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ABSTRACT

Financial Intermediation with Contingent Contracts and Macroeconomic Risks*

We examine financial intermediation when banks can offer deposit or loan contracts contingent on macroeconomic shocks. We show that the risk allocation is efficient provided there is no workout of banking crises. In this case, banks will shift part of the risk to depositors. In contrast, under a workout of banking crises, depositors receive non-contingent contracts with high interest rates while entrepreneurs obtain loan contracts that demand a high repayment in good times and little in bad times. As a result, the present generation overinvests and banks create large macroeconomic risks for future generations, even if the underlying risk is small or zero.

JEL Classification: D41, E40 and G20
Keywords: banking regulation, financial intermediation, macroeconomic risks and state contingent contracts

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1 Introduction

Banking crises are associated with high costs. Such banking crises are often caused by economic downturns. Gorton (1988) conducts a seminal empirical study to differentiate between the sunspot view and the business-cycle view of banking crises. He finds that bank panics are systematically linked to business cycles. Subsequent work by Kaminsky and Reinhart (1999) and Demirgüç-Kunt and Detragiache (1998) have come up with further insights, providing evidence for factors that may cause financial fragilities and that may ultimately lead to banking crises. These results suggest that banking crises tend to erupt when the macroeconomic environment is weak, particularly when output growth is low.

It is a widely held view that traditional contractual arrangements in banking leave banks subject to the risks associated with systematic or macroeconomic[1] shocks, and that this may be inefficient. Ways in which deposit and loan contracts might be designed to reduce macroeconomic risks on the balance sheets of banks appear to be one of the most important research issues related to banking crises. This is also the focus of the present paper. We examine the incidence of macroeconomic risks when banks can write deposit and loan contracts contingent on macroeconomic events.

We consider an overlapping generations model in which financial intermediaries such as banks can alleviate agency problems in financial contracting. Banks compete for funds and offer credit contracts to potential borrowers. We allow for macroeconomic shocks affecting the average productivity of investment projects.

We distinguish between bailout and failure, depending on whether insolvent banks are bailed out or have to go bankrupt. The main conclusions are as follows: Suppose that the regulator commits to bankruptcy for insolvent banks. Then, financial intermediation yields an efficient risk allocation. If macroeconomic shocks are small, depositors and entrepreneurs are offered non-contingent deposit and loan contracts. All macroeconomic risk is borne by entrepreneurs. The inside funds of entrepreneurs act as a buffer for macroeconomic risks. If macroeconomic shocks are larger, banks write state contingent contracts for depositors and debtors. Part of the macroeconomic risk is

[1] We use the terms systematic and macroeconomic shocks as synonyms.

shifted to consumers, since entrepreneurs cannot bear the entire risk.

The risk allocation changes completely if bank deposits are guaranteed and, hence, future generations provide funds to pay back banks' obligations to the previous generation in order to prevent them from becoming insolvent. With bailout, competing banks try to generate a profitable (positive intermediation margin) and a non-profitable (negative intermediation margin) state of the world. In the good state with high productivity of investment projects, they request high loan interests from entrepreneurs. In order to motivate entrepreneurs to invest rather than to save, banks request very low repayments in the bad state with low productivity of investment projects. Deposit rates are non-contingent since deposits are insured by the next generation. Competition among banks for the creation of a profitable state pushes deposit rates up to the high repayment of entrepreneurs in this state. As a result, banks create a state of the world with high repayment obligations to depositors, but with very low pay-back requirements for entrepreneurs. This creates large risks for future generations, even if the underlying risk is small or zero. This is called the risk-generation effect. As a consequence of the risk-generation effect, the present generation receives higher interest rates on savings than in a situation with bank failures. This induces overinvestment among the current generation at the expense of future generations.

Allowing for equity issuing does not alleviate the incentive for banks to create profitable and non-profitable states under the bailout regime. In competition, banks are unable to raise equity. Shareholders demand at least the same expected returns on equity as depositors receive. This is, however, infeasible as future generations repay deposits but not equity. Capital adequacy rules are necessary to induce sufficient bank capital.

Our paper is related to the recent discussions on regulatory issues regarding financial intermediaries. First, our model can explain that competition of financial intermediaries under a bailout system increases the underlying aggregate risk, since banks compete to create profitable states of the world. The usual regulatory discussion has focused on the behavior of single institutions (see e.g. Dewatripont and Tirole 1994) or on the incidence of aggregate risk on the banking system without contingent contracts (Blum and Hellwig 1995 and also Gehrig 1997). The former literature has pointed out and tested (e.g. Keeley 1990) that a low charter value increases a bank's incentive to take on risk (see Freixas and Rochet 1997 for a survey). Our model shows that this risk-taking incentive for bank managers must be complemented by the risk-generating effect that we introduce in this paper. Even if the underlying productivity risk is small or zero, competition among banks under a bailout approach yields large macroeconomic risks for future generations.

Second, it has been pointed out by Hellwig (1995a, 1998) that it is unclear why the terms of the deposit contracts cannot be made contingent on aggregate events, such as productivity shocks or fluctuations in the gross domestic product. Hellwig [1998] offers three explanations for this phenomenon: lack of awareness among contractors; moral hazards for banks or deposit insurance; transaction costs and the market-making role of financial intermediaries. Our model indicates that bailouts of banking crises or explicit deposit insurance will not lead to contingent deposit contracts, but to contingent loan contracts with very large differences in state-dependent repayments. State-dependent deposit contracts only occur for large productivity shocks and a regulatory scheme that induces bankruptcy of insolvent banks. Our analysis indicates that making deposit and loan contracts contingent on variations in aggregate income under a bailout approach is inefficient and should even be prevented by regulatory action.

Third, our model may explain why banks are unable to raise sufficient equity without capital adequacy requirements. Competition among banks, in conjunction with bailouts in banking crises, impedes banks from raising equity. Capital requirements are traditionally viewed as a form of prudential regulation that induces banks to internalize the risk of their investment decisions. Our model provides a complementary justification of capital adequacy rules as they need to solve the equity-raising dilemma.[2]

Our model builds on the concepts of how financial intermediation, coupled with adverse selection and moral hazard, can be integrated into dynamic general equilibrium frameworks as first developed by Williamson (1986, 1987) and Uhlig (1995). The novel elements of this paper are the introduction and the examination of the impact of macroeconomic shocks in conjunction with state contingent deposit and loan contracts.

[2] Capital adequacy rules can solve equity raising problems but may reinforce future macroeconomic fluctuations, as shown by Blum and Hellwig (1995).

The paper is organized as follows. The next section describes the model. In the third section, we derive the equilibrium in the intermediation market without the presence of macroeconomic shocks. In section four we introduce temporary productivity shocks, state contingent deposit and loan contracts, and regulatory schemes. In sections five and six, we examine small and large productivity shocks under different regulatory schemes. In section seven, we consider the equity raising dilemma. Section eight presents our conclusions.

2 Model

We consider a generation of agents living for two periods. For most of our analyses, it will be sufficient to look at the generation born in a particular period t. However, regulatory policies such as bailouts will require the existence of more than one generation to guarantee credible deposit insurance by taxing future generations. Further generations are introduced as needed.

The generation under consideration consists of a continuum of agents, indexed by [0,1]. There are two classes of agents in each generation. A fraction η of individuals are potential entrepreneurs. The rest, $1-\eta$, of the population are consumers. Potential entrepreneurs and consumers differ in that only the former have access to investment technologies. There is one physical perishable good that can be used for consumption or investment. Each individual in each generation receives an endowment e of the good when young and none when old.

Each entrepreneur has access to a production project that converts time t goods into time $t+1$ goods. The required funds for an investment project are $F := e + I$. Hence, an entrepreneur must borrow I units of the goods in order to undertake the investment project. The class of entrepreneurs is not homogeneous. We assume that entrepreneurs are indexed by a quality parameter q uniformly distributed on $[\overline{q_t}-1, \overline{q_t}]$, $\overline{q_t} > 1$, in the population of entrepreneurs. If an entrepreneur of type q obtains additional resources I and decides to invest, he realizes investment returns in the next period of:

$$q(I + e). \tag{1}$$

$\overline{q}_t$ is the aggregate indicator of the productivity of investment projects in period t. If $\overline{q}_t$ is uncertain in period $t-1$, generation $t-1$ faces macroeconomic risk. For simplicity, we assume that potential entrepreneurs are risk neutral and are only concerned with consumption in their old age, i.e., they do not consume when young. Consumers consume in both periods. They have utility functions $u(c_t^1, c_t^2)$ defined over consumption in the two periods. The variables c_t^1, c_t^2 are the consumption of the consumer born in period t when young and old respectively. Consumers are risk-averse. If a household can transfer wealth between the two periods at a riskless real interest rate, denoted by r_t, the solution of the household's intertemporal consumption problem generates the saving function, denoted by $s\{r_t\}$. We follow the standard assumptions in the OG literature that the substitution effect (weakly) dominates the income effect, i.e., savings are a weakly increasing function of the interest rate. We drop the time index whenever convenient.

We will perform our analysis in a perfect information context. We briefly provide the underlying agency conflicts that provide the rationale for the occurrence of financial intermediation and the assumptions of our model. Depositors face the following informational asymmetries. The quality q is known to entrepreneurs but not to depositors. Moreover, depositors cannot verify whether an entrepreneur invests (see Gersbach and Uhlig 2004). To alleviate such agency problems in financial contracting, financial intermediation can act as delegated monitoring in the sense proposed by Diamond (1984). We assume that there are banks, indexed by j, which are capable of financing entrepreneurs. For all our arguments, it will be sufficient that two banks exist and compete. As delegated monitors, banks act as information providers concerning private investment projects.

We assume that banks can completely alleviate agency problems in contracting. This is equivalent to the assumption that monitoring technologies are efficient enough to reduce the private benefits of entrepreneurs who try to shirk and want to consume the funds they obtain [see Gersbach and Uhlig 2004].[3] For simplicity, we assume that monitoring outlays for a bank per credit contract are negligible. Our analysis, however, is also applicable to the case where banks can completely alleviate agency problems in contracting by investing a fixed amount per credit contract in monitoring. In this case, the interest rate spread will be positive and in equilibrium will cover the costs of monitoring.[4] For simplicity of presentation, we assume in this paper that such fixed monitoring costs are zero.

If banks can completely alleviate the agency problems of entrepreneurs, only entrepreneurs who wish to invest will apply for credits. We now return to the perfect information context. First, we discuss the nature of contracts offered by banks indexed by $j = 1, 2, \cdots$. Bank j can sign deposit contracts $D(r_j^d)$ where $1 + r_j^d$ is the repayment offered for one unit of resources. Loan contracts of bank j are denoted by $C(r_j^c)$ where $1 + r_j^c$ is the repayment required from entrepreneurs for one unit of funds. Banks also stipulate that entrepreneurs must invest their endowments if they apply for loans.[5] If macroeconomic risk is present, we allow for contracts to be conditioned on the realization of $\overline{q}_t$ or on the resulting GDP in period $t-1$. In such cases, state contingent deposit or loan contracts can be written.

Note that the availability of production technologies from period t to $t+1$ allows depositors and entrepreneurs of each generation to trade amongst themselves.[6] Generations are connected by financial intermediaries which represent the sole long-living institution. A new generation is affected by the preceding generation when banks have accumulated either profits or losses. In the former case, a generation may buy the shares of the banks. Our focus is on Bertrand competition, therefore the price of bank shares is zero. Thus, this case is trivial and shall be neglected. In the latter case, a generation may be forced by regulation or may wish to rescue banks by fulfilling the

[3] Moreover, banks are able to secure the liquidation value of investment projects if investing borrowers cannot pay back.

[4] A further extension could allow banks to compete on monitoring intensity, which may increase risk generation when banks choose a low intensity of monitoring (see e.g. Gehrig and Stenbacka (2004).

[5] The fact that an entrepreneur who applies for a loan also invests his equity is a standard assumption which we also employ.

[6] In this model, intergenerational trade does not improve autarky for all generations. In particular, insuring depositors against the macroeconomic risk by taxing future generations will make some future generations worse off.

obligations to the preceding depositors. This will be the focus of our analysis. Losses of banks will only occur if aggregate risk is present and hence there is uncertainty about $\overline{q}_t$.

3 Equilibrium without Macroeconomic Shocks

We begin with a discussion of the case where macroeconomic shocks are exempted, as this will prove useful in understanding the results presented later in this paper. We treat each generation and each intermediation game separately. At the end of this section we will discuss the cases restricted by the set of equilibria.

We first derive the equilibrium in the intermediation market for the period under consideration. For simplicity of exposition, we assume that only two banks are present. Obviously deposit and loan contracts will have a length of one period, as no transformation of maturities needs to take place. We examine the following four-stage intermediation game.

Period t

1. Banks offer deposit contracts to consumers and entrepreneurs.
2. Banks offer credit contracts to entrepreneurs.
3. Consumers and entrepreneurs decide which contracts to accept. Resources are exchanged.

Period $t + 1$

4. Entrepreneurs pay back. Banks pay back depositors.

The game is a multi-stage game with observed actions. That is, actions at each stage are chosen simultaneously, and players know the actions in all previous stages when they enter the next stage. In the following we discuss the main assumptions of the intermediation game. We assume that banks cannot ration deposit contracts in stage

3.[7] Loans are rationed when the amount of deposits at a particular bank is insufficient to fund all borrowers who have applied. If loan applicants are rationed at a particular bank, we assume that the probability of each of the said loan applicants obtaining a credit is the same.

We next consider the loan application decision of an entrepreneur with quality q, given that he observes r_j^d, r_j^c of banks. If he obtains a loan, he also has an incentive to invest, since banks can alleviate agency problems in contracting completely. If he applies for a loan at the bank offering the lowest loan rate, his terminal wealth or consumption $W(q)$ will amount to

$$W(q) = q(e+I) - I(1+\min\{r_j^c\}) \tag{2}$$

If he does not apply, he obtains $e(1+\max\{r_j^d\})$ by saving his endowments. Thus, there exists a critical quality parameter, denoted by $q^*(r_j^c,\ r_j^d)$, and given by

$$q^*(\min\{r_j^c\}, \max\{r_j^d\}) = 1 + \frac{I\min\{r_j^c\} + e\max\{r_j^d\}}{e+I} \tag{3}$$

which motivates entrepreneurs with $q \geq q^*$ to take out loans and entrepreneurs with $q < q^*$ to save.

However, the decision whether to apply for loans or to save may also depend on rationing expectations. We assume that rationed entrepreneurs applying for a loan at bank j will go to the bank that offers the most favorable deposit contracts. There are three possibilities for formulating the rationing schemes.

First, under myopic no-rationing, entrepreneurs make loan application decisions with the assumption that they will not be rationed at banks that offer the highest deposit rate.[8] Using this scheme, all entrepreneurs apply to banks with the lowest loan rate within the set of banks that offer the highest deposit rate. Second, under simple rationing entrepreneurs take into account that they may be rationed at any bank when applying for credits. The rejected entrepreneurs then choose banks with the highest deposit interest rate and save. Third, under complex rationing, entrepreneurs apply first for loans at the bank with the lowest loan rate. If they are rejected, they

[7] This assumption coincides with current regulations in most countries.

[8] As only those banks will obtain deposits, it is intuitive to restrict no-rationing expectations to these banks.

may try the second bank. If an entrepreneur wishing to invest is rejected twice, he chooses to save at the bank with the highest deposit rate. Gersbach (1998) shows that all three rationing schemes lead to the same equilibrium, in which banks make zero profits when no macroeconomic shocks are present. In equilibrium, no rationing will occur. In order to explore the impact of macroeconomic risk and the role of state contingent deposit and loan contracts, we assume myopic no-rationing throughout the paper. This greatly simplifies the exposition.[9] In all equilibria studied in this paper, the no-rationing expectations of entrepreneurs are indeed self-fulfilling.

Note that we have assumed that banks can completely alleviate agency problems in contracting and thereby securing repayments. Thus, they are not concerned about low-quality entrepreneurs applying, since such entrepreneurs would have less consumption than with saving endowments. Banks are assumed to maximize expected profits. Hence, conditional on granting a credit to an entrepreneur and receiving funds from savers, profits per credit of a bank j amount to:

$$G_j = I(1 + r_j^c) - I(1 + r_j^d) = I(r_j^c - r_j^d) = I\Delta_j \tag{4}$$

Δ_j is the intermediation margin of bank j. In order to derive the intermediation equilibrium, we assume that savings are never sufficient to fund all entrepreneurs. Since the deposit rate r_j^d cannot exceed $\bar{q} - 1$ without causing losses for banks, and we have assumed that the savings of consumers are weakly increasing in the deposit rate, a sufficient condition is:

$$(1 - \eta)\, s\, \{\bar{q} - 1\} < \eta\, I \tag{5}$$

We also assume that investments exceed savings at zero deposit and loan interest rates. In this case $q^* = 1$ and entrepreneurs with $q \geq 1$ apply for loans, while entrepreneurs with $q < 1$ save their endowments. Therefore, we assume

$$(1 - \eta)s[0] + \eta\, e\big(1 - (\overline{q} - 1)\big) < \eta\, (\overline{q} - 1)\, I. \tag{6}$$

[9] As in Gersbach (1998) where no macroeconomic risk is present, we expect our results to be quite robust with regard to different rationing schemes on the loan side, as more sophisticated rationing expectations tend to lower the profits of banks that deviate from the candidate equilibrium we derive in this paper.

Together, the boundary conditions ensure that savings and investment can be balanced at positive interest rates. Finally, we assume that banks that are unable to pay back go bankrupt.

A subgame perfect Nash equilibrium among banks with myopic beliefs of entrepreneurs is a tuple

$$\left\{ \left\{ r_j^{d*} \right\}_{j=1,2},\ \left\{ r_j^{c*} \right\}_{j=1,2} \right\}$$

so that

- entrepreneurs take optimal credit application and saving decisions with the expectations that loan applicants are not rationed at banks offering the highest deposit rate,
- no bank has an incentive to offer different deposit or loan interest rates,
- no rationing occurs in equilibrium.

Therefore, the strategy spaces of banks are deposit and loan contracts.[10] In the appendix it is shown:

Proposition 1

Suppose $\overline{q} \leq 2$. Then, there exists a unique equilibrium of the intermediation game with

(i)

$$r^* = r_j^{c*} = r_j^{d*} \qquad \forall_j$$

(ii) r^* is determined by

$$(1-\eta)\, s\ \{r^*\} + \eta e\Big(1 + r^* - (\bar{q} - 1)\Big) = \eta\, (\bar{q} - (1 + r^*))\ I$$

(iii)

$$q^* = 1 + r^*$$

[10]Usually, interest rates on deposits and loans are constrained in such a way that repayments of debtors in stage 4 are non-negative.

Hence, the intermediation game yields the competitive outcome in which savings and investments are balanced and in which there is a common interest rate for loans and deposits. For the purpose of this paper, the most important conclusion from proposition 1 is that intermediation margins are zero in equilibrium and savings and investments are balanced.

Due to the switching possibility open to entrepreneurs, the two-sided price competition of banks yields the Walrasian outcome. Hence, in our model the incentive of banks to corner one side of the market in order to obtain monopoly rents on the other side does not destroy the perfect competition outcome.[11] Suppose a bank offers a deposit rate slightly above r^* in order to attract all depositors. If this bank raises r^c in order to exploit its monopoly power among entrepreneurs, a portion of entrepreneurs will switch market sides. This, however, causes large excess resources for the deviating bank, inducing a loss greater than the excess returns from the remaining entrepreneurs.

In equilibrium, all entrepreneurs with projects whose returns are equal or above r will obtain funds and invest.

Aggregate income, denoted by y_t^0, is given by:

$$y_t^0 = e + \eta(I + e) \cdot \left\{ \frac{\overline{q}^2 - (1 + r^*)^2}{2} \right\} \tag{7}$$

The first term represents the aggregate endowment in period t. The second term captures the output generated by investments in the last period. Note that banks do not need to put up equity to perform their intermediary function, as they can fully diversify their lending activities.

[11] See Stahl (1988) and Yanelle (1989 and 1997) for seminal contributions on the theory of two-sided intermediation and Gehrig (1997) for a recent extension to differentiated bank services.

4 Temporary Productivity Shocks, Contracts, and Regulation Schemes

In this section, we consider the possibility of aggregate productivity shocks. We assume that $\overline{q}_\tau = \overline{q}$ in all periods τ, except period t. In period t, $\bar{q}_t$ is assumed to be $\bar{q}^1$ with probability p (state 1 or good state) or $\bar{q}^2$ with probability $1-p$ (state 2 or bad state). The distribution of the entrepreneurs' qualities varies accordingly. We assume $\bar{q}^2 < \bar{q}^1$. $z = \bar{q}^1 - \bar{q}^2$ denotes the size of the shock. $\bar{q}^e = p \cdot \bar{q}^1 + (1-p)\bar{q}^2$ is the average productivity of the best possible qualities.

We maintain the assumptions that savings and investment can be potentially balanced at positive interest rates for any of the following constellations. In particular, we assume that the boundary conditions (5) and (6) in the last section hold for both shock scenarios $\overline{q}^2$ and $\overline{q}^1$.

Equilibria of the intermediation game in period $t-1$ will now crucially depend on the regulator's approach to banking crises. A banking crisis occurs when one or both banks, and thus the whole banking system, is unable to repay depositors. We distinguish between two polar cases when banking crises occur: bailout and failure. If the regulator commits to failure, banks that are unable to satisfy depositors go bankrupt. If the regulator commits to bailout, he will tax future generations to save banks.[12]

With bailout, we assume that banks expect losses to be precisely recovered such that they will have zero profits in the future. If banks incur no losses in period t, they will anticipate zero profits due to Bertrand competition. The assumption ensures that we can define an equilibrium of the financial intermediation game for a particular period.

While we compare the consequences of two regulatory schemes with commitment toward banking crises, our analysis can also be discussed in the following manner. Suppose that the current generation can determine the regulatory approach toward banking crises. If the costs in establishing a new banking system after the failure of the existing

[12] While we focus on polar cases of regulatory approaches toward banking crisis, there are intermediate scenarios when the regulator taxes the current generation to bail out banks. As long as taxation is lump-sum, the qualitative nature of our results with respect to the risk-generation effect do not change. Of course, the implication that the current depositors benefit at the expense of future generations under a bailout scheme does not hold anymore.

one are negligible, the current generation always chooses failure when faced with the case of a banking crisis. If the costs are prohibitively high and must be borne by the current generation, banks would be saved.

With stochastic aggregate productivity shocks, banks can offer state-contingent contracts in period $t-1$. We use $C(r_j^{c1}, r_j^{c2})$ to denote the credit contract offered by bank j. r_j^{c1} and r_j^{c2} denote the interest rate demanded from borrowers in states 1 and 2 respectively. Similarly, $D(r_j^{d1}, r_j^{d2})$ denotes deposit contracts with deposit rates r_j^{d1} and r_j^{d2}, depending on the realization of macroeconomic shocks. We maintain the assumption that banks are risk-neutral.[13]

Since consumers are risk-averse, they prefer a riskless interest rate over a lottery $\{r_j^{d1}, r_j^{d2}\}$ with the same expected interest rate. We assume that the consumers' intertemporal preferences and their attitudes towards risk generate the saving function, now denoted by $s\{r_j^{d1}, r_j^{d2}\}$.

The expected deposit rate is denoted by $r_j^{de} = pr_j^{d1} + (1-p)r_j^{d2}$. Similarly, the expected interest rate on loans is given by $r_j^{ce} = pr_j^{c1} + (1-p)r_j^{c2}$. To simplify notation we use the following convention. An entrepreneur is characterized by his quality in the good state, $q \in [\overline{q}^2 - 1, \overline{q}^2]$, or by his quality in the bad state, $q - z \in [\overline{q}^1 - 1, \overline{q}^1]$ or by his average quality, denoted by q^e, and given by

$$q^e = p \cdot q + (1-p)(q-z). \tag{8}$$

The critical entrepreneur is denoted by $q^{e*}(r_j^{c1}, r_j^{c2}, r_j^{d1}, r_j^{d2})$. An entrepreneur with an expected quality q^e and associated quality q in the good state faces the following choices. Applying for a credit yields expected wealth:

$$\begin{aligned} E(W(q)) = p\Big\{&\max\big\{q(I+e) - I(1+r_j^{c1})\big\}, 0\Big\} \\ &+ (1-p)\Big\{\max\big\{(q-z)(I+e) - I(1+r_j^{c2}), 0\big\}\Big\} \end{aligned} \tag{9}$$

Note that in the bad state, the project returns may be insufficient to pay back the loan. Saving funds yields expected wealth

[13] Since entrepreneurs as owners of banks are risk-neutral, the assumption follows naturally. If entrepreneurs were risk-averse, there exist various justifications of the "as-if risk neutrality" assumption, because banks can rely on the law of large numbers to smooth out idiosyncratic risk [see Hellwig 1995b].

$$e\Big(p(1+r_j^{d1})+(1-p)(1+r_j^{d2})\Big)=e(1+r_j^{de})$$

Potential entrepreneurs are risk-neutral. Thus, the comparison of the expected wealth between investing and saving determines the critical quality level above which entrepreneurs choose to invest. In the following section, we examine the intermediation game in period $t-1$, depending on the size of the shock.

5 Small Productivity Shocks

We first consider the case when shocks are so small that funded and investing entrepreneurs are always able to pay back. The upper limit for small shocks will be given in the next proposition. In this case, the critical entrepreneur in terms of expected quality would be given by:

$$q^{e*}=1+\frac{I\min\{r_j^{ce}\}+er\max\{r_j^{de}\}}{e+I} \tag{10}$$

such that entrepreneurs with $q^e \geq q^{e*}$ apply for loans while entrepreneurs with $q^e < q^{e*}$ save their endowments.[14] Note that q^{e*} implies a critical value in the good state, denoted by q^* and defined by:

$$q^{e*}=p\,q^*+(1-p)(q^*-z)$$

We first derive the equilibrium when the regulator commits to failure. In the case of failure, depositors know that banks can never pay back a promised deposit rate if the lending rate is lower in the same state of the world. Hence, we restrict our analysis to $r_j^{d1} \leq r_j^{c1}$ and $r_j^{d2} \leq r_j^{c2}$. For instance, if $r_j^{d1} > r_j^{c1}$ were offered, depositors would simply count on $r_j^{d1}=r_j^{c1}$.

Provided funds are received and credit is granted to the entrepreneur, expected profits per credit of bank j when there is no bailout amount to

$$\begin{aligned}E(G_j)&=p\cdot I(r_j^{c1}-r_j^{d1})+(1-p)I(r_j^{c2}-r_j^{d2})\\&=I(r_j^{ce}-r_j^{de})\end{aligned} \tag{11}$$

[14]Note that under myopic rationing $\min\{r_j^{ce}\}$ is restricted to the set of banks that offer the highest deposit rate.

The critical entrepreneur in equilibrium is denoted by q_f^{e*}. We obtain:

Proposition 2

Suppose that the regulator commits to failure. Then, there exists a unique equilibrium of the intermediation game if

$$z \leq \frac{e(1+r^f)}{p(e+I)}$$

where r^f is determined by:

$$(1-\eta)\ s\left\{r^f, r^f\right\} + \eta e\Big(1 + r^f - (\bar{q}^e - 1)\Big) = \eta\Big(\bar{q}^e - (1+r^f)\Big) \cdot I$$

The equilibrium is given by

(i)

$$r^f \ = r_j^{c1} = r_j^{c2} = r_j^{d1} = r_j^{d2}, \qquad \forall j$$

(ii)

$$q_f^{e*} = 1 + r^f$$

The proof is given in the appendix. Note that the equilibrium interest rates, the critical entrepreneur, and the upper bound of the shock are fully determined by the exogenous variables. The proposition implies that financial intermediation with a commitment to bankruptcy of insolvent banks by the regulator yields an efficient intragenerational allocation of risks for the generation under consideration. Risk-neutral entrepreneurs can bear the entire macroeconomic risk, since they can repay the same interest rate in both states. The productivity shock is fully absorbed by the fluctuation of the entrepreneurs' income. Banks never default in equilibrium.

Suppose, however, the regulator commits to bailouts. In this case, banks might be tempted to request particularly high interests rates on loans in the good state and a low interest rate in the bad state. It is instructive to show first that for this reason the efficient risk allocation can no longer be an equilibrium.

Proposition 3

Suppose that the regulator commits to bailouts. Then, efficient risk allocation cannot be an equilibrium.

The proof is given in the appendix. In the next proposition we establish the equilibrium of the game. The critical entrepreneur who is indifferent between saving and applying for a loan in the case of bailouts is denoted by q_w^{e*}.

Proposition 4

Suppose $(\overline{q}^e - 1 - p)e + (\overline{q}^e - 2p)I \leq 0$. Suppose that the regulator commits to bailouts. Then, there exists a unique equilibrium with:

(i)

$$r^w = r_j^{c1} = r_j^{d1} = r_j^{d2}$$

(ii)

$$r_j^{c2} = -1$$

(iii) r^w is determined by

$$(1-\eta) \cdot s\{r^w,\ r^w\} + \eta e \cdot \Big(q_w^{e*} - (\overline{q}^e - 1)\Big) = \eta(\overline{q}^e - q_w^{e*})I$$

with

$$q_w^{e*} = 1 + \frac{I\{pr^w - (1-p)\} + er^w}{e+I}$$

The proof is given in the appendix. The intuition for this result is as follows. With bailout, banks wish to create a profitable state, i.e., a state of the world where $r_j^{c1} - r_j^{d1}$ is large, while being unconcerned about losses in the other state. In the good state competition drives profits to zero and we have $r_j^{c1} = r_j^{d1}$. In order to demand high interest rates from entrepreneurs in one state of the world, banks do not require any repayment in the bad state. This motivates entrepreneurs to apply for loans. The condition in proposition 4 is fulfilled as long as the expected upper level of the productivity is not too high and the probability of the good state is not too low.[15]

[15] If the condition in proposition 4 is not fulfilled, the results remain qualitatively the same. Banks will still demand less repayment from entrepreneurs in the bad state . However, $r_j^{c2} = -1$ is no longer feasible in equilibrium, since the average loan interest rate would induce too much investment.

Proposition 4 holds independently of the size of the shock, provided $\overline{q}^e$ holds to the aforementioned condition. Thus, even if the macroeconomic risk is small, future generations face large aggregate risks.

Proposition 4 holds even if there is no macroeconomic risk whatsoever, i.e., $\bar{q}^2 = \bar{q}^1$. This case occurs if there are sunspot random variables with the probability distribution $(p, 1-p)$, upon which banks write contingent deposit and loan contracts. Proposition 4 shows that banks generate risk for future generations. Hence, we use the term risk-generation effect rather than the well-known risk-shifting effect to describe the equilibrium outcome in proposition 4, as risk is generated even if there is no underlying real risk. An immediate consequence is:

Proposition 5

Suppose $(\overline{q^e} - 1 - p)e + (\overline{q^e} - 2p)I \leq 0$. *Suppose that the regulator commits to bailouts. In the bad state, future generations face losses equal to the savings of the last generation.*

Obviously propositions 4 and 5 are extreme, since banks are able to write contracts with entrepreneurs demanding negative interest rates in one state of the world. If we restrict the set of contracts to non-negative interest rates, our results are qualitatively the same, but the potential losses for future generations dwindles. In the bad state banks will demand $r_j^{c2} = 0$.

In the next proposition, we compare the interest rates and investment levels for both regulatory schemes.

Proposition 6

The comparison between bailout and failure yields:

(i) $r^w > r^f$

(ii) $q_w^{e*} < q_f^{e*}$

The proof is given in the appendix. As proposition 6 implies, under the bailout regime the current generation overinvests compared to the bank failure regime, and depositors receive attractive interest rates. Since entrepreneurs do not need to pay back in one state of the world under bailout, a larger percentage of entrepreneurs choose to invest rather than save in comparison to the failure regime.[16]

6 Large Productivity Shocks and Bank Failure

In this section, we complete our analysis with the examination of the case where the shock is large. If the shock is sufficiently large, this makes complete insurance of depositors in the failure regime impossible. The essential condition is that the wealth of entrepreneurs is insufficient to insure depositors, i.e., $z \geq \frac{e(1+r^f)}{p(e+I)}$, where r^f is determined by proposition 2. We obtain:

Proposition 7

Suppose that the regulator commits to failure and that $z > \frac{e(1+r^f)}{p(e+I)}$. *Then, there exists an equilibrium of the intermediation game with:*

(i)

$$r^1 = r_j^{c1} = r_j^{d1}, \qquad \forall_j$$

(ii)

$$r^2 = r_j^{c2} = r_j^{d2}, \qquad \forall_j$$

(iii)

$$r^1 = \frac{I(1+r^2) + (e+I)\ \{zp - 1 - (1-p)r^2\}}{p(e+I)}$$

(iv) r^2 *is determined by*

$$(1-\eta) \cdot s\left\{r^1(r^2),\ r^2\right\} + \eta e\Big(q^* - (\bar{q}^e - 1)\Big) = \eta(\bar{q}^e - q^*) \cdot I \quad \textit{with}$$

(v)

$$q_f^{e*} = 1 + pr^1 + (1-p)r^2 = \frac{I\,(1+r^2)}{e+I} + zp$$

[16]To prevent the overinvestment result, the regulator could fix deposit rates at the level r^f from the outset. Such an ex ante deposit rate ceiling would not, however, eliminate the risk generation incentive of banks, since banks would still like to create a profitable and an unprofitable state of the world on the loan side.

The proof is given in the appendix. Hence, with large productivity shocks banks offer state-contingent deposit and loan contracts. Part of the macroeconomic risk is shifted to depositors. This prevents the aggregate risk from being shifted to future generations. Note that there is room for further improvements in risk allocation by repackaging deposit contracts into two securities. Risk-neutral entrepreneurs who save could hold very risky contracts. Risk-adverse consumers could be offered less risky or even riskless contracts. More refined contract arrangements like these would further improve intra-generational risk allocation without a shift of aggregate risk to future generations.

7 Raising Equity and Capital Requirements

Up to now we have examined cases where banks were not forced to put up capital in order to perform intermediation. On the one hand, banks could completely diversify idiosyncratic risks. On the other hand, banks were allowed to write state contingent deposit and loan contracts, or shift aggregate risk to future generations. In this section, we allow banks to raise equity. Under failure, there is no incentive to raise equity since the competition of banks shifts aggregate risk to entrepreneurs and consumers.

Suppose that banks can additionally offer equity contracts in the case of bailouts. An equity contract specifies that the holder will either receive a proportional part of a bank's profit as a dividend in the next period or, in the case of default, receive nothing. We obtain:

Proposition 8

Suppose that $(\overline{q}^e - 1 - p)e + (\overline{q}^e - 2p)I \leq 0$. *Suppose that the regulator commits to bailouts. Then, banks cannot successfully offer equity contracts in equilibrium.*

Proof :

Consider the candidate equilibrium without equity contracts, described in proposition 4, that involves deposit contracts $r_j^{d1} = r_j^{d2} = r^w$. In equilibrium we also have $r_j^{c1} = r^w$ and $r_j^{c2} = -1$. Suppose that a bank, say bank 1, wishes to offer equity contracts. Risk-neutral, non-investing entrepreneurs would only apply for such contracts if the average repayment was at least $1 + r^w$ and thus equal to the return on deposits. As the average expected repayment in the candidate equilibrium is equal to $p(1 + r^w)$, a deviating bank must increase the expected repayment from borrowers as the deposit rate is $1 + r^w$. The only conceivable way is to offer $r_1^{d1} = r_1^{d2} = r^w + \varepsilon$ ($\varepsilon > 0$) and to exploit the monopoly power on the loan side. The same arguments as in proposition 4 show that profits cannot be increased in this way and hence returns on equity are bounded by $p(1 + r^w)$. Accordingly, banks cannot offer equity contracts with expected returns equal to or greater than $1 + r^w$. Thus, no bank can successfully offer equity contracts in the candidate equilibrium.

■

The preceding proposition illustrates that competition, in conjunction with bailouts, impedes the possibilities of banks to raise equity. Hence, regulatory requirements that banks must hold equity in a certain proportion to outstanding loans can induce banks to raise equity.[17] Clearly, forcing banks to hold equity decreases the incentives to create risk. Capital requirements are traditionally viewed as a form of prudential regulation, which induces banks to internalize the risk of their investment decisions. Our model provides a new variation. Capital adequacy rules are needed to solve the equity-raising dilemma. However, it is clear that the issue of capital adequacy rules is much more complex than the brief account we offer here.

8 Conclusions

We have examined the incidence of macroeconomic shocks in a model of financial intermediation under different regulatory schemes regarding banking crises. Our analysis indicates that the combination of allowing banks to fail and contingent deposit and loan contracts tends to yield an efficient intra-generational risk allocation. Together with a large number of further issues to be considered in banking regulation (see Dewatripont and Tirole (1994), Hellwig (1998), Freixas and Rochet (1997), Bhattacharya, Boot and

[17]Obviously, we have to worry about the existence of equilibria in which banks issue both deposit and equity contracts. This will be taken up in future research.

Thakor (1998), and Allen and Santomero (1998)), the results may help to design an overall second-best banking regulation scheme.

The current framework should allow for a number of useful extensions. For instance, the decision whether or not to rescue insolvent banks may depend on the majority voting in a particular period. It is obvious that there are conflicting interests concerning the appropriate regulatory scheme. A generation supports the bailout of banks when its individuals are old depositors. A young generation will be harmed by taxation if they have to resolve banking crises and pay back the depositors. Hence, regulatory schemes depend on the relative sizes of generations and on potential costs in establishing new banks. The political economy of regulatory schemes could provide useful insights into the timing of bank failures and workouts.

9 Appendix

Proof of proposition 1:

We first show the existence of the equilibrium. Note that r^* is uniquely determined. The boundary conditions ensure that at least one solution exists. For sufficiently high interest rates, investments become zero, and hence the left side of the equation for r^* is greater than the right. For $r^* = 0$, the boundary condition ensures that the right side is greater than the left side. The mean value theorem establishes that at least one solution exists, since both sides are continuous in r.

Moreover, the left side of the implicit equation for r^* in proposition 1 is monotonically increasing in r^*. In contrast, the right side is decreasing in r^*. Hence, the solution is unique.

Loan application decisions of entrepreneurs are optimal, given $r^d = r^c = r^*$. Profits of banks per credit contract are zero (see Equ. (4)).

Changing one interest rate, while leaving the other at r^*, is never profitable for a bank. Consider a change of r_j^d. Profits are either negative provided $r_j^d > r^*$, or a deviating bank obtains no resources if $r_j^d < r^*$. Consider a change of r_j^c. Profits are negative since the interest rate margin is negative, or the deviating bank does not obtain loan applicants due to our rationing assumption.

Suppose, however, bank j offers slightly better conditions for depositors ($r_j^d = r^* + \epsilon$) and tries to exploit its monopolistic power on the lending side, i.e., the bank changes both interest rates.

Since bank j would obtain all deposits, entrepreneurs can only receive loans at this bank. Hence, profits of the deviating bank, denoted by π_j amount to:

$$\begin{aligned}\pi_j = \eta(\bar{q} - q^*) \cdot I(1 + r_j^c) - \eta e\Big(q^* - (\bar{q} - 1)\Big)(1 + r^* + \epsilon) \\ - (1 - \eta)s\left\{r^* + \epsilon\right\}(1 + r^* + \epsilon)\end{aligned} \tag{12}$$

where

$$q^* = 1 + \frac{I \cdot r_j^c + e(r^* + \epsilon)}{e + I}$$

and

$$r_j^c > r^* + \epsilon$$

Note that bank j has excess resources of

$$(1-\eta)s\left\{r^* + \epsilon\right\} + \eta e\Big(q^* - (\bar{q} - 1)\Big) - \eta(\bar{q} - q^*) \cdot I$$

which, however, can neither be invested nor used in the next period since the good is perishable. We obtain

$$\begin{aligned}\frac{\partial \pi_j}{\partial r_j^c} &= \eta\left\{(\bar{q} - q^*) \cdot I - \frac{I}{e+I} \cdot I(1 + r_j^c)\right\} - \eta e \frac{I}{e+I} \cdot (1 + r^* + \epsilon) \\ &= \frac{\eta I}{e+I}\Big\{(\bar{q} - 1)(e+I) - 2Ir_j^c - I - e(1 + 2r^* + 2\epsilon)\Big\} \\ &< \frac{\eta I}{e+I}\Big\{(\bar{q} - 2)(e+I)\Big\}\end{aligned}$$

Therefore, $\frac{\partial \pi_j}{\partial r_j^c}$ is negative if $\overline{q} \leq 2$.

Hence, profits are decreasing for $r_j^c \geq r^* + \epsilon$ with the loan interest rate. Thus, bank j cannot make profits by offering $r_j^d = r^* + \epsilon$ and some lending rate $r_j^c \geq r^* + \epsilon$. Finally, it is obvious that setting $r_j^d = r^* + \varepsilon$ and $r_j^c < r^* + \varepsilon$ is not profitable because profits are negative.

Uniqueness follows through similar observations. Any interest rate constellation which would yield excess resources can be improved by a deviating bank. Nor can any interest rate constellation with $r^d < r^c$ and no excess resources be an equilibrium. A bank can profitably deviate by setting $r^d + \varepsilon$, $(\varepsilon > 0)$ and $r^c - \delta$, $(\delta > 0)$, where δ must be selected so that no excess resources occur.

■

Proof of proposition 2:

We observe that, given r_j^{ce} and r_j^{de}, and hence a given critical entrepreneur q^{e*} and a given profit per credit, banks can offer risk-averse depositors the highest utility by setting $r_j^{d1} = r_j^{d2}$. Hence, Bertrand competition will lead to $r_j^{d1} = r_j^{d2} = r_j^{de}$. Moreover, banks are forced to offer $r_j^{ce} = r_j^{de}$. Raising r_j^{de} slightly and increasing r_j^{ce} to obtain monopoly profits from entrepreneurs is not profitable for the same reasons as outlined in proposition 1. $r_j^{d1} = r_j^{d2} = r_j^{de} = r_j^{ce}$ and the repayment conditions $r_j^{d1} \leq r_j^{c1}$ and $r_j^{d2} \leq r_j^{c2}$ imply $r_j^{c1} = r_j^{c2} = r_j^{d1} = r_j^{d2}$.

This equilibrium interest rate is denoted by r^f and determined by the saving and investment balance. Finally, we need to verify that banks are able to pay back in both states of the world, as otherwise their deposit rates would not be credible. In the bad state the repayment condition is given by

$$(q^* - z)(e + I) = (q^{e*} - zp)(e + I) \geq I\,(1 + r^f)$$

Using $q^{e*} = 1 + r^f$ this implies

$$z \leq \frac{e(1 + r^f)}{p(e + I)}$$

■

Proof of proposition 3:

Consider the risk allocation of proposition 2. A bank j can consider the following deviation by offering the interest rates:

$$r_j^{d1} = r_j^{d2} = r^f + \epsilon$$

$$r_j^{c1} = r^f + \delta$$

$$r_j^{c2} = r^f - \frac{p\delta}{1 - p}$$

where δ is larger than ϵ. Bank j would obtain all deposits since $r_j^{de} > r^f$. The critical entrepreneur amounts to

$$q^{e*} = 1 + \frac{Ir^f + e(r^f + \epsilon)}{e + I} = 1 + r^f + \frac{e\epsilon}{e + I}$$

Hence, for sufficiently small ϵ, savings and investments are almost balanced. Since $r_j^{d1} < r_j^{c1}, r_j^{d2} > r_j^{c2}$, bank j will not be able to pay back depositors in the second state. However, when banking crises are worked out, expected bank profits per credit amount to

$$E(G_j) = p \cdot I(\delta - \epsilon) \tag{13}$$

For a sufficiently small amount for ϵ, excess resources from depositors are negligible. However, by choosing $\delta > \epsilon$ and making δ sufficiently large, expected profits will be large. Hence, the profitable deviation of bank j eliminates the existence of the efficient intra-generational risk allocation equilibrium.

■

Proof of proposition 4:

We first observe that r^w is uniquely determined. The left side of the implicit equation for r^w in proposition 4 is increasing in r^w, since $s\{r^w,\ r^w\}$ and q_w^{e*} are monotonically increasing in r^w. In contrast, the right side is decreasing in r^w. The corresponding boundary conditions ensure that a unique solution exists.

The most promising deviation of bank j would be[18]

$$r_j^{d1} = r_j^{d2} = r^w + \epsilon \tag{14}$$

$$r_j^{c2} = -1 \tag{15}$$

The bank would obtain all resources and would try to maximize expected profits by choosing the monopoly interest rate r_j^{c1}, as entrepreneurs expect to obtain loans at the

[18] It is straightforward, but tedious to check that any other potential deviation is not profitable.

deviating bank j only. Expected profits are given by

$$
\begin{aligned}
E(\pi_j) = p \cdot \Big\{ \eta(\bar{q}^e - q^*) \cdot I\Big(1 + r_j^{c1}\Big) - \eta e\Big(q^* - (\bar{q}^e - 1)\Big)(1 + r^w + \epsilon) \\
-(1-\eta) \cdot s\{r^w + \epsilon,\ r^w + \epsilon\}(1 + r^w + \epsilon)\Big\} \\
\text{with:} \qquad q^* = 1 + \frac{I\Big(p r_j^{c1} - (1-p)\Big) + e(r^w + \epsilon)}{e + I}
\end{aligned}
\tag{16}
$$

We obtain:

$$
\begin{aligned}
\frac{\partial E(\pi_j)}{\partial r_j^{c1}} &= \frac{p\,\eta\, I}{e+I} \cdot \Big\{ (\bar{q}^e - 1)(e + I) \\
&\quad - I\left\{p r_j^{c1} - (1-p)\right\} - e(r^w + \epsilon) - pI(1 + r_j^{c1}) - ep(1 + r^w + \epsilon)\Big\} \\
&= \frac{p\,\eta\, I}{e+I} \cdot \Big\{ (\bar{q}^e - 1)(e + I) - I(2p r_j^{c1} + 2p - 1) \\
&\quad - e(p + r^w(1+p) + \epsilon(1+p))\Big\} \\
&\le \frac{p\,\eta\, I}{e+I} \cdot \Big\{ (\bar{q}^e - 1 - p)(e + I) + I(1-p)\Big\} \\
&\le 0,\ \text{if } (\bar{q}^e - 1 - p)e + (\bar{q}^e - 2p)I \le 0
\end{aligned}
\tag{17}
$$

Note that we have used $r_j^{c1} = r^w = 0$ and $\varepsilon = 0$ to obtain the inequality. Hence, the deviation is not profitable if the assumption of the proposition holds.

■

Proof of proposition 6:

We compare the savings and investment balance in both cases. Suppose that $r^w < r^f$. This implies that

$$q_w^{e*} < 1 + \frac{I\, r^f + e\, r^f}{e + I} = 1 + r^f = q_f^{e*}$$

Hence, using proposition 2, we obtain:

$$(1-\eta)\, s\left\{r^f, r^f\right\} + \eta\, e\left(q_w^{e*} - (\bar{q}^e - 1)\right) < \eta\,(\bar{q}^e - q_w^{e*})\, I.$$

The strict inequality is reinforced when r^f is lowered to r^w in $s\{r^w, r^w\}$ because savings will slightly increase in accordance with a rise in the real interest rate. This is, however, a contradiction to the savings and investment balance in the bailout case, hence we obtain $r^w > r^f$. Moreover, $r^w > r^f$ implies that $q_w^{e*} < q_f^{e*}$ in order to balance savings and investments.

■

Proof of proposition 7:

a) We construct the equilibrium in the following way. In the bad state the interest rate r^2 in (iii) is determined by the requirement that the critical entrepreneur can simply pay back what he owes. We must have

$$(q^* - z)(e + I) = I\,(1 + r^2) \tag{18}$$

Using

$$q^e = pq + (1-p)(q-z)$$

which implies for the critical quality levels $q^{e*} = p\,q^* + (1-p)(q^* - z)$

$$q^* - z = q^{e*} - zp$$

we obtain

$$(q^{e*} - zp)(e + I) = I\,(1 + r^2) \tag{19}$$

Inserting $q^{e*} = 1 + pr^1 + (1-p)r^2$, which follows from equation (10), yields

$$r^1 = \frac{I\,(1 + r^2) + (e + I)\,\{zp - 1 - (1-p)\,r^2\}}{p\,(e + I)}$$

which corresponds to (iii). (v) follows by solving equation (19) for q^{e*}.

b) For sufficiently large productivity shocks we always have $r^1 > r^2$.

Using (iii), $r^1 > r^2$ implies

$$\begin{gathered} p(e+I)r^2 < p(e+I)\,r^1 = I(1+r^2) + (e+I)\left\{zp - 1 - (1-p)\,r^2\right\} \\ er^2 < I + (e+I)(zp-1) \end{gathered} \tag{20}$$

For a given r^2, q^{e*} is increasing in z. In order to fulfill the savings/investment balance in (iv), an increase in z leads to a decline in r^2. Hence, for sufficiently high z, equation (20) is fulfilled.

c) Expected profits of banks are zero. Suppose bank j offers deposit interest rates r^1 and $r^2 + \epsilon$. Since bank j obtains all deposits, it could change the individually optimal interest rates on loans. In order to avoid an excess resource problem, bank j needs to ensure that enough entrepreneurs want to apply for credits. Therefore, q^e should not rise above $q^{e*} = 1 + pr^1 + (1-p)r^2$.

If the deviating bank wishes to achieve $q^e = q^{e*}$

$$q^{e*} = 1 + \frac{I\, r^{ce} + e \cdot \Big(pr^1 + (1-p)(r^2 + \epsilon)\Big)}{e + I} = 1 + pr^1 + (1-p)r^2$$

we obtain

$$r^{ce} \leq pr^1 + (1-p) \cdot r^2 \leq r^{de} = pr^1 + (1-p)(r^2 + \varepsilon)$$

Accordingly, expected profits per credit amount to

$$\begin{aligned} E(G_j) &= p(r_j^{c1} - r_j^{d1}) \cdot I + (1-p)(r_j^{c2} - r_j^{d2}) \cdot I \\ &= I\,(r^{ce} - r^{de}) \\ &\leq 0 \end{aligned}$$

Hence, the deviation does not benefit bank j. Similar reasoning for any other potential deviation establishes that $\{r^1, r^2\}$ is an equilibrium.

■

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