Multiple Equilibria in Markets with Screening

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Abstract

This paper adds endogenous screening to Broecker (1990) and shows the possibility of multiple screening equilibria. A high intensity of screening by a bank decreases average quality of firms applying to other banks, which in turn have further incentives to screen. The link between the degree of concentration of the banking industry and the extension of credit is also discussed.

Key words: Banks - Asymmetric Information - Externalities.

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1. Introduction

The information-gathering and information-processing functions of banks have crucial implications for the nature of banking competition. This point has been stressed by Broecker (1990) who analyzes a credit market where banks use imperfect and independent tests to assess the ability of potential creditors to repay a loan. Since the screening process induces a bank to fund higher quality projects rather than low quality ones, it lowers the average quality of applicants to other banks. This entails a negative screening externality between banks. Shaffer (1997) finds supportive evidence of this effect using a large sample of U.S. commercial banks during the period 1986-1995.

This paper extends Broecker's analysis by adding two levels of screening, and shows the possibility of multiple screening equilibria under general assumptions[1]. While the negative screening externality appears in his model when banks lower their interest rate, it appears here when banks select the higher level of screening. The resulting decrease in quality of the pool of firms applying to other banks is a further incentive to screen. Consequently, several equilibria with different levels of screening by banks can arise for a given set of fundamentals.

Section 2 presents the model. Section 3 describes the two possible screening equilibria. Section 4 shows how multiple equilibria arise. The last section provides some concluding remarks and suggests some macroeconomic extensions of the model.

2. The model

The model extends Broecker (1990) by a choice of the intensity of screening and the explicit introduction of time. A credit market populated by $N \geq 2$ banks is considered with two types of firms, denoted by $j = g, b$. Banks and entrepreneurs (or firms) are risk-neutral. All projects require the same amount of investment, which is normalized to unity. A project yields $X > 0$ if successful with probability p_j, $j = g, b$ and zero in case of failure with probability $1 - p_j$. While an investment project of type g is socially valuable, the type b one is not:

$$p_g X > r > p_b X,$$

where r is the safe gross interest rate.

Entrepreneurs have no initial wealth and rely on banks to finance their projects. Funds are raised through a standard debt contract that requires a fixed repayment R_t at date t in the non-bankruptcy state. With limited liability, the expected return to the firm is $p_j(X - R_t)$. An entrepreneur is willing to undertake the project if the expected return is positive, that is $R_t \leq X$.

Time is introduced by assuming that firms can visit at most one bank in one period. At each date, a continuum of size 1 of g projects and a continuum of size l of b projects enter the market. Together with the old ones, they randomly choose a bank not already visited and privately negotiate the interest rate. The bank makes an offer which may be refused by the customer who may then shop for further offers[2].

The option value from a firm's perspective depends on its expectations about future pricing policies of other banks. The more stringent these policies are expected to be, the lower the option value. Banks offer an interest rate such that a g applicant does not wait for another proposal:

$$p_g(X - R_t) \geq \beta^j p_g(X - R_{t+j}) \qquad \forall j = 0, 1, ... \tag{2.1}$$

where $\beta < 1$ is the rate at which firms discount future profits. Next, banks decide whether to screen. They have access to a screening technology that imperfectly distinguishes profitable projects from unprofitable ones. Let $\alpha_{it} = 0, 1$ denote the screening decision of some bank i at date t. $\alpha_{it} = 1$ if the bank invests in information on applicants, and $\alpha_{it} = 0$ if it does not collect information. The screening test yields a signal that is either G or B, B meaning rejected. Type b firms produce a B signal with probability q_b, whereas g firms produce a B signal only with probability $q_g < q_b$.[3]

It is assumed that banks do not share screening evaluations of firms. The recent literature on evaluation sharing suggests that this kind of information is difficult to communicate if the quality of the evaluation cannot be assessed, if information produced about a borrower creates a market power, or if information is complex, not standardized, subjective or costly compared to the size of the loan (Shaffer 1997,Avery et al. 1999 and Jappelli-Pagano 1993, 2002 and references therein). Hence, the model is not suited to study markets for personal loans and trade credit where evaluations are commonly shared. This is different for young firms without credit history, or companies of medium and large size. The information needed to assess their creditworthiness is more complex and therefore less likely to be standardized and transferable.

Screening by banks costs $c > 0$ per applicant. Part of the evaluation costs could also be borne by loan applicants (see e.g. Bernanke and Gertler 1990). For example, banks could ask an application fee as in De Meza and Webb (1988) in order to partially recoup their costs of screening. Modifications of the way the screening is paid for would not alter the properties of the model insofar as they cannot serve as a free sorting device. While there is no self-selection if entrepreneurs do not know their type, this is also the case, as in the model, if the residual revenue of the firms in case of success is independent of their risk type.

Let lQ_{it}^b (respectively Q_{it}^g) be the number of b (g) firms which visit a bank i at date t. These numbers depend on past screening decisions and will be made explicit below. Banks obtain funds from depositors at the safe gross interest rate r. The bank's profit is expressed as:

$$\pi(\alpha_{it}; Q_{it}^g, lQ_{it}^b) = Q_{it}^g[(1-\alpha_{it}q_g)(p_g R_t - r) - \alpha_{it}c] + lQ_{it}^b[(1-\alpha_{it}q_b)(p_b R_t - r) - \alpha_{it}c] \tag{2.2}$$

In case of screening ($\alpha_{it} = 1$), all projectholders are funded (the average expected surplus of the pool of applicants will be taken to be positive). The first term of the profit is the net return from accepted g firms, whose surplus from the lending relationship is positive. The second term represents the net return of b firms, which is assumed to be negative

The Nash equilibrium interest rate of the game is equal to X regardless of the actual level of screening. To prove this claim, note first that $R_t = X$ is feasible, satisfies the end of search condition (2.1), and cannot be raised by a bank without violating the participation constraint of the firm. On the other hand, if the interest rate were lowered, the bank would not maximize profits given expected future interest rates. Second, the case in which all the banks set a common interest rate less than X cannot be a Nash equilibrium as a bank would increase its profit by charging a slightly higher interest rate while preserving the end of search condition (2.1).

In the following, I focus on symmetric equilibria in which the level of screening, denoted α_t, is identical across banks at all dates. Symmetric equilibria appear if firms apply with the same probability to banks which have not been already visited. In that case, each bank faces the same number of each type of firms, that is the fraction $1/N$ of lQ_t^b or Q_t^g, the two aggregate populations of firms.

Note that the bank's objective (2.2) is by nature static. This is because a rejected firm cannot apply a second time to the same bank. As a result the screening decision does not affect the bank's profit at future dates. Yet screening decisions have implications for other banks' future screening choices, because they determine the ratio of unprofitable firms staying in the market. This interaction can be best understood as an intertemporal screening externality, the consequences of which are discussed below.

3. Intertemporal equilibrium

An intertemporal equilibrium is a sequence of static equilibria made conditional on future interest rate offers and on past screening decisions summarized by the state variables Q_t^g and Q_t^b. Attention is restricted to steady state equilibria, in which screening is invariant through time (the subscript t is therefore dropped).

Whenever banks screen, type $j = b, g$ firms are rejected in proportion q_j. If banks repeatedly screen, lq_b^n unprofitable firms and q_g^n profitable firms are eventually turned down N times and leave the market. Hence, the stationary number of j firms visiting a bank is $\overline{Q}^j = 1 + q_j + q_j^2 + ... + q_j^{N-1}$, $j = b, g$. Permanent screening arises if:

$$\begin{cases} \pi(1; \overline{Q}^g, l\overline{Q}^b) > \pi(0; \overline{Q}^g, l\overline{Q}^b) \\ \pi(1; \overline{Q}^g, l\overline{Q}^b) \geq 0 \end{cases}$$

If banks do not screen, all firms are funded as soon as they enter the credit market: $Q^j = 1$, $j = b, g$. Prolonged pooling is sustainable if:

$$\begin{cases} \pi(0; 1, l) \geq \pi(1; 1, l) \\ \pi(0; 1, l) \geq 0 \end{cases}$$

4. The equilibrium level of screening

The following proposition states that the same fundamentals may result either in permanent screening or in permanent pooling:

Proposition 1. There exists a set of values for the parameters $(l, c, p_b, p_g, q_b, q_g)$, for which either a screening or a pooling equilibrium may occur.

Proof of proposition 1. To prove such a proposition, it is useful to begin by defining the value function $V(.)$, attached to investing in information:

$$V(lQ^b/Q^g) \overset{(def)}{=} \frac{1}{Q^g}[\pi(1; Q^g, lQ^b) - \pi(0; Q^g, lQ^b)]$$
$$= \frac{lQ^b}{Q^g}[q_b(r - p_b X) - c] - q_g(p_g X - r) - c$$

The ratio lQ^b/Q^g sums up the effects of past screening decisions by other banks on a given bank's choice whether to invest in screening or not. For the signal to be informative $q_b > q_g$, or equivalently $\overline{Q}^b/\overline{Q}^g > 1$ must hold. As $q_b(r - p_b X) - c > 0$ (the converse case would mean $\pi(1; \overline{Q}^g, l\overline{Q}^b) < \pi(0; \overline{Q}^g, l\overline{Q}^b)$, causing the signal to be worthless), $V(.)$ is increasing in lQ^b/Q^g. This entails $V(l\overline{Q}^b/\overline{Q}^g) > V(l)$. Since $Q^b/Q^g > 0$, $V(lQ^b/Q^g)$ is also increasing in the number of bad firms, l. Moreover, $V(lQ^b/Q^g)$ is necessarily negative for any l which is small enough, and positive for any l which is large enough. Hence, there exists a range of values for l such that $V(l\overline{Q}^b/\overline{Q}^g) > 0 \geq V(l)$ or equivalently, for l such that:

$$\pi(1; \overline{Q}^g, l\overline{Q}^b) - \pi(0; \overline{Q}^g, l\overline{Q}^b) > 0 \geq \pi(1; 1, l) - \pi(0; 1, l)$$

Those last inequalities characterize the existence of multiple screening equilibria. □

The mechanism behind this result is intuitive. If banks expect a high (respectively, low) quality pool of applicants they will find little (much) reason to screen, hence there will be few (many) low quality rejects being returned to the applicant pool. Then, the pool will be of high (low) quality, confirming the banks' expectations.

The model also has implications for the link between the degree of concentration of the banking industry and the extension of credit. A long-held view is that aggregate credit should be lower in concentrated banking markets because of monopoly power. In the model the number of banks affects the incentives to fund projects as it modifies the relative population of each risk type in the credit market. It is shown that a concentrated banking market leads to a less cautious credit policy and possibly a higher level of credit.

Proposition 2. A screening equilibrium is less likely when the number of banks is small.

Proof of proposition 2. As in the proof of the previous proposition, let us define the value of screening when all other banks screen applicants:

$$V(l\overline{Q}^b/\overline{Q}^g) = \frac{l\overline{Q}^b}{\overline{Q}^g}[q_b(r - p_b X) - c] - q_g(p_g X - r) - c$$

V depends on the number of banks through the proportion of bad projects $l\overline{Q}^b/\overline{Q}^g$ in the credit market, with $\overline{Q}^b/\overline{Q}^g = (1+q_b+..+q_b^{N-1})/(1+q_g+...+q_g^{N-1})$. A higher $\overline{Q}^b/\overline{Q}^g$ raises the value of screening and the likeliness of a screening equilibrium. It remains to show that $\overline{Q}^b/\overline{Q}^g$ is increasing in N. This is the case if: $(1 + ... + q_b^{N-1} + q_b^N)/(1 + ... + q_g^{N-1} + q_g^N) > (1 + ... + q_b^{N-1})/(1 + ... + q_g^{N-1})$ or if:

$$\frac{q_b^N}{q_g^N} > \frac{1 + ... + q_b^{N-1}}{1 + ... + q_g^{N-1}} \tag{4.1}$$

This inequality is proven by induction. It is true for the smallest case $N = 1$ since the signal is informative : $q_b > q_g$. Provided that (4.1) is true, the following sequence of inequalities hold: $(1+...+q_g^{N-1})/q_g^N > (1+...+q_b^{N-1})/q_b^N \Rightarrow (1+...+q_g^{N-1})/q_g^N+q_g^N/q_g^N > (1+...+q_b^{N-1})/q_b^N+q_b^N/q_b^N \Rightarrow (1+...+q_g^{N-1}+q_g^N)/q_g^N > (1+...+q_b^{N-1}+q_b^N)/q_b^N \Rightarrow (1+...+q_g^{N-1}+q_g^N)/q_g^N > (q_g/q_b)\,(1+...+q_b^{N-1}+q_b^N)/q_b^N$ since $q_b > q_g$. Hence: $q_b^{N+1}/q_g^{N+1} > (1 + ... + q_b^N)/(1 + ... + q_g^N)$ which proves the inductive step. As a result, the value of screening V is increasing with N. $\square$

The banking concentration produces two effects on the likeliness of a loan applicant to be granted a loan. Fewer banks means fewer opportunities to be accepted by one of them for a given level of screening. On the other hand, fewer banks improves the average quality of the pool and makes banks less cautious when they select their customers (proposition 2). Hence the commonly asserted link between concentration and low aggregate credit is not confirmed by the model, as a limited number of banks may screen less and fund more projects.

Proposition 2 has another implication. The pooling equilibrium remains unaffected by the number of banks since all projects are funded. This means that as the banking market becomes more concentrated, the region of multiple equilibria shrinks. Hence, a more concentrated banking industry may be associated with less instability in lending standards.

Some policy implications can also be drawn. A high level of screening hurts future profits of banks by deteriorating the quality of the pool of applicants. As in Broecker (1990), this interaction is not internalized by banks and acts as a negative externality. Therefore, it can be shown that the screening equilibrium is inefficient if the pooling equilibrium can be implemented at the same time as an equilibrium[4].

Finally, in a context of overscreening, a policy that encourages more lending may have a beneficial "pump-priming" effect, similar to that demonstrated in a different (but also information-based) context by Lang and Nakamura (1993). If one bank extends more credit by lowering the level of screening, the quality of applicants increases for other banks and may lead them to lower their own standards, thus moving the economy toward a high credit equilibrium and a low, yet more efficient, level of screening.

5. Conclusion

This article has shown that a simple extension of Broecker (1990) may straightforwardly lead to multiple screening equilibria in the credit market. The result confers a key role on banks optimism or pessimism about the risk type of loan applicants and may shed light on some recent macroeconomic facts. In a broad literature survey, Berger and Udell (2003) argue that, whereas banks' lending behavior is procyclical, their lending standards are countercyclical. Banks take significantly more risks during the expansion phase, even though these risks materialize later. This note offers a microeconomic framework which may be useful to discuss such issues by examining the economic value of information about loan applicants. Further research could embed the screening decision in a full-fledged macroeconomic setting that endogenizes the cost of funds as a function of aggregate credit, and by studying the resulting dynamics of screening.

A variable level of selection may also contribute to a better understanding of credit crunch episodes. A credit crunch is usually defined as a sharp decline in the supply of credit that is abnormally large for a given stage in the business cycle (Bernanke and Lown 1991). An obvious way to reduce the supply of credit is to raise the level of screening. In the model, banks are shown to become more selective when the perceived quality of the pool of applicants worsens. Such a worsening characterizes the beginning of a recession and thus may pave the way for a credit crunch.

Finally, as suggested by the title of this note, and previously outlined by Broecker, the basic setting of multiple and independent testing can be applied to other markets in which uninformed agents evaluate applicants. The multiple equilibria result may be relevant for markets of skilled workers or the refereeing process of research articles (see also Nakamura, and Shaffer 1991).

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Footnotes

[1] See Gale (1993), Thakor (1996), Manove et al. (2001), and Gehrig and Stenbacka (2003) for other models of endogenous screening.

[2] This is a natural and established way of modeling the bargaining process in the literature about sequential search (e.g. Burdett and Judd 1983 in the product market or Bizer and DeMarzo 1992 in the banking market). The alternative case a of publicly released interest rate offer is examined by Broecker (1990).

[3] The assumptions of binary signals (G or B) in presence of a binary borrower types (g or b) are not restrictive. Because the lending decision is necessarily binary (lend or reject), a more complex set of signals would necessarily map onto a binary choice variable and can thus be adequately represented as binary themselves. More generally, the crucial element is that an unprofitable project is more likely to be discarded than a profitable applicant when a bank invests in a screening process.

[4] A similar result can be found in the more general framework of Cooper and John (1988). The screening externality studied here can be interpreted as a type of strategic complementarity between banks.