MEDDELANDEN FRÅN
SVENSKA HANDELSHÖGSKOLAN

SWEDISH SCHOOL OF ECONOMICS
AND BUSINESS ADMINISTRATION
WORKING PAPERS

461

Thomas Gehrig & Rune Stenbacka

SCREENING CYCLES

AUGUSTI 2001

Key words: banking competition, financial stability, lending cycles, screening

JEL Classification: D83, E32, E44

Distributor:

Library
Swedish School of Economics and Business Administration
P.O.Box 479
00101 Helsinki
Finland

Phone: +358-9-431 33 376, +358-9-431 33 265
Fax: +358-9-431 33 425
E-mail: publ@shh.fi
http://www.shh.fi/link/bib/publications.htm

SHS intressebyrå IB (Oy Casa Security Ab), Helsingfors 2001

ISBN 951-555-698-8
ISSN 0357-4598

SCREENING CYCLES*

Thomas Gehrig

University of Freiburg and CEPR, London

Rune Stenbacka

Swedish School of Economics, Helsinki

28 June 2001

We demonstrate how endogenous information acquisition in credit markets creates lending cycles when competing banks undertake their screening decisions in an uncoordinated way, thereby highlighting the role of intertemporal screening externalities induced by lending market competition as a structural source of instability. We show that uncoordinated screening behavior of competing banks may be not only the source of an important financial multiplier, but also an independent source of fluctuations inducing business cycles. The screening cycle mechanism is robust to generalizations along many dimensions such as the lending market structure, the lending rate determination and the imperfections in the screening technology.

---

* We are grateful for the comments by Hannu Vartiainen and seminar participants at the Swedish School of Economics in Helsinki. Financial support of the Academy of Finland, the DAAD and the Hanken Foundation is gratefully ackowledged.

I. Introduction

Stylized facts point to business cycles as substantial, persistent and asymmetric fluctuations in aggregate output. Even in big and fairly well diversified economies these fluctuations represent an sizeable fraction of the economic activity. The typical business cycle pattern offers support for the view of these fluctuations as persistent and asymmetric in the sense that downward movements have been sharper and quicker than phases of economic recovery and fast growth.

Random economy wide shocks could represent a natural candidate for explaining business cycles. Such an explanation, however, seems far from sufficient since the fluctuations in exogenous factors such as government policy, natural resources, weather etc. are not large enough to account for the fluctuations in aggregate output. For that reason economists have recently directed much attention to finding and characterizing mechanisms which transform minor shocks to some or all parts of the economy into large, persistent and asymmetric fluctuations in aggregate output. In this respect the credit market has been in the focus of much attention.

Models addressing financial accelerator effects emphasize mechanisms whereby adverse shocks to the economy are endogenously amplified and propagated by credit market imperfections. These models are surveyed within a dynamic general equilibrium framework by, for example, Bernanke, Gertler and Gilchrist (2000). On an intuitive level already Fisher (1933) discussed how credit constraints propagate the effects of shocks on aggregate output and asset prices. According to Fisher, the more the private sector places emphasis on solving its debt problem the deeper the economy will be caught in a debt trap. In an influential recent article Kiyotaki and Moore (1997) constructed a model of a dynamic economy where borrowers' credit limits are affected by the prices of the collateralized assets. Their analysis shows how the dynamic interaction between credit limits and asset prices will constitute an important transmission mechanism whereby shocks to the economy persist, amplify and spill over across different sectors.

In the present analysis we introduce a transmission mechanism whereby large, persistent and asymmetric fluctuations in economic activity might be created and amplified through endogeneous screening investments by lenders engaged in repeated noncooperative competition. A crucial starting point of our analysis is the absence of a credible institution for information exchange between banks. Within such a context the non-cooperative information acquisition decisions of banks with perfect recall creates a dynamic link between the banks' screening of loan applications. Projects denied funding by one bank in one period will approach rival banks in subsequent periods leading to systematic dynamics of the pool of project applications. This dynamic link will generate a pool-worsening externality between competing lenders since the proportion of non-creditworthy projects will increase in the pool of project applications facing a particular bank.

The screening-induced lending cycles implied by our model should be seen as a mechanism complementary to that of Kiyotaki and Moore (1997). In principle, in both models the operation of a lending industry with rational banks endogenously generates substantial, persistent and asymmetric fluctuations. However, the screening-induced lending cycles predicted by our model are more robust insofar as they are generated not only in response to exogenous shocks, but even in a stationary economic environment. On the other hand, our type of screening-induced lending cycles emerges only insofar as there is repeated non-cooperative screening and lending rate competition among banks, but not in the context of a monopoly bank protected from competition.

Our model can also be viewed as a contribution to the literature on the relationship between banks' incentives for ex ante monitoring and lending market structure. The existing literature focusing on this relationship within the framework of a static context, for example, Gehrig (1998) and Kanniainen and Stenbacka (2000), has shown that competition tends to undermine the incentives to avoid project-specific classification errors. In this respect the present paper emphasizes an additional mechanism. Uncoordinated screening by competing banks generates a pool-worsening external effect whereby competition opens up a probability of entering a phase of inactivity, where no projects are funded. Also if the pool-worsening effect is not strong enough to induce inactivity it will nevertheless increase the lending rate relative to that which a static banking oligopoly would charge.

Our model makes it possible to characterize the nature of the screening-induced lending cycles. We find that these cycles are affected by the number of competing banks as well as by the growth rate of the economy in the sense of the size of the newly born generation of project holders relative to the size of the incumbent vintage of entrepreneurs.

Our analysis proceeds as follows. Section II presents the basic framework. Section III analyses a coordinated banking industry operating in the absence of competition. Section IV presents the central result and demonstrates how competition in a banking duopoly gives rise to dynamic instability and cycles in screening and lending. Section V outlines generalizations and a discussion of the basic results. Section VI concludes.

II. The Model with Costly Screening

We assume that there is a pool of risky projects. The implementation of each project requires one unit of funding. The projectholders are equipped with no capital of their own and do not have access to outside equity capital. Thus, we assume that the projects will have to be fully financed by banks making use of standard debt contracts exhibiting limited liabilility. The banking industry attracts funds at a competitive deposit market equal to the (safe) interest rate $r_0 \geq 0$. For subsequent use we let $R_0 = 1 + r_0$.

There are two types of agents, entrepreneurs and banks. They are both impatient with discount factors $\delta_e < 1$ and $\delta_b < 1$, respectively.

Entrepreneurs can be of two types. Depending on the borrower-specific type they control a G (good) or B (bad) project. We assume that a project of type G has a success probability π as well as an associated return under success, R_G, satisfying $\pi R_G > 1$. The type-G projects yield a zero return only under failure, but the success probability of this project type is sufficiently high so as to justify funding. Projects of type-B are assumed to always generate a zero return. Thus, there is a substantial quality difference between the project types in the sense that only projects of type G are creditworthy, while type-B projects always generate a zero return.

Banks cannot directly distinguish type-G from type-B applicants. However, they have access to a screening technology. We will concentrate the analysis of sections III and IV on the case of perfect screening technologies and only in section V we briefly discuss the case of imperfect screening. Hence, assume for now that by spending a fixed project-specific monitoring expenditure $c>0$ the bank can determine the type of a project application with certainty. Clearly, if the bank makes use of the available screening technology it is optimal to grant credit to those projects classified as G, while denying finance to those classified as B.

The banking industry operates with an infinite horizon *t=0,1,2, ...*. In each period there are $B \geq 1$ banks.

Each period new potential projects enter the banking market. Denote the mass of entering projects in period t by η_t and the proportion of profitable (good) projects by $0 < \lambda_t < 1$. In principle, both the size of the pool of new projects as well as its composition may vary over time in the business cycle. Since our concern is to analyze how the conduct of banks engaged in repeated competition may generate cycles, we will be largely concerned with a stationary pool of new projects so as to actually bias the model against cycling.[1] Thus, we assume $\eta_t = \eta = 1$ and $\lambda_t = \lambda$ for *t=1,2,...* .

In each period t banks face a pool of project applications consisting of new entrants and, in addition, applicants that have been rejected by some rival bank some earlier period. The statistical properties of this pool depend among others on whether banks recall earlier applications and on the extent to which the banking industry adopts information sharing. We assume *perfect recall* on the side of the banks. Hence a rejected applicant will direct future funding applications to rival banks and leave the pool of applicants when the set of banks is exhausted. Moreover, we assume that banks do *not share information* about earlier screening results. Accordingly, the pool of applications for a given bank consists of a random allocation of the new vintage of projects and a share of opportunistic applications of formerly rejected entrepreneurs.

Hence, banks need to decide about their screening and lending activities. They can lend without screening, they can provide screened lending only, or they can remain inactive altogether.

After the screening results are obtained, or when the bank decides to offer unscreened loans, the banks and the entrepreneurs enter the stage of lending rate negotiations. The lending rate negotiations take place between the banks and the G-type entrepreneurs if the banks conduct monitoring, while these negotiations capture all entrepreneurs if loans are granted without monitoring. We assume that a successful

---

[1] Clearly, while we predominantly concentrate on the endogenous generation of cycles, our analysis has implications for the amplification of exogenous shocks.

entrepreneur can always threaten to acquire a second screen from a competing bank at some later period. However, since this second offer is subject to some delay, the current bank can exert some market power and thereby extract some rent. When entrepreneurs get a second screen they can enforce a contract at marginal costs due to Bertrand competition among the two rival banks.[2] Let $n \geq 1$ be the expected time for another screen from some rival bank. In this case the current bank can charge the rate $R = (1-\delta_e^n)R_G + \frac{R_0}{\pi}$, which implies a mark-up of $(1-\delta_e^n)R_G$ over the banks' expected cost of funding for screened finance, $\frac{R_0}{\pi}$. Thus, the mark-up is a decreasing function of the entrepreneur's discount factor, δ_e, while it is an increasing function of the delay in acquiring a second screen, n. If the bank faces no competition we assume that it extracts all the surplus by charging $R^m = R_G$.[3]

In case of inactivity the new project holders will face hold up and we focus on two conceivable alternative outcomes in such a case. In principle, the entrepreneur could remain with the same bank until this bank becomes active again or, alternatively, the entrepreneur could choose another bank. We will treat separately two rematch assumptions, the scenario of passive entrepreneurs (P) and the scenario of a random rematch in the next period (R).

(P) Passive entrepreneurs will stay with the inactive bank until it starts screening again.

(R) Passive entrepreneurs of period *t* are re-matched randomly in the next period *t+1*, and thus join the pool of entering entrepreneurs.

Accordingly, in scenario (P) banks will not have to worry about the potential loss of good customers in periods of inactivity, since those are staying until the screening

---

[2] In the sequel we will concentrate on pool characteristics which generate screening incentives for banks. Hence we will not be particularly interested in the case of unscreened finance, as the analysis of this case is completely straightforward with no interesting dynamics.

[3] Our qualitative results are not very sensitive with respect to the particular negotiation procedure chosen. See section V for more discussion on this point.

starts again. In case (R), on the contrary, the bank has to be concerned about loosing good risks to other banks in periods of inactivity.[4]

Clearly, entrepreneurs that have been rejected after the first screen will strategically select the next application and possibly stay with that bank until they receive another (negative) result.[5]

We proceed in the next section by characterizing the banking equilibrium and, in particular, banks' screening decisions for a coordinated (cartellized) banking industry. In section IV we subsequently extend our analysis to the case of non-cooperative competition.

III. The Monopoly Bank

The case of a monopoly bank is particularly simple, since in such an environment the bank can always extract all the project surplus. Thus loan pricing is straightforward and we can concentrate on the screening activity of the monopolist.

Basically, the monopolist can pursue three strategic options: (i) inactivity (no lending and no screening), (ii) screening and lending to approved projects and (iii) universal lending without screening. While unscreened lending requires a sufficiently good pool of applicants and inactivity will occur for a sufficiently adversely selected pool, screening and lending will occur for the intermediate case of a pool of applicants that is moderately adversely selected.

When facing the proportion λ of creditworthy projects the monopolist will engage in project-specific monitoring if the returns on screened lending exceed the costs of funding a screened loan, i.e.

$$\pi \lambda R_G \quad \geq \quad \lambda R_0 \; + \; c \; ,$$

or equivalently

---

[4] We will see in section IV that the rematch assumption will affect the intensity of competition between banks for high-quality projects.

[5] The assumption that B-type entrepreneurs stay in the market may seem to conflict with our assumption of perfect screening. However, small degrees of imperfection would provide a positive incentive to B-type entrepreneurs.

$$R_G \geq \frac{R_0}{\pi} + \frac{c}{\pi\lambda} . \tag{1}$$

Alternatively, for a sufficiently good pool of project applicants, more precisely

$$\lambda \geq \bar{\lambda} = \frac{R_0 - c}{R_0} , \tag{2}$$

it is worthwhile for the bank to grant finance to all project applicants rather than to engage in project-specific screening.

Thus, project-specific monitoring does not pay off when the bank faces a pool of applicants of sufficiently good quality. However, as the proportion of good applicants lies below the threshold defined by (2), the bank's screening investment is profitable. Intuitively, such an upper bound makes sense, because the bank cannot regain the screening outlays unless the proportion of creditworthy applicants is sufficiently low. We can immediately observe that the threshold (2) satisfies intuitively appealing comparative statics properties.

Further, the option with project-specific screening is feasible only insofar as the lending rate consistent with screening does not violate the individual rationality constraint of the projectholders, i.e.

$$\frac{R_0}{\pi} + \frac{c}{\pi\lambda} \leq R_G ,$$

which is equivalent to

$$\lambda \geq \frac{c}{\pi R_G - R_0} = \underline{\lambda} . \tag{3}$$

Hence, for a sufficiently unfavourable pool of project applications, i.e. for $0 \leq \lambda < \underline{\lambda}$, it is optimal for the banking industry to simply withdraw from the funding activities. Such an economy will be characterized by inactivity.

In order for project-specific monitoring to be optimal with respect to a non-empty interval of pool compositions we have to make sure that $\underline{\lambda} < \bar{\lambda}$. In fact, it includes nothing but straightforward calculations to verify that this condition holds true under the assumptions made.

While the argument so far only applies to a single period of lending, it readily generalizes to the case of repeated lending. Because of perfect recall in each period the bank is only concerned about the pool of new projects. Hence lending decisions in each period will depend on the composition of the pool of new projects in each period. If that pool is stationary (in size and quality), also the bank's lending decision will not change across periods.

Hence, we can summarize the characterization of the lending decisions of a bank operating in a stationary lending environment and without competition in Proposition 3.1.

Proposition 3.1 *In a stationary environment the composition of the pool of project applicants determines whether a monopoly bank will never grant a loan, screen each period and grant loans to approved projects or always grant loans without screening in all periods. Such stationary equilibria are characterised by the stationary quality* $\mu_t = \lambda$ *of the pool of applications in each period with*

(i) inactivity for each t (t=1,2,...) *if* $0 \leq \lambda < \underline{\lambda}$

(ii) screening with lending at rate R_G *for each t* *if* $\underline{\lambda} \leq \lambda \leq \bar{\lambda}$

(iii) funding all projects without screening at the rate R_G *for each t* *if* $\bar{\lambda} < \lambda \leq 1$.

Accordingly, with a banking monopoly or with a completely coordinated banking industry the funding activities are stable in a stationary envirnoment. The monopolist implicitly exercises perfect recall and implicitly ensures perfect communication across periods. Both assumptions eliminate all potential dynamic links. Hence, in a coordinated environment lending cycles require exogenous variation in the composition of the pool of new applicants across periods. A distinguishing feature of competition, however, seems to be the lack of (complete) coordination.[6] Will this lack of coordination render cycles possible or will it even generate cycles by necessity?

IV. Banking Competition: The Case of Duopoly

Uncoordinated competition generates an important intertemporal link. Rejected loan applicants get another chance to apply for loans at another bank next period, and, hence, these applicants tend to reduce the quality of competitors' pools of applicants. How does this pool-worsening effect impact on banks' screening incentives and lending rates in equilibrium?

We will start with the case of duopoly and passive entrants since this allows to demonstrate the role of the externality most easily. We will then continue to analyse random rematches and comment on more general market structures in section V.

i) *Passive Entrants*

With passive entrants each duopoly bank essentially attracts half of the profitable projects each period. Since those passive entrepreneurs stay until they are screened, they will ultimately be financed from the bank they were initially matched with. In this scenario there is virtually no competition for the good entrepreneurs among banks.

However, banks may decide not to screen each period. To see what happens in this case we consider a period t in which both banks have engaged in screening. This implies that all available worthwhile projects of earlier periods get funding. Hence in period *t+1* the individual pools of each bank consist of 50 percent of new applicants plus the mass of projects that have been rejected in the previous period by the rival bank. Accordingly, each bank faces a pool of a quality $\mu_{b,t+1} = \frac{\frac{\lambda\eta_{t+1}}{2}}{\frac{\eta_{t+1}}{2} + \frac{(1-\lambda)\eta_t}{2}} = \frac{\lambda}{2-\lambda} < \lambda$,

which is lower than the quality of the newly-born generation of projects. This quality may well fall short of the critical level $\underline{\lambda}$ for profitable screening. If this happens the

6 See Bolton, Farrell, 1990.

bank - in fact both banks - will prefer not to screen in period *t+1*. So screening implies that each bank faces formerly rejected applicants in its pool in addition to the new applicants. Since banks do not communicate they cannot distinguish the different vintages of applicants.

If both banks decide to remain passive in period *t+1* the pool will improve again in period *t+2* because of the inflow of a pool of new applicants with higher average quality. Hence, $\mu_{b,t+2} = \dfrac{\dfrac{\lambda\eta_{t+1}}{2} + \dfrac{\lambda\eta_{t+2}}{2}}{\dfrac{\eta_{t+1}}{2} + \dfrac{\eta_{t+2}}{2} + \dfrac{(1-\lambda)\eta_t}{2}} = \dfrac{2\lambda}{3-\lambda} > \dfrac{\lambda}{2-\lambda}$. If the pool is not yet good enough to render screening profitable in period *t+2* it will improve over time until eventually screening is profitable again.

These two counteracting forces, screening-induced pool worsening and the pool improvement after periods of inactivity, are the mechanisms that may generate persistent screening cycles.

Before we state the result, we still need to discuss lending rate setting. Note that periods of inactivity increase the cost of delay for entrepreneurs. If they have to anticipate a spell of n periods of inactivity at the rival bank, the costs of delay are $(1-\delta_e^n)R_G$, which determines the mark-up the bank can demand in current negotiations. Accordingly, the current negotiation will imply a repayment obligation of $R(n) = (1-\delta_e^n)R_G + \dfrac{R_0}{\pi}$.

At this lending rate screening will be profitable provided that $\lambda(\pi R(n) - R_0) - c \geq 0$, which implies a critical level of pool composition $\underline{\lambda}(n) = \dfrac{c}{\pi R(n) - R_0} = \dfrac{c}{(1-\delta_e^n)\pi\ R_G}$.

We can now state the simplest set of conditions under which banking competition will necessarily generate a regular 2-cycle.

Proposition 4.1 (Equilibrium with passive entrants) *:*

Consider the case of passive entrants, i.e. assumption (P). If $\delta_b < 1$ *and if both* $\frac{\lambda}{2-\lambda} < \frac{c}{\left(1-\delta_e^2\right)\pi\ R_G}$ *and* $\frac{2\lambda}{3-\lambda} > \frac{c}{\left(1-\delta_e\right)\pi\ R_G}$, *there is a unique and symmetric banking equilibrium with regular 2-cycles consisting of alternating phases of lending and inactivity. In active periods the lending rate is given by* $R(2) = \left(1-\delta_e^2\right)R_G + \frac{R_0}{\pi}$.

Proof: The proof proceeds in three steps. First we will show that there is no equilibrium with one bank continuously screening in in all periods. Then we show that the policy of each bank will involve a 2-cycle.

(a) Without loss of generality assume that bank 1 will screen continuously. If bank 2 decides to screen in period *t*, the return to bank 1 from screening in period *t*+1 is negative

$$u_{1,t+1} = \lambda \frac{\eta_{t+1}}{2}\left(\pi\ R(2) - R_0\right) - \left(\frac{\eta_{t+1}}{2} + (1-\lambda)\frac{\eta_t}{2}\right)c =$$

$$= \frac{1}{2}\left(\lambda\left(\pi\ R(2) - R_0\right) - (2-\lambda)c\right) < 0\ ,$$

which holds in light of the lending rate equilibrium as well as the condition that $\frac{\lambda}{2-\lambda} < \frac{c}{\left(1-\delta_e^2\right)\pi\ R_G}$. Analogously, we can apply the conditions of the proposition to show that postponing the undertaking of screening to period *t + 2* reduces the costs by the factor $\delta_b < 1$ without sacrificing the present value of future gains from further screening and lending. Accordingly, continuous screening does not constitute a best response to continuous screening of the rival.

(b) Under the assumptions concerning the quality of the initial pool, the state of the quality of the overall pool of applicants of a particular bank can only have three values: $\frac{\lambda}{2-\lambda}$ after a period of screening by the rival, $\frac{2\lambda}{3-\lambda}$ after a period of inactivity and a prior period of screening by the rival and λ after a period of screening and rival's inactivity. Under the assumptions on the initial pool screening is unprofitable only when the pool characteristic is $\frac{\lambda}{2-\lambda}$. Hence, for both banks the phase of inactivity can last at most for 1 period. Accordingly, two types of equilibria may emerge: synchronized cycles and unsynchronized cycles. With synchronized cycles both banks are screening in the same period and they are inactive in the subsequent period, while with unsynchronized cycles banks are taking turns in screening and lending.

The existence of a synchonized cycle is readily established since no bank has an incentive to deviate in any period. Clearly, the lending rate is determined by $R(2)=\left(1-\delta_e^2\right)R_G+\frac{R_0}{\pi}$, since the threat of acquiring a second screen involves the delay of two periods in this equilibrium. A deviation could either be deferred lending or early lending in a period of equilibrium inactivity. Since neither type of a deviation will change the overall number of creditworthy projects funded by a bank, a bank's deviation will only affect the time structure of its own pools. Deferred lending essentially means that a (positive) lending surplus gets discounted by $\delta_b<1$, which reduces the bank’s overall payoff. Foregoing a period of inactivity, i.e. early lending, implies an earlier realization of the costs of screening an unprofitable pool. Also such a deviation cannot be profitable.

(c) The non-existence of an asymmetric cycle stems from the fact that it implies positive screening in precisely those periods in which the pool is adversely selected and no screening, when it is profitable to do so.

Accordingly, there is a unique equilibrium in screening. This is symmetric and requires both banks to simultaneously alternate between screening and inactivity.

Q.E.D.

Proposition 4.1 demonstrates quite forcefully that uncoordinated competition undermines stability in the banking industry. The decision of a bank to reject an applicant reduces the quality of the pool of applications facing competitors and, hence, necessarily reduces their (future) screening incentives. Thus, screening generates a dynamic externality on competitors since the screening efforts cannot be coordinated under noncooperative competition.

The cycling nature of the equilibrium is quite straightforward, given the pool-worsening effect after a screening period and the pool improvements subsequent to a period of inactivity. With passive entrants there is further no role for strategic manipulations of the pool of applicants. Each bank is simply optimizing its screening decision in each period subject to the pool composition prevailing. Given that each bank ultimately screens exactly half of all the profitable projects and all the unprofitable ones, one might conjecture that the timing of screening is irrelevant. However, this is not the case. By deferring screening in periods that can be clearly identified with negative profits the expected costs of screening can be reduced. Hence, discounting by banks is a crucial feature for the emergence of cycles.

In the absence of a time preference for banks, cycles may still arise, but stationary equilibria may also emerge with constant screening in all periods. In this case banks lend at the constant interest rate of $R(1) = (1-\delta_e) R_G + \frac{R_0}{\pi} < R(2)$.

ii) Random Re-matching

The complete absence of strategic interaction associated with passive entrepreneurs may seem artificial and too strong. Alternatively, entrepreneurs could actively solicit a rematch, or just search a match with the other bank. In both cases, the incentives of banks to remain inactive are reduced, since a period of inactivity implies a loss of a positive measure of profitable clients in the period of inactivity. Accordingly, the existence of cycles will require a certain amount of discounting by the banks in order to render deviations unprofitable. Hence, we here establish that an alternative assumption about entrepreneurs’ behaviour, assumption (R), will tighten the conditions for the existence of symmetric equilibria, but such an assumption of active entrepreneurs neither completely eliminates the occurrence of symmetric cyclical equilibria nor does it necessitate the occurrence of such equilibria.

Proposition 4.2 (Equilibrium with random rematching)

Consider the case of random rematches, i.e. assumption (R). There is a critical level $\overline{\delta}_b < 1$ *such that for any* $\delta_b < \overline{\delta}_b$ *there is a unique and symmetric banking equilibrium with a regular 2-cycle consisting of one period of lending and one period of inactivity, if* $\frac{\lambda}{2-\lambda} < \frac{c}{(1-\delta_e^2)\pi R_G}$ *and* $\frac{2\lambda}{3-\lambda} > \frac{c}{(1-\delta_e)\pi R_G}$. *In lending periods the lending rate is given by* $R(2) = (1-\delta_e^2)R_G + \frac{R_0}{\pi}$.

Proof: The proof parallels that of Proposition 4.1. Hence, we shall only provide the argument for the existence of a symmetric stationary equilibrium with the regular succession of one period of screened lending and a period of inactivity. Since deferred lending implies discounting of the benefits from screening a profitable pool by one period, only deviations from a period of inactivity have to be considered. Let *t* be a period of joint screening, *t+1* a period of inactivity and *t+2* again a period of screening etc. If bank 1 deviates and screens in period *t+1* its period payoffs are

$$\tilde{u}_{1,t+1} = \lambda \frac{\eta_{t+1}}{2}\left(\pi R(1) - R_0\right) - \left(\frac{\eta_{t+1}}{2} + (1-\lambda)\frac{\eta_t}{2}\right) c$$

and subsequently its profits in period t+2 are

$$\tilde{u}_{1,t+2} = \lambda\left(\frac{\eta_{t+1}}{4} + \frac{\eta_{t+2}}{2}\right)\left(\pi R(2) - R_0\right) - \left(\frac{\eta_{t+1}}{4} + \frac{\eta_{t+2}}{2}\right) c .$$

In the candidate (symmetric) equilibrium payoffs are

$$\hat{u}_{1,t+1} = 0 \qquad \text{and}$$

$$\hat{u}_{1,t+2} = \lambda\left(\frac{\eta_{t+1}}{2} + \frac{\eta_{t+2}}{2}\right)\left(\pi R(2) - R_0\right) - \left(\frac{\eta_{t+1}}{2} + \frac{\eta_{t+2}}{2}\right) c .$$

Thus, the proposed deviation is profitable if and only if

$$\tilde{u}_{1,t+1} + \delta_b \tilde{u}_{1,t+2} > \hat{u}_{1,t+1} + \delta_b \hat{u}_{1,t+2} .$$

The present value of the continuation payoffs after period *t+2* is identical in the two regimes. Straightforward calculations establish that the proposed deviation is profitable, whenever[7]

$$\delta_b \;>\; 2\;\frac{\lambda(\pi R(1)-R_0)-(2-\lambda)c}{\lambda(\pi R(2)-R_0)-(3-2\lambda)c}\;=\;\bar{\delta}_b\;.$$

Substituting the equilibrium values for the rate negotiations yields

$$\bar{\delta}_b \;=\; 2\frac{(1-\delta_e)\pi R_G-(2-\lambda)c}{(1-\delta_e^2)\pi R_G-(3-2\lambda)c}\;\;.$$

Accordingly, for $\delta_b \le \bar{\delta}_b$ the symmetric 2-cycle constitutes a banking equilibrium. The argument for uniqueness parallels that of Proposition 4.1

Q.E.D.

The argument of Proposition 4.2. is similar to that of Proposition 4.1. However, under the random rematch assumption banks can strategically affect the number of profitable entrepreneurs they are funding. This feature renders inactivity more costly to banks and enhances their incentives to deviate from inactivity in a given period. This incentive is, however, counteracted by the costs of sceening an adversely selected pool. If time preference is high enough, deferred screening will remain valuable, even at the cost of loosing some profitable projects.

The requirement of a higher degree of time preference implies that screening cycles will be more likely in periods of higher real rates of interest.

Overall the basic mechanism characterized by Propositions 4.1 and 4.2 delineates how uncoordinated screening by competing banks will generate an externality causing substantial instability in the credit markets. This instability shows up as an intertemporal agglomeration of funding activities so that phases of boosted screened funding alternate with phases of inactivity during which the credit market does not channel funds to

---

[7] The derivation uses the fact that $\frac{\lambda}{3-2\lambda} < \frac{\lambda}{2-\lambda}$ whenever $\lambda < 1$.

profitable projects. If for some reason or another there is a social long-term interest in shortening the phases of inactivity that could be achieved by implementing policies that would lower the threshold $\underline{\lambda}(2) = \frac{c}{\left(1-\delta_e^2\right)\pi \, R_G}$. Policies of subsidising the screening activities of banks would lower c, thereby serving as one natural way of achieving such a policy objective.

Rajan (1994) has developed an alternative explanation for why banks' credit policies fluctuate, thereby contributing to business cycles. Rajan's explanation builds on bank managers endowed with short horizons boosting credit policies in order to affect the stock or labor market's perceptions of their abilities. Rajan's mechanism has one common feature with our screening externality. The credit fluctuations are generated not only in response to exogenous shocks, but even in a stationary economic environment, like in our model. Rajan, further, reports evidence from the banking crisis in New England in the early 1990's in support of the assumptions and predictions of his model.

Note also that even the case, in which all unserved customers change their bank after they experience a period of inactivity, is altogether quantitatively very similar to the scenarios we have investigated. In this case, however, the incentive to avoid inactivity is somewhat stronger and hence the bound on the discount factor needs to be tighter. But again, cycles will occur by necessity, as soon as banks are sufficiently impatient, or when real rates of interest are sufficiently large.

V. Generalizations and Discussion

So far the analysis has concentrated on the case of two banks and the existence of regular 2-cycles. However, the analysis above suggests that the present framework can generate substantially richer dynamics even in the case of only two banks. Moreover, the results can be quite easily generalized to larger numbers of banks, to different specifications of the lending rate negotiations and to the more realistic case of imperfect screening. Finally we briefly discuss the role of information sharing and its implication for screening cycles.

V.1 Dynamics

In order to intuitively explore the extended dynamic implications we simplify the strategic interaction by concentrating on the case of passive entrepreneurs, i.e. assumption (P). Proposition 4.1 provides conditions on the characteristics of the (stationary) pool of new projects that generate a regular 2-cycle. Accordingly, a 2-cycle will occur, when the pool has improved to a sufficient extent after one period of inactivity, i.e. $\frac{2\lambda}{3-\lambda} > \underline{\lambda}(2) = \frac{c}{\pi R(2) - R_0}$. What if one period of inactivity is not enough to generate a sufficiently profitable pool? Then further periods of inactivity will monotonically increase the proportion of unscreened entrepreneurs and thereby the relevant pool of applications monotonically improves. What if *n-1* periods do not suffice but *n* do? Under assumption (P), both banks basically only need to await the first period, which allows profitable lending. As the proof of Proposition 4.1 demonstrates, with the current composition of the incoming generation of potential borrowers there will not be two consecutive periods of screened lending. Accordingly, the unique banking equilibrium is symmetric and sees one period of lending after any *n-1* periods of inactivity. Thus, under such circumstances a unique n-cycle equilibrium emerges.

As we may directly conclude from Proposition 4.2, under different rematch assumptions the dynamics will become more complex. However, the basic intuition survives. As long as banks are sufficiently patient, because of the pool-worsening effect from the screening externality there cannot exist an equilibrium with two consecutive periods of continued screened lending.

V.2 Several Banks

In the presence of the screening technology outlined above, unprofitable entrepreneurs will belong to the pool of loan applicants for a longer period as the number of banks increases. This will have two effects, both contributing to the detrimental welfare implications of intensified lending market competition in the sense of a larger number of banks. Firstly, of course, an extended number of banks means that the screening costs associated with unprofitable project holders are multiplied by the number of banks performing credit tests. Secondly, as the unprofitable projects are present in the pool of applicants for a longer period it follows that the quality of this pool deteriorates. For that reason, the economy will face prolonged phases of inactivity as the dynamic process of recovery to activity threshold will be slower. However, in our setting the lending rate negotiations will not be affected by the number of banks exceeding two, since a successful entrepreneur only needs one additional screen to force potential lenders into Bertrand type competition.

V.3 Lending Rate Negotiations

So far we have assumed that the bargaining power of the bank is constrained by external competition imposed by rival banks. Alternatively, we could model the interest rate determination through an axiomatic bargaining process like Nash bargaining. To explore the implications of such an alternative approach, let us assume that the bank's bargaining power is given by $\beta, \quad 0 \le \beta \le 1$. The objective function of the bank is given by $E\Pi = \pi R - R_0$ with an outside option of $E\Pi^0 = 0$ associated with no lending. Correspondingly, a project holder facing an interest rate of R would have a profit $E\Gamma = \pi(R_G - R)$, while having the outside option of funding from a rival bank with a delay of n periods and thereby an outside option of $E\Gamma^0 = \delta_e^n \pi (R_G - R)$. Within such a context lending rate determination through Nash bargaining involves the optimization problem

$$\max_R \quad \Omega(R) = \left(E\Pi - E\Pi^0\right)^{\beta} \left(E\Gamma - E\Gamma^0\right)^{1-\beta},$$

which implies the sufficient and necessary condition

$$\beta \frac{\pi}{\pi R - R_0} - (1-\beta) \frac{\pi (1-\delta_e^n)}{\pi (1-\delta_e^n)(R_G - R)} = 0.$$

From solving this equation we find the Nash bargaining solution, R^N, to be given by

$$R^N(n,\delta_b,\delta_e,\beta) \quad = \quad \beta R_G \quad + \quad (1-\beta)\,\frac{R_0}{\pi} \ .$$

Consequently, the Nash bargaining solution is a weighted average of the return from a high-quality project and the bank's expected cost of funding for screened finance, with the relative weights being exactly the bargaining power of the bank and the project holder, respectively.

The Nash bargaining solution offers one specification for a negotiation procedure determining the lending rate $R(n,\delta_b,\delta_e,B)$ as the outcome of a bargaining process. As we can infer from the detailed argument above, the general nature of our conclusions regarding banks' incentives for screening will not change. Of course, the precise level of the critical pool composition will now depend on the bank's bargaining power so that $\underline{\lambda}(\beta) = \dfrac{c}{\pi R(n,\delta_b,\delta_e,\beta) - R_0}$. Whenever $\dfrac{\lambda}{2-\lambda} < \underline{\lambda}(\beta)$ and $\delta_b < 1$, there cannot be an equilibrium with the bank screening in each period and, consequently, cyclicality of the type outlined in section IV will arise.

V.4 Imperfect Screening

Our analysis can be generalized to incorporate imperfect screening in a straightforward way. On the one hand, with imperfect credit tests each additional competing bank means an added positive probability of obtaining finance due to the presence of classification errors. Thus, in the presence of screening imperfections each competing bank adds to the probability of survival of bad entrepreneurs. On the other hand, the screened pool of project applications will be less adversely selected than under perfect screening, since with screening imperfections some good entrepreneurs may have been rejected earlier due to so so-called α-errors.

In order to outline the nature of the pool-worsening screening externality in the presence of imperfect credit tests we let α denote the conditional probability that a truly good project is denied funding, while β denotes the conditional probability that a truly bad project passes the credit test so as to obtain finance. In order to illustrate how the pool-worsening external effect survives incorporation of imperfect screening technologies in the simplest possible way we focus on a banking duopoly in the case with passive entrants (Assumption **(P)**).

Suppose that the bank duopolists have engaged in screening in period t. Also suppose, as we did in the previous section, that the banks face a stationary environment with subsequent generations of project applications exhibiting constant size and quality from one period to another. Then we find that each bank will face a period-(t+1) pool composition of quality

$$\mu_{b,t+1} = \frac{\frac{\eta}{2}\lambda + \frac{\eta}{2}\lambda\alpha}{\frac{\eta}{2} + \frac{\eta}{2}\left[(1-\lambda)(1-\beta) + \lambda\alpha\right]} < \lambda ,$$

where the inequality formally demonstrating the pool-worsening externality holds if and only if $\alpha+\beta<1$. But, the latter always holds as long as the credit test is at all informative.[8] Consequently, generalizations to incorporate imperfect screening technologies will not qualitatively change the industry dynamics, because the intertemporal pool-worsening effect induced by lending market competition will survive such a generalization. But, of course, the magnitude of the imperfections in the screening technology will affect the screening incentives and thereby the magnitude of the pool-worsening externality created by competing credit tests. For that reason imperfections in the screening technology can also be expected to impact on the precise characteristics of the screening cycles.

V.5 Information Sharing

Our analysis crucially relies on the assumption that banks do not share project-specific information about the credit-worthiness test. While this assumption seems to correspond to observed institutions of information exchange in the banking industry – typically in many countries only “black” information is exchanged, which is ex-post

[8] With a completely uninformative screening technology it holds that $\alpha+\beta=1$.

information[9] – we would also expect strategic reasons for misrepresentation of initial assessments. In fact, banks typically have strategic reasons to transmit inaccurate information to rival banks in order to raise rivals' costs, which will have the strategic advantage of reducing the aggressiveness of rivals. The costly establishment of institutions for verification of shared information seems to be the only way of overcoming these incentives for strategic information transmission. Consequently, the establishment of such an institution for truthful information transmission would represent one mechanism for elimination of the externalities created by non-coordinated screening activities of competing banks. Of course, information sharing may have additional consequences. Information sharing between banks may serve as a collusive device, as demonstrated by Gehrig and Stenbacka (2001), and such considerations have to be taken into account when evaluating the overall welfare implications of institutions for information sharing.

VI. Concluding Comments

Our analysis has highlighted the role of the intertemporal screening externality induced by lending market competition as a structural source of instability in the banking industry. While earlier work has already emphasized the potentially harmful consequences of screening on competition in banking (Broecker (1990)), our article is the first strategic analysis drawing out the dynamic implications of the screening externality. We demonstrate how endogenous information acquisition in credit markets characterized by asymmetric information can create lending cycles as long as competing banks undertake their screening decisions in an uncoordinated way. In the environment of our model such screening cycles emerge in response to competition between banks, while project-specific information exchange between banks or cartellization of the banking industry would eliminate such fluctuations.

While there are certainly many complementary mechanisms that may generate business cycles, our analysis has established that the uncoordinated screening behavior of competing banks may be the source of an important multiplier for any form of

[9] See Japelli and Pagano, 1999.

exogenous business cycles. We have also shown that screening cycles may, in fact, be an independent source of lending fluctuations, and hence, cause business cycles. Even though our basic model exhibits the basic screening cycle mechanism in a very simple and highly stylized framework we have reasons to conjecture this mechanism to be a very robust phenomenon. As was outlined in our analysis, at a fundamental level the screening cycle mechanism is robust to alterations and generalizations along many dimensions such as the market structure and dynamics of competition in the banking industry, the lending rate determination and the imperfections in the screening technology.

VII. References

Bernanke, B., Gertler, M. and S. Gilchrist, 2000, The Financial Accelerator in a Quantitative Business Cycle Framework. In J. Taylor and M. Woodford, eds., *Handbook of Macroeconomics*, Amsterdam, North-Holland, chapter 21.

Bolton, P. and J. Farrell, 1990: Decentralization, Duplication, and Delay, *Journal of Political Economy 98.4*, 803-826.

Broecker, T. , 1990: Credit-Worthiness Tests and Interbank Competition, *Econometrica 58*, 429-452.

Fisher, I., 1933: The Debt-Deflation Theory of Great Depressions, *Econometrica* 1, 337-357.

Gehrig, T., 1998: Screening, Cross-Border Banking, and the Allocation of Credit, *Research in Economics* 52(4), 387-407.

Gehrig, T. and R. Stenbacka, 2001: Information Sharing in Banking: A Collusive Device?, mimeo, University of Freiburg.

Japelli, T. and M. Pagano, 1999: Information Sharing, Lending and Defaults: Cross-Country Evidence, CEPR-discussion paper 2184, London.

Kanniainen, V. and R. Stenbacka, 2000: Lending Market Structure and Monitoring Incentives, working paper, Swedish School of Economics.

Kiyotaki, N. and J. Moore, 1997: Credit Cycles, *Journal of Political Economy* 105, 211-248.

Kocherlakota, N., 2000: Creating Business Cycles Through Credit Constraints, *Federal Reserve Bank of Minneapolis Quarterly Review* 24, No. 3, 2-10.

Rajan, R., 1994, Why Bank Credit Policies Fluctuate: A Theory and some Evidence, *Quarterly Journal of Economic*s 109, 399-441.