for the estimation using income. They are significantly different at 95% (but not 99%) in the choice of Moneylender and Both.

[29] See Appendix A for a description of how expected income is measured.

[30] After trying different geographical units, the village was chosen because it was the only unit where the dispersion in the interest rates within a unit was significantly lower than across units.

[31] The standard errors are computed using the outer product of the gradient (OPG) estimator. Since the ML estimation yields estimates that are functions of the parameters of interest, we use the Delta Method to obtain the desired standard errors.

Table 3
Maximum likelihood estimates.

Variable	Not using expected income				Using expected income			
	Common		Different		Common		Different	
	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.	Coef.	S.E.
Distribution								
μ_ζ		–		–	−0.203	0.0126	−0.145	0.0127
μ_κ		–		–	0.989	0.0199	0.780	0.0226
σ_ζ		–		–	0.964	0.0063	0.934	0.0059
σ_κ		–		–	1.551	0.0131	1.542	0.0135
ρ		–		–	−0.871	0.0038	−0.846	0.0050
Fixed cost of formal access								
Constant (in baht)	3262.0	114.9	8959.9	2798.5	685.9	4.3	1640.3	283.2
Formal Inst. in Village		–	0.805	0.3522		–	0.619	0.0009
Past Mem. Formal Inst.		–	0.791	0.1034		–	0.607	0.0016
Past Mem. Informal Inst.		–	1.122	0.1631		–	0.958	0.0030
Member of Village Com.		–	1.204	0.1678		–	0.557	0.0513
Education		–	1.031	0.0168		–	0.997	0.0101
Savings in formal inst.		–	0.079	0.0070		–	0.226	0.0086
Region (Northeast)		–	0.927	0.1164		–	1.061	0.0669
Fixed cost of informal access								
Constant (in baht)	143.3	91.8	54.0	34.6	1.0	4.1	10.9	3.3
Enforcement constraint								
Constant		–	1.063	0.0220		–	0.885	0.0107
Member of Village Com.		–	0.845	0.0165		–	0.997	0.0056
Sex of head (Male)		–	0.923	0.0143		–	1.088	0.0100
Education		–	1.016	0.0024		–	1.021	0.0011
Region (Northeast)		–	1.229	0.0153		–	1.008	0.0065
Number of Obs.	2520		2520		2203		2203	
Log-Likelihood	−5677.56		−5317.20		−50,596.30		−41,832.76	

distributional parameters are fixed to those found in the last two columns. From Table 3, one can obtain the distribution of scale K and ability z by using the log-normal distribution formulas.[32] For the "Different" specification, ability z is distributed with mean 1.34 and variance 6.22, whereas the scale K has mean 0.72 million baht and a variance of 25.17 million baht. The implied coefficient of correlation between z and K is −0.19. The estimated mean and variance of scale K are comparable to the mean wealth of 1.05 million baht and variance 17.67 million baht.

When the fixed cost of formal finance is common across households, it is estimated at 3262 baht (US$130) or 686 baht, depending on whether expected income is used in the estimation. This cost is less than 2.40% of the average formal loan size when expected income is not used, and .95% when it is used.

When the fixed cost of formal finance is allowed to vary across households, the intercept ranges from 8960 baht (US$358) to 1640 baht. This still amounts to less than 5% of the average formal loan size. This intercept is the cost per loan that a household would face if its vector of characteristics was zero in all the variables considered, which is hardly the case. Indeed, the average fixed cost is 3155 baht or 436 baht depending on whether expected income is used in the estimation. The coefficients of these variables are shown in exponential form and are thus multiplicative of this constant term. Thus, if the coefficient is lower (higher) than one, the variable *reduces* (increases) the cost.

When income is used, the presence of a formal institution in the village significantly lowers the cost of formal finance due to lower transport costs. But other household characteristics are also relevant. For example, social capital lowers the fixed cost when income is used in the estimation as well as having savings with a formal institution regardless of whether income is used. In addition, having borrowed from a formal institution in the past lowers the fixed transaction cost by 40 and 20 Percent with and without income, respectively. However, borrowing from an informal source does not lower the fixed cost of formal credit. Hence, the data do not support the "syndication" argument developed in Jain (1999) and Conning (2001, 2005), which predicts that formal lenders benefit from the screening done by informal lenders by providing only partial finance and forcing borrowers to resort to informal lenders. The fixed costs of informal finance are estimated at less than 150 baht in all specifications. This finding complements the work of Siamwalla et al. (1993), also in Thailand, and Udry (1993) and Aryeetey (1997) in Africa. These authors find that information asymmetries are unimportant within rural communities, and since informal lenders often live in the same village, they are easily accessible.

Table 3 also reports how household characteristics affect the value of defaulting on the bank loan contract. Education consistently increases the value of default significantly across specifications. Households with a male head face higher value of default when expected income is used but lower when it is not. In addition, when the likelihood only maximizes the financial choice, social capital lowers the value of default, suggesting it is a good proxy for trust, and being in the Northeast raises it significantly, maybe due to poorer enforcement.

Although the data reject that the fixed cost of formal credit and value of default are uniform across households, the estimation reveals that the fixed cost is nevertheless relatively small.

6.2. Goodness of Fit and Predictions

Table 4 reports the average of the predicted fractions (in columns) for each actual borrowing choice (in rows) for the "Differentiated Default and Cost" specification both when income is used and not used. Thus, the diagonal elements of the matrix report the percentage of correct predictions under each estimation.

Although the model is able to correctly predict more than half of the times the financial choice for households that self-finance, it is less successful in replicating households that report other financial choices. The intuition for why the model assigns too much probability

[32] Suppose that $x = \log(X)$ and $y = \log(Y)$. Then if (x,y) follow a bivariate normal distribution with parameters $(\mu_x, \mu_y, \sigma_x^2, \sigma_y^2, \rho)$, the distribution of X has mean $\mu_X = e^{\mu_x + \frac{\sigma_x^2}{2}}$ and variance $\sigma_X^2 = e^{2\mu_x + \sigma_x^2}\left(e^{\sigma_x^2} - 1\right)$. Analogous expressions can be derived for Y. Finally, the coefficient of correlation is $\rho_{XY} = \frac{e^{\rho\sigma_x\sigma_y} - 1}{\sqrt{e^{\sigma_x^2} - 1}\sqrt{e^{\sigma_y^2} - 1}}$.

Table 4
Goodness of fit by borrowing choice.

	Self-finance	Bank	Moneylender	Bank–m. lender
Not using income				
Self-finance	57.49	17.40	16.42	8.69
Bank	63.63	18.96	7.37	10.03
Moneylender	50.14	17.78	22.29	9.79
Bank and moneylender	59.10	20.48	8.09	12.33
Using income				
Self-finance	55.95	25.75	5.25	13.05
Bank	59.96	25.64	1.94	12.47
Moneylender	41.26	32.56	6.67	19.50
Bank and moneylender	51.08	30.17	2.46	16.29

Note: In rows, reported choice, and in columns, predicted choice.

mass to the self-finance choice has to do with the estimated mean log of ability ζ and log of scale κ. The point of highest density falls in region **S** for the median household that resorts to the bank, the moneylender, or both.

We now use the estimates from the specifications where cost and value of default are household-specific to explore how often households face a binding enforcement constraint. In both specifications, the model predicts that roughly 86% of the households that borrow from the bank are constrained, as it pays to borrow up to the constrained limit given that on average they face a relatively low fixed cost.

But how important are enforcement problems along with fixed costs overall? Panel A in Table 5 reports the predicted average growth rate of income and investment that would result, respectively, without fixed costs but limited enforcement, perfect enforcement but fixed costs, and no fixed costs and perfect enforcement, relative to the benchmark estimation from the data where enforcement is limited and fixed costs are present.

According to these results, while the reduction in fixed costs would have little impact on the growth of investment and income, if banks could enforce credit contracts perfectly, income would increase by 20%, whereas investment would more than double. Thus, government intervention should be devoted toward policies that mitigate the enforcement problem (rather than lowering transaction costs), an issue to which we turn next.

6.3. Policy analysis

The model is well suited to assess the impact of specific policies that have been used in Thailand and elsewhere to foster rural financial development. We first consider a policy of subsidized credit, where an interest rate ceiling is imposed below the market rate. We then consider a policy of active village-level branch expansion. Both these policies were implemented in the creation of BAAC. Its mandate calls for portfolio allocation targets with subsidized credit, and its increased capitalization by the government has fueled its aggressive expansion into rural areas (Fitchett, 1999).[33] Finally we consider a land titling program. Although Thailand experienced a similar program in the 1980s, there are still rural pockets, especially those close to Forest Reserves, where instead of formal titles, the government issued special titles that contained explicit restrictions to the sale and rental of the land. These titles are not accepted as collateral by financial institutions. [34]

Table 5
Percentage growth in investment k and income y.

	Not using exp. Inc.		Using exp. Inc.	
	k	y	k	y
Panel A: Relevance of market imperfections				
Limited enforcement, no fixed costs	0.3	0.4	0.1	0.1
Perfect enforcement, fixed costs	195.6	19.8	209.5	21.6
Perfect enforcement, no fixed costs	201.2	21.0	210.3	21.8
Panel B: Policy analysis				
5 percent cut in formal interest rate	0.8	0.9	1.0	1.3
Creation in formal institution in village	0.2	0.3	0.1	0.1
Land titling program	82.5	12.63	89.02	13.12

Note: For each household, 1000 (z,K)-pairs are simulated from the estimated bivariate distribution. Using each household's vector of characteristics and estimated parameters, the investment and income are computed under each scenario and under the benchmark of limited enforcement and fixed costs. Growth rates of investment k and income y for each household and scenario are computed relative to the benchmark and the overall mean is reported.

In the context of the model, the first policy amounts to lowering the interest rate that formal institutions charge, the second that all households live in a village with a formal credit institution, and the third to considering that all land can be used as collateral, resulting in a decrease in η for individuals with untitled land.[35]

Two major caveats qualify the results. First, no attempt is made to quantify the costs of implementing such policies, so the results are only indicative of gross benefits. Second, we perform a partial equilibrium analysis in the sense that changes in one parameter or variable do not affect others.[36] Despite these shortcomings, the results reveal substantial differences in the impact of the policies considered and are consistent with the recent Thai rural policy debate.

Table 6 reports the percentage change in the predicted fraction of households making each financial choice for each policy considered relative to the benchmark estimations.

With a subsidized credit policy, the government is inducing agents to start up projects that at the previous interest rate were not profitable. This implies that the average entrepreneurial ability in the pool of formal loan applicants decreases. Although an interest rate reduction succeeds in drawing a larger fraction of households to the bank in detriment to the use of moneylenders, enforcement problems become more acute.[37] In light of these numbers, it becomes clear why the literature has stressed the low repayment rates (or high default rates) associated with such a policy.[38]

The creation of a formal institution in the village effectively lowers the fixed transaction cost without affecting the pool of loan applicants at the low end. However, it does not alleviate enforcement problems, so once formal financing is more attractive (given the lower fixed cost), agents are more likely to be constrained and will resort to both formal and informal sources more often.

Only the land titling program succeeds in dramatically lowering the fraction of agents that resort to both sources of credit. If more assets can now be used as collateral, the bank will have less problems in advancing the unconstrained amount, and so informal finance is less needed.

Panel B of Table 5 reports the average growth in income and investment resulting from the policies considered. Fig. 5 complements

[33] The first two types of policies have been analyzed extensively in the literature by the collection of articles in Von Pischke et al. (1983); Braverman and Guasch (1986, 1993); Hoff and Stiglitz (1993); Besley (1994); and Yaron (1994).

[34] The land titling policy has been suggested by Feder et al. (1988) and Feder (1993). See Giné (2010b) for more details about the issuance of special titles in Forest Reserve areas.

[35] Appendix A describes how η was constructed.

[36] This can be problematic for the case of the interest rate charged by moneylenders. As studied in Hoff and Stiglitz (1997), a subsidized credit policy will have general equilibrium effects in the informal sector, thereby altering the interest rate effectively charged by moneylenders.

[37] Indeed, one can check from Eq. (5) that the loan size decreases with the formal interest rate.

[38] See Conning and Udry (2007) for an excellent discussion of the pitfalls of such policy.

Table 6
Percentage change in predicted probabilities of financial choices.

	S	B	M	BM
Not using expected income				
5 percent cut in formal interest rate	−0.64	3.26	−3.82	1.20
Creation of formal institution in village	−0.61	4.01	−7.18	3.78
Land titling program	−2.26	16.46	−6.32	−7.88
Using expected income				
5% cut in formal interest rate	−0.84	2.76	−2.32	0.39
Creation of formal institution in village	−0.37	1.17	−1.92	1.12
Land titling program	−0.88	14.72	−1.88	−11.96

Note: Financial Choices are Self-finance (S), Bank (B), Moneylender (M), and Bank and Moneylender (BM).

Table 5 by displaying the conditional average income growth as a function of wealth for the estimation that does not use expected income.[39]

As expected, the land titling program has the largest impact, given the importance of enforcement constraints relative to the fixed transaction costs considered. Notice also that those with some land-holdings gain the most, while the richest do not benefit at all because they always self-finance.

If we take these numbers as an indication of where the largest payoffs to policy are, then it is clear that efforts should be focused on improving the enforcement of private contracts and the registration of titled property or even conversion of government deeds to full title deeds. These recommendations coincide with government thinking as evidenced by the creation in 2003 of the Asset Capitalization Bureau. This bureau was specifically established to review the property rights of assets, including land and machinery, so that they could be used as collateral.

7. Conclusions

This paper sheds light on the mechanism underlying access to credit when multiple lenders coexist. We construct and estimate a contract theory model based on limited enforceability and fixed transaction costs, two important features of rural financial markets. The advantage of using a structural approach in the estimation is twofold. First, we are explicit about the source of unobserved heterogeneity. This allows us to identify the parameters of the model given the data. Second, and most important, the model allows a quantitative assessment of different government policies often used in rural development.

Several points arise from the results. First, while the cost of accessing a formal institution is estimated at US$130 or US$30 depending on the specification, informal lenders are accessible at no cost. Second, although this fixed cost of access to formal finance is not uniform across households, it is relatively small. Thus, the limited ability that formal institutions have to enforce contracts more than fixed transaction costs explains the diversity of lenders.

These fixed transaction costs are incurred before the loan is taken and thus do not include expenses borne by the lender to monitor while the loan is active; the costs are presumably recovered in the interest rate. In any event, using Banerjee's (2003) transaction costs taxonomy, we find that the estimated magnitude of the “ex-ante monitoring” expenses is not important.

If we compare the estimated set-up with a frictionless one without fixed transaction costs and perfect enforcement, average income would increase by 21% under both specifications. This number seems to suggest that market imperfections are important and that there may be a role for government intervention. In trying to suggest where the largest payoffs to policy intervention are, we provide some evidence as to why policies designed to provide cheap credit to rural households may not be as effective as a land titling program, provided that the court system is efficient.[40]

Obviously, lower interest rates as a result of efficiency gains in intermediation will increase the number of households resorting to formal institutions. This argument is, in fact, the main rationale for the presence of micro-finance institutions in rural areas as they take advantage of their innovative lending methodology.

But the point still remains that the key constraint to efficiency is the inability of formal lenders to enforce contracts. Therefore, policies that mitigate the enforcement problem seem to be warranted.

Appendix A. Data

A.1. Wealth of the household b and scale k

The scale k, at which the household operates its project, consists of all assets and inputs used in production. This comprehensive measure includes the house, the current value of land-holdings, ponds, buildings, vehicles, equipment, livestock, and other household, agricultural, and business assets. Depending on the asset, households are asked the current or historical value of the asset.[41] Following Paulson et al. (2006), if the historical worth is given, we compute the current value by first converting the purchasing price to 1997 baht using the Thai consumer price index, and then depreciating the asset at a rate of 10% per year.

Wealth b is the portion of the scale k that is owned and is computed as the difference between scale k and loans taken l.[42] Without knowing whether the loan is spent, we would observe $k=\sum A_i$ if the loan is spent, where A_i is the current value of a given asset i. We would then infer wealth by computing $b=k-l$. Analogously, if the loan is not spent, we would then observe $b=\sum A_i$ and estimate the scale as $k=b+l$. Although both approaches have obvious drawbacks, we assume that the loan is spent.

A.2. Expected income y

According to the model, net income is $y=y^e+\delta k$, where y^e is the reported expected net income. We use *expected* rather than *realized* because the model is deterministic. Fortunately, after the current net profit is elicited, the survey asks for an estimate of next year's net profit, which is the measure we use.[43]

[39] The analogous figure with the parameters of the estimation that used expected income is similar and hence omitted.

[40] Paulson et al. (2006) suggest that the credit market imperfections in Thailand are better explained by moral hazard than limited liability. They thus conclude that policies should enhance the monitoring capabilities of lenders. If better monitoring prevents bank borrowers from running away with the loans, then better monitoring will be equally effective in this model as a land titling program that would increase the amount of wealth that can be pledged as collateral, because both reduce the incentive ex-ante to default on the bank loan.

[41] Households report the *current* value of land-holdings, livestock, and the house, and the *historical* value of ponds and all other assets. Typical household assets include refrigerators, washing machines, and furniture. Under agricultural assets one finds tractors, machinery, and tools, and under business assets there are inventories, equipment, and furniture.

[42] Given our interest in determining the cost of accessing credit, the loan amount l is the sum of all outstanding loans. From the loans recorded in the survey, 63% were taken for productive purposes; 17.67% were consumption loans; 6.45% were used to pay for ceremonies, educational and medical expenses; and 5.46% were used to re-lend or repay past outstanding loans. The remaining 7.4% of the loans had other purposes. The category “productive purposes” includes loans to purchase or repair vehicles, buildings, and equipment, as well as livestock, and fertilizer, pesticide, herbicide and seeds.

[43] The exact wording of the question is: “What is your best guess about what the household's net profit will be next year?”

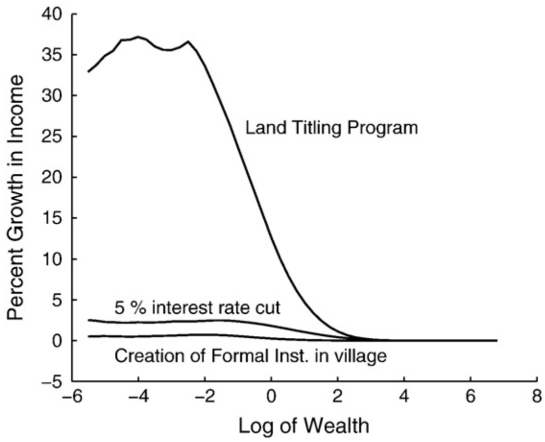

Fig. 5. Percentage income growth from different policies. All household characteristics except wealth are fixed at the sample mean. For each household, 1000 (z,K) pairs are generated from the estimated distribution. The net income under the benchmark and under the different policies is computed, as well as the average income growth over the 1000 (z,K) generated pairs. This average income growth, conditional on wealth, is then smoothed using local weighted regressions.

A.3. Working-to-total capital η

To determine whether an asset can be used as collateral, the model emphasizes the legal status, rather than the physical nature of the asset *per se*. But since working capital depreciates fully, all fixed capital is treated as if it could be used as collateral. For estimation purposes, we consider total capital investment as the sum of *collateralizable* fixed assets, *uncollateralizable* fixed assets, and working capital, $k = k^F_{\text{uncol}} + k^F_{\text{col}} + k^W$. We divide fixed assets into k^F_{col} and k^F_{uncol} by running a regression of the total amount pledged as collateral on a constant and the value of several types of assets owned by the household. We then compute our estimate of fixed capital that can be used as collateral k^F_{col} as the sum of all assets that are statistically significant. Likewise, those assets not significant in the regression are added to capital not used as collateral k^F_{uncol}. We use owned titled and non-titled land—cultivated and other—ponds, buildings used for business and agricultural purposes, and large vehicles such as tractors, trucks, and pick-up trucks also used for business and agricultural purposes.[44] Finally, we include the value of other business and agricultural assets such as inventories, equipment, furniture, etc.

Confirming the common practice of banks, our estimate of fixed capital used as collateral includes all titled land (cultivated and other), ponds, and buildings for agricultural purposes.[45]

The ratio η is the fraction of capital that banks cannot seize, and it is computed as:

$$\eta = 1 - \frac{k^F_{\text{col}}}{k} \tag{10}$$

The fraction of total non-depreciated capital is no longer $\delta = \tilde{\delta}(1-\eta)$, because this expression assumes that fixed capital that cannot be used as collateral depreciates fully. Rather, the parameter δ is computed as

$$\delta = \tilde{\delta}\frac{k^F_{\text{uncol}} + k^F_{\text{col}}}{k}. \tag{11}$$

[44] As described in Feder et al. (1988) and Giné (2010b), the Thai government issues different land property documents depending on the legal status, transfer rights, and other stipulations. For our purposes, it is important to note that not all land titles are used as collateral.

[45] The results of the regression can be found in Giné (2010a).

Appendix B. Analytical derivation of the finance map

In this appendix we provide a closed-form solution for the different cutoff curves. The segments denoted $K^S_M(z)$ are found by equating the net incomes from self-financing Y_S with borrowing from a moneylender Y_M and solving for the scale K. We obtain

$$(z+\delta-r_M)(K-b) \geq \Gamma_M \quad \text{or} \quad K^S_M = b + \frac{\Gamma_M}{z-r_M+\delta}. \tag{12}$$

The vertical segment at ability z^{Bc}_S is found by equating Y_S and the net income from borrowing from a bank and being constrained Y_{Bc}. This yields a quadratic expression in ability z that does not depend on the scale K:

$$b \geq \frac{\Gamma_B}{z+\delta-\eta}\left[\frac{\eta}{z+\delta-r_B} - 1\right]. \tag{13}$$

Given that when $\Gamma_B = 0$, the positive root is $z = r_B - \delta$ and the negative is $z = \eta - \delta$, the positive is chosen because it satisfies $z \geq r_B - \delta$, a necessary condition for optimal investment to be positive.

Finally, the segment denoted $K^S_{Bu}(z)$ comes from equating the net incomes from self-finance Y_S with going to the bank and obtaining unconstrained credit Y_{Bu}.

$$(z+\delta-r_B)(K-b) \geq \Gamma_B \quad \text{or} \quad K^S_{Bu}(z) = b + \frac{\Gamma_B}{z-r_B+\delta}. \tag{14}$$

Note that the expressions in Eqs. (12) and (14) are similar. Next, the cutoff level $K^{Bu}_M(z)$ is found by equating the net income of unconstrained borrowing from the bank Y_{Bu} with the net income of resorting to a moneylender Y_M. This yields

$$b \leq K - \frac{\Gamma_B - \Gamma_M}{r_M - r_B} \quad \text{or} \quad K^{Bu}_M(z) = b + \frac{\Gamma_B - \Gamma_M}{r_M - r_B} \tag{15}$$

which does not depend on the ability z. The cutoff curve $K^{EC}(z)$ is precisely k^c in Eq. (5) and divides agents into those that will obtain a constrained amount from those that will receive the unconstrained maximum capacity K.

The curve $K^{BM}_{Bc}(z)$ is found by equating the net incomes Y_{Bc} and Y_{BM}. This yields a quadratic expression in z,

$$\Gamma_M \geq (z+\delta-r_M)\left[K - \frac{br_B}{\eta-(z+\delta-r_B)}\right] \tag{16}$$

which in terms of K can be rewritten as

$$K^{BM}_{Bc}(z) = \frac{\Gamma_M}{z+\delta-r_M} + \frac{br_B}{\eta-(z-r_B+\delta)}. \tag{17}$$

Finally, we need to compare the net income Y_{Bc} with the net income Y_M on the one hand, and Y_M with Y_{BM} on the other, delivering the curve $K^M_{Bc}(z)$ and the cutoff ability z^{BM}_M respectively. Therefore, comparing Y_{Bc} with Y_M we obtain

$$\frac{\eta b r_B}{\eta-(z-r_B+\delta)-\Gamma_B} = zK-(K-b)r_M + \delta K - \Gamma_M \tag{18}$$

or in terms of K,

$$K^M_{Bc}(z) = \frac{1}{z+\delta-r_M}\left[\frac{b\eta r_B}{\eta-(z-r_B+\delta)} - br_M - (\Gamma_B - \Gamma_M)\right]. \tag{19}$$

Now comparing Y_M with Y_{BM} we get

$$b\left[\frac{r_B}{\eta-(z-r_B+\delta)}-1\right] = \frac{\Gamma_B}{r_M-r_B} \tag{20}$$

which does not depend on K. Solving for z, we obtain,

$$z_M^{BM} = \eta-\delta+\frac{\Gamma_B r_B}{\Gamma_B+b(r_M-r_B)}. \tag{21}$$

This completes the characterization of the cutoff curves in Fig. 2 in the text.

B.1. Proof of Proposition 1

The goal is to show that for certain values of wealth, some regions that appear in Fig. 2 merge or disappear altogether. We assume throughout that $0 \le \eta \le 1$ and $r_M > r_B > 1$.

First, we check when regions **M** and **BM** exist. For this, we find all ability levels z such that $K_{Bc}^M(z) = K_{Bc}^{BM}(z)$. From Eqs. (17) and (19) or the map in Fig. 2, we know that z_M^{BM} in Eq. (21) is a root. In addition, $z_a = r_M - \delta$ and $z_b = r_B + \eta - \delta$ are also roots.

Note that $z_b > z_a$ as long as $\eta > r_M - r_B$. Thus, regions **M** and **BM** will disappear if $\eta \le r_M - r_B$. In addition, it is always the case that $z_b > z_M^{BM}$ because $r_M > r_B$ and $b \ge 0$ by assumption. Finally, the top region **M** will exist if (and only if) $z_M^{BM} > z_a$. Some algebra indicates that this condition, as assumed in Fig. 2, is satisfied as long as

$$b < \frac{\Gamma_B[\eta-(r_M-r_B)]}{(r_M-\eta)(r_M-r_B)} = \tilde{b}. \tag{22}$$

We now want to determine when the two regions **M** in Fig. 2 merge. It is useful to define abilities $z_{M,Bu}^{EC}$ and z_M^{Bu} as the level of ability z such that $K^{EC}(z) = K_M^{Bu}(z)$ and $K_S^{Bu}(z) = K_S^M(z)$ respectively. Some algebra yields

$$z_{M,Bu}^{EC} = \eta-\delta+\frac{r_B(\Gamma_B-\Gamma_M)}{b(r_M-r_B)+\Gamma_B-\Gamma_M} \quad \text{and} \quad z_M^{Bu} = \frac{\Gamma_B r_M-\Gamma_M r_B}{\Gamma_B-\Gamma_M}-\delta. \tag{23}$$

It turns out that both regions merge whenever $z_{M,Bu}^{EC} > z_M^{Bu}$. We can write this last condition solving for wealth b as

$$b < \left[\frac{\Gamma_B-\Gamma_M}{r_M-r_B}\right]\frac{\Gamma_B(r_B-r_M)+\eta(\Gamma_M-\Gamma_B)}{\Gamma_B(r_M-\eta)-\Gamma_M(r_B-\eta)} = \hat{b}. \tag{24}$$

Finally, one can show by combining the expressions in Eqs. (22) and (24) that $\hat{b} < \tilde{b}$ always.

Appendix C. Likelihood function

For an entrepreneur with income $Y = y_i$, financing decision $L = l_i$ and characteristics ν_i, the likelihood can be obtained using Bayes Law as,

$$f(y_i, l_i | \nu_i, \theta) = Pr[Y = y_i | L = l_i, \nu_i] \times Pr[L = li | \nu_i]. \tag{25}$$

Using the fact that net income $y_i = y(z, K)$ is a function of the unobserved variables, we can solve for $K_i = K(y_i, z)$. The first term of Eq. (25) can thus be written as

$$Pr[Y = y_i | L = l_i, \nu_i] = \int_{\zeta \in \mathcal{Z}_{l_i}} h(\zeta, \kappa(y_i, \exp(\zeta)))d\zeta \tag{26}$$

where $h(\zeta, \kappa)$ denotes the joint density of the log ability ζ and log scale κ, and the set $\mathcal{Z}_{l_i}$ contains all points in the domain of ζ where l_i is the optimal financial choice. The second term in the RHS of (25) is the probability of a given financial choice L:

$$Pr[L = li | \nu_i] = \int_{\zeta \in \mathcal{Z}_{l_i}(\kappa)}\left[\int_{\kappa \in \mathcal{K}_{l_i}(\zeta)} h(\zeta, \kappa)d\kappa\right]d\zeta \tag{27}$$

where now the sets $\mathcal{Z}_{l_i}(\kappa)$ (or $\mathcal{K}_{l_i}(\zeta)$) contain all points ζ (or κ) making l_i optimal with variable κ (or ζ) held fixed. This double integral can be rewritten using the fact that log ability ζ and log scale κ follow a bivariate normal distribution:

$$\kappa | \zeta \sim N\left(\alpha_\zeta + \beta\zeta, \left(1-\rho^2\right)\sigma_\kappa^2\right), \text{ where } \alpha_\zeta = \mu_\kappa - \beta\mu_\zeta \text{ and } \beta = \rho\frac{\sigma_\kappa}{\sigma_\zeta}. \tag{28}$$

Thus,

$$\begin{aligned} Pr(L = l_i | \nu_i) &= \int_{\zeta \in \mathcal{Z}_{l_i}(\kappa)} \phi\left(\frac{\zeta-\mu_\zeta}{\sigma_\zeta}\right)\left[\int_{\kappa \in K_{l_i}(\zeta)} \phi\left(\frac{\kappa-\alpha_\zeta-\beta\zeta}{\sqrt{1-\rho^2}\sigma_\kappa}\right)d\kappa\right]d\zeta \\ &= \int_{\tilde{\zeta} \in \mathcal{Z}_{l_i}(\tilde{\kappa})}\left[\Phi\left(\tilde{\kappa}_{l_i}\left(\tilde{\zeta}\right)\right)-\Phi\left(\tilde{\kappa} l_i\left(\tilde{\zeta}\right)\right)\right]\phi\left(\tilde{\zeta}\right)d\tilde{\zeta} \end{aligned} \tag{29}$$

where ϕ and Φ denote, respectively, the probability and cumulative densities of a standard normal distribution. In addition, $\tilde{\kappa}_{l_i}\left(\tilde{\zeta}\right)$ is short-form notation for

$$\tilde{\kappa}_{l_i}\left(\tilde{\zeta}\right) = \frac{\kappa_{l_i}\left(\tilde{\zeta}\right)-\alpha_\zeta-\beta\left(\mu_\zeta+\sigma_\zeta\tilde{\zeta}\right)}{\sqrt{1-\rho^2}\sigma_\kappa} = \frac{\kappa_{l_i}\left(\tilde{\zeta}\right)-\mu_\kappa-\rho\sigma_\kappa\tilde{\zeta}}{\sqrt{1-\rho^2}\sigma_\kappa} \tag{30}$$

so that a tilde on a variable denotes the normalized variable. Clearly, $\overline{\kappa}_{l_i}(\zeta)$ and $\underline{\kappa}_{l_i}(\zeta)$ are bounds such that given log ability ζ, the financial choice l_i is optimal for any $\kappa \in [\underline{\kappa}_{l_i}(\zeta), \overline{\kappa}_{l_i}(\zeta)]$.

We compute the integral in Eq. (29) by partitioning it into different sub-integrals with general support $[a,b]$ and possibly $[a,\infty)$. We then approximate numerically each integral with support $[a,b]$ using Gauss-Legendre quadrature with 48 points in $[-1,1]$ with an appropriate change of scale. Analogously, integrals with support $[a,\infty)$ are approximated using Gauss-Laguerre with 48 points in $[0,\infty)$.

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