Lending to Uncreditworthy Borrowers

Rajdeep Sengupta[*,†]

Federal Reserve Bank of St. Louis

September 2008

Abstract

How might a low cost of funds prompt lenders to include uncreditworthy borrowers in their loan portfolio? This paper presents a theoretical study into how lender competition can affect borrower quality, especially when the cost of funds is low. I study equilibria in credit markets where lenders poach on borrowers in a bid to gain market share. An incumbent's advantage over any outside lender stems from its knowledge of (i) the risk profile of its (creditworthy) clients and (ii) uncreditworthy types in the borrower population. Screening is costly, and the uninformed lender's ability to use collateral as a screening mechanism depends on its cost advantage over its informed rival. Nevertheless, the outside lender can pool uncreditworthy borrowers with creditworthy types, but only if it has a low cost of funds. Therefore, while a secular decline in the cost of funds leaves the uninformed lender's ability to screen uncreditworthy borrowers unchanged, it opens the opportunity for them to pool these borrowers with creditworthy types. This not only facilitates entry of outside lenders into "high-risk" credit markets, but also makes it optimal for them to poach borrowers from rivals by including uncreditworthy borrowers in their loan portfolio.

Keywords: lender competition, credit allocation, borrower quality, uncreditworthy.

JEL: G14; G21; D43.

---

[*]Thanks to Eric Bond, Martin Brown, Andrew Daughety, Tom Jackman, Esa Jokivuolle, Georg Keienberg, Aksel Mjos, Steven Ongena, Sangsoo Park, Jennifer Reinganum, Suresh Sundaresan, and David Wheelock for their comments and suggestions.

[†]Research Division, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, MO 63166-0442, Phone: (314) 444-8819, Fax: (314) 444-8731, E-mail: rajdeep.sengupta@stls.frb.org.

1 Introduction

> There is doubtless an unfortunate tendency among some, I hesitate to say most, bankers to lend aggressively at the peak of a cycle and that is when the vast majority of bad loans are made.
>
> —Remarks by Chairman Alan Greenspan on Banking Supervision, before the Independent Community Bankers of America, March 7, 2001

How might the ease of credit creation at the upward phase of the credit cycle lead to a deterioration of loan quality? How can a low cost of funds prompt lenders to include uncreditworthy borrowers in their loan portfolio? These questions lie at the heart of how events and policy might conspire to precipitate financial crises. Although the importance of these questions is widely appreciated, there has been little theoretical analysis to establish this causal link.

This paper is a theoretical study of how lender competition can affect borrower quality, especially when the cost of funds is low. For this purpose, we study equilibria in credit markets where lenders poach on borrowers in a bid to gain market share. The biggest impediment to borrower poaching in credit markets is that inside lenders (incumbents who already exist in this market) have arguably better information on borrower quality than outside lenders (entrants or new lenders). Incumbent lenders gain knowledge about borrower quality from previous lending relationships (Boot, 2000; Boot and Thakor, 2000). Consequently, their lending rates to existing customers are adjusted according to the customer's credit risk.[1]

In addition, any incumbent is likely to have identified a section of the borrower population as "bad risk": borrowers whose likelihood of default is so high that it is not

[1] Under adverse selection, riskiness is an exogenous and unobservable characteristic of agents. Accordingly, the characterization of risk throughout this article refers to unobservable risk (i.e., risk conditional on observables).

profitable to lend to them at any rate.[2] As a result, informed lenders may offer prohibitively expensive terms or simply refuse to relend after learning that they are bad risks. Although this implies that such borrowers are likely to be denied loans from their current lenders, they may choose to apply for loans from other (new) lenders in the future (Sharpe, 1990). This has important implications for borrower poaching and lender competition in credit markets.

In this paper, I examine the problem of competition between an inside (informed) lender and an outside (uninformed) lender, in which the insider's information advantage extends to uncreditworthy borrowers as well. Accordingly, I assume that the insider has knowledge about "prospective" uncreditworthy borrowers from previous transactions. Therefore, not only does the uninformed lender have to sort creditworthy borrowers of different risk quality, but it also has to avoid lending to uncreditworthy borrowers.[3] Following Besanko and Thakor (1987), I assume that the uninformed lender uses collateral to screen out bad risks and to sort high-risk borrowers from low-risk ones.[4]

The results of this paper are summarized as follows. Equilibrium contract offers depend on three parameters of the model, namely, (i) the uninformed lender's cost advantage over its informed rival, (ii) the distribution of types in the borrower population, and, most notably, (iii) the level of the uninformed lender's cost of funds. The cost of screening is linked to collateral requirements in the contract. Unlike the uninformed lender's offers in a screening equilibrium, the informed lender does not require a borrower to post collateral. Therefore, the uninformed lender's ability to screen borrowers of infe-

[2]Even though existing customers are deemed creditworthy, they can differ in their credit risk. Accordingly, the paper will distinguish between two types of "good-risk" or creditworthy borrowers: high-risk and low-risk borrowers. A third category of borrowers will be classified as "bad-risk" or uncreditworthy borrowers.

[3]This paper question takes on greater relevance since previous research, like Sengupta (2007), examines a problem of entry in which lenders compete over the incumbent's clients only. Therefore, this model relaxes the restrictive assumption that all borrowers are known to be creditworthy.

[4]The uninformed lender offers different loan contracts by varying repayment and collateral requirements on the loan. Borrowers who belong to a superior type select loans with a higher collateral requirement in exchange for a lower repayment because they have a lower probability of defaulting on the loan.

rior quality depends on the magnitude of its cost advantage over its informed rival. Put differently, the uninformed lender can screen borrowers only if it has a sufficiently large cost advantage over its rival. On the other hand, the uninformed lender's ability to pool borrowers depends, in addition to its having the cost advantage, on the level of its cost of funds.[5] Pooling borrowers implies that expected profits from superior types covers expected losses from inferior types. A lower cost of funds facilitates pooling because it increases profit margins from superior types and reduces losses from inferior types. Finally, the choice between screening borrowers and pooling them will depend ultimately on the distribution of types in the borrower population. The uninformed lender typically prefers to screen out uncreditworthy borrowers instead of pooling them. Therefore, in markets where its cost advantage is sufficiently high so that such screening is feasible, the uninformed lender usually gains market share by screening out bad-risk types. However, the informed lender dominates in markets where the uninformed lender's cost advantage is not sufficiently large to screen away uncreditworthy borrowers.

The theoretical novelty of this paper lies in the equilibria that prevail when the uninformed lender has a sufficiently low cost of funds in addition to its cost advantage. The low cost of funds makes it feasible for the uninformed lender to pool creditworthy and uncreditworthy types. Pooling is profitable in market segments composed of predominantly one (creditworthy) borrower type. For example, in market segments where the fraction of both high-risk and bad-risk borrowers is extremely small, the uninformed lender can pool them with low risks. Conversely, if a large proportion of borrowers are high risks, they can be pooled with bad-risk types. Two important features of these pooling equilibria need to be highlighted. First, it is optimal for an uninformed lender to include uncreditworthy types in its loan portfolio rather than screen out these borrowers. Second, the uninformed lender gains market share if the proportion of high risks is either low or high,

[5]Both pooling and screening equilibria require that the uninformed lender have a cost advantage. However, only the screening equilibria require that this cost advantage be sufficiently large.

while the incumbent dominates for intermediate values. Accordingly, for low cost advantages, the uninformed lender's ability to gain market share changes non-monotonically; it first declines and then rises with increases in average borrower quality.[6]

A highlight of these results is that there exist equilibria wherein it is optimal for the uninformed lender to include uncreditworthy borrowers in its portfolio. This occurs when the uninformed lender has a low cost of funds—a necessary condition for pooling creditworthy with uncreditworthy borrowers. Pooling is profitable when the uninformed lender is either unable to screen (because of a low cost advantage) or finds screening unprofitable (because the mix of borrowers in the population predominantly comprises a single type). It is important to mention that such pooling equilibria are precluded as long as both lenders have the same cost of funds (see Rothschild and Stiglitz, 1976). What sustains pooling equilibria in these cases is the inability of the informed lender to undercut the uninformed lender's offer to creditworthy types.

A secular decline in the cost of funds leaves the cost advantage of the uninformed lender, and thereby its ability to screen borrowers, unchanged. However, if this decline is sufficiently large, it opens opportunities for the uninformed lender to pool. This allows it to capture market share while generating sufficient profits from high risks that can offset losses from uncreditworthy borrowers. The result has important policy implications: a secular decline in cost of funds can induce lenders to include uncreditworthy borrowers in their loan portfolio. To summarize, excessive easing of monetary policy can adversely affect loan quality in credit markets.

In an excellent survey on monetary policy and asset price volatility, Bernanke and Gertler (1999) outline two strands of literature that discuss how loan quality is adversely affected at the upward phase of a credit cycle. One strand explores how concerns about financial instability arise when financial liberalization (e.g., deregulation in the banking

[6]It is not uncommon to get non-monotonicity results in a model with three agent types. A somewhat different, yet notable example is the signaling model in Feltovich, Harbaugh, and To (2002).

sector) is not well coordinated with the regulatory safety nets (e.g., deposit insurance and lender-of-last-resort provisions). Increased bank competition, arising out of deregulation of entry, provides additional incentives for managers and stakeholders to take on extra risk given the guaranteed funds available because of deposit insurance (Keeley, 1990; Besnako and Thakor, 1993). While much of this literature relies on the agency problems that arise out of deposit insurance (see Allen and Gale, 2004 and references therein for an excellent survey), this paper shows that such "excessive" risk-taking can occur even in the absence of such insurance. In this sense, the implications of the model have a broader appeal to all financial intermediaries and not just commercial banks.

A second strand of literature is concerned with how credit quality deteriorates with an upturn of the credit cycle through the asset-based lending channel. During the upward phase of the credit cycle, competitive leveraged bidding can raise asset prices. This in turn encourages further lending against these assets, increasing demand and asset prices through a dynamic multiplier effect (Kiyotaki and Moore, 1997). Finally, the deterioration of loan quality comes about "as lenders become less concerned about the ability of the borrowers to repay loans and instead rely on further appreciation of the asset to shield themselves from losses" (Mishkin, 2008). The difference in this paper is that the equilibria described here are not the result of any "irrational exuberance" on the part of lenders, but merely from standard optimizing behavior on the part of lenders competing to increase market share.

The causal link described in the paper is independent of the traditional asset-based lending mechanism. The emphasis here lies in the role of lender competition and information asymmetry in establishing the causal link between a low cost of funds and a decline in borrower quality. Nevertheless, it is important to mention that the two mechanisms are not in conflict. In fact, it is not difficult to view the two mechanisms as reinforcing each other in practice to exacerbate this decline in average borrower quality. I describe this in greater detail in Section 6, arguing that the deterioration of borrower quality during the recent housing boom in the United States also could be explained in terms of this model. The model puts forward a theoretical explanation as to how an easing of monetary policy by lowering the Fed funds rate from 6.5 percent in July 2000 to 1 percent in April 2004 could be a significant factor in this decline.

The rest of this paper is organized as follows. Section 2 provides the basic setup for the model. Section 3 describes the set of candidate equilibria in which borrowers go to the uninformed lender for loans. Section 4 uses numerical methods to solve for equilibria of the model. In particular, this section determines the conditions under which the candidates listed in Section 3 emerge as the equilibria of the game. Section 5 highlights the important result of how a decline in the cost of funds makes it optimal for lenders to include uncreditworthy borrowers in their portfolio. Section 6 discusses the implications of this result in the context of the current crisis in the subprime mortgage market in the United States and Section 7 concludes.

2 Preliminaries

The basic setup of this paper is similar to that of Besanko and Thakor (1987). Entrepreneurs (also called borrowers) can borrow a dollar from a lender and invest in a project. The project returns x if it succeeds (with probability $1-\theta$) and zero if it fails (with probability θ). Lenders' loan contracts consist of a repayment R and a collateral requirement C. Borrowers' reservation utility and lenders' cost of funds are denoted by V^0 and ρ, respectively. A lender can recover only a fraction, β, of the collateral, which the borrower loses if she defaults on the loan. Thus, the parameter β is a measure of the disparity in the borrower and lender valuation of collateral. Both lenders and borrowers are risk neutral. Lenders' profits from the loan contract (R, C) is given by

$\pi(R, C, \theta) = (1-\theta)R + \beta\theta C - \rho$, while a borrower's payoff under the same contract is $V(R, C, \theta) = (1-\theta)(x-R) - \theta C$. Therefore, a loan contract (R, C) generates a social surplus of $[(1-\theta)x - \rho - V^0] - (1-\beta)\theta C$. Notably, a strictly positive collateral requirement entails a deadweight loss of $(1-\beta)\theta C$, implying that, *ceteris paribus*, zero-collateral loan contracts are first-best.

The model assumes a fixed pool of borrowers indexed by their risk parameter, θ, the probability of default. The fraction ν_l of entrepreneurs are low-risk ($\theta = \theta_l$), the fraction ν_h of borrowers are high-risk ($\theta = \theta_h$), and the fraction ν_b are bad-risk types ($\theta = \theta_b$), with $0 < \theta_l < \theta_h < \theta_b < 1$ and $\nu_h + \nu_l + \nu_b = 1$. Bad-risk borrowers are uncreditworthy in that the surplus generated on loans to them is strictly negative (i.e., $(1-\theta_b)x < \rho + V^0$, for all ρ). Both high-risk and low-risk borrowers are creditworthy (or "good"-risk) in that all loan contracts generate a positive social surplus (i.e., $(1-\theta_k)x > \rho + V^0$, where $k = h, l$). Stated differently, a lender with complete information would always extend loans to good risks and deny them to bad risks.

In this setting, this paper analyzes competition between an informed (incumbent) lender that has complete information about borrower creditworthiness and an uninformed lender (new or outside lender) that is unable to distinguish between borrowers' risk types. The informed lender (or Lender-I) is (pre-entry) a price-setting monopolist whose cost of funds is ρ^I. The uninformed lender (or Lender-U) is a new or outside lender whose cost of funds is ρ^U. Lender-I's private information here extends not only to its existing (and therefore) creditworthy clients but also to other "prospective" uncreditworthy borrowers that Lender-U would like to avoid. Lender j's offer to borrower k is denoted by (R_k^j, C_k^j), where $j = I, U$ and $k = b, h, l$. The lender's profits from this offer are given by $\pi_k^j = (1-\theta_k)R_k^j + \beta\theta_k C_k^j - \rho^j$ if the borrower accepts the loan contract and zero otherwise. Thus, its overall profit is written as $\Pi^j \equiv \nu_b\pi_b^j + \nu_h\pi_h^j + \nu_l\pi_l^j$.

The timing of the game can be described as follows. Nature selects borrower types.

The informed lender can distinguish borrower types and offers one contract for each type. The uninformed lender cannot distinguish between types and therefore offers a menu of contracts. Lenders offer contracts simultaneously. Finally, borrowers either accept or reject contracts.

After eliminating a set of dominated strategies for each lender, I describe the set of contracts that each lender can offer in equilibrium. For the informed lender, the result is stated in the following lemma:

Lemma 1 *For borrowers of type $k = b$, the informed lender denies credit. For borrowers of type $k = h, l$ the informed lender offers a contract from the set $Z_k^I(\rho^I) = \{(R_k^I, 0) : R_k^I \in [\underline{R}_k^I(\rho^I), \bar{R}_k]\}$, where $\underline{R}_k^I(\rho^I) = \frac{\rho^I}{1-\theta_k}$ and $\bar{R}_k = x - \frac{V^0}{1-\theta_k}$ are the first-best (zero-collateral) minimum and maximum repayments, respectively.*

Since the uninformed lender denies credit to bad risks, they continue to receive their reservation payoff V^0. Also, the contract $(\underline{R}_k^I(\rho^I), 0)$ yields borrower k the maximum utility Lender I can provide, denoted $\bar{V}_k^I(\rho^I)$, and is defined by

$$\bar{V}_k^I(\rho^I) \equiv (1 - \theta_k)x - \rho^I,\ k = h, l. \tag{1}$$

The uninformed lender faces borrowers with two different types of participation constraints. For good risks ($k = h, l$), the participation constraints are determined by the payoffs that the borrowers receive from loan contracts offered by the informed lender (i.e., V_k^I) . For bad risks, however, the participation constraint is given by V^0, the reservation utility of the borrower (the opportunity cost of her time). The uninformed lender's offers can be summarized in terms of the following Lemma.

Lemma 2 *(a) The uninformed lender does not require the bad-risk borrower to secure* *loans with collateral (i.e., $C_b = 0$). Therefore, contracts that pool bad risks with other types are zero-collateral contracts. (b) Contracts that sort adjacent borrower types require that the local incentive constraints of the inferior type bind in equilibrium. (c) Overall expected profits from contract offers are non-negative. Finally, expected profits from loans to low-risk types are non-negative.*

Result (a) from Lemma 2 is standard in the principal agent literature. Result (b) follows from the fact that (under competition) inferior types try to mimic superior types and the uninformed principal will always choose to offer incentive schemes that are just as good as the inferior agent's outside alternative. Finally, (c) follows from (b) because the low-risk type is the best-quality borrower. If profits from a loan contract to a low-risk borrower are negative, the uninformed lender can remove this contract offer without affecting the incentive constraints for other types.

I focus exclusively on pure strategy equilibria. To derive a characterization of equilibria, I hold the uninformed lender's cost of funds constant at ρ^U and vary the informed lender's cost of funds ρ^I. As is standard in the principal agent literature, I will assume that if the borrower is indifferent between two loan contracts *offered by the same lender*, the contract that the lender prefers is chosen. Also, if a borrower is indifferent between contracts offered by either lender, in equilibrium, she chooses to borrow from the lender that makes higher profits from the contract.

3 Candidate Equilibria

This section begins with a description of the candidate equilibria for a particular case of this model—namely, the situation in which the uninformed lender screens all borrowers. Following this, I describe other candidate equilibria of the model. As will be evident, it

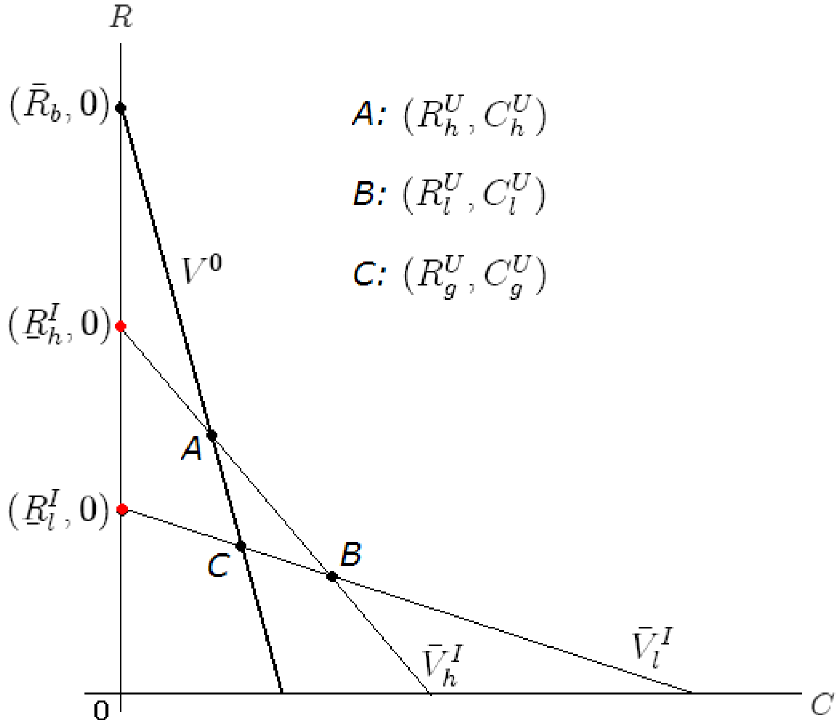

Figure 1: Lender-U's contract offers under different equilibria in (R, C) space. Borrowers' payoffs increase as one moves southwest, while lenders' profits increase to the northeast. Lender-U offers $(\underline{R}_l^I, 0)$ and $(\underline{R}_h^I, 0)$ in Pool-1 and Pool-2, respectively. For Hybrid-1, the Lender-U pools bad risks and high risks at $(\underline{R}_h^I, 0)$ and sorts low risks at (R_l^U, C_l^U). For Hybrid-2, Lender-U screens out bad risks at $(\bar{R}_b, 0)$ and pools good risks at (R_g^U, C_g^U). Finally, Lender-U screens high risk at (R_h^U, C_h^U) for Screen-1 and low risks at (R_l^U, C_l^U) for Screen-2.

is difficult to provide an analytical solution to this model. Therefore, in the next section, numerical examples are used to determine the conditions under which the candidates (described below) emerge as the equilibria of the model.

Lender-U can successfully sort all borrowers only if its incentive scheme yields each borrower at least as much utility as contracts offered by Lender I. Consequently, Lender-U faces borrowers whose reservation utilities are determined by the maximum utility that Lender I can offer borrowers. These reservation utilities for the high- and low-risk borrower—namely, $\bar{V}_h^I$ and $\bar{V}_l^I$—are shown by the indifference curves through $(\underline{R}_h^I, 0)$ and $(\underline{R}_l^I, 0)$ in Figure 1. Figure 1 illustrates the (candidate) equilibria in (R, C) space. Borrowers' payoffs increase as one moves southwest, while lenders' profits increase to the northeast. Because the informed lender denies credit to the bad risks, their reservation utility is V^0 (i.e., $\bar{V}_b^I = V^0$). This is shown in Figure 1 by the (bold) indifference curve through $(\bar{R}_b, 0)$, where $\bar{R}_b = x - \frac{V^0}{1-\theta_b}$, is the (minimum) repayment for which the bad-risk types reject the uninformed lender's offer.

A *first candidate (screening) equilibrium*, denoted as *Screen-1*, is one where the uninformed lender screens all borrower types. The uninformed lender offers contract menu $\{(\bar{R}_b, 0); (R_h^U, C_h^U); (R_l^U, C_l^U)\}$. The informed lender offers $(\underline{R}_h^I, 0)$ to high risks, $(\underline{R}_l^I, 0)$ to low risks, and denies credit to bad-risk types. The bad-risk borrowers reject the uninformed lender's offer of $(\bar{R}_b, 0)$. The good-risk types (both h and l) borrow from the uninformed lender, selecting loan contracts with strictly positive collateral requirements. The contract offers to high and low risks are shown as points **A** and **B** in Figure 1: The contract for low-risk borrowers has a lower repayment and a higher collateral requirement than that for high-risk borrowers. As a result, *local* incentive constraints (i.e., incentive constraints for adjacent types) bind in equilibrium. It follows that $V_b(\bar{R}_b, 0) = V_b(R_h^U, C_h^U)$ and $V_h(R_h^U, C_h^U) = V_h(R_l^U, C_l^U)$ in this screening equilibrium.

Evidently, the cost of screening is borne only by the uninformed lender. Therefore, to successfully screen or sort borrower types, the uninformed lender needs to have a large cost advantage over its informed rival. Stated differently, this candidate equilibrium is feasible only if the uninformed lender's cost advantage is sufficiently large so that two screening cutoffs (one for each pair of adjacent types) are satisfied. The first cutoff is $\tilde{\rho}_S^{b,h}$ for screening the bad-risk types from the high-risk types, and the second is $\tilde{\rho}_S^{h,l}$ for screening the high-risk types from the low-risk types. Also, as shown in appendix, the screening cutoffs are independent of the distribution of borrower types in the population and are given by

$$\tilde{\rho}_S^{h,l} = \frac{1}{1-(1-\beta)\theta_l}\rho^U$$
$$\tilde{\rho}_S^{b,h} = \frac{\theta_b-\theta_h}{\theta_b(1-\theta_h)-\beta\theta_h(1-\theta_b)}\rho^U + \frac{(1-\beta)\theta_h(1-\theta_h)}{\theta_b(1-\theta_h)-\beta\theta_h(1-\theta_b)}[(1-\theta_b)x - V^0].$$

Therefore, to screen all borrower types the uninformed lender's cost advantage needs to be sufficiently large; that is, it must be true that $\rho^I > \max(\tilde{\rho}_S^{b,h}, \tilde{\rho}_S^{h,l})$.

However, if for example, $\tilde{\rho}_S^{h,l} > \rho^I \geq \tilde{\rho}_S^{b,h}$, the uninformed lender cannot sort good-risk borrowers into high-risk and low-risk types, but it can still screen out bad risks. This gives us a *second candidate (screening) equilibrium,* denoted as *Screen-2*, where the uninformed lender captures the high-risk types by screening out bad risks. Here, the uninformed lender's offer is given by $\{(\bar{R}_b, 0); (R_h^U, C_h^U); (R_l^1, C_l^1)\}$, where $\pi_l^U(R_l^1, C_l^1) = 0$. The informed lender denies loans to bad risks and offers $(\underline{R}_h^I, 0)$ and $(R_l^I, 0)$ to high and low risks, respectively, such that $V_l(R_l^1, C_l^1) = V_l(R_l^I, 0)$. Except for low-risk types, the equilibrium behavior of agents in *Screen-2* is similar to that in *Screen-1*. In *Screen-2,* low risks borrow from the informed lender whose profits from low-risk types are strictly positive.

TABLE 1. Uninformed lender's offers under different candidate equilibria

Candidate equilibria	*Profit*	*Customer types borrowing from U*	*Contract menu*	*Breakeven cutoff*
Pool-1	Π_P^1	(b,h,l)	$(\underline{R}_l^I, 0)$	$\tilde{\rho}_P^1$
Pool-2	Π_P^2	(b,h)	$(\underline{R}_h^I, 0)$	$\tilde{\rho}_P^2$
Screen-1	Π_S^1	$(h);(l)$	$(\bar{R}_b, 0); (R_h^U, C_h^U); (R_l^U, C_l^U)$	$\tilde{\rho}_S^{b,h}$, $\tilde{\rho}_S^{h,l}$
Screen-2	Π_S^2	(h)	$(\bar{R}_b, 0); (R_h^U, C_h^U); (R_l^1, C_l^1)$	$\tilde{\rho}_S^{b,h}$
Hybrid-1	Π_Y^1	$(b,h);(l)$	$(\underline{R}_h^I, 0); (R_l^U, C_l^U)$	$\tilde{\rho}_P^1$, $\tilde{\rho}_S^{h,l}$
Hybrid-2	Π_Y^2	(h,l)	$(\bar{R}_b, 0); (R_g^U, C_g^U)$	$\tilde{\rho}_Y$

Alternatively, if $\tilde{\rho}_S^{b,h} > \rho^I \geq \tilde{\rho}_S^{h,l}$, then neither screening equilibrium described above is feasible. Given that the uninformed lender can still sort the low-risk types, it follows that *a third candidate (hybrid) equilibrium* is possible in this situation, denoted as *Hybrid-1.* In general, a hybrid equilibrium can be described as one in which the uninformed principal pools or bunches offers to adjacent types while sorting (or screening out) the third type. In *Hybrid-1*, the uninformed lender seeks to pool bad risks with high risks while sorting them from low-risk types. It offers the menu $\{(\underline{R}_h^I, 0); (R_l^U, C_l^U)\}$ while the informed lender's offers are the same as that in *Screen-1.* In equilibrium, all borrowers would go to the uninformed lender whose aggregate profits would depend on the distribution of bad risks in the population. With $\rho^I \geq \tilde{\rho}_S^{h,l}$, its profits from loans to low risks are non-negative. However, by pooling bad risks with high risks, the uninformed lender can no longer ensure strictly positive profits from its offer of $(\underline{R}_h^I, 0)$ unless the proportion of bad risks in the population is sufficiently small. I return to this point below in my discussion of pooling equilibria.

The *fourth candidate (hybrid) equilibrium,* denoted as *Hybrid-2*, involves bunching good risks and screening out bad risks. Here, the uninformed lender offers $\{(\bar{R}_b, 0); (R_g^U, C_g^U)\}$, where (R_g^U, C_g^U) is shown by the point **C** in Figure 1. It follows that $V_b(\bar{R}_b, 0) = V_b(R_g^U, C_g^U)$ and $V_l(\underline{R}_l^I, 0) = V_l(R_g^U, C_g^U)$. Again, the informed lender's offers are the same as those in *Screen-1.* The bad-risk borrowers reject the uninformed lender's offer of $(\bar{R}_b, 0)$ and the good-risk types (both h and l) borrow from the uninformed lender. Evidently, the uninformed lender's offer in *Hybrid-2* involves pooling and therefore is feasible only if the proportion of high risks in the population is sufficiently small. *Hybrid-2* is feasible for the uninformed lender only if $\rho^I \geq \tilde{\rho}_Y(\nu_h, \nu_l)$, where $\tilde{\rho}_Y(\nu_h, \nu_l)$ denotes the hybrid cutoff for the uninformed lender.

The last two candidate equilibria involve pooling contracts. In *Pool-1*, the uninformed lender pools all borrowers by offering $(\underline{R}_l^I, 0)$. This subsidizes losses from bad risks and high risks with profits from low risks. Therefore, *Pool-1* is feasible only when the proportion of low risks in the population is high; this is denoted by the breakeven cutoff $\tilde{\rho}_P^1(\nu_h, \nu_l)$. The uninformed lender can also pool bad risks with high risks. This is given by *Pool-2*, where the uninformed lender offers $(\underline{R}_h^I, 0)$ and the breakeven cutoff for such a contract is given by $\tilde{\rho}_P^2(\nu_b, \nu_h)$. The contract offers by the uninformed lender for each of the six candidate equilibria are given in Table 1.

In summary, there are three categories of candidate equilibria: pooling, screening, and hybrid. Within each category, candidate-1 has a larger number of customer types going to the uninformed lender for loans than candidate-2. For example, in candidate equilibrium *Hybrid-2*, the uninformed lender screens out the bad risks but in *Hybrid-1* it pools them with high risks. In fact, if the uninformed lender can screen the low-risk borrowers (i.e., if $\rho^I \geq \tilde{\rho}_S^{h,l}$), then the uninformed lender's profits from offers in *Screen-1* dominate those from offers in *Screen-2*. Similarly, the uninformed lender's offers in *Hybrid-1* dominate those in *Pool-2*. Finally, the informed lender dominates if ρ^I is strictly lower than all of the breakeven cutoffs given in the last column of Table 1.

4 Numerical Examples

In this section, I use numerical examples to solve for the equilibrium using different sets of parameter values. The aim of the exercise is to derive conditions under which the candidates listed in Table 1 emerge as the equilibrium of the model. The uninformed lender's profits under each candidate equilibrium are calculated for each point in the parameter space.[7] The candidate equilibrium in which the uninformed lender maximizes profits emerges as the actual equilibrium (at that point in the parameter space).

A closer look at the candidate equilibria in Table 1 reveals two types of costs for

[7]The choice of parameter values is motivated purely in terms of exposition; the aim here is to illustrate the conditions under which each of the six candidates emerge as equilibria in the model.

the uninformed lender. The first type arises from costs of cross-subsidization in pooling different borrower types. In such pooling equilibria, profits from superior types are used to cover losses from inferior ones. Pooling costs increase with the proportion of inferior types in the pool, and therefore, these equilibria prevail only when the borrower population has a sufficiently large proportion of superior types. The second type are screening costs that arise because of the expected deadweight losses in liquidating collateral. This cost increases with decreases in β.[8] Therefore, in describing the equilibria of the model, it is critical to distinguish between the uninformed lender's *cost advantage* ($\rho^I - \rho^U$) and *the level of its cost of funds* (the numerical value of ρ^U). As will be explained below, the former distinction determines the uninformed lender's ability to screen borrowers, whereas the latter determines its success in pooling borrower types.

I begin with a discussion of the equilibria for higher numerical values of the uninformed lender's cost of funds. Parameter values of $x = 16$, $V^0 = 2$, $\theta_b = 0.7$, $\theta_h = 0.4$, $\theta_l = 0.2$, and $\rho^U = 4.3$ are used to generate Figure 2, which describes the solution to the model in (ν_h, ρ^I) space. For these values, it follows that $\tilde{\rho}_S^{h,l} > \tilde{\rho}_S^{b,h}$. This implies that if the uninformed lender can sort among good risks, it can also screen out the bad risks. The dotted lines in the graphs denote the uninformed lender's cost of funds, ρ^U. The colored regions denote equilibria in which the uninformed lender is able to secure at least one creditworthy borrower type. On the other hand, if the uninformed lender's cost advantage is sufficiently small, the informed lender dominates (i.e., all borrowers go to the incumbent for loans), as shown by the white region above the dotted line in Figure 2. Evidently, the informed lender dominates in this region because the uninformed lender is unable to screen out bad risks despite its cost advantage.

The four subplots in Figure 2 are solutions to the model for different values of β (= 0.35 or 0.65) and ν_b (= 0.3 or 0.1). With a high cost advantage, the uninformed

[8] As mentioned earlier, the cost of screening is given by the expected deadweight loss $(1 - \beta)\theta C$ from the collateral requirement on the loan. Consequently, the smaller the proportion β that the lender can recover on default, the higher the cost of screening.

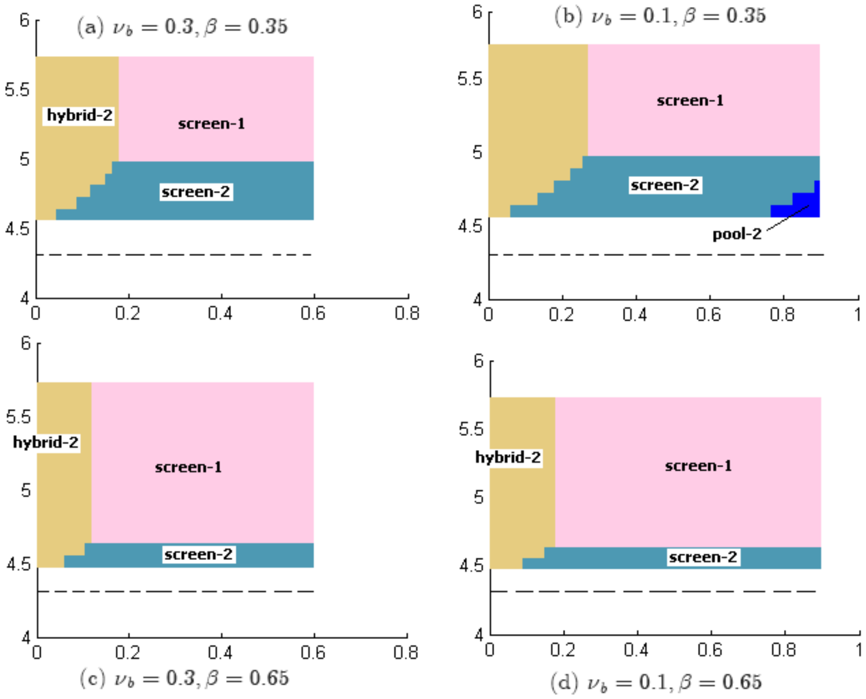

Figure 2: Solution in (ν_h, ρ^I) space with some bad-risk types $(\nu_b > 0)$ in borrower population. The dotted lines in the graphs denote the Lender-U's cost of funds, ρ^U. The graphs are drawn to parameter values $x = 16$, $V^0 = 2$, $\theta_b = 0.7$, $\theta_h = 0.4$, $\theta_l = 0.2$ for $\rho^U = 4.3$ and $\rho^I = [2.8, 5.6]$. The value of ν_b varies from 0.1 in (a) to 0.3 in (d). For (a) and (b), we take $\beta = 0.35$, $\tilde{\rho}_S^{b,h} = 4.56$, $\tilde{\rho}_S^{h,l} = 4.94$, while for (c) and (d), we use $\beta = 0.65$, $\tilde{\rho}_S^{b,h} = 4.46$, $\tilde{\rho}_S^{h,l} = 4.62$.

lender can screen all borrower types and the equilibrium for high ν_h is given by *Screen-1*. Alternatively, it screens out bad risks but pools creditworthy types and candidate *Hybrid-2* emerges as the equilibrium for low ν_h. When the uninformed lender's cost advantage is lower (say, $\tilde{\rho}_S^{h,l} > \rho^I > \tilde{\rho}_S^{b,h}$), it can screen out bad risks from high risks but it cannot sort high-risk from low-risk types. Consequently, when Lender-U's cost advantage is low, *Screen-2* replaces *Screen-1* for higher values of ν_h.

In summary, when its cost of funds, ρ^U, is moderately high, the uninformed lender can successfully poach borrowers only if its cost advantage, $\rho^I - \rho^U$, is significantly high. The results are given for both $\beta = 0.35$ and $\beta = 0.65$ to show how the screening cutoff for low risks, $\tilde{\rho}_S^{h,l}$, changes with β. Clearly, as the screening mechanism becomes costlier (lower β), the uninformed lender needs a bigger (threshold) cost advantage to screen all

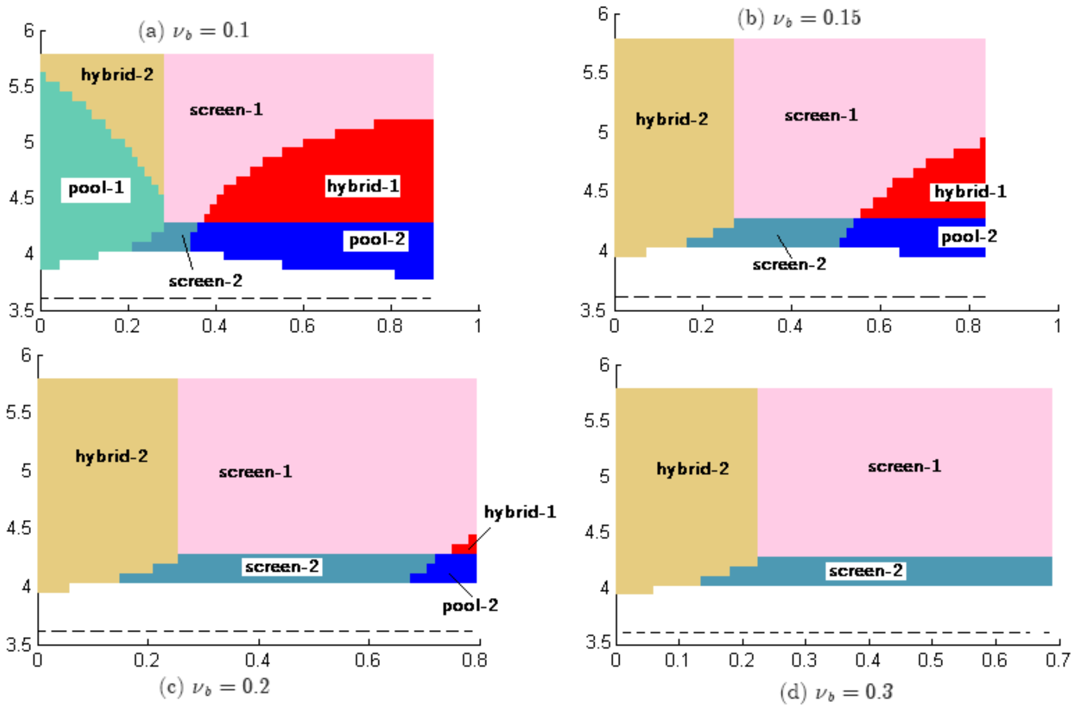

Figure 3: Solution in (ν_h, ρ^I) space for $\tilde{\rho}_S^{h,l} > \tilde{\rho}_S^{b,h}$ when the Lender-U's cost cost of funds (dotted line), ρ^U, is small. The graphs are drawn to parameter values $x = 16$, $V^0 = 2$, $\theta_b = 0.7$, $\theta_h = 0.4$, $\theta_l = 0.2$ for $\beta = 0.25$, $\rho^U = 3.6$, and $\rho^I = [2.8,\ 5.6]$. As a result $\tilde{\rho}_S^{h,l} = 4.94 > \tilde{\rho}_S^{b,h} = 4.56$, so that Lender-$U$ can screen high-risks as in Screen-1. The value of ν_b varies from 0.1 in (a) to 0.3 in (d).

borrower types. In terms of Figure 2, this is given by the larger region under *Screen-2* for a lower $\beta = 0.35$ than the same region for a higher $\beta = 0.65$.

However, important changes in the equilibrium are observed for a lower cost of funds for the uninformed lender (i.e., low numerical values of ρ^U). Low values of ρ^U reduce the costs of pooling and give rise to situations where pooling candidates emerge as the equilibria in the model. One such example is given by the solution with the same parameter values as in the previous example, but for $\rho^U = 3.6$. Four subplots of equilibrium regions are shown for $\nu_b = 0.1, 0.15, 0.2$, and 0.3 in Figure 3. As before, the regions of the parameter space where the informed lender dominates are shown in white.

A similar subplot of the four equilibrium regions is given in Figure 4 for a different set of parameter values: $x = 21$, $V^0 = 3$, $\theta_b = 0.8$, $\theta_h = 0.4$, $\theta_l = 0.2$, and $\rho^U = 1.4$.

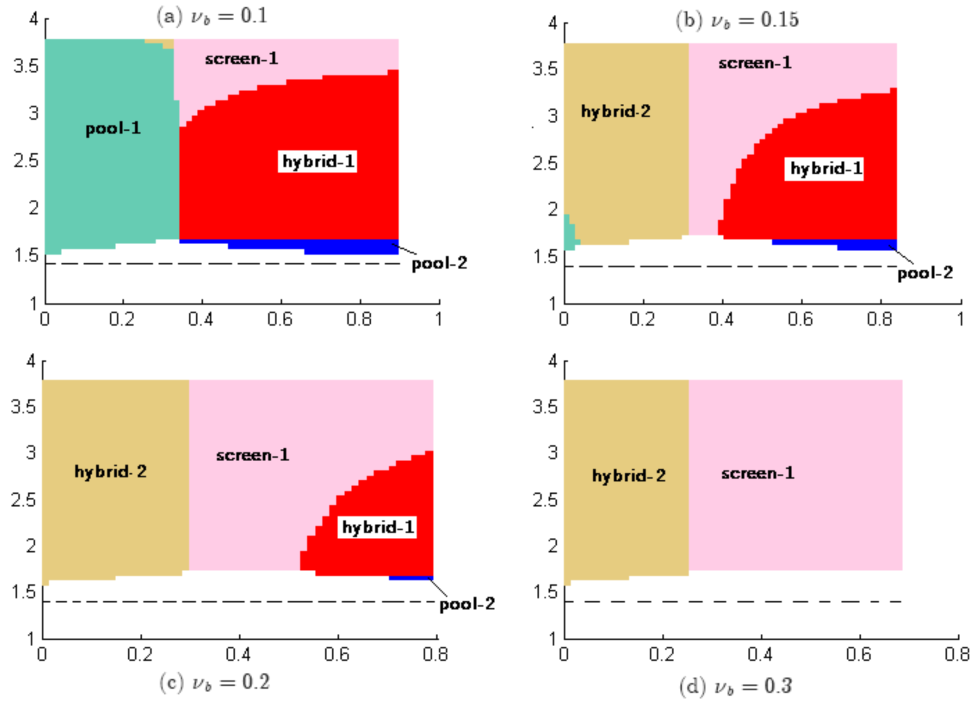

Figure 4: Solution in (ν_h, ρ^I) space for $\tilde{\rho}_S^{h,l} < \tilde{\rho}_S^{b,h}$ when the Lender-U's cost cost of funds (dotted line), ρ^U, is small. The graphs are drawn to parameter values $x = 21$, $V^0 = 3$, $\theta_b = 0.8$, $\theta_h = 0.4$, $\theta_l = 0.2$ for $\beta = 0.15$, $\rho^U = 1.4$ and $\rho^I = [1.2, 3.6]$. As a result, $\tilde{\rho}_S^{h,l} = 1.72 > \tilde{\rho}_S^{b,h} = 1.69$, so that Lender-$U$ cannot screen high risks as in Screen-1. The value of ν_b varies from 0.1 in (a) to 0.3 in (d).

The subplots correspond to the same set of values of $\nu_b = 0.1, 0.15, 0.2,$ and 0.3. The key difference between Figure 3 and Figure 4 lies in the screening cutoffs: The low-risk screening cutoff ($\tilde{\rho}_S^{h,l}$) is strictly greater than the bad-risk cutoff ($\tilde{\rho}_S^{b,h}$) in Figure 3, while the opposite is true for Figure 4. As discussed below, this leads to differences in the equilibrium offers of the uninformed lender in these two situations. In what follows, I discuss features of the equilibrium for both Figure 3 and Figure 4 in terms of the four cases given below.

Case (i) $\rho^I < \min\{\tilde{\rho}_S^{b,h}, \tilde{\rho}_S^{h,l}\}$**.** Since the uninformed lender cannot screen adjacent types, the discussion here will focus on the following three candidates: *Pool-1*, *Pool-2,* and *Hybrid-2*. Importantly, Figures 3 and 4 show that the informed lender can dominate in regions even if the uninformed lender has the cost advantage (i.e., regions above the dotted line). This holds true in part because, as mentioned earlier, screening out bad risks is costly. On the other hand, pooling borrowers can be costly as well, and this cost depends on the proportion of inferior types in the borrower population. In the absence of bad-risk types in the borrower population, any cost advantage is sufficient for the uninformed lender to capture creditworthy types. However, as long as there are uncreditworthy types, the informed lender can dominate the market even when its rival has the cost advantage. This is shown by the white region just above the dotted line in Figures 3 and 4.

However, if the proportion of bad-risk types is sufficiently small (for example, $\nu_b \leq 0.15$), pooling contracts are available to the uninformed lender as shown in Figures 3(a) and (b) and 4(a) and (b). In addition, if ν_h is low, then the uninformed lender either pools all borrowers or pools the good risks while screening them from bad risks. Thus, either *Pool-1* or *Hybrid-2* emerges as the equilibrium. The cutoff for *Hybrid-2*, $\tilde{\rho}_Y(\nu_h, \nu_l)$, is increasing and convex in ν_h. A higher cost advantage is needed for pooling a larger proportion of high risks in the population. Candidate *Hybrid-2* dominates *Pool-1* for higher ν_b because a larger proportion of bad risks implies that it is now more profitable to screen them out than it is to pool them with good risks.

On the other hand, if the proportion of high risks in the population is large, the uninformed lender can pool them with bad risks and *Pool-2* is the equilibrium for large values of ν_h. An interesting feature of the equilibrium in these regions is that, while pooling is feasible for high or low values of ν_h, the informed lender dominates for intermediate values of ν_h. This happens in situations where the proportion of high risk is neither too large to be pooled with bad risks nor too small to be pooled with low risks. In these regions the uninformed lender would ideally like to screen out bad risks, but is unable to do so since $\rho^I < \tilde{\rho}_S^{b,h}$.

Case (ii) $\tilde{\rho}_S^{b,h} < \rho^I < \tilde{\rho}_S^{h,l}$. This situation arises in Figure 3 but not in Figure 4. For low values of ν_b, the equilibrium is similar to that in the previous case: *Pool-1* and *Hybrid-2* emerge as the equilibria for low ν_h, whereas *Pool-2* is the equilibrium at high ν_h. But whereas earlier the informed lender dominated at intermediate values of ν_h, the uninformed lender can now capture the high-risk market by screening high risks from bad risks. This is shown by the region labeled *Screen-2* in Figure 3. Note that the size of this region increases (at the expense of *Pool-2*) with increases in ν_b because pooling higher proportions of bad risks is no longer profitable as it increases costs of cross-subsidization. Therefore for higher values of ν_b, pooling equilibria are replaced by *Screen-2* (for high ν_h) and *Hybrid-2* (for low ν_h).

Case (iii) $\tilde{\rho}_S^{b,h} > \rho^I > \tilde{\rho}_S^{h,l}$. This situation arises in Figure 4 but not in Figure 3. As mentioned earlier, the uninformed lender cannot screen bad risks from high risks but can now use contracts in *Hybrid-1* where it bunches bad risks with high risks while sorting low-risk types. In fact, this contract dominates the uninformed lender's offers in *Pool-2* for $\rho^I > \tilde{\rho}_S^{h,l}$. Therefore, for high ν_h, *Hybrid-1* replaces *Pool-2*, as shown in Figure 4(a)-(c). Obviously, the region labeled *Hybrid-1* shrinks with increases in ν_b because pooling higher proportions of bad risks increases costs of cross-subsidization. For low ν_h, the equilibrium is given by *Pool-1* or *Hybrid-2*, just as in the previous case. However, unlike the previous case, the uninformed lender cannot screen high risks from bad risks for the intermediate values of ν_h. Nor can it pool high risks, either with low risks or with bad risks. As a result, the informed lender continues to dominate in this intermediate region.

Case (iv) $\rho^I > \max(\tilde{\rho}_S^{b,h}, \tilde{\rho}_S^{h,l})$. This implies that, for small values of ν_b, the complete set of contracts listed in Table 1 yields strictly positive profits to the uninformed lender. Among them, the uninformed lender's offers in *Pool-2* and *Screen-2* are dominated by those in *Hybrid-1* and *Screen-1,* respectively. Consequently, the uninformed lender chooses among contract offers in the four alternatives: *Pool-1, Screen-1*, *Hybrid-1,* and *Hybrid-2*. Clearly, for high cost advantages of the uninformed lender, *Hybrid-2* and *Screen-1* dominate because they not only screen out the bad risks but also include low-risk types. Note, however, that uninformed lender offers in *Hybrid-1* continue to dominate *Screen-1* for high ν_h and low ν_b despite the fact that the uninformed lender can now screen high risks from bad risks. This is because the cost of cross-subsidization for high ν_h and low ν_b is still less than the costs of screening.

5 Lending to Uncreditworthy Borrowers

In this section, I discuss the equilibria where lending to uncreditworthy types is optimal for the uninformed lender. It is important to begin by noting that while the uninformed lender's ability to screen borrowers depends on its cost advantage over its rival, its ability to pool borrowers depends on the level of its cost of funds. As before, I restrict this discussion to the interesting case(s) where an uninformed lender has the cost advantage.

I begin with a description of the equilibria for the situation in which the lenders' cost of funds are high or moderately high. If the proportion of bad-risk types in the market is sufficiently large, the uninformed lender can gain market share only by screening out these uncreditworthy types. Even when Lender-U pools creditworthy borrowers under *Hybrid-2*, it must successfully screen out uncreditworthy ones. Moreover, screening equilibria like the ones shown as *Screen-1* and *Screen-2* in Figure 2 require that Lender-U's cost advantage be sufficiently large. Unless this condition is satisfied, the uninformed lender fails to gain market share and the informed lender dominates.

The list of equilibria changes significantly if the cost of funds for the uninformed lender is sufficiently low. A low cost of funds allows the uninformed lender to pool creditworthy borrowers with uncreditworthy types. As a result, pooling is possible even though the uninformed lender's cost advantage is not large enough to screen adjacent borrower types. This is best shown as the equilibria in *Pool-2* and *Hybrid-1* in Figures 4 (a) and (b) and 5 (a) and (b).[9] Pooling is profitable only when the borrower market consists predominantly of only one (creditworthy) borrower type. Elsewhere, the uninformed lender needs to screen to capture market share, failing which, the informed lender dominates the market.[10]

Perhaps the most remarkable result is available in terms of the equilibria shown as *Hybrid-1*. Interestingly, for very small ν_b, *Hybrid-1* prevails even when the uninformed lender can screen all borrower types. Under these circumstances, pooling uncreditworthy borrowers yields higher profits than screening them because the uninformed lender has a very low cost of funds. The full scope of equilibria can be best understood in terms of Figure 5, which replicates the equilibria in Figure 3 in terms of three simplex diagrams. These diagrams illustrate how the equilibria change with changes in the cost advantage of Lender-U.

[INSERT FIGURE 5 HERE]

In summary, when the proportion of either creditworthy type in the borrower pool is extremely large (i.e., $\nu_g \approx 1, g = h, l$), the equilibrium has the uninformed lender pooling creditworthy borrowers with uncreditworthy borrowers. Herein lies the causal link between a low cost of funds and lending to uncreditworthy borrowers. Starting from a point where the cost of funds is moderately high, consider a situation where policy decisions exogenously lower the cost of funds for either lender. This does not change

[9] Pool-1, which includes pooling all borrower types, occurs only when the (average) borrower quality in the market is good, as when low-risk types make up the bulk of the borrower pool.

[10] This non-monotonicity result is different from situations in which the uninformed lender can costlessly screen out bad risks. There, Lender-U can confirm that any customer coming to it for loans is creditworthy. Therefore, its cost advantage is sufficient to obtain at least the inferior type from among the pool of creditworthy borrowers. And, as average borrower quality increases, it can pool borrowers of inferior quality with superior ones. Accordingly, its ability to gain market share increases monotonically with increases in borrower quality.

the uninformed lender's cost advantage and hence leaves its ability to screen borrowers unaltered. However, this situation can significantly enhance the uninformed lender's ability to poach borrowers from the informed lender by pooling creditworthy borrowers with uncreditworthy ones. Such pooling equilibria require that there exist predominantly one creditworthy borrower type in the market under consideration. For example, if the uninformed lender has reason to believe that most borrowers in the market are high-risks and creditworthy, it may be optimal to include uncreditworthy borrowers in its portfolio, if only to poach creditworthy ones from its informed rival.

6 Implications of the Model

This model builds on a large body of theoretical work on competitive screening models. Starting with the seminal paper by Rothschild and Stiglitz (1976) on lender competition in insurance markets, this literature extends to more recent work by Brueckner (2000) on adverse selection in the mortgage market. More importantly, these stylized models help increase our understanding of competition under asymmetric information across a variety of financial market settings. In each case, the theoretical models describe a different screening device but the underlying mechanism is qualitatively similar. Riskier borrowers are ex ante less willing to enter into contracts that require them to forego a greater share of their payoffs in the event of the adverse outcome (the single-crossing property). In the context of insurance markets, Rothschild and Stiglitz (1976) show that riskier individuals select contracts with a lower deductible and higher insurance premium. Similarly, Brueckner (2000) argues that riskier borrowers agree to a price premium for high loan-to-value (LTV) mortgages. Evidently, the results in our framework of competition among asymmetrically informed lenders can be extended to most debt markets in general and the current turmoil in the mortgage market in particular.[11] Needless to say, recent events are more complex than the mechanisms outlined in the stylized model. Accordingly, the aim here is somewhat modest: I discuss the causal link established above in light of some of the evidence on recent events in financial markets. What follows is a simple description of the intuition and some anecdotal evidence in support of the arguments.

6.1 An Example: Subprime Mortgage Market

While prime loans are made to borrowers with strong credit histories and a demonstrated capacity to repay, loans to subprime borrowers involve elevated credit risk. In the early years, a majority of subprime lenders were a combination of non-depository finance companies, specialized subprime mortgage lenders, and local depository institutions (Temkin, Johnson, and Levy, 2002). Subsequently, subprime originations increased at a high rate of 25 percent per year from 1994 to 2003.[12] Of course, other factors like changes in the regulatory structure and intense competition that drove down profits in the prime market significantly influenced the increase in subprime lending (Gramlich, 2004).

Subprime loans typically have higher LTV ratios and a significant majority of subprime mortgages are refinances, emphasizing the role of repeated interaction(s) between borrowers and lenders in this market. Using First American Loan Performance data on over seven million securitized loans, Bhardwaj and Sengupta (2008) find that between 60 to 72 percent of first-lien subprime originations between 1998 and 2007 were refinances. As the subprime market grew, poaching borrowers became increasingly relevant because major players increased market share at the expense of other informed lenders, including local lending companies.[13]

[11] An earlier version of this paper discussed the relevance of this model in the context of the entry of mainstream sources of finance to the areas of microfinance in developing countries.

[12] *Mortgage Market Statistical Annual*, Inside Mortgage Finance Publications, various issues.

[13] It is important to point out that, of the largest and most notable subprime lenders in 2004 and 2005 such as Ameriquest, New Century, Countrywide, and Wells Fargo, only Countrywide ranked among

Translating the more general credit market framework to the case of the mortgage market is simpler if we abstract from asset price movements. To describe the lender competition and equilibrium in the context of the mortgage market, we use the screening mechanism described in Brueckner (2000).[14] Brueckner (2000) argues that uninformed lenders can induce borrower separation by using a price premium on loans with higher LTV. Just like the mechanism outlined in this paper, borrowers with higher unobservable risk self-select into contracts with higher LTV (lower collateral requirement) and higher repayment. It is important to point out that the loan amount in the model is one dollar. Therefore, in the context of mortgage financing, the collateral requirement in the model turns out to be the inverse of the LTV ratio on mortgages.

In terms of the mechanism described in the paper, competition would require uninformed lenders to screen borrowers conditional on observable risk. Lenders wary about unobservable risk characteristics of subprime borrowers would ideally want borrowers to satisfy a higher downpayment requirement before approving the mortgage. This unobservable risk component assumes greater importance because a significant proportion of subprime borrowers had incomplete or impaired documentation on loans. Interestingly, however, there has been sharp increase in LTV on first-lien subprime mortgage originations from 2003 to 2005 (Bhardwaj and Sengupta, 2008).

A plausible explanation for this increase in LTV on mortgage contracts can be given in terms of the pooling equilibria described in the model. Screening equilibria in the model require both a significant cost advantage over the informed lender to cover screening costs and the low-risk borrower's ability to post the required collateral. It is not clear to what extent either condition was met on subprime mortgage lending. It is even less certain if this could be used as an effective means of poaching borrowers. In this scenario, a

the top 10 lenders in 2000 (*Mortgage Market Statistical Annual*, Inside Mortgage Finance Publications, various issues).

[14] A complete and formal description of the details is available in Brueckner (2000). The model abstracts from choice of housing consumption and prepayment risk.

large secular decline in the cost of funds, as witnessed in the first half of this decade, would allow for pooling equilibria. Accordingly, lenders allowing higher LTV (and higher interest rates) on mortgage contracts could successfully attract borrowers away from local competition.[15] By doing so, they could effectively be pooling creditworthy borrowers with uncreditworthy ones.

Generally, lenders would be less inclined to raise interest rates and relax LTV requirements because of the fear that such loans are attractive to bad-risk types. However, in an environment where credit is cheap, lenders expect to cover these losses from bad-risks with profits from good-risk types.[16] It is not clear if this was a conscious forethought strategy by subprime lenders or whether such pooling was viewed as a viable option under the circumstances as the events developed.

7 Conclusion

This paper presents a simple theoretical model as to how a low cost of funds prompts lenders to include uncreditworthy borrowers in their loan portfolio. A secular decline in the cost of funds does not help uninformed lenders to screen uncreditworthy borrowers, but it does allow them to pool these borrowers with creditworthy types. This not only facilitates entry of outside lenders into high-risk credit markets, but also makes it optimal for them to poach borrowers from rivals by including non-creditworthy borrowers in their loan portfolio. The framework is particularly relevant in explaining how an easing of monetary policy at the early part of this decade could be a significant factor in lending to uncreditworthy borrowers in the mortgage market.

[15] This would be especially true for borrowers seeking to refinance mortgages and/or extracting equity on their homes. It is interesting to note that the proportion of first-lien subprime mortgages in the (cumulative) LTV range of 90-100 increased from 3 percent in 1998 to 40 percent in 2006 (Bhardwaj and Sengupta, 2008).

[16] Ex post, it is difficult to argue that lenders did not err in their estimates on the proportion of bad risks in the borrower population.

In conclusion, it is crucial to mention that the choice of the screening model is driven by two considerations. The first is to illustrate how lender competition in the face of a low cost of funds can adversely affect borrower quality. The second is to demonstrate that this effect can occur in the absence of an asset price boom. It is important to illustrate that the causal link laid out in the model is independent of the traditional asset-based lending channels typically used to describe this link. However, it is equally important to emphasize that this link can occur in the presence of, or perhaps even reinforce, the traditional asset-based lending channel.

References

Allen, F. and D. Gale, (2004). "Competition and Financial Stability." Journal of Money, Credit, and Banking, 36(3), 453-480.

Bernanke, B. and M. Gertler, (1999). "Monetary Policy and Asset Price Volatility." Federal Reserve Bank of Kansas City, Economic Review, 84(4), 17-51.

Besanko, D. and A.Thakor, (1987). "Collateral and Rationing: Sorting Equilibria in Monopolistic and Competitive Credit Markets." International Economic Review 28, 671-689.

Besanko, D. and A.Thakor, (1993). "Relationship Banking, Deposit Insurance and Bank Portfolio Choice." In C. Mayer, Capital Markets and Financial Intermediation (P. 292-319). Cambridge University Press: New York.

Bhardwaj, G. and R. Sengupta, (2008). "Where's the Smoking Gun? A Study of Underwriting Standards for US Subprime Mortgages." Federal Reserve Bank of St. Louis, Working Paper.

Boot A. and A. Thakor,(2000). "Can Relationship Banking Survive Competition?" Journal of Finance, American Finance Association, 55(2), 679-713.

Boot, Arnoud W. A., (2000). "Relationship Banking: What Do We Know?" Journal of Financial Intermediation 9(1), 7-25.

Brueckner, J. K. (2000). "Mortgage Default with Asymmetric Information." Journal of Real Estate Finance and Economics 20(3), 251-74.

Feltovich, N., R. Harbaugh and T. To, (2002). "Too Cool for School? Signaling and Countersignaling." RAND Journal of Economics, 33, 630-649.

Gramlich, E.M., (2004). "Subprime Mortgage Lending: Benefits, Costs, and Challenges." At the Financial Services Roundtable Annual Housing Policy Meeting, Chicago, Illinois.

Keeley, M., (1990). "Deposit Insurance, Risk and Market Power in Banking." American Economic Review, 80, 1183-1200.

Kiyotaki, N. and J. Moore, (1997). "Credit Cycles." Journal of Political Economy 105(2), 211-247.

Mishkin, F.S., (2008). "The Federal Reserve's Tools for Responding to Financial Disruptions." At the Tuck Global Capital Markets Conference, Tuck School of Business, Dartmouth College, Hanover, New Hampshire.

Mortgage Market Statistical Annual, Inside Mortgage Finance Publications, various issues.

Rothschild, M. and J.E. Stiglitz, (1976). "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." Quarterly Journal of Economics 90(4), 630-49.

Sharpe, S.A., (1990) "Asymmetric Information, Lender Lending, and Implicit Contracts: A Stylized Model of Customer Relationships." Journal of Finance 45(4), 1069-87.

Sengupta R., (2007) "Foreign Entry and Lender Competition." Journal of Financial Economics 84(2), 502-528.

Temkin, K., Johnson, J., and D. Levy, (2002). "Subprime Markets, the Roles of GSEs, and

Risk-Based Pricing." U.S. Department of Housing and Urban Development, March 2002.

Appendix

Uninformed lender's offer in Screen-1

The following results are obtained for $\rho^I > \max(\tilde{\rho}_S^{b,h}, \tilde{\rho}_S^{h,l})$. The uninformed lender's optimization problem is given as follows:

$$\max \quad \Pi^U \equiv \nu_b \pi_b^U + \nu_h \pi_h^U + \nu_l \pi_l^U,$$

where $\pi_k^U = (1-\theta_k)R_k^U + \beta\theta_k C_k^U - \rho^U$, subject to the following participation constraints

$$\begin{aligned} V_b(R_b, C_b) &\leq V^0 && (2)\\ V_h(R_h, C_h) &\geq V_h^I && (3)\\ V_l(R_l, C_l) &\geq V_l^I && (4) \end{aligned}$$

and the following incentive compatibility constraints

$$\begin{aligned} V_b(R_b, C_b) &\geq V_b(R_h, C_h) && (5)\\ V_b(R_b, C_b) &\geq V_b(R_l, C_l) && (6)\\ V_h(R_h, C_h) &\geq V_h(R_b, C_b) && (7)\\ V_h(R_h, C_h) &\geq V_h(R_l, C_l) && (8)\\ V_l(R_l, C_l) &\geq V_l(R_b, C_b) && (9)\\ V_l(R_l, C_l) &\geq V_l(R_h, C_h). && (10) \end{aligned}$$

Claim 3 *In any solution, $C_b = 0$.*

Suppose not. Let $\{(R_b^1, C_b^1), (R_h, C_h), (R_l, C_l)\}$ be a solution. Consider contract (R_b^2, C_b^2) where $R_b^2 > R_b^1$, $C_b^2 < C_b^1$ such that

$$V_b(R_b^1, C_b^1) = V_b(R_b^2, C_b^2). \qquad (11)$$

It can be shown that the uninformed lender can increase profits by replacing contract (R_b^1, C_b^1) with contract (R_b^2, C_b^2). Note that since (R_b^1, C_b^1) satisfies (2), (4), and (5), so does (R_b^2, C_b^2). For (R_b^2, C_b^2) to satisfy (7), it needs to be shown that $V_h(R_b^1, C_b^1) \geq V_h(R_b^2, C_b^2)$. That is, $(1-\theta_h)(R_b^2 - R_b^1) \geq \theta_h(C_b^1 - C_b^2)$. Using (11), we get

$$(\frac{1-\theta_h}{\theta_h})(R_b^2 - R_b^1) \geq (C_b^1 - C_b^2) = (\frac{1-\theta_b}{\theta_b})(R_b^2 - R_b^1)$$

which holds true, since $\theta_b > \theta_h$. Similarly, (9) is also satisfied.

Moreover,

$$\begin{aligned}
\pi_b(R_b^1, C_b^1) - \pi_b(R_b^2, C_b^2) &= (1-\theta_b)(R_b^2 - R_b^1) + \beta\theta_b(C_b^2 - C_b^1) \\
&= (1-\beta)(1-\theta_b)(R_b^2 - R_b^1) > 0. \qquad \text{[using (11)]}
\end{aligned}$$

Claim 4 *In any solution, the incentive constraint of the bad-risk w.r.t the high-risk must bind, that is, $V_b(R_b, 0) = V_b(R_h, C_h)$.*

Suppose not. Let $\{(R_b, 0), (R_h^1, C_h^1), (R_l, C_l)\}$ be a solution. Consider contract (R_h^2, C_h^2), where $R_h^2 > R_h^1$, $C_h^2 < C_h^1$ such that

$$V_b(R_b, 0) = V_b(R_h^2, C_h^2) \tag{12}$$

$$V_h(R_h^1, C_h^1) = V_h(R_h^2, C_h^2). \tag{13}$$

It can be shown that the uninformed lender can increase profits by replacing contract (R_h^1, C_h^1) with contract (R_h^2, C_h^2). Note that since (R_b^1, C_b^1) satisfies (2), (7), and (8), so does (R_h^2, C_h^2). For (R_h^2, C_h^2) to satisfy (10), it needs to be shown that $V_l(R_h^1, C_h^1) \geq V_l(R_h^2, C_h^2)$. That is, $(1-\theta_l)(R_h^2 - R_h^1) \geq \theta_l(C_h^1 - C_h^2)$. Using (13), we get

$$(\frac{1-\theta_l}{\theta_l})(R_h^2 - R_h^1) \geq (C_h^1 - C_h^2) = (\frac{1-\theta_h}{\theta_h})(R_h^2 - R_h^1)$$

which holds true, since $\theta_b > \theta_h$. Similarly, (9) is also satisfied.

Moreover,

$$\begin{aligned}
&\pi_h(R_h^2, C_h^2) - \pi_h(R_h^1, C_h^1) \\
= \; &(1-\theta_h)(R_h^2 - R_h^1) + \beta\theta_h(C_h^2 - C_h^1) \\
= \; &(1-\beta)(1-\theta_h)(R_h^2 - R_h^1) > 0. \qquad \text{[using (13)]}
\end{aligned}$$

Claim 5 *In any solution, the incentive constraint of the high-risk w.r.t the low-risk must bind, that is, $V_h(R_h, C_h) = V_h(R_l, C_l)$.*

Suppose not. Let $\{(R_b, 0), (R_h, C_h), (R_l^1, C_l^1)\}$ be a solution. Consider contract (R_l^2, C_l^2) where $R_l^2 > R_l^1$, $C_l^2 < C_l^1$ such that

$$V_h(R_h, C_h) = V_h(R_l^2, C_l^2) \tag{14}$$

$$V_l(R_l^1, C_l^1) = V_l(R_l^2, C_l^2) \tag{15}$$

It can be shown that the uninformed lender can increase profits by replacing contract (R_l^1, C_l^1) with contract (R_l^2, C_l^2). Note that since (R_l^1, C_l^1) satisfies (3), (9), and (10), so does (R_l^2, C_l^2).

It can be shown that (R_l^2, C_l^2) satisfies (5). Suppose not. Then it follows that $V_b(R_b, 0) < V_b(R_l^2, C_l^2)$. Using Remark 2, this implies $V_b(R_l^2, C_l^2) > V_b(R_b, 0) = V_b(R_h, C_h)$. That is, $(1-\theta_b)(R_h - R_l^2) > \theta_b(C_l^2 - C_h)$. From (14),

$$(\frac{1-\theta_b}{\theta_b})(R_h - R_l^2) > (C_l^2 - C_h) = (\frac{1-\theta_h}{\theta_h})(R_h - R_l^2)$$

which is impossible. Hence, (5) must be true.

Moreover,

$$\begin{aligned} & \pi_l(R_l^2, C_l^2) - \pi_l(R_l^1, C_l^1) \\ = \; & (1-\theta_l)(R_l^2 - R_l^1) + \beta\theta_l(C_l^2 - C_l^1) \\ = \; & (1-\beta)(1-\theta_l)(R_l^2 - R_l^1) > 0. \qquad \text{[using (15)]} \end{aligned}$$

Claim 6 *The participation constraints for both high- and low-risk borrowers must bind.*

Suppose not. Let $\{(R_b, 0), (R_h^1, C_h^1), (R_l^1, C_l^1)\}$ be a candidate solution such that $V_h(R_h^1, C_h^1) > \bar{V}_h^I$ and $V_l(R_l^1, C_l^1) > \bar{V}_l^I$. The aim here is to show that the solution $\{(R_b, 0), (R_h^2, C_h^2), (R_l^2, C_l^2)\}$ for which

$$V_h(R_h^2, C_h^2) = \bar{V}_h^I \qquad (16)$$

$$V_l(R_l^2, C_l^2) = \bar{V}_l^I \qquad (17)$$

$$V_b(R_b, 0) = V_b(R_h^2, C_h^2) = V_b(R_h^1, C_h^1) \qquad (18)$$

$$V_h(R_h^2, C_h^2) = V_h(R_l^2, C_l^2) \qquad (19)$$

satisfies all constraints but gives strictly greater profits for the uninformed lender.

For (R_l^2, C_l^2):

Constraints (3) and (8) are satisfied by construction.

It can be shown that (R_l^2, C_l^2) satisfies (5). Suppose not. Then it follows that $V_b(R_b, 0) < V_b(R_l^2, C_l^2)$. Using Remark 2, this implies $V_b(R_l^2, C_l^2) > V_b(R_b, 0) = V_b(R_h^2, C_h^2)$. That is, $(1-\theta_b)(R_h^2 - R_l^2) > \theta_b(C_l^2 - C_h^2)$. From (14),

$$(\frac{1-\theta_b}{\theta_b})(R_h^2 - R_l^2) > (C_l^2 - C_h^2) = (\frac{1-\theta_h}{\theta_h})(R_h^2 - R_l^2)$$

which is impossible. Hence, (5) must hold.

For (9), the proof is by contradiction. If not true, then $V_l(R_b, 0) > V_l(R_l^2, C_l^2)$ holds. That is, $\theta_l C_l^2 > (1-\theta_l)(R_b - R_l^2)$. Also, because (5) holds, it follows that $V_b(R_b, 0) \geq V_b(R_l^2, C_l^2)$. That is, $(1-\theta_b)(R_b - R_l^2) \geq \theta_b C_l^2$. Combining both inequalities,

$$C_l^2 > (\frac{1-\theta_l}{\theta_l})(R_b - R_l^2) > (\frac{1-\theta_b}{\theta_b})(R_b - R_l^2) \geq C_l^2$$

which is impossible. Hence, it must be true that $V_l(R_l^2, C_l^2) \geq V_l(R_b, 0)$

For (10), the proof is again by contradiction. If not true, then $V_l(R_h^2, C_h^2) > V_l(R_l^2, C_l^2)$ holds. That is $(1-\theta_l)(R_h^2 - R_l^2) < \theta_l(C_l^2 - C_h^2)$. Also, because (19) holds, it follows that $(1-\theta_h)(R_h^2 - R_l^2) = \theta_h(C_l^2 - C_h^2)$. Combining both,

$$(C_l^2 - C_h^2) > (\frac{1-\theta_l}{\theta_l})(R_h^2 - R_l^2) > (\frac{1-\theta_h}{\theta_h})(R_h^2 - R_l^2) = (C_l^2 - C_h^2)$$

which is impossible. Hence, it must be true that $V_l(R_l^2, C_l^2) \geq V_l(R_h^2, C_h^2)$.

For (R_h^2, C_h^2):

Constraints (2), (4) and (8) are satisfied by construction.

For (7), the proof is by contradiction. If not true, then $V_h(R_b, 0) > V_h(R_h^2, C_h^2)$ holds. That is $\theta_h C_h^2 > (1-\theta_h)(R_b - R_h^2)$. Also, because (18) holds, it follows that $V_b(R_b, 0) = V_b(R_h^2, C_h^2)$. That is $(1-\theta_b)(R_b - R_h^2) = \theta_b C_h^2$. Combining both inequalities,

$$C_h^2 > (\frac{1-\theta_h}{\theta_h})(R_b - R_h^2) > (\frac{1-\theta_b}{\theta_b})(R_b - R_h^2) = C_h^2$$

which is impossible. Hence, it must be true that $V_h(R_h^2, C_h^2) \geq V_h(R_b, 0)$.

Using (19), we can show that (10) holds exactly as before. Thus, $\{(R_b, 0), (R_h^2, C_h^2), (R_l^2, C_l^2)\}$ satisfies all constraints. Furthermore,

$$\begin{aligned}
& \pi_h(R_h^2, C_h^2) - \pi_h(R_h^1, C_h^1) \\
= \; & (1-\theta_h)(R_h^2 - R_h^1) + \beta\theta_h(C_h^2 - C_h^1) \\
= \; & (1-\theta_h)(R_h^2 - R_h^1) - \beta\theta_h(\frac{1-\theta_b}{\theta_b})(R_h^2 - R_h^1) \quad \text{[using (18)]} \\
= \; & [\theta_b(1-\theta_h) - \beta\theta_h(1-\theta_b)]\theta_b^{-1}(R_h^2 - R_h^1) > 0.
\end{aligned}$$

Also, note that $V_l(R_l^1, C_l^1) > \bar{V}_l^I$ implies that $(1-\theta_l)(\underline{R}_l^I - R_l^1) \geq \theta_l C_l^1$. Moreover, $V_l(R_l^2, C_l^2) = \bar{V}_l^I$ implies $(1-\theta_l)(\underline{R}_l^I - R_l^2) = \theta_l C_l^2$. Combining the two,

$$(1-\theta_l)(R_l^2 - R_l^1) > \theta_l(C_l^1 - C_l^2) > \beta\theta_l(C_l^1 - C_l^2). \tag{20}$$

Now

$$\begin{aligned}
& \pi_l(R_l^2, C_l^2) - \pi_l(R_l^1, C_l^1) \\
= \; & (1-\theta_l)(R_l^2 - R_l^1) + \beta\theta_l(C_l^2 - C_l^1) \\
= \; & (1-\theta_l)(R_l^2 - R_l^1) - \beta\theta_l(C_l^1 - C_l^2) > 0. \quad \text{[using (20)]}
\end{aligned}$$

Thus, the uninformed lender's maximum profits are given by

$$\Pi_{S-1}^U \equiv \nu_h\pi_h^U + \nu_l\pi_l^U \equiv \nu_h[(1-\theta_h)R_h^U + \beta\theta_h C_h^U - \rho^U] + \nu_l[(1-\theta_l)R_l^U + \beta\theta_l C_l^U - \rho^U]$$

where $R_l^U = C_l^U = \rho^I$, and

$$R_h^U = \frac{\theta_b}{\theta_b - \theta_h}\rho^I - \frac{\theta_h}{\theta_b - \theta_h}[(1-\theta_b)x - V^0]$$
$$C_h^U = -\frac{1-\theta_b}{\theta_b - \theta_h}\rho^I + \frac{1-\theta_h}{\theta_b - \theta_h}[(1-\theta_b)x - V^0].$$

A Uninformed lender's offer in other candidate equilibria

From the previous section, it is easy to see that the uninformed lender's offer to high risks in Screen-2 will be given by (R_h^U, C_h^U). Thus, its payoff is

$$\Pi_{S-2}^U \equiv \nu_h[(1-\theta_h)R_h^U + \beta\theta_h C_h^U - \rho^U].$$

The screening cutoff is given by setting the above profit function to zero.

$$\tilde{\rho}_S^{b,h} = \frac{\theta_b - \theta_h}{\theta_b(1-\theta_h) - \beta\theta_h(1-\theta_b)}\rho^U + \frac{(1-\beta)\theta_h(1-\theta_h)}{\theta_b(1-\theta_h) - \beta\theta_h(1-\theta_b)}[(1-\theta_b)x - V^0].$$

Note that any contract that pools high risks and bad risks is dominated by $(\underline{R}_h^I, 0)$. Similarly, any contract that pools all borrowers is dominated by $(\underline{R}_l^I, 0)$. Hence, the uninformed lender's offers in the candidate hybrid equilibria follows as in Section 3.