The Workout of Banking Crises: A Macroeconomic Perspective*

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Abstract

This paper provides a macroeconomic perspective for government interventions in banking crises. We illustrate how vulnerabilities of the banking sector may build up over time and thus destabilize a banking system. A crisis occurs when a large number of banks fail to meet capital requirements or are insolvent. Based on a macroeconomic model with financial intermediation, our reasoning suggests that in good and moderate times strict enforcement of capital adequate rules suffices. Interest rate intervention or cartelization and restructuring of the banking industry becomes necessary in critical times. These policies should be reenforced by random bail-outs and subsidies in bad times.

Keywords: Financial intermediation, macroeconomic risks, banking crises, deposit insurance, banking regulation.

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1 Introduction

The role of governments in banking crises is one of the major unresolved issues in banking regulation, cf. Bhattacharya, Boot & Thakor (1998). Since a complete elimination of such financial instabilities with regulation is seemingly unattainable, managing banking crises should be an integral part of banking regulation and of macroeconomic policy.

A banking crisis occurs when a large number of banks fails to meet regulatory capital requirements or even are insolvent. Banking crises are most often caused by negative macroeconomic risk factors banks are exposed to as well as by contagion and amplification mechanisms that decrease banks' capital. The crises in Latin America of the 1980s and early 1990s, in East Asia later that decade, and the more prolonged one in Japan may serve as examples which were to a large extent caused by negative macroeconomic events, cf. Borio (2002). The devastating effects of banking crises on economies, including budgetary consequences of possible government bail-outs, has brought the problem of optimal policy design to the top of the international policy agenda.

Most of the theoretical literature on banking treats the issue of supervision and regulation of banks from a more or less microeconomic perspective. Much of this work uses static partial-equilibrium models to analyze the behavior of individual banks in response to supervisory and regulatory actions. Among many aspects, the question whether to bail out or to close a bank in financial distress has been debated intensively. The problem of closing a bank can be treated by means of the so-called *'constructive-ambiguity'* principle, according to which a regulator has full discretion to close a bank.[1] On the one hand, bail-outs create well-known moral hazard problems. On the other hand, the costs of closing a bank including the costs of negative externalities may be prohibitively high. For this reason, it has been argued by Mishkin (1995) and others[2] that bailing out banks might be socially desirable. The decision whether or not to close a particular bank may depend on many indicators, among which are the level of uninsured debt on a bank's balance sheet (Freixas 1999), the size of a bank (Goodhart & Huang 1999), or aggregate investment returns (Cordella & Yeyati 1999).

Macroeconomic aspects of banking regulation are often set aside.[3] Although a general agreement on what a macroeconomic perspective should be alike is not fully established yet, we believe that a macroeconomic perspective should take into account effects on the real output and, most importantly, the feedback effects of banking crises and regulatory

[1]Two concepts of constructive ambiguity have been discussed in the literature. In Freixas (1999), the central bank follows a mixed strategy when deciding on the bail-out of a single bank. In Goodfriend & Lacker (1999) and Repullo (1999), the central bank's bail-out policy is non-random but perceived as being random by outside observers.

[2]Depending on the evaluation of the different costs, authors come to different conclusions about the desirability of government interventions. While Freixas, Parigi & Rochet (1998), Santomero & Hoffmann (1998), or Cordella & Yeyati (1999) support this view, authors like Humphrey (1986) and Schwartz (1995) advocate a non-interventionist's view. A comprehensive discussion of this issue is found in Goodhart (1995).

[3]The importance of macroeconomic implications of capital adequacy rules have first been identified by Blum & Hellwig (1995).

policies on the future evolution of an economy. From a macroeconomic perspective, the fate of a single bank is of minor importance as long as the size of the bank and the externality of closing it are negligible. Rather than considering the behavior of a single bank, the focus should therefore be more on the whole banking sector. Macroeconomic regulation policies should be aimed at working out a system-wide crisis when a large number of banks are insolvent or do not meet regulatory capital requirements. Clearly, a macroeconomic perspective of regulation and supervision in banking crises should extend and complement the microeconomic point of view.

There are at least five macroeconomic policy measures in banking crises that should be taken into consideration: strict enforcement of capital-adequacy rules, subsidies for banks financed by taxes or seigniorage, deposit-rate controls and/or low short-term interest rates set by the central bank, cartelization as well as restructuring of the banking sector, and random bail-outs. We will argue in the paper that deposit rate controls and cartelization have very similar macroeconomic effects for closed economies and for this reason are to a certain extent equivalent measures. On a conceptual level, random bail-outs in a crisis may be interpreted as a macroeconomic version of the constructive ambiguity principle discussed above. From a macroeconomic point of view, random bail-outs are thus motivated by severe concerns about the solvency of a whole banking sector. The design of a corresponding policy should ensure the survival of bailed-out banks, see Erlenmaier & Gersbach (2001) for further details.

The present paper provides a macroeconomic perspective on how governments and central banks should handle banking crises in which a large number of banks are unable to fulfill regulatory capital requirements or even are insolvent. Although a complete comparison of all possible intervention policies is beyond the scope of this paper, the purpose of this research is to provide a suitable framework for the assessment of at least some of the policy measures listed above.[4] Our reasoning is based on a model in which financial intermediation is integrated into a macroeconomic model with overlapping generations, developed in Gersbach & Wenzelburger (2001, 2002). For tractability, we use a relatively simple model of a bank and focus on aggregate solvency problems of a banking system.

Our model is based on the assumption that the costs of closing many banks including the costs of negative externalities incurred by such closures are prohibitively high such that banks should and, in fact, will be bailed out as soon as a system-wide financial distress occurs. We presume that the effects of the bail-out policy has no or only negligible effects on the ex-ante behavior of banks. The presumption rests on two assumptions. First, if banks are bailed out only in system-wide crises, the ex-ante behavior of an individual bank is not grossly distorted. Second, by means of the constructive ambiguity principle, socially undesirable incentive effects can be reduced.

A banking crises in our model results from a repeated common exposure of banks to macroeconomic risk factors which remain on the banks' balance sheet. These risk factors are exogenously given and are possibly amplified by endogenous choices of banks

[4] The design of short-term interest rate policies for small open economies requires a broader macroeconomic framework than provided here.

and other agents of the economy. The vulnerabilities of the banking sector may for this reason build up over time and turn into a crisis.

Our model is coined in terms of an explicit stochastic difference equation which allows to study the effects of various policy interventions. As a first result, we show that a competitive banking system is vulnerable to crises, since intermediation margins do not allow for premiums of macroeconomic risks firms are exposed to. A repeated spell of negative macroeconomic shocks may turn a healthy banking system into a fragile one. Although banks can use new funds to cover losses, a banking system which has lost its capital will collapse with certainty.

Second, we suggest the following three stages of intervention with policy measures which should be applied in banking crises:

1. Strict capital adequacy rules in good and moderate times.
2. Interest rate intervention or cartelization and restructuring of the banking industry in critical times.
3. Random bail-outs and subsidies in bad times.

Any policy measure against a banking crises has to take into account not only costs like GDP losses and shadow costs of taxation but also its effectiveness in terms of how fast it can be implemented. Since this analysis is not fully carried out, the hierarchical order is still tentative. There are at least three caveats of our three-stage policy proposal. First, banking crises are often linked with debt crises, currency crises, and asset market crashes. Financial instabilities of these types require a broader macroeconomic perspective which may require other priorities. For instance, the appropriate interest rate policy central banks should adopt when banking and currency crises occur jointly has not been resolved yet. Second, it is far from being obvious why contractual arrangements that shift more macroeconomic risks to depositors could not prove to be socially more desirable without contradicting the economic role of banks. Third, we do not address the problem of bailing out a heterogeneous banking industry which may require incomplete bail-outs at the second stage.

The paper is organized as follows. In the next section, we introduce the framework of our model including possible policy measures. In Section 3, we summarize our main insights. In Section 4 we provide a tentative discussion of what an optimal policy mix should look alike and Section 5 concludes with a list of open research issues.

2 The framework

2.1 Macroeconomic environment

For the framework of our reasoning we briefly review an overlapping generations model with financial intermediation introduced in Gersbach & Wenzelburger (2001, 2002). Time is infinite in the forward direction and divided into discrete periods indexed by t. There is one physical good that can be used for consumption or investment. Each generation consists of a continuum of agents with two-period lives, indexed by $[0,1]$. Each individual of each generation receives an endowment e of goods when young and none when old. The endowment may be thought of being obtained from short-term production with inelastically supplied labor. Generations are divided into two classes. A fraction η of the individuals are potential entrepreneurs, the rest $1-\eta$ of the population are consumers. Potential entrepreneurs and consumers differ in the fact that only the former have access to investment technologies.

Consumers are endowed with preferences over consumption in the two periods of their lives with c_t^1, c_t^2 denoting youthful and old-age consumption of a consumer born in period t, respectively. For tractability, let $u(c_t^1, c_t^2) = \ln(c_t^1) + \delta \ln(c_t^2)$ be the intertemporal utility function of a consumer, where $\delta\,(0 < \delta < 1)$ is the discount factor. Given an initial endowment e and a certain interest rate, each young household saves the amount $s = \frac{\delta e}{1+\delta}$. Aggregate savings of all households then is $S = (1-\eta)s$.

Each entrepreneur has access to a production project that converts period-t goods into period-$t+1$ goods. For simplicity, we assume that potential entrepreneurs are risk neutral and consume only when old. The required funds for an investment project are $e + I$. An entrepreneur must borrow I units of the goods in order to undertake the investment project. The entrepreneurs are heterogeneous and indexed by a quality parameter i which is uniformly distributed on $[0, \eta]$. Banks cannot observe the quality of investment projects and banks are thus subject to adverse selection problems. We assume that banks have access to sufficiently efficient monitoring to secure either the maximal possible loan and interest repayment or the liquidation value of the entrepreneur's project.[5] If an entrepreneur of type i obtains additional resources I and decides to invest, he realizes investment returns in the next period of

$$f_i(q, e+I) = (1+i)\, q f(e+I),$$

where f denotes a standard atemporal neoclassical production function. f is assumed to be twice differentiable, strictly monotonically increasing, strictly concave, and to satisfy the Inada conditions. The parameter $q \in \mathbb{R}_+$ is subject to exogenous stochastic noise governed by an i.i.d. process $\{q_t\}_{t\in\mathbb{N}}$ which is uniformly distributed on the compact interval $[\underline{q}, \overline{q}] \subset \mathbb{R}_+$.

Entrepreneurs operate under limited liability. Given some loan interest rate r^c and

[5] A detailed discussion of the interaction of adverse selection and moral hazard in the underlying model of financial intermediation can be found in Gersbach (1999).

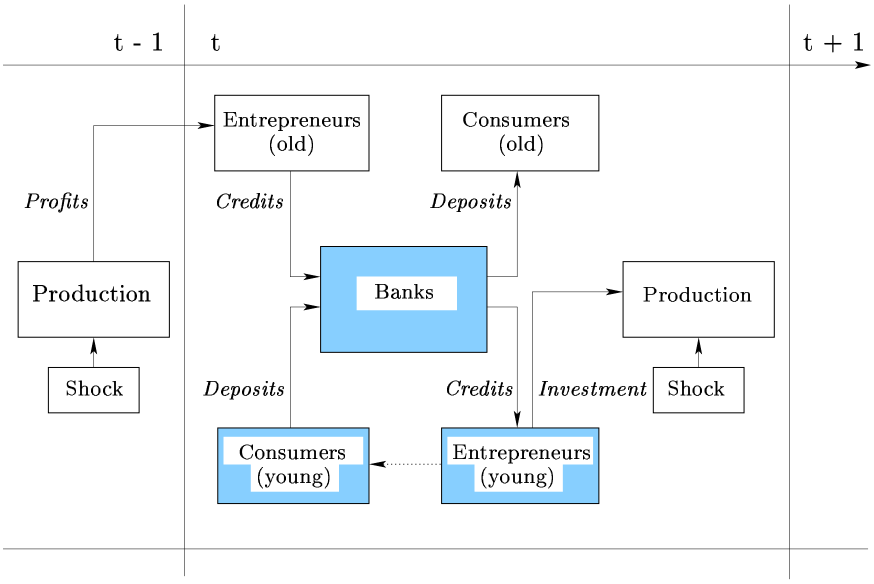


Figure 1: Sectors of the economy.

banks monitoring technologies, the expected profit of an investing entrepreneur i is

$$\Pi(i, r^c, I) := \int_{\mathbb{R}_+} \max\{(1+i)q\, f(e+I) - I(1+r^c), 0\}\, \mu(dq),$$

where μ denotes the probability distribution of the shocks. Following Gersbach & Wenzelburger (2001), set $\underline{r} = (1+i)\underline{q}f(e+I)/I - 1$ and $\overline{r} = (1+i)\overline{q}f(e+I)/I - 1$. Then the expected profit $\Pi(i, r^c, I)$ of entrepreneur i is

$$\Pi(i, r^c, I) = \begin{cases} (1+i)f(e+I)\frac{\overline{q}+\underline{q}}{2} - I(1+r^c) & \text{if } r^c \leq \underline{r} \\ \frac{(1+i)f(e+I)}{2(\overline{q}-\underline{q})}\left[\overline{q} - \frac{I(1+r^c)}{(1+i)f(e+I)}\right]^2 & \text{if } \underline{r} < r^c < \overline{r} \\ 0 & \text{if } \overline{r} \leq r^c. \end{cases} \tag{1}$$

There are $n (n > 1)$ banks, indexed by $j = 1, \ldots, n$, that can finance entrepreneurs. Banks are owned by the entrepreneurs, the ownership of banks is transfered to the next generation through bequests. Each bank j can sign deposit contracts $D(r_j^d)$, where $1 + r_j^d$ is the repayment offered for 1 unit of resources. Loan contracts of bank j are denoted by $C(r_j^c, I_j)$, with $1 + r_j^c$ denoting the repayment required from entrepreneurs for 1 unit of funds and I_j the loan size. All deposits and loan contracts last for one period, and loan sizes are bounded from above by I^*. A risk-neutral entrepreneur with quality parameter $i \in [0, \eta]$ will invest, if

$$\max_{1 \leq j \leq n} \left\{\Pi(i, r_j^c, I_j)\right\} \geq e \max_{1 \leq j \leq n} \{1 + r_j^d\}.$$

The three different sectors of the economy, consumers, entrepreneurs, and banks are displayed in Fig. 1.

2.2 Banking sector

We distinguish between two possible *intermediation games* that determine the interest rates in each period. In the *first scenario*, banks set deposit and loan rates without any intervention by a regulator. In the *second scenario*, a regulator stipulates interest rates on deposits, denoted by r^d_{reg}, and thus applies deposit rate control. In Sec. 2.3, we will outline how other policy measures may be integrated into this framework. The timing of actions in the economy within a typical period t is as follows.

1. Old entrepreneurs pay back with limited liability. The current deficits or reserves are determined. Excess reserves are distributed among shareholders according to pay-out rules.

2. Banks maximize profits in each period.[6] In the *first scenario* banks set interest rates on deposits and loans under strict enforcement of capital requirements. In the *second scenario* either banks' realized profits are too low or they have made losses. Then a regulator will intervene by setting fixed interest rates on deposits. Banks will set interest rates on loans and offer deposit contracts to consumers as well as deposit and credit contracts to entrepreneurs.

3. Consumers and entrepreneurs decide which contracts to accept. Resources are exchanged and banks pay back depositors.

4. Young entrepreneurs produce subject to a macroeconomic shock.

Let d denote the current reserve (deficit) level of the banking system. There are two boundary values for d. Denote by $\overline{d} := \eta I^* - S$ the value of reserves that would allow all entrepreneurs to invest, since $S + \overline{d} = \eta I^*$ assuming that $\overline{d} > 0$. If $d > \overline{d}$, then banks have more reserves than needed to finance all entrepreneurs and hence resources are available in excess for any pair of deposit and loan interest rates. Similarly, let $\underline{d} := -[S + \eta e]$ denote the maximal deficit that still allows to balance liabilities in a particular period but not for new investments. For $d = \underline{d}$, all possible savings are needed to pay back obligations to the last generation. $\underline{d} < d$ ensures that there are enough saving entrepreneurs to finance new investment projects and to meet the liabilities of the last generation. If $d < \underline{d}$, the banking system cannot fulfill its obligations anymore and as a whole is bankrupt thus causing the economy to collapse.

An intermediation problem therefore arises only when $d \in [\underline{d}, \overline{d}]$. Before we establish an equilibrium for the two intermediation games, notice first that for each $d \in [\underline{d}, \overline{d}]$ and each $S/\eta \leq I \leq I^*$, there exists a critical entrepreneur $i^G = i^G(d, I)$, given by

$$i^G(d, I) := \frac{\overline{d} - d}{e + I}$$

[6] This assumption is crucial, because banks' behavior as well as competition among banks depend on whether return on equity or expected profit is maximized.

such that savings and investments are balanced, that is,

$$S + e\, i^G(d, I) + d = [\eta - i^G(d, I)]I. \tag{2}$$

Using (1), a straightforward calculation shows that for each $d \in [\underline{d}, \overline{d}]$ and each $I \in (S/\eta, I^*]$, there exists an equilibrium interest rate $r^* = r(d, I)$, given by[7]

$$r(d, I) := \frac{\big(1 + i^G(d, I)\big) f(e + I)\overline{q}}{I} \left[1 + \frac{\overline{q} - \underline{q}}{\overline{q}} \frac{e}{I} - \sqrt{\left(1 + \frac{\overline{q} - \underline{q}}{\overline{q}} \frac{e}{I}\right)^2 - 1} \right] - 1, \tag{3}$$

such that

$$\Pi\big(i^G(d, I), r(d, I), I\big) = e\,\big(1 + r(d, I)\big), \quad d \in [\underline{d}, \overline{d}], \quad S/\eta \le I \le I^*$$

and savings and investments balance, that is, (2) holds.

Assuming that depositors are fully protected through bail-outs of the next generation, a *subgame-perfect equilibrium* of the intermediation game is a tuple

$$\left\{ \left\{ r_j^{d*} \right\}_{j=1}^n, \; \left\{ r_j^{c*} \right\}_{j=1}^n \right\}$$

such that entrepreneurs take optimal credit application and saving decisions and no bank has an incentive to offer different deposit or loan interest rates. According to Proposition 1, Gersbach & Wenzelburger (2001), for each $d \in [\underline{d}, \overline{d}]$ and each loan size $I \in (S/\eta, I^*]$, a unique subgame-perfect equilibrium exists, in which savings and investments are balanced, all entrepreneurs $i \in [0, i^G(d, I)]$ save, and all entrepreneurs $i \in [i^G(d, I), \eta]$ invest. In the first scenario, all banks have the same deposit and loan interest rates in equilibrium which, in addition, coincide and are given by the equilibrium interest rate $r^* = r(d, I)$ defined in (3).

In the second scenario with a regulator setting $r^d \le r^*$ as the deposit interest rate for all banks, loan interest rates in equilibrium coincide across all banks and compute as

$$r^{c*} = r^c(d, I, r^d) := \frac{\big(1 + i^G(d, I)\big) f(e + I)\overline{q}}{I} \left[1 - \sqrt{\frac{2(\overline{q} - \underline{q})e\,(1 + r^d)}{\big(1 + i^G(d, I)\big) f(e + I)\overline{q}^2}} \right] - 1. \tag{4}$$

It is moreover shown in Gersbach & Wenzelburger (2002) that the loan size I is always maximal across banks and equal to I^*, if banks are allowed to choose $I \in [S/\eta, I^*]$. In what follows we henceforth drop the superscript $*$ by writing $I = I^*$. At this stage it is important to note that the symmetry of banks allows us to focus on the banking system as a whole. (Note also that it suffices to consider an individual bank.)

An important feature of the subgame-perfect equilibrium defined by (3) is that banks receive no premium on the default risk associated with the macroeconomic risk. This is a consequence of banks' optimization behavior and the price competition in the banking sector. Much of the analysis of this paper rests on this strong presumption which causes zero intermediation margins. Similar results are likely to be obtained for less extreme cases in which intermediation margins are low. However, the situation will change, if banks can fully internalize downside risks such that macroeconomic risk factors is reflected in loan pricing. Then a banking system will become less fragile.

[7]For simplicity, we assume $\frac{I}{e} \le \frac{2\underline{q}}{\overline{q} - \underline{q}}$. See Gersbach & Wenzelburger (2001) for the general case.

2.3 Intervention rules

Let us discuss two intervention possibilities. Consider first *strict enforcement of capital-adequacy rules* which is defined by the following two rules. A *capital adequacy rule* requires that each bank fulfills

$$\frac{d_t}{[\eta - i^G(d_t, I)]I} > \alpha, \tag{5}$$

where $0 \leq \alpha \leq 1$. The capital adequacy rule (5) states that a regulator intervenes if current realized reserves fall below a certain threshold given by a percentage α of last period's credit volume $[\eta - i^G(d_t)]I$. Due to the symmetry of banks, in our model the whole banking system has to satisfy this requirement. Setting aside all complications of defining the equity of a bank, α is set to 0.08 in our model. This is in accordance with the first Basel Accord.

Strict enforcement of capital adequacy rule means that the bank (and thus the banking system) must fulfill the capital adequacy rule (5) in the same period in which new credit and deposit contracts are offered. Otherwise the bank has to go bankrupt. If the current level of reserves is insufficient, banks may comply with the capital adequacy rule (5) by lowering the loan size I for the investment projects of the subsequent period.[8]

An alternative intervention policy is to put off strict enforcement of the capital adequacy rule and intervene with other measures. Let us discuss a regulator who intervenes by ceiling the deposit rates as soon as reserves have fallen below a critical level and strict enforcement of capital adequacy rules has been put off. Such an intervention rule is referred to as *interest-rate intervention* or, equivalently, *cartelization intervention*.[9] An *interest-rate intervention* can be introduced as follows. Let d_{reg} denote the critical level of reserves below which intervention occurs. Choose a non-decreasing function $g : [\underline{d}, \overline{d}] \rightarrow [0, 1]$ by setting

$$g(\underline{d}) := 0 \quad \text{and} \quad g(d) = 1 \quad \text{for} \quad d \geq d_{reg}.$$

g may be continuous but could also be defined by setting $g(d) := 0$ for $d \in [\underline{d}, d_{reg}]$. An *interest-rate intervention rule* $\psi : [\underline{d}, \overline{d}] \rightarrow \mathbb{R}_+$ is given by setting

$$r^d = \psi(d) := g(d)r^*(d). \tag{6}$$

ψ is designed as to model a regulator who intervenes with an otherwise competitive outcome if and only if $d < d_{reg}$. In doing so, $r^c = r^c\big(d, \psi(d)\big)$ describes the loan interest rate for all values of $d \in [\underline{d}, \overline{d}]$, whereas $\psi(d) = r^*(d) = r^c(d)$ is equivalent to the competitive outcome with no intervention.

[8] Letting capital requirements operate directly through the loan size for entrepreneurs is a simplification. Since all entrepreneurs are identical from the banks perspective, reducing loans symmetrically across entrepreneurs to satisfy regulatory requirements does not violate optimal responses by banks. Note also that the strict enforcement requires an immediate adjustment of loans such that the capital adequacy rule with current reserves is met.

[9] The scope of this intervention rule is, of course, limited, if banks have to fear deposit withdrawals.

The important feature of the model is that a low r^d will cause a high loan interest rate[10] and thus large intermediation margins. Observe that in our model interest-rate intervention in the extreme case $r^d = 0$ is equivalent to allowing the banking industry to form cartels. In such a cartel, banks would coordinate on deposit interest rates and then choose loan interest rates such that aggregate profits are maximized implying that investments and savings balance. An important prerequisite for successful interest-rate interventions is a low interest-rate elasticity for deposits which is assumed to be zero throughout the paper.

Two other policy measures to manage banking crises can be fitted into our framework in a straightforward manner. First, subsidies to banks which increase banks' reserves in a particular period. These could be financed by taxing the initial endowments of young and old consumers. Second, in the case of deficits when d_t is negative, random bail-outs amounts to canceling out the balance sheets of a subset of randomly chosen banks. This will decrease deficits. To fulfill complete insurance of deposits, depositors of defaulting banks must be compensated with taxes from all consumers and entrepreneurs. Note that taxing endowments not only reduces savings of consumers but also equity of entrepreneurs which in turn has an effect on the productivity of the economy.

A third policy measure is the short-term interest rate policy by a central bank. However, such an intervention requires a monetary framework which in our model is missing. It is an open issue whether central bank-interest rate polices can replicate effects similar to those of deposit rate controls in real models.

2.4 Evolution of the economy

We are now in a position to set up equations which govern the evolution of reserves (deficits) of the banking system. Let $d_t \in [\underline{d}, \overline{d}]$ be the current level of reserves (deficits) at the beginning of an arbitrary period t and assume that the firms have encountered the shock q_t. Then, according to Gersbach & Wenzelburger (2001), repayments of firms are given by

$$P(d_t, q_t, r^d) = \int_{i^G(d_t)}^{\eta} \min\Big\{(1+i)q_t\, f(e+I)\,,\; I\big(1+r^c(d_t, r^d)\big)\Big\} di,$$

where the loan interest rate is given by (4). Banks raise funds $S + e\, i^G(d_t)$ that have to be payed back with interest at the end of period t. Each q and each $r^d \geq 0$, the function $G(q, \cdot, r^d) : [\underline{d}, \overline{d}] :\to (-\infty, \overline{d}]$ is defined by

$$G(q, d, r^d) = \min\left\{\overline{d}\,,\; P(d, q, r^d) - [S + e\, i^G(d)]\,(1 + r^d)\right\}.$$

Given a policy rule ψ defined in (6), the new level of reserves (deficits) d_{t+1} is then determined by

$$d_{t+1} = G\big(q_t, d_t, \psi(d_t)\big), \quad d_t \in [\underline{d}, \overline{d}], \tag{7}$$

[10]Because savings and investments remain balanced we even have $\frac{\partial r^c}{\partial r^d} < 0$. Qualitatively, however, it suffices that intermediation margins increase sufficiently.

where q_t is the current shock. Here, Equation (7) describes a stochastic difference equation. Since we assume that $\{q_t\}_{t\in\mathbb{N}}$ is an i.i.d. process, the sequence of reserves $\{d_t\}_{t\in\mathbb{N}}$ generated by (7) is a Markov process, see Lasota & Mackey (1994). If $d_{t+1} \geq 0$, then all depositors have been payed back and d_{t+1} represents the reserves of banks at the beginning of period $t+1$. The minimum operator appearing in the definition of G implies that reserve levels above the value $\overline{d}$ will be payed out to the entrepreneurs who are assumed to own the banks. If $\underline{d} < d_{t+1} < 0$, then the banks made losses and d_{t+1} is the amount of liabilities that could not be covered by loan repayments of entrepreneurs. Hence, banks in period $t+1$ have to raise enough new funds to pay back d_{t+1} to the depositors born in period t. If $d_{t+1} < \underline{d}$, then, as discussed above, banks are bankrupt and the economy collapses. It is shown in Gersbach & Wenzelburger (2001) that there exists a policy rule such that the deficit level stays above $\underline{d}$. In fact, it is not difficult to see that the policy rule defined in (6) satisfies this condition. This implies that the resulting Markov process is always bounded from above by $\overline{d}$ and from below by $\underline{d}$.

Finally, if $d \in [\underline{d}, \overline{d}]$ is the reserve level of an arbitrary period, *aggregate income* of the economy in the next period is given by

$$Y\big(d, q, I\big) = e + \int_{i^G(d,I)}^{\eta} \big(1+i\big) q\, f\big(e+I\big)\, di. \tag{8}$$

Since $i^G(d, I)$ is decreasing in d, it is clear that $Y(d, q, I)$ is increasing in d. High banks reserves are good for the economy because more entrepreneurs can be financed. Of course, one might think of other channels through which lower bank capital might constrain loan supply. However, we do not expect that the policy implications for managing banking crises will fundamentally differ from the case developed here.

3 Intervention from a macroeconomic perspective

3.1 The need for intervention

In this section we develop our main argument that a competitive banking system may fail to prevent a system-wide insolvency in the banking sector. This in turn may result in a collapse of the economy. Such an insolvency may happen regardless of whether the system is subject to regulatory capital requirements or not. A collapse is a state of the economy in which banks' obligations to depositors cannot be fulfilled. Adopting a macroeconomic perspective, we discuss possible intervention policies of a regulating authority which are capable of preventing a collapse and which are aimed at avoiding economic downturns with low aggregate income incurred by banking crises.

For the scenario described in Sec. 2, it is relatively easy to establish (Gersbach & Wenzelburger 2001, Lemma 4) that no intervention is necessary, if macroeconomic shocks are sufficiently positive. In such cases aggregate productivity of firms and hence their repayments are high enough such that the banking system does not suffer from large-scale defaults of firms. If macroeconomic shocks are negative, however, banks incur higher losses on firm defaults than they earn interest on their equity. Hence, bank capital decreases.

As a consequence, Propositions 3 and 4 in Gersbach & Wenzelburger (2001) show that the economy will collapse with probability one, if aggregate productivity of firms is on average too low. This result is caused by the asymmetric impact of macroeconomic shocks on bank reserves and by the inability of the banking system to recover from losses. A sufficiently negative shock causes a decline in the repayment capacity of firms and thus results in losses of banks. To cover losses, banks need new funds on which they have to pay interest. However, since intermediation margins are too small, the system will collapse after sufficiently many periods. It is a striking fact that this collapse will occur with certainty for *any* initial level of reserves prescribed by some capital adequacy rule if average repayments per unit of loan are too low.

One of the main reasons for the inability to recover from losses is that intermediation margins of competing banks do not allow for a premium on the macroeconomic risk debtors are exposed to. In other words, the interplay between the common exposure of banks to the risk of failing debtors, and a highly competitive banking industry makes a banking system vulnerable and thus necessitates intervention beyond capital adequacy. Since in our model aggregate income is monotonically increasing in reserve levels of the banking system, the broad objective of intervention is to minimize the extent and duration of low or negative bank capital in order to prevent severe losses in GDP.

We distinguish between two forms of banking crises. Critical times when capital in the banking sector is below regulatory capital but still positive and bad times when the banking system is insolvent. As discussed above (see also Gersbach & Wenzelburger 2001), an insolvent banking system does not collapse immediately since banks can use new funds to cover deposit obligations. Only if losses cannot be covered by new funds, a collapse occurs. The state of the economy in which bank losses are equal to funds from new depositors is called consumption trap. In the consumption trap, the accumulated deficit level is maximal and equal to $\underline{d}$. Then all new funds are needed to cover current liabilities. Hence, no profitable investments can be financed and aggregate income is minimal.

3.2 How intervention works

From a macroeconomic perspective, the goal of any intervention policy must be to reverse bad and critical times with low reserves and low aggregate income and to sustain good times in which aggregate incomes are on a high level. Let us investigate how intervention can achieve this goal by focusing on two intervention policies introduced in Sec. 2.3: strict enforcement of capital adequacy rules and deposit rate control which, in the context of this paper, is equivalent to a cartelization of the banking industry.

Reversing bad times requires that the banking system by itself or with the help of a regulator can decrease the current deficit such that the region $(0, \overline{d}]$ is reached within finite time. In technical terms, this means that for each trajectory $\{d_t\}_{t\in\mathbb{N}}$ of the system

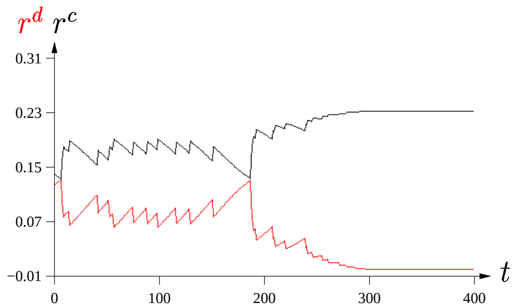
(7), which is allowed to start with an arbitrary reserve (deficit) level $d_0 \in (\underline{d}, \overline{d}]$, reaches the interval $(0, \overline{d}]$ in finite time with probability one. *Preserving times* in the range $(0, \overline{d}]$ requires that either the banking system itself or the regulator is able to sustain the current level of reserves in the range $(0, \overline{d}]$. This implies for the case of interest rate intervention the existence of an intervention rule ψ and a loan size I such that each trajectory $\{d_t\}_{t \in \mathbb{N}}$ of (7), which is allowed to start with any reserve level $d_0 \in (0, \overline{d}]$, stays within the interval $(0, \overline{d}]$.

Interest Rate Intervention

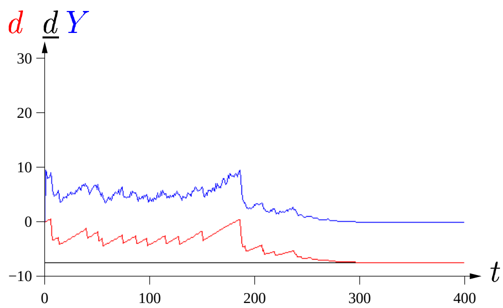
We first discuss interest rate intervention. In order to prevent a collapse, an intervention policy has to ensure that all future deficits stay above $\underline{d}$ with certainty. This is satisfied, if

$$G\big(d, q, \psi(d)\big) \geq \underline{d}, \quad \text{for all} \quad d \in [\underline{d}, \overline{d}], \; q \in [\underline{q}, \overline{q}].$$

Proposition 5 in Gersbach & Wenzelburger (2001) shows that there always exist an interest-intervention rule ψ that avoids a collapse. However, when regulatory intervention with interest rates aims just at avoiding a collapse, the economy is likely to remain with low aggregate incomes, that is, with low GDP levels. This phenomenon is illustrated in Fig. 2 which shows a particular example for which the economy converges to the consumption trap $\underline{d}$. Here we have set $I = 80$ for the loan size, whereas the parameter $\gamma = 0.9$ corresponds to a laissez-faire policy aimed at just preventing collapse. Notice that $\underline{d} \approx -8$. The complete parameterization is found in Appendix A.



(a) Interest rates



(b) Deficits and aggregate incomes

Figure 2: Converging to the consumption trap, $I = 80$, $\gamma = 0.9$.

Interventions must be substantially stronger in order to restore good times. We consider this much more demanding problem in two steps: first, avoidance of converging to the consumption trap and second reversing bad or critical times. To avoid the consumption trap, intervention rules have to prevent the deficits from converging to $\underline{d}$ such that all future deficits stay strictly above $\underline{d}$ with certainty. This aim requires an interest-intervention rule ψ such that

$$G\big(d, q, \psi(d)\big) > d$$

at least for deficit levels d close to $\underline{d}$ and sufficiently positive shocks q.

If this is not the case, Lemma 5 in Gersbach & Wenzelburger (2001) shows that under certain conditions, setting deposit rates $r^d = \psi(d)$ sufficiently small prevents the economy from converging to the consumption trap. The economy may become arbitrarily close to the trap, but deficits can be kept strictly above $\underline{d}$ with certainty. A major assumption for this result is that the probability for repayments that are higher than deposit obligations is sufficiently high.

In order to reverse bad and critical times, any intervention policy not only has to be able to prevent the consumption trap but also to reduce the current deficit by creating profits for banks through higher intermediation margins. Thus, we seek an interest-rate intervention rule ψ so that

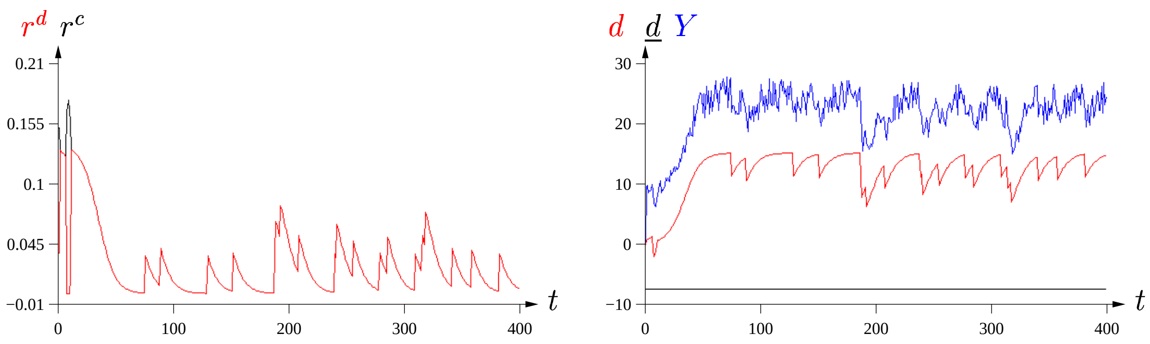
$$G\big(d, q, \psi(d)\big) > d, \quad d \in (\underline{d}, d_{reg}]$$

with sufficiently high probability. According to Proposition 7 in Gersbach & Wenzelburger (2001), an interest-intervention rule ψ exists which reverses bad times, provided that repayments of firms are on average high enough.

Necessary conditions for preserving good times require intervention rules which keep reserves within the interval $[0, \overline{d}]$. This is equivalent to a policy rule ψ that ensures

$$G\big(d, q, \psi(d)\big) \geq 0, \quad \text{for all} \ \ d \in [0, \overline{d}], \ q \geq \underline{q}.$$

Sufficient conditions for preserving times in $[0, \overline{d}]$ for the case of interest-rate interventions are given by Proposition 8 in Gersbach & Wenzelburger (2001). Fig. 3 provides an example in which bad times are reversed by means of interest-rate intervention with strong reduction of deposit rates, $\gamma = 10$. It is readily seen from the figure that the banking system is able to preserve good times without regulation as soon as their reserve level is sufficiently high.



(a) Interest rates

(b) Reserves and aggregate incomes

Figure 3: Reversing bad and preserving good times, $I = 10$, $\gamma = 5$.

It turns out that for interest rate intervention, reversing critical and preserving good times requires higher productivity of firms than reversing bad times.

Strict Enforcement of Capital Adequacy Rules

We turn now to enforcement of capital adequacy rules. Obviously, if $d \leq 0$, strict enforcement of capital adequacy rules will imply an immediate bankruptcy of banks and thus an immediate collapse, since banks have no possibilities to fulfill the rule. Hence, strict enforcement is only meaningful for the case of reserves $d > 0$.

Theorem 1 in Gersbach & Wenzelburger (2002) states conditions under which a strict enforcement of capital-adequacy rules suffices to prevent the consumption trap, provided that firms' repayments in the worst case scenario are high enough.

Sufficient conditions for preserving times in $[0, \overline{d}]$ are given by Theorem 2 in Gersbach & Wenzelburger (2002) for the case of strict enforcement of capital-adequacy rules. Strict enforcement of capital adequacy rules can only work, if bank reserves are still sufficiently positive since loan sizes cannot be lowered below a threshold value without causing a substantial decline of bank reserves in the next period.[11] Preserving times in $[0, \overline{d}]$ can be achieved by delayed enforcement of capital adequacy rules where the regulator allows some additional time within which banks have to fulfill the capital adequacy rule. Theorem 1 in Gersbach & Wenzelburger (2002) states conditions under which a delayed enforcement of capital-adequacy rules suffices to prevent the consumption trap, provided that firms' repayments in the worst case scenario are sufficiently high.

The success of capital requirements depends on the economic fundamentals in a much more entangled way than interest-rate interventions. Strict enforcement of capital-adequacy rules may enhance the productivity of firms and thus their repayments. However, whenever macroeconomic shocks cause the capital of banking system to deteriorate sufficiently, a strict enforcement of capital adequacy rules is insufficient to resolve a banking crisis and its use could be extremely harmful.[12] In such a case, interest-rate interventions become necessary.

4 Towards an optimal policy mix

The discussion of possible intervention policies so far was exclusively concerned with protecting an economy from long-lasting episodes with low aggregate income. The problem of finding a socially desirable combination of policy measures was completely set aside. Although this issue has not been treated explicitly in our two papers cited in the references, we would like to outline some basic ideas from a macroeconomic perspective.

Any regulatory setup has to deal with the dilemma that strict enforcement of capital-

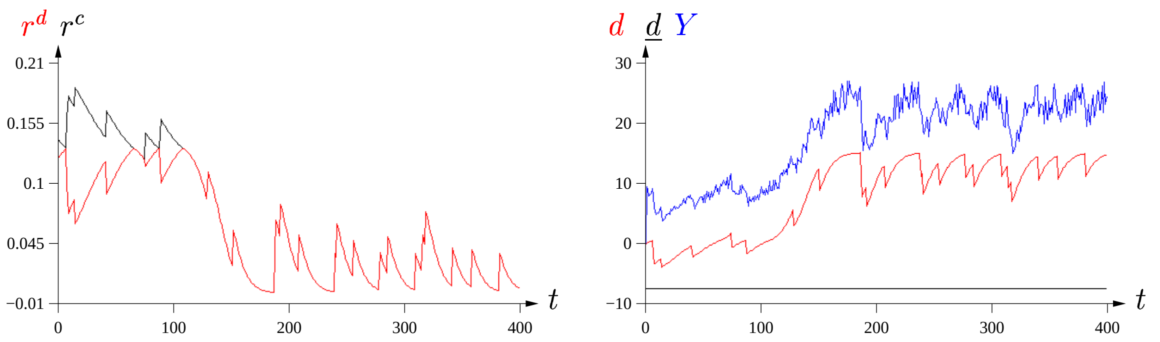
[11]Below a certain threshold value of the loan size banks encounter excess savings and deposits even if all entrepreneurs invest.

[12]The proposed revision of the Capital Accord (Basel II) will make capital requirements more risk-sensitive. Hence, it is likely that minimum capital requirements will be more pro-cyclical than under current arrangements. In particular, they could increase considerably in critical times, thus making regulatory forbearance and intervention by other means than capital adequacy rules even more likely.

adequacy rules in critical or even bad times can imply a socially harmful decline in aggregate bank credits, first pointed out by Blum & Hellwig (1995). As the results for our simple model confirm, such a decline may result in significant losses in aggregate incomes (8).[13] This is due to the fact that reducing the credit line reduces aggregate output and thus GDP. As pointed out above, there is no chance that the rules can be fulfilled, if banks' capital is below a certain level. Immediate regulatory forbearance is not needed as long as bank capital is still close to the capital required by regulation. In such a case, the banking system has good chances to return to good times without large GDP costs and seems to be better off without further intervention.

However, in critical times when strict enforcement of capital requirements is insufficient to prevent a banking crisis, capital adequacy rules should temporarily be put off. This is the case when bank capital has substantially fallen below regulatory capital, but still is well above zero. Such regulatory forbearance should be combined with inducing or allowing for higher intermediation margins to enforce recapitalization of banks.[14] As argued above, this can be achieved by ceiling interest rates on deposits or, equivalently, by allowing for a short-term cartelization of the banking industry.

The time it takes a banking system to recover from a crisis with interest rate intervention may be, however, quite long which again is costly for the economy. This observation is illustrated in Fig. 4 which displays the same situation as in Fig. 3 except that the interest-rate intervention less stringent, $\gamma = 0.97$. A comparison of both panels shows that a weaker intervention policy may considerably delay the recovery of the economy in terms of GDP. On the other hand, if the productivity of firms is



(a) Interest rates

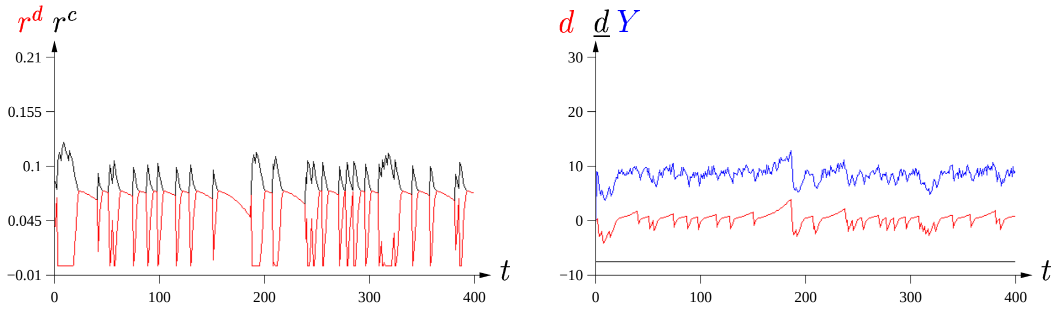
(b) Deficits and aggregate incomes

Figure 4: Delayed reversal of bad times, $I = 80$, $\gamma = 0.97$.

too low, stronger intervention rules might become necessary. This is witnessed in Fig. 5 which displays the situation of Fig. 3 where the production elasticity is lowered to $a = 0.41$. Despite persistent interest-rate interventions, the GDP level does not recover and remains on a relatively low level.

[13] Moreover, large-scale bankruptcies of banks which enhance this effect could hardly be ruled out if capital adequacy rules are strictly enforced.

[14] Possibly with limitations on dividend pay-out policies of banks.



(a) Interest rates

(b) Deficits and aggregate incomes

Figure 5: Failure of reversing bad times, $I = 80$, $\gamma = 5$, $a = 0.41$.

To accelerate the recapitalization of the banking sector, subsidies to banks which are financed by taxing consumers and entrepreneurs may be appropriate. Subsidies as ultimate measures could be combined with random bail-outs, where a certain fraction of banks are forced into bankruptcy. To avoid contagion and run effects on other banks, a regulator might simultaneously pledge and ensure that the remaining banks are bailed out. Such random bail-outs have three advantages over a complete bail-out as long as the fraction of defaulting banks is small and negative externalities for the economy remain negligible. First, the level of subsidies required to save the banking system decreases. Second, the surviving banks may take over assets of defaulting banks and will receive more new funds for refinancing purposes. Both effects improve the financial position of the surviving institution. Third, letting some banks go bankrupt in crises alleviates negative incentive effects from bail-out policies.

In summary, a hierarchy of policy measures to manage banking crises might be a useful start for a policy guideline in this area. The results of our simple model suggest that interventions should start with strict enforcement of capital-adequacy rules, followed by interest-rate ceiling/cartelization and finally subsidies accompanied by random bail-outs should be taken into consideration.

5 Conclusions and further research issues

While most of our results can be derived in a more or less straightforward manner, there are a variety of unresolved issues. First, from a theoretical point of view, it remains unclear why the exposure of a banking system to macroeconomic risks cannot be reduced. On the one hand, loan interest rates could contain a premium for macroeconomic risks which would serve as a buffer against negative effects. Currently, banks are moving into this direction. On the other hand, taking off risks factors from the balance sheets of banks could be achieved through deposit and loan contracts that are contingent on the main macroeconomic risk factors. The variety of arguments why such arrangements have not been implemented yet (Hellwig (1998) and Gersbach (1999)) are not entirely convincing. Since entrepreneurs and depositors will always bear the risk as well as the costs of a banking crisis, a contractual allocation of macroeconomic risks that shifts more risks to entrepreneurs and even depositors could prove to be more efficient.

Second, the scope of this research has essentially been a normative one. An equally important issue is whether a proposed policy measures will indeed be implemented by regulators and central banks. An important strand of the literature has investigated a regulator's incentives to apply closure rules from a more microeconomic perspective. Boot & Thakor (1993) examined closure rules that result in socially optimal bank portfolio choices. They find that the regulator's optimal bank closure policy is not strict enough for social optimality. The analysis has been extended by Acharya & Dreyfus (1989), Fries, Mella-Barral & Perraudin (1997), and Mailath & Mester (1994). Finally, Repullo (1999) considers government agencies with different objective functions and investigates which of these agencies should make bail-out decisions. He finds that central banks should be responsible for dealing with small solvency shocks, while a deposit-insurance agency should be in charge of the larger ones. Macroeconomic aspects are usually not taken into these considerations. As for other matters, stringent intervention rules which force current generations to bear the costs of a banking crisis will be implemented only if politics is concerned about future generations.

Finally, an adequate treatment of the role of central banks in a banking crisis has not yet been accomplished. It is by no means obvious whether mere monetary policies such as lowering short-term interest rates are capable of resolving a severe banking crisis. To address this issue as well as banking crises solely caused by liquidity squeezes and international financial crises, one needs a model that takes international capital movements, exchange rates, and feedback effects on the domestic economy into account.

A Parameterization of the model

All simulations of the paper are carried out with the program package MACRODYN , cf. Böhm & Schenk-Hoppé (1998). We used the following parameterizations:

1. Endowments: $e = 10$, discount factor $\delta = 0.5$, fraction of entrepreneurs $\eta = 0.5$.

2. Shock process: $\{q_t\}_t$ i.i.d. uniformly distributed on $[\underline{q}, \overline{q}]$ with $\underline{q} = 7.8$, $\overline{q} = 10$.

3. Technology: Cobb-Douglas production function

$$y = f(e + I) := b/a\,(e + I)^a\,, \quad \text{where} \;\; a = 0.44,\; b = 0.5.$$

4. Regulation:

$$r_{reg}(d) = \begin{cases} r^*(d) & \text{if } d > d_{reg}, \\ \big(1 + r^*(d)\big)\, g(d) - 1 & \text{if } d \leq d_{reg}, \end{cases}$$

where

$$g(d) = \beta \left[\left(1 - \frac{1}{1+r^*(\underline{d})}\right) \left(\frac{d-\underline{d}}{d_{reg}-\underline{d}}\right)^{\gamma} + \frac{1}{1+r^*(\underline{d})} \right] \quad \text{for } d \leq d_{reg}.$$

and

$$\alpha = 0.08, \quad \beta = 1, \quad \text{and} \quad \gamma \geq 0.$$

The parameter α determines d_{reg} and γ describes the adjustment speed of the deposit-rate ceiling. The particular values for the remaining parameters, the loan size I and the adjustment speed γ are read off the corresponding captions.

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