Mismatch in Credit Markets

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Abstract: This paper studies a decentralized credit market where borrowers and lenders engage in costly search to establish bilateral credit relationships. We endogenize the market participation decision by borrowers to capture entry and exit of entrepreneurs who depend on access to credit for survival. We allow incentive frictions in the form of moral hazard to interact with search frictions in setting up incentive compatible optimal loan contracts. We find that entry and incentive frictions are important in determining the extent of credit rationing, while search and incentive frictions are important for determining the likelihood of credit market breakdown. We also show that the rate of time preference of lenders and the duration of loan contracts are important factors in determining whether or not productive firms are rationed.

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1 Introduction

> *Time* runs a close second to *cash* on every entrepreneur's list of scarce resources. (W. E. Wetzel, Jr., *The Portable MBA in Entrepreneurship*, p. 185)

Credit markets are capricious and susceptible to occasional breakdowns. Various explanations for the turbulence in credit markets have been proposed largely based on theories of informational imperfections.[1] But these theories do not explain the phenomenon of mismatches. Mismatches occur when idle funds coexist with profitable but unexploited investment opportunities and are found in most accounts of credit crises. The phenomenon occurs partly because markets for information-intensive loans made to entrepreneurs tend to be localized and satisfy many of the characteristics of a search market as originally proposed by Stigler (1961).[2] The extent of mismatch helps explain unfulfilled demand for credit and the tightness of credit markets. Because access to credit is an important factor for the survival of small entrepreneurs, mismatch ultimately helps determine credit market participation and the likelihood of breakdown.

Information and matching frictions coexist even when credit markets are functioning normally. Entrepreneurs, who exist in the financial twilight zone between bankruptcy and survival, are racing against time on the lookout for funds. Sometimes they qualify for funding and sometimes they are rejected, but the search goes on until they find funds or else run out. On the other side of the market, lenders spend costly time and resources looking to turn their idle funds into active investments. Part of the cost comes from search and screening to identify potentially viable credit relationships. Once viable credit partners have been identified, resources are used to negotiate contracts that are mutually

[1] In credit markets, imperfections arising from moral hazard and adverse selection problems have been identified as a important factor leading to the rationing of credit and possible bank failures. There has been an extensive literature following Diamond and Dybvig (1983) on bank runs (e.g., see Diamond and Rajan (2001) and papers cited therein) as well as a broader literature on financial fragility (e.g., see Allen and Gale (2000) on financial contagion and Lagunoff and Schreft (2001) on instability of financial networks).

[2] As Blanchflower and Oswald (1998) observe, where to find funding is a paramount problem for existing and would-be entrepreneurs. Hart and Moore (1994) provide another reason for mismatch not based on search frictions but on the threat of debt repudiation.

advantageous and incentive compatible. While the difference between normal and abnormal credit market behavior is fluid, at some point breakdown occurs and the market ceases to exist at a local level or even at a national level. Because such breakdowns are associated with potentially large social costs, it is important to understand this phenomenon and to what extent informational and matching frictions reinforce one another.

In this paper we combine information, matching, and entry frictions in a simple general equilibrium model of decentralized trade. Our analysis describes the optimal loan contracts and equilibria that emerge in such an environment. The important question of when credit rationing arises and when markets break down is also investigated.

Our model has several features that are of interest. Borrowers and lenders choose whether or not to participate in a decentralized loan market where search for bilateral credit relationships is costly. Some participating borrowers and lenders form credit relationships that enable borrowers to finance investment projects which yield a productive rate of return. These returns are divided up between the borrower in the form of profits and the lender in the form of an interest payment. Because of incentive frictions that arise from asymmetric information, borrowers may at a price abscond with the borrowed funds. Loan contracts are hence negotiated to incorporate incentive compatibility to overcome the moral hazard problem.[3] Thus, credit rationing, in the sense of borrowers receiving fewer funds than desired, may emerge endogenously.[4] In equilibrium, optimal loan contracts and the extent of credit rationing are determined jointly with market liquidity (or aggregate lending), borrower market participation, and the tightness of the credit market (or the excess demand for loans as measured by the ratio of unmatched borrowers to unmatched lenders).

Our perspective differs in some significant ways from previous work on bilateral search in credit markets. Diamond (1992) is the original paper in the area and most closely related to our work. We diverge along several dimensions and consider endogenous matching probabilities and endogenous market participation. However, the most important innovation is that we integrate information frictions into a search framework and thus allow for the

[3]See Banerjee and Newman (1993) and Acemoglu (2001) for other work on borrowers who abscond.

[4]Credit rationing here follows the notion of Jaffee and Russell (1976) rather than the notion of Stiglitz and Weiss (1981), where observationally identical agents may or may not receive funds.

possibility of endogenous rationing. Shi (1996) and Wasmer and Weil (2000) also analyze search and credit but with an entirely different purpose. While Shi is mainly interested in how credit arrangements compare to monetary exchange, Wasmer and Weil are interested in how credit market imperfections affect labor market frictions. Neither of these papers considers asymmetric information which is essential for understanding credit rationing.

We find that the nature of the optimal incentive-compatible contract in equilibrium varies with borrower productivity. If productivity falls below a threshold that is determined by default costs, credit markets break down and cease to exist. If productivity exceeds this threshold, firms will be rationed unless lenders are sufficiently patient, in which case there is no rationing. Even very productive firms may be rationed if the rate of time preference is sufficiently low or the length of the loan contract period is sufficiently short. Intuitively, a low rate of time preference raises the present discounted value of absconding with borrowed funds and a short contract duration lowers the value of the match for a borrower who must search again in the credit market. Also, we find that credit market tightness and the extent of credit rationing are positively related when entry is exogenous. But when entry is endogenous, there generally does not exist a monotonic relationship between the two. Intuitively, credit may continue to be rationed in a market where it is relatively easy for borrowers to locate lenders because high market interest rates drive productive firms out of the loanable funds market. Finally, we show that entry and incentive frictions are important in determining the extent of credit rationing, while entry and search frictions are important for determining the likelihood of credit market breakdown.

2 The Basic Environment

Time is continuous. There are two types of economic agents, those endowed with resources ("lenders") and those endowed with an "investment" technology which uses those resources to generate a positive return ("borrowers"). Our model focuses on the loanable funds market where available funds provided by a continuum of lenders are channeled to a continuum of potential borrowers through a decentralized credit market. Let N^L and N^B represent the mass of lenders and borrowers in this environment. For convenience, we normalize the measure of lenders to unity. Lenders and borrowers (bilaterally) meet with each other for the purpose of establishing a credit relationship. We define N_u^i to be the number of unmatched agents and N_m^i as the number of matched agents of type i where $i = L, B$. By normalizing the mass of lenders to unity, we have: $N_u^L + N_m^L = 1$. A central feature of the loan market highlighted by our model is that market liquidity is determined by credit market tightness. Given the populations of lenders and borrowers, a measure of credit market tightness in our set-up is given by the ratio of unmatched lenders to unmatched borrowers, or N_u^B/N_u^L. Intuitively, if this ratio is high, then there are many potential borrowers relative to lenders with idle funds. Because it is more difficult for borrowers to locate potential lenders under these circumstances, we say that the credit market is "tight."

Utility generated from consumption is assumed to be linear for both types of agents. Since the focus of this paper is on how credit market frictions and market liquidity affect credit arrangements between borrowers and lenders rather than the intertemporal consumption and saving decisions of households, this simplifying assumption is adopted without loss of generality for our purpose. An unmatched lender consumes his flow endowment ω as he searches for borrowers with whom to trade this endowment for the promise of a future payment. A borrower begins the search period with only his investment technology and searches for potential lenders to finance their project. Lenders contact borrowers at a rate of μ, while borrowers contact lenders at a rate of η. Due to asymmetric information about the borrower's behavior, the lender is unsure about whether the borrower will invest in a productive project or take the money and run. Thus, once a borrower and a lender meet, the lender will set an incentive compatible loan contract to prevent the borrower from absconding with the funds. The contract specifies a gross interest payment, R, and the fraction of available funds actually lent out, $q \leq 1$. When this loan contract is established, the lender gives up a portion of the endowment, $q\omega$, to the borrower and consumes the residual portion $(1 - q)\omega$ while waiting for the end of the contract period. The contract period ends when borrowers and lenders are separated at which time the lender pays the borrower an amount $Rq\omega$. The exogenous separation rate is given by δ, and hence the length of the contract period is given by $1/\delta$ and the appropriate gross interest rate is given by δR. After both members of the match become separated, they re-enter the pool of unmatched borrowers and lenders and again search for credit opportunities.

If borrowers in this model know with certainty that the loan will be repaid, our preferences imply that it will be optimal for the lender to set $q = 1$ and lend all of the endowment to the borrower in exchange for the future payment. However, borrowers in our model may choose to default on the loan and abscond without repayment. When this occurs, the defaulter bears two costs. First, we assume that the defaulter is excluded from any future credit transactions. Second, we assume that the borrower must forfeit a real resource cost that is measured as a fraction θ of total loanable funds. This cost is meant to capture the outside penalty of default and may represent legal or institutional features. A natural interpretation is the cost of bankruptcy where the creditor has no claims on the residual portion of the loan. This moral hazard feature is what may cause loanable funds to be rationed (i.e., $q < 1$). That is, lenders will use this quantity rationing feature of the loan contract so as to insure incentive compatibility and repayment.

We can now characterize the dynamic problem facing borrowers and lenders in our economy. Let J_u and J_m denote the lender's value associated with being in the unmatched (u) and matched (m) states. These asset values can be expressed as:

$$rJ_u = \omega + \mu\left(J_m - J_u\right) \tag{1}$$

$$rJ_m = (1-q)\omega + \delta[Rq\omega + (J_u - J_m)] \tag{2}$$

where $r > 0$ is the rate of time preference. Equation (1) says that the flow value associated with an unmatched lender is the flow of consumption from his endowment and arrival rate of borrowers times the net value gained when a loan contract is implemented and the match is formed. Equation (2) says that the flow value associated with a matched lender is the flow of consumption of the residual endowment and the rate at which the contract expires times the interest payment and net value of returning to the unmatched pool.

Similarly, let Π_u and Π_m denote the borrowers's value associated with being in the unmatched and matched states, respectively. Their asset values in the two states are:

$$r\Pi_u = \eta\left(\Pi_m - \Pi_u\right) \tag{3}$$

$$r\Pi_m = Aq\omega + \delta[-Rq\omega + (\Pi_u - \Pi_m)] \tag{4}$$

Equation (3) simply states that the flow value associated with an unmatched borrower is the rate at which they contact lenders times the net value gained when becoming matched with a lender. Equation (4) says that the flow value associated with a matched borrower is the stream of returns the borrower obtains from implementing the investment project and the value associated with separation which occurs at rate δ. When this occurs, the borrower makes the interest payment $Rq\omega$, gains the state of returning to the unmatched borrowers' pool, and looses the state of being a matched borrower.[5]

Subtracting (1) from (2) gives us the lenders' value of being matched relative to being unmatched as:

$$J_m - J_u = \frac{(\delta R - 1)\, q\omega}{r + \delta + \mu} \tag{5}$$

Notice that equation (5) implies that a necessary condition for an active loan market requires $J_m - J_u > 0$ or $\delta R > 1$. Otherwise, the economy will degenerate into an autarchic state where no credit activity occurs. We will assume that this condition holds.

Similarly, subtracting (3) from (4) gives us the borrowers' value of being matched relative to being unmatched as:

$$\Pi_m - \Pi_u = \frac{(A - \delta R)\, q\omega}{r + \delta + \eta} \tag{6}$$

We note that The relative values given by (5) and (6) are aggregate expressions. However, each individual borrower is atomistic and take their unmatched value Π_u as given when evaluating their matched value. We take this into account and rewrite (4) gives,

$$\Pi_m = \frac{(A - \delta R)\, q\omega + \delta\Pi_u}{r + \delta} \tag{7}$$

[5]For simplicity we have assumed that borrowers do not have any assets. More generally, if borrowers also have an asset ω^B, equation (3) must be modified to $r\Pi_u = \omega^B + \eta\left(\Pi_m - \Pi_u\right)$. If these assets are jointly productive with the endowment of the lender then equation (4) changes to $r\Pi_m = A(q\omega + \omega^B) + \delta[-Rq\omega + (\Pi_u - \Pi_m)]$. Another possibility (that is also beyond the scope of this paper) is that borrower's assets could be used as collateral for loans. For a discussion of these and related issues see, for instance, Bernanke and Gertler (1989) and Hart and Moore (1994).

In the presence of the moral hazard problem, a loan contract must be incentive compatible to eliminate borrowers' default in equilibrium. Specifically in our framework, incentive compatibility means that the value associated with being a matched firm must be at least as great as the value associated with taking the funds and absconding:

$$(1-\theta)\frac{q\omega}{r} \leq \Pi_m \tag{8}$$

where the left hand side of (8) gives the present discounted value of absconding as the discounted value of the funds borrowed net of the cost expressed as a fraction θ of the loan.[6] Substitution of (7) into this above inequality (8) gives,

$$q\omega\left[(1-\theta)(\frac{r+\delta}{r}) - (A-\delta R)\right] \leq \delta\Pi_u \tag{9}$$

From (9) we see that an increase in the loan interest rate δR or an increase in the total quantity of the loan $q\omega$ increases the likelihood of absconding. An incentive compatible loan contract is defined as a pair (q, R) such that (9) is satisfied.

When borrowers and lenders meet, they bargain over the terms of the contract. We will assume that the outcome of this bargaining game is consistent with the Nash bargaining solution where the contract (q, R) is designed to maximize the joint surplus of the funds suppliers and demanders $S = (J_m - J_u)^{1/2}(\Pi_m - \Pi_u)^{1/2}$, subject to the incentive compatibility constraint (9) and $q \in [0, 1]$. Using (5) and (7), maximization of the joint surplus implies $\frac{dS}{dq} > 0$ and, from $\frac{dS}{dR} = 0$,

$$\delta Rq\omega = (Aq\omega - r\Pi_u)\Gamma + (1-\Gamma) \tag{10}$$

where $\Gamma \equiv \frac{r+\delta+\mu}{2(r+\delta)+\mu}$ is monotone increasing function of μ. Notice that if the pair (q, R) is not incentive constrained (that is, the incentive compatibility constraint is not binding), then an optimal loan contract will always involve the lender loaning out his entire endowment or $q = 1$.[7]

[6] So far we have assumed, like Diamond (1990), that the penalty for defaulting is exclusion from the credit market forever. Perhaps this assumption is too harsh in light of modern bankruptcy laws. If instead credit market participation is allowed after payment of the default penalty, the incentive compatibility constraint becomes $(1-\theta)\frac{q\omega}{r} + \Pi_u \leq \Pi_m$. One can easily verify that most of our qualitative results in the following sections are unchanged, even though the IC locus is now upward-sloping, $\delta R \leq B - \frac{r\Pi_u}{Q}$.

[7] Suppose instead we assume that production is finalized after separation (not before as assumed in (4)).

3 Characterization of the Loan Contract

We proceed by describing the optimal loan contract in the presence of incentive frictions that cause a moral hazard problem. The optimal contract must be incentive compatible and satisfy the Nash bargaining condition. Both conditions can be represented in an intuitive graphical fashion.

Formally, an optimal loan contract is a pair (R, q) such that (i) $q = 1$ and R solves (10) if this pair satisfies (9), or otherwise (ii) $q < 1$ and R solves (10) and (9) with equality. We define this latter case as a situation where the optimal loan contract is characterized by credit rationing. For analytic convenience, define $Q \equiv q\omega$. Thus, one can express the optimal loan contract in terms of $(Q, \delta R)$ by rewriting equations (10) and (9) as:

$$\delta R = \left(A - \frac{r\Pi_u}{Q}\right)\Gamma + (1 - \Gamma) \tag{11}$$

$$\delta R \leq B + \frac{\delta\Pi_u}{Q} \tag{12}$$

where $B \equiv A - (1-\theta)\frac{r+\delta}{r}$.

The determination of the optimal incentive compatible loan contract can be accomplished graphically in $(Q, \delta R)$ space with the origin defined as $Q = 0$ and $\delta R = 1$. We construct the graph in three steps.

First, we plot the surplus maximization condition (11) and call it the SM locus. This locus is upward-sloping and concave with a horizontal intercept $Q_{SM} = \frac{r\Pi_u}{A-1}$ and slope $\frac{\Gamma r\Pi_u}{Q^2}$. An optimal loan contract must be along this SM locus. The slope of the SM locus can be interpreted in terms of the bargaining power of borrowers versus lenders. For example, a steep SM curve, resulting from a faster arrival rate of borrowers, μ, or long loan contract period, low δ, increases the bargaining power of lenders. Hence they can demand a higher interest rate (δR) for a given increase in the loan quantity Q and this implies a steeper SM locus.

In this case (4) changes to $r\Pi_m = \delta[(A-R)q\omega + (\Pi_u - \Pi_m)]$. Ultimately, this means that (10) simplifies to $\delta Rq\omega = \frac{(\delta A-1)q\omega - r\Pi_u}{2}$. While we do not persue this simplification here, it should be noted that the Nash bargaining condition becomes independent of μ under this new timing assumption. In turn, the loan contract becomes independent of loan market tightness.

Second, we plot the incentive compatibility condition (12) with equality in $(Q, \delta R)$ space and call it the IC locus. This locus is downward-sloping and convex to the origin such that $\lim_{Q \longrightarrow 0} \delta R = \infty$ and $\lim_{Q \longrightarrow \infty} \delta R = B$ and has slope $\frac{-\delta \Pi_u}{Q^2}$. Also, for $B < 1$, IC has a horizontal intercept at $Q_{IC} = \frac{\delta \Pi_u}{1-B}$. Any $(Q, \delta R)$ in the area below the IC locus satisfies the incentive compatibility constraint.

Third is the property that an optimal loan contract must always have q as large as possible within the feasible range $[0, 1]$. Formally, we can plot $Q = \omega$ as the upper bound for q. This means that if an optimal loan contract exists, it must be on the part of the SM locus that is to the right of the IC locus and to the left of the $Q = \omega$ locus with the highest q. The existence of an active loanable funds market for all $\delta R > 1$ requires the condition that $A > 1$ and this is satisfied for a sufficiently productive economy.

Figure 1 segments our characterization of the optimal loan contract into three cases, depending on the relative position of the SM and IC loci. Case I indicates a situation when the SM locus is everywhere below IC. Hence all combinations of $(Q, \delta R)$ along the SM locus are incentive compatible and the optimal loan contract is the one with the highest value of q, implying $Q^* = \omega$ and the absence of credit rationing (see point E).

When the IC locus crosses the SM locus as in Case II, the amount of funds available in the economy is central for characterizing the optimal incentive compatible loan contract. When the amount of funds available is low (say, $\omega = \omega^L$), the optimal loan contract represented by $(Q^L, \delta R^L)$ is at point E^L where credit rationing is absent (i.e., $q = 1$). However, when the amount of funds available is high with $\omega = \omega^H$, the incentive compatibility constraint is now binding. As a consequence, there will be a unique optimal loan contract represented by $(Q^H, \delta R^H)$. In this case credit rationing emerges because the highest q attainable is strictly less than one (see point E^H where $Q^H < \omega^H$). Intuitively, loaning out a higher quantity of available funds increases the incentives for the borrower to abscond and leads to a binding incentive compatibility constraint. Since credit rationing only occurs when the endowment is sufficiently high and no rationing occurs otherwise, we will call this the "conditional (credit rationing) equilibrium."[8]

[8]Other assumptions may change the size of the credit rationing region. For example, allowing the

Finally, Case III shows that if the IC locus crosses the horizontal axis at a point lower than SM, there exists no incentive compatible combination of $(Q, \delta R)$ and no equilibrium loan contract. This is the "non-active" credit market outcome and is comparable to a credit market breakdown. After completely characterizing the steady state equilibrium, we will return to a more detailed analysis of the conditions consistent with each of these possible equilibrium outcomes.

4 Loanable Funds Equilibrium

The previous section discussed the properties of incentive compatible optimal loan contracts given the rates by which borrowers and lenders are matched. We now close the model by characterizing the steady state process by which lenders and borrowers meet. This will in turn pin down the equilibrium contact rates by which agents are matched, the steady state population of matched and unmatched borrowers and lenders, and hence equilibrium credit market tightness.

The flow of lenders into the state of being matched is given by μN_u^L and the flow of borrowers into the matched state is given by ηN_u^B. In a steady-state loanable funds equilibrium, the flow of funds supplied must be equal to the flow of funds demanded:

$$\mu N_u^L = \eta N_u^B = m_0 M(N_u^L, N_u^B) \tag{13}$$

where the matching technology M that brings borrowers and lenders together is strictly increasing and concave, satisfying the constant-returns-to-scale property, the standard Inada conditions, and the boundary conditions $M(0, \cdot) = M(\cdot, 0) = 0$.

Let us define the "tightness" of the loan market by $\tau \equiv \frac{N_u^B}{N_u^L}$. When τ is high, it is

borrower to use the loanable funds to produce before absconding means that the incentive compatibility condition changes from (8) to $(1-\theta)\frac{Aq\omega}{r} \leq \Pi_m$. Equation (12) is the same except for $B^* = A[1-(1-\theta)\frac{r+\delta}{r}] < B$. This implies that the IC locus is everywhere below the original IC curve derived above. Hence, the set of incentive compatible contracts shrinks and credit rationing becomes more likely. This situation allows borrowers to divert assets and returns rather than only the productive assets. The circumstances in Hart and Moore (1998) where borrowers can only divert the returns to the project is captured in a related incentive compatibility condition where $(1-\theta)\frac{(A-1)q\omega}{r} \leq \Pi_m$.

relatively difficult for borrowers to locate lenders and the market is tight.[9] With these properties, we can rewrite the steady state condition in terms of our tightness measure:

$$\mu = \eta\ \tau = m_0 M(1, \tau) \tag{14}$$

It is straightforward to show that (14) implies μ is increasing in τ whereas,

$$\eta \equiv \eta(\tau) = m_0 M(\frac{1}{\tau}, 1) \tag{15}$$

is decreasing in τ; moreover, both μ and η are increasing in m_0, $\frac{\mu}{\eta} = \tau$ (independent of m_0), $\lim_{\tau \to 0} \mu(\tau) = 0$ and $\lim_{\tau \to \infty} \eta(\tau) = 0$. This relationship is often referred to as the Beveridge curve in the search equilibrium literature. For labor markets the curve relates the unemployment rate to the vacancy rate (or establishes a relationship between the associated flow contact rates), while for credit markets we relate the capital unemployment rate to a measure of how much idle funds there are in the system.

From (6) and (7), we can eliminate Π_m to obtain the unmatched value facing each potential borrower:

$$\Pi_u = \frac{\eta}{r + \delta + \eta} \frac{(A - \delta R)Q}{r} \tag{16}$$

There is a large mass of potential borrowers. Borrower entry into the loan market is determined by assuming each borrower faces a fixed cost v for setting up the investment technology. By equilibrium entry, borrowers enter into the unmatched pool of borrowers until their unmatched value is driven down to the entry cost, or,

$$\Pi_u = v \tag{17}$$

Using the Beveridge curve relationship, we can substitute (16) into (17) to yield:

$$\frac{\eta(\tau)}{r + \delta + \eta(\tau)}(AQ - \delta RQ) = rv \tag{18}$$

[9] This is the most convenient way to measure tightness in our model. An alternative measure is the ratio of unmatched to total borrowers in the market $\frac{N_u^B}{N^B}$. Since this measure is proportional to τ (see Appendix), our measure is without loss of generality.

or, after substituting in (11) and $\frac{\mu}{\eta} = \tau$,

$$Q = \frac{rv}{A-1}\left(1 + \tau + \frac{2(r+\delta)}{\eta(\tau)}\right) \tag{19}$$

This is referred to as the ex ante zero profit curve (ZP), which is strictly increasing and strictly concave in (Q, τ) space with a horizontal intercept $\frac{rv}{A-1}$.[10]

A loanable funds equilibrium with firm entry is therefore a triplet $(Q^*, \delta R^*, \tau^*)$ that satisfies the optimal incentive compatible loan contract (11) and (12) as specified in the previous section, (17) and the ZP condition given by (19). Figure 2 provides an illustration of this steady state equilibrium by combining Case II from Figure 1 in the top panel with the ZP locus in the bottom panel (whereby we note that this locus has the same horizontal intercept as the SM locus). Thus, a loanable funds equilibrium is determined in a recursive manner. The optimal incentive compatible contract pins down the equilibrium $(Q^*, \delta R^*)$. Then the ZP locus determines equilibrium entry and hence the market tightness measure τ^* that is consistent with the optimal contract.

Once this triplet is determined, it is straightforward to derive the steady state populations of matched and unmatched borrowers and lenders. From (15) and (14), we have η^* and μ^*, respectively. Because the inflow of unmatched lenders being matched must equal the outflow of matched lenders being separated: $\mu^* N_u^L = \delta N_m^L$. Substituting the population identity, $N_u^L + N_m^L = 1$, into this equilibrium flow condition gives:

$$N_m^{L*} = \frac{\mu^*}{\delta + \mu^*} = N_m^{B*} \quad \text{and} \quad N_u^{L*} = \frac{\delta}{\delta + \mu^*} \tag{20}$$

From this it is easy to see that the equilibrium number of unmatched borrowers is $N_u^{B*} = \tau^* N_u^{L*}$. It is straightforward to verify that when a loanable funds equilibrium exists, it is unique. Hence, in general, not only does the optimal loan contract determine market tightness and liquidity, but market tightness in turn also affects the optimal loan contract.

[10] A sufficient condition for the concavity of the ZP locus is given by the envelope condition $\frac{(1/\tau)M_{HH}}{M_H} > -2$. For example, this is trivially satisfied for the Cobb-Douglas case.

5 Equilibrium Analysis

We now analyze the properties of the steady state loanable funds equilibrium. We identify the conditions that are consistent with existence of the steady state and show that we can differentiate between three possible regimes. Specifically, based on the equations underlying Figure 2, we have:

Proposition 1. (*Characterization of the Optimal Loan Contract*). We establish the following properties regarding the possible loanable funds equilibrium outcomes:

(i) If $(A-1) < (1-\theta)$, then there does not exist an incentive compatible loan contract and the loan market is non-active (Case III).

(ii) If $(1-\theta) \leq (A-1) < 2(1-\theta)$ and ω is sufficiently high, then there exists a credit rationing equilibrium where $q < 1$ (Case II).

(iii) Let $\overline{r} = \frac{(1-\theta)[2\delta+\mu]}{(A-1)-2(1-\theta)}$. If $2(1-\theta) < (A-1)$ and ω is sufficiently high, then $r < \overline{r}$ implies that there exists a credit rationing equilibrium where $q < 1$ (Case II) and $r \geq \overline{r}$ implies that the incentive compatibility constraint never binds the equilibrium loan contract (Case I).

Proof: See Appendix. □

Proposition 1 outlines the region of the parameter space consistent with the various possible equilibrium outcomes discussed in the previous section. This Proposition has a very intuitive interpretation. Loosely, if the productivity of the investment project is sufficiently low relative to the incentive friction, then there will always the incentive incentive to abscond for any loan contract along the SM locus. In this case (Case III), there is no active loanable funds equilibrium and the loan market "fails" to function. Once productivity begins to exceed a threshold level (Case II), lenders begin channeling loanable funds to borrowers, but the quantity is rationed. Finally, if productivity is sufficiently high, then whether or not there is rationing can be expressed in terms of the rate of time preference. In particular, if the rate of time preference is sufficiently small, then the present discounted value of consumption generated from absconding for the borrower becomes greater than the value of being matched in the loanable funds market. Lenders must continue to ration loans so that the incentive compatibility binds (Case II). If, on the other hand, the rate of time preference is very large, there will never be an incentive for the borrower to abscond and all loan contracts are incentive compatible (Case I).

Proposition 1 establishes that credit rationing of productive firms depends on a threshold $\overline{r}$. Next, we consider the underlying changes to this threshold that make credit rationing of productive firms more likely.

Proposition 2. (*Credit Rationing*). Given a sufficient productivity of the investment project $[(A-1) > 2(1-\theta)]$,

(i) An exogenous increase in market tightness (τ) increases the likelihood of credit rationing. For all $r > 0$, there exists $\tau < \infty$ sufficiently large such that equilibrium credit rationing will occur.

(ii) An increase in the loan contract period (duration), or decrease in δ, leads to an increase in the set of incentive compatible contracts and an increase in the loan market equilibrium interest rate. If the latter effect dominates the former, credit rationing is likely to occur.

Proof:

(i) The proof follows directly from Proposition 1. From (14) an (exogenous) increase in τ increases the frequency at which lenders meet borrowers, μ. Since $\frac{\partial \overline{r}}{\partial \mu} > 0$ it follows that an increase in market tightness expands the set of feasible rates of time preference consistent with the credit rationing equilibrium. As τ becomes arbitrarily large, $\overline{r} \to \infty$.

(ii) This follows directly from the observation that $\lim_{Q\to\infty} \delta R_{SM}$ and $\lim_{Q\to\infty} \delta R_{IC}$ are decreasing in δ. $\square$

To see the intuition behind this result, suppose that the initial steady state equilibrium is given by Case I. In this case, every loan contract that maximizes the joint match surplus of borrowers and lenders is incentive compatible. The Beveridge curve relationship given by (14) implies that an increase in market tightness increases the rate that lenders contact borrowers. This increases the threat point and bargaining power of lenders when negotiating the loan contract. As a result, the SM locus shifts upwards and this reduces the set of Q and δR combinations consistent with incentive compatibility. If the increase in market tightness is sufficiently large, IC will eventually intersect with the SM locus and credit will begin to be rationed at a higher equilibrium interest rate. Thus, we are more likely to see credit rationed in situations where the lack of liquidity in the credit market makes it difficult for borrowers to find loan opportunities.

A longer contract period (low δ) increases the set of incentive compatible contracts since the borrower can enjoy the productive benefits supported by the loanable funds for a greater period of time. This is captured by an upward shift of the IC locus. However, a longer contract period also makes the match more valuable to the borrower and biases the bargaining power towards lenders. Consequently, the SM locus shifts upwards as well. In Case II, the market equilibrium loan rate increases in both the case where there is no rationing ($\omega = \omega^L$) and when there is rationing ($\omega = \omega^H$). Whether or not credit rationing is more likely depends upon whether the bargaining effect dominates the incentive compatibility effect. If so, then the a longer contract period both increases rationing and the equilibrium loan rate.

Proposition 2 showed that an exogenous increase in the tightness of the credit market will eventually lead to credit rationing. However, because entry decisions of borrowers are endogenized in general equilibrium, this may no longer be the case. In particular, we find

Proposition 3. (*Market Tightness vs. Credit Rationing*) There is no necessary positive relationship between credit market tightness and the extent of credit rationing in general equilibrium.

To illustrate this proposition, consider the following comparative steady state analysis of an increase in funds matching efficacy (m_0) that improves matching for both lenders and borrowers in Case II. This is illustrated in Figure 3. Under our funds matching framework, a rise of m_0 raises the effective contact rate of funds suppliers Γ and strengthens their bargaining power. As a consequence, joint surplus maximization grants relatively higher returns to the suppliers, implying an increase in R for each given value Q. That is, the SM locus rotates upwards. From the ZP relationship, an increase in m_o will raise the matching rate $\eta(\tau)$ of borrowers. For a given Q determined by the optimal loan contract, more potential borrowers enter and hence the loan market becomes tighter. That is, the ZP locus twists toward the vertical axis.

For the case of $\omega = \omega^L$ where the incentive compatibility constraint is not binding, the equilibrium loan rate rises as the market participation (or tightness) increases. For the case of $\omega = \omega^H$, rationing increases in response to the increased entry of potential borrowers and a higher equilibrium loan rate is required to satisfy incentive compatibility. However, the increased severity of credit rationing reduces potential borrowers' expected profit, thereby decreasing their entry. Due to this latter opposing effect, the net change in the tightness of the loan market is ambiguous. Hence, an observed increase in credit rationing need not imply increased tightness in the credit market.

6 The Role of Market Frictions

We next explicitly consider the impact of search frictions (finite m_0), market entry frictions (v), and incentive frictions (θ) on the structure of optimal lending arrangements and steady state equilibrium in the loanable funds market. Each of these frictions is considered separately so that their relative contributions to explaining credit rationing and market failure can be isolated and analyzed.

6.1 Search Frictions

Without search frictions, credit market participants do not have to wait to set up a credit arrangement. In this case, we have

Proposition 4. (*Search Frictions*). In the absence of search frictions, the equilibrium loan contract and the existence of equilibrium credit rationing are independent of market tightness.

Proof: The absence of search frictions occurs in the limiting case where $m_0 \longrightarrow \infty$. The Beveridge curve relation implies that while μ and $\eta \longrightarrow \infty$, $\tau \equiv \mu/\eta$ will remain bounded by the constant returns to scale property of the matching technology. Using these and $\lim_{m_0 \longrightarrow \infty} \Gamma = 1$, the steady state equilibrium conditions (11), (12), and (19) are now given by $\delta R = A - \frac{rv}{Q}$, $\delta R \leq B + \frac{\delta v}{Q}$, and $Q = \frac{rv}{A-1}(1+\tau)$, respectively. Since τ no longer appears in the SM and IC loci, the optimal loan contract is independent of market thickness. □

This result says that search frictions are crucial for a linkage between market tightness, the optimal loan contract, and credit rationing. If borrowers and lenders can meet and enter into a lending agreement instantaneously, their relative bargaining position will not be affected by the tightness of the market. In this situation the only equilibrium outcomes are the conditional (Case II) and non-active (Case III) steady states. Because of the entry costs on the borrower's side, a reduction in search frictions increases the relative ease with which lenders locate borrowers. As in Proposition 2, this causes an upward shift in the SM locus. As the loan equilibrium interest rate rises, lenders must ration in order to keep the contract incentive compatible. The absence of search frictions in general equilibrium can be seen as a limiting case of this sequence of partial equilibrium events.

6.2 Entry Frictions

Here we consider costless entry of borrowers into the credit market. Under these circumstances, the demand for funds is perfectly elastic and we establish

Proposition 5. (*Entry Frictions*). In the absence of entry frictions, there does not exist a credit rationing equilibrium. Equilibrium in the loan market is characterized by either an active no rationing loanable funds market or a non-active loan market.

Proof: The absence of firm entry frictions occurs in the limiting case where $v \rightarrow 0$. Since there is now unrestricted borrower entry, the steady state conditions described (11), (12) are now given by $\delta R = \Gamma(A-1)+1$, $\delta R \leq B$. Existence of an active loanable funds market requires $\Gamma(A-1)+1 < B = A-(1-\theta)(\frac{r+\delta}{r})$. Satisfaction of this condition implies that all combinations of $(Q, \delta R)$ along the (horizontal) SM locus is incentive compatible and there is no credit rationing, $q = 1$. $\square$

To obtain intuition behind this result, suppose that the initial steady state equilibrium is given by the active no rationing equilibrium of Case I. In this situation, $B > \Gamma(A-1)+1$. Lower entry frictions encourages the entry of borrowers and this drives down their unmatched value. This rotates the SM locus clockwise as lenders take advantage of their increased bargaining power. At the same time, a lower unmatched value for the borrower must be compensated by a decrease in the loan rate or loan quantity to maintain incentive compatibility. In the limiting case as these costs vanish, no contract that offers an interest rate above B will be incentive compatible and no interest rate above $\Gamma(A-1)+1$ will be consistent with the optimal loan contract. Hence, there will only be an active no rationing equilibrium.

Alternatively, suppose that the initial steady state equilibrium is given by the conditional equilibrium of Case II. In this situation, $B < \Gamma(A-1)+1$. Lower entry frictions encourages the entry of borrowers and this drives down their unmatched value. As lenders take advantage of their increased bargaining power, the interest rate consistent with the optimal loan contract rises and the SM locus rotates clockwise. In the limiting case as entry costs vanish, the interest rate approaches its maximum value given by $\Gamma(A-1)+1$. At the same time, a lower unmatched value for the borrower must be compensated by a decrease in the loan rate or loan quantity to maintain incentive compatibility and this is captured by a counterclockwise rotation of the IC locus. In the limiting case as these entry costs vanish, no contract that offers an interest rate above B will be incentive compatible. Hence, as no optimal loan contract will be incentive compatible, the credit market fails to function there will only be a non-active equilibrium.

Furthermore, recall that Case I captures an active loan market equilibrium with no credit rationing only if the potential supply of loanable funds (ω) is sufficiently large. If ω is small then there may not be any positive rate of interest consistent with the optimal loan contract. However, as entry costs for borrowers are driven to zero, there will emerge an active non-rationing credit market equilibrium. If, on the other hand, the economy was initially characterized by the conditional Case II, possibly with credit rationing, then a removal of entry barriers will lead to a breakdown of the credit market and non-existence.

6.3 Incentive Frictions

Finally, we investigate the role of moral hazard for credit arrangements in the decentralized market. We detail how the equilibrium is affected if the cost of absconding is driven down to zero.

Proposition 6. (*Incentive Frictions*). In the absence of incentive frictions, there only exists an active, no rationing loanable funds market equilibrium.

Proof: The absence of incentive frictions corresponds to the limiting case where the costs of absconding as a fraction of total funds, $\theta \to 1$. It is immediate from Proposition 1 that for any given $A > 1$, we can rule out (i) the non-active equilibrium and (ii) the credit rationing equilibrium with $(A-1) \in (1-\theta, 2(1-\theta)) = \emptyset$. In the case where $(A-1) > 2(1-\theta)$, $\overline{r} = \frac{(1-\theta)[2\delta+\mu]}{(A-1)-2(1-\theta)} = 0$. Hence, all $r > 0$ satisfies $r > \overline{r}$ and in this case there exists the active, no rationing equilibrium. $\square$

Proposition 5 says that the moral hazard problem arising from incentive frictions is crucial in explaining the existence of both credit rationing and credit market failure. In the presence of these incentive frictions, search frictions provide a link between market liquidity and credit market tightness and credit rationing. Finally, borrower entry frictions also play a crucial role in explaining credit rationing. While the absence of such frictions do not preclude the non-active equilibrium, it does rule out credit rationing as an equilibrium outcome.

7 Duration of Loan Contracts

An innovative aspect of this our search model of the credit market is that it incorporates (exogenously) a variable capturing the duration of the loan contract. This was denoted by δ

(where $\frac{1}{\delta}$ corresponds to the length of the loan period). For example, in the previous section we discussed how an increase in the period of the loan contract can affect the incentive compatibility, the interest rate offer, and the possibility of credit rationing. An interesting application of this framework would be to study how the period of the loan contract affects the interest rate offer and vice versa. A simple illustration of this would be to consider the case of the active equilibrium with no credit rationing (Case I). Here, the optimal contract interest rate is just given by substituting $Q^* = \omega$ into (11) to get:

$$\delta R^* = [A - \frac{rv}{\omega}]\Gamma + (1 - \Gamma) \tag{21}$$

Notice that as long as $(A-1) > \frac{rv}{\omega}$, which is satisfied if the supply of loanable funds ω or the productivity of the investment project A is sufficiently large. In this case a decrease in δ, or increase in the length of the loan contract, increases Γ and hence the optimal loan interest rate δR^*. One could interpret this as an upward sloping yield curve in $(\frac{1}{\delta}, \delta R)$ space. While beyond the focus of this paper, it would be of interest in future work to more completely analyze the term structure properties of a search model of credit.

A related issue would be to extend our model to address the endogenous joint determination of the quantity, loan rate, and loan contracting period. One way to approach pinning down $(Q, \delta R, \delta)$ is to have all three objects be the outcome of decentralized bilateral bargaining between lenders and borrowers. In other words, have them be a solution to a Nash bargaining problem (P) which maximizes the joint surplus of the lender and borrower:

$$\max_{q\omega,\, \delta R,\, \delta} \quad (J_m - J_u)^{1/2}(\Pi_m - \Pi_u)^{1/2} \tag{P}$$

$$\text{s.t.} \quad J_m - J_u = \frac{(1-q)\omega + \delta R q\omega - rJ_u}{r+\delta} \quad \text{and} \quad \Pi_m - \Pi_u = \frac{(A - \delta R)q\omega - r\Pi_u}{r+\delta}$$

In addition to the bargaining condition for δR given in (11), we now have an additional first order condition associated with δ that, after simplification, is given by,

$$Rq\omega\left(\frac{1}{J_m - J_u} - \frac{1}{\Pi_m - \Pi_u}\right) = \frac{1}{r+\delta} \tag{22}$$

Because the expression in brackets is equal to zero ($J_m - J_u = \Pi_m - \Pi_u$), this implies an optimal choice of $\delta^* \to \infty$. That is, instantaneous credit transactions and separations maximize the joint surplus of a borrower-lender pair when production is instantaneous at the time of a match. This result delivers an important message. In our admittedly highly stylized framework, where long-term relationships only lower search costs but do not alter incentive frictions, there exists no reason to continue a credit relationship. This is because the marginal gain in matched values from continuing a relationship is dominated by the marginal loss in unmatched values (via the bargaining threat points). Undoubtedly, adding more realistic features to the model will provide additional incentive to prolonging credit relationships. For instance, allowing learning and diminishing incentive frictions over the time agents are matched may yield outcomes that favor long-term relationships. Although it is beyond the scope of the current paper to go further along this path, we would like to point out that there is an active literature exploring long-term credit relationships.[11]

8 Concluding Remarks

This paper has presented a simple search-theoretic model of the credit market. The model features endogenous entry and moral hazard because they are particularly important factors in determining the fortunes of entrepreneurs. Our analysis describes the optimal incentive compatible loan contracts and equilibria that emerge in such an environment. While we tie the extent of mismatch to the tightness of credit markets, we find that mismatch and tightness are somewhat of a "red-herring" for understanding the extent of credit rationing. This is because endogenous entry severs any relationship between credit market tightness and credit rationing. We also show that entry and incentive frictions are important factors for determining when credit markets breakdown. In other words, the ease of entry into the credit market and the ease of exit from the credit market (via default) are important for market breakdown. This suggests that understanding the boundaries of the market is fundamental for understanding credit market breakdown. Finally, we show that search and incentive frictions are important for determining the extent of credit rationing. In other words, it is the ease of finding a credit partner and the ease of undoing a partnership that are

[11] For instance, Hart and Moore (1998) investigate mechanisms and incentives to renegotiate debt contracts in the face of credit market imperfections anf incomplete contracting.

important for rationing. This suggests that understanding the boundaries of a relationship is fundamental for understanding rationing. We believe that our simple framework will be a useful vehicle for further investigation into these boundary issues.

There are several other possibilities for future work. First, it would be interesting to reexamine the optimal loan contract and the likelihood of market breakdowns under alternative setups of the moral hazard problem. In passing we have identified several possibilities that are of general interest. In particular, one may allow the borrower to use the loanable funds to produce before absconding or permit the absconder to participate in the loan market after paying for the penalty of bankruptcy. Moreover, following Hart and Moore (1994 and 1998), one could contrast the situation where the lender can divert project returns only to the situation where part of the underlying assets can be diverted. In any case, the incentive compatibility constraint must be modified, which may lead to different equilibrium outcomes. Second, one might argue there is too much randomness in our matching model and that this randomness exaggerates the moral hazard problem and diminishes the benefit of long-term relationships. One way to address this issue is to adopt the directed-search price-posting game developed by Peters (1991). Specifically, there are two segregated submarkets: one similar to the environment in the present paper and one with lenders requiring full credit documentation (that presumably minimizes the incentive frictions). Since all borrowers are identical *ex ante*, each lender in each segregated submarket posts for all borrowers the flow interest rate and the duration of the loan contract to maximize the expected value subject to a no-arbitrage condition that ensures all borrowers receive equal value *ex ante*. As a consequence, the loan contracts are generally different between the two submarkets, and free mobility of borrowers results in different matching probabilities and hence different measures of tightness within the two credit markets.

Appendix

Proof to Proposition 1

(i) Consider the case where $(A-1) < (1-\theta)$. This implies that $B \equiv A-(1-\theta)(\frac{r+\delta}{r}) < 1$ so that the IC locus has a horizontal intercept at $Q_{IC} = \frac{\delta \Pi_u}{1-B}$. Suppose there exists an active loanable funds equilibrium. This implies:

$$\frac{\delta \Pi_u}{1-B} = Q_{IC} < Q_{SM} = \frac{r\Pi_u}{A-1}$$

$$\text{or,} \;\; r(1-B) < \delta(A-1)$$

$$\text{or,} \;\; r[(1-\theta)-(A-1)] < \delta[(A-1)-(1-\theta)] \tag{A1}$$

since the right hand side of this expression is negative while the left-hand side is positive, we have a contradiction. Hence, no active loanable funds equilibrium exists. (Case III)

(ii) Consider the case where $(1-\theta) \leq (A-1) \leq 2(1-\theta)$. From the SM locus given by (11) notice that $\lim_{Q\to\infty} \delta R_{SM} = \Gamma(A-1)+1$. Similarly, from the IC locus given by (12), $\lim_{Q\to\infty} \delta R_{IC} = B$. If $B < 1$, then from (23) we know $Q_{IC} \leq Q_{SM}$ and there exists a loanable funds equilibrium. Since the SM locus must cross the IC locus, we have the credit rationing case where $q < 1$ for ω sufficiently large. For $B > 1$, we need to verify that,

$$\lim_{Q\to\infty} \delta R_{SM} > \lim_{Q\to\infty} \delta R_{IC}$$

$$\text{or,} \;\; \Gamma(A-1)+1 > B$$

$$\text{or,} \;\; [\frac{r+\delta+\mu}{2(r+\delta)+\mu}](A-1)+1 > A-(1-\theta)(\frac{r+\delta}{r})$$

$$\text{or,} \;\; r[(A-1)-2(1-\theta)] < (1-\theta)[2\delta+\mu] \tag{A2}$$

Since the right-hand side of (23) is non-positive and the right-hand side is strictly positive, this condition holds. Thus, there is a unique credit rationing equilibrium where the SM locus intersects the IC locus (Case II).

(iii) Consider the case where $(A-1) > 2(1-\theta)$. Solving for r in (23) gives,

$$r < \frac{(1-\theta)(2\delta+\mu)}{(A-1)-2(1-\theta)} \equiv \overline{r} > 0$$

This condition is sufficient to guarantee that $\lim_{Q\to\infty} \delta R_{SM} > \lim_{Q\to\infty} \delta R_{IC}$ and the existence of a credit rationing equilibrium (Case II). However, if $r \geq \overline{r}$, then $\lim_{Q\to\infty} \delta R_{SM} \leq \lim_{Q\to\infty} \delta R_{IC}$ and every loan contract along the SM locus is incentive compatible. The incentive compatibility constraint does not bind in this case and there is no rationing (Case I). $\square$

Measures of Credit Market Tightness

An alternative measure of credit market tightness is given by the ratio of unmatched borrowers to the total pool of borrowers or the "capital unemployment rate" (κ):

$$\kappa = \frac{N_u^B}{N_u^B + N_m^B}$$

Since $N_u^B = \tau N_u^L$ and $N_m^B = N_m^L = \frac{\mu}{\delta} N_u^L$, we have:

$$\kappa = \frac{\tau}{\tau + \mu/\delta} = \frac{\tau}{\tau + m_0 M(1,\tau)/\delta} = \frac{1}{1 + \frac{m_0}{\delta} M(\frac{1}{\tau}, 1)} \equiv \kappa(\tau) \tag{A3}$$

From (23), it is easily verified that κ is monotonically increasing in τ.

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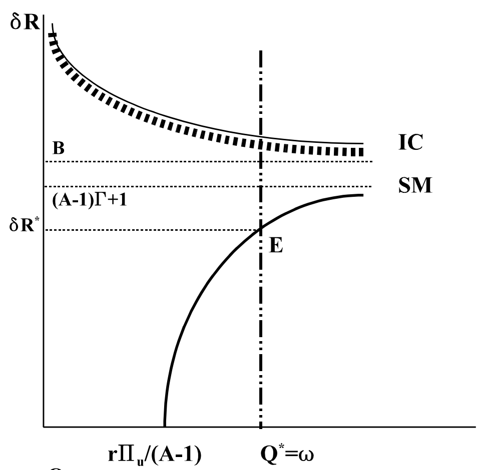
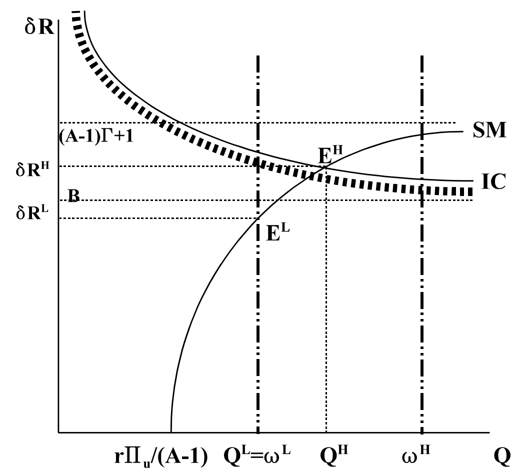
Figure 1: Optimal Incentive Compatible Loan Contract (Q = Τq and *R)

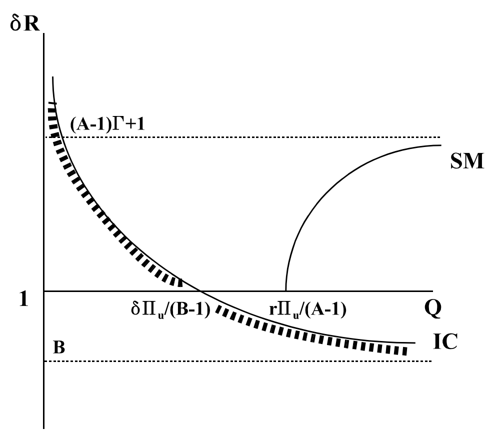
Case I: $(A-1)>2(1-\theta)$ **and** $r \geq \bar{r}$



Case II: $(A-1)>2(1-\theta)$ **and** $r<\bar{r}$
or $(1-\theta) \leq (A-1) \leq 2(1-\theta)$



Case III: $(A-1)<(1-\theta)$



Notes: There are three cases, depending on the relative position of the SM and IC loci:

1. Case I — incentive compatibility constraint never binds;
2. Case II — incentive compatibility constraint binds only when funds available are high and in that case, the amount of loan is rationed;
3. Case III — optimal incentive compatible loan contract does not exist.

Figure 2: Steady-State Loanable Funds Equilibrium

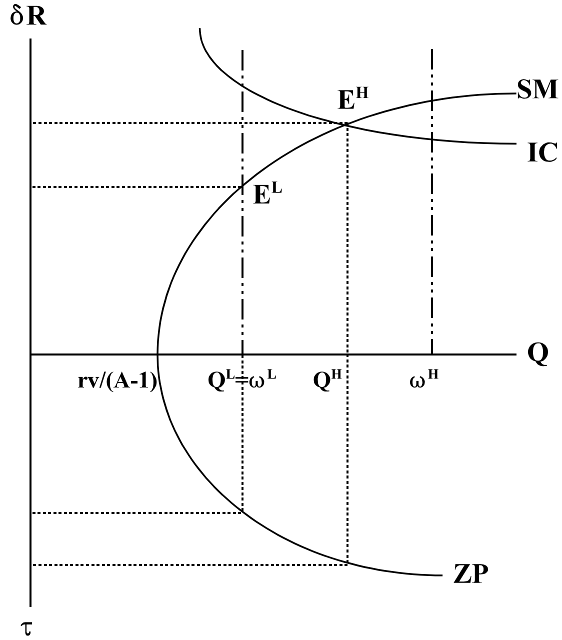


Figure 3: Equilibrium Responses to a Reduction in Search Frictions (Higher m_0)