Does Interbank Borrowing Reduce Bank Risk?

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Abstract:

In this paper we investigate whether interbank exposures create incentives for interbank monitoring as "signalled" by reduced level of risk undertaking of the interbank borrowing banks. We present a model of the credit market based on asymmetric information and moral hazard. Assuming that banks have monitoring costs benefits compared to depositors regarding the lending activities of the other banks, we show that interbank lending induces the borrowing banks to engage in less risky lending activities than banks that finance themselves predominantly in the deposit market. We empirically test the implications of the model on a large sample of banks from 10 Central and Eastern European countries. The results of the empirical analysis generally confirm the implications of the model.

Key words: bank specialization, interbank market, risk undertaking, transition countries

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1. Introduction

Recent literature on interbank exposures has emphasized the role of the interbank market as a source of contagion (Allen and Gale, 2000 and Freixas, Parigi and Rochet, 2000). However, Rochet and Tirole (1996) argue that, by generating incentives for lending banks to monitor interbank-borrowing banks, interbank exposures may also contribute to prudent market behavior and reduce the risk of bank failures and systemic distress. The idea is that banks are particularly good at identifying the risks of other banks (Calomiris, 1998). Provided with proper incentives, they can perform a complementary task to bank regulation and supervision by the authorities[1].

Despite the obvious appeal of this idea, empirical research on the issue is limited. In a first step in this direction, Furfine (2001) examines the pricing of interbank lending agreements as an indicator for the ability of banks to monitor their interbank borrowers. Since interbank loans on the federal funds market are large and uncollateralized, they expose lending institutions to significant credit risk. Lending banks, therefore, have an incentive to monitor their counterparties and price these loans as a function of the credit risk of the borrowing bank. Furfine's empirical results support this hypothesis by showing that borrowing banks with higher profitability, higher capital ratio, and fewer problem loans pay lower interest on federal funds loans. However, the impact is fairly small; for example, a one standard deviation rise in the loan-to-capital ratio raises the spread by merely 1.5 basis points.

A potential reason for the small economic significance of the results and the low empirical research interest in the issue is that economic analysis of interbank trade has so far concentrated on highly developed banking markets, where interbank exposures are mostly

[1] The idea of using banks as monitors of other banks is a part of a broader concept of using market discipline based on market information as a complement to bank supervision and regulation (Berger, Davis and Flannery, 1998; De Young et al, 1998; Peek, Rosengren and Tootell, 1999).

generated by short term liquidity needs (Bhattacharya and Gale, 1987; Allen and Gale, 2000; Hellwig, 1994). In contrast, Rochet and Tirole (1996) study the incentives for interbank monitoring generated by long-term lending commitments. In this paper, we focus on a sample of countries where interbank trade is the result of long-term specialization of some banks in issuing deposits and of others in lending to nonbanks. In such an environment, interbank lending is characterized by longer-term maturities. This provides a more suitable framework to test whether interbank lending is accompanied by interbank monitoring.[2]

More specifically, we study a sample of Central and Eastern European (CEE) countries, where interbank trade is mostly caused by specialization. Bank specialization in CEE has been the result of the fast liberalization of the banking industries which took place in an environment of immature and malfunctioning banking regulation. The former monobank systems in these countries were liberalized in the early 1990s and a large number of new players entered the market. Nevertheless, in several countries, the successor institutions of the monobanks managed to exploit the advantages of their widespread branch networks and customer relations to specialize in deposit raising activities and preserve large market shares in the market for customer deposits. However, these banks are very inactive in the market for loans for private[3]. In contrast, most of the new entrant banks specialize in providing credit to the new emerging private sector. As a result of this specialization, large incumbent banks gather persistently more funds as customer deposits than they distribute to the nonfinancial sector. In contrast, new entrant banks, have less customer deposits than the amount of loans

[2] Although the role of specialization as a cause of interbank trade has still not been studied thoroughly, initial studies indicate that it is a valid explanation for the very high intensity of interbank trade in countries with relatively underdeveloped financial systems. See e.g. Galmes and Manzano (1995) for the Spanish banking system , Slide and Cole (1998) for Indonesia, and Bonin et al (1998) for several Central and Eastern European (CEE) transition economies.

[3] The literature on transition states the lack of relations to newly created enterprises, expertise in proper credit allocation activities, and state-of-the-art market orientation as sources of the incumbent banks' inability to provide credit to the private sector. Another potential reason is the fact that, for a private enterprise, to receive a credit from a large bureaucratic banking institution is associated with some extra costs beyond the interest rate paid. Such costs would include time spent in a bureaucratic credit approval procedure, but in extreme cases it could also include bribery, etc.

they could finance (Bonin et al, 1998). Where this is the case, the interbank market tends to clear the discrepancies between deposits and loans for banks with a strong specialization in the one or the other direction. Thus, a banking system with a "two-tier market structure" has emerged. The first tier consists of incumbent banks that gather deposits from the nonbank public and transfer them through the interbank market to the second tier banks, mainly new entrants, which provide credit to the nonfinancial sector. Within this structure, the new banks that borrow from the incumbent banks and lend to the nonbank public are typically much smaller than the incumbent banks. As a result, there is not much pressure on governments to extend deposit guarantees or bail out financially troubled interbank-borrowing banks, since the perceived risk of systemic crisis is small. In contrast, incumbent banks typically enjoy explicit bail-out guarantees or are covered by deposit insurance offered by the governments. This reinforces their competitive advantage in the market for deposits. At the same time, the incentives for interbank monitoring are not distorted by the expectation that the borrowing bank will be bailed out by the government (e.g., Rochet and Tirole, 1996).

In the next section, we present a model of the credit market based on asymmetric information and moral hazard. We assume that large banks have monitoring cost advantages over depositors regarding the lending activities of other banks. In this setting, we show that banks that finance themselves through the interbank market finance less risky projects in equilibrium than banks that fully finance themselves through customer deposits[4]. The reason is that the former are monitored by their creditors in the interbank market, while the latter are not.

In section 3, we present our data set and in section 4 we provide empirical evidence for the two-tier structures of the banking industry in CEE countries based on the flow of funds from

[4] This result is consistent with Billet, Garfinkel and O'Neal (1998) who postulate that banks have the ability to thwart market-based monitoring by shifting their liabilities from uninsured depositors with a great incentive to monitor to insured depositors with little incentive to monitor.

the large banks to the rest of the banking system.[5] In section 5 we test the main hypotheses derived from the theoretical model and some related extensions. Section 6 concludes.

2 Bank specialization, Interbank Borrowing, and Monitoring

We introduce a model where monitoring of bank investment behavior is necessary to prevent a credit market collapse but is too costly to be performed by the individual depositors. In this situation, the monitoring function can be performed by large banking institutions which lend funds to smaller banks and have, due to economies of scale, cost advantages in monitoring the credit activities of the banks borrowing funds from them. In our model banks are able to refinance in two segmented markets: the market for customer deposits and the interbank market[6]. If a bank chooses to refinance in the interbank market its investment behavior will be monitored, whereas if it refinances in the customer deposits market it will not be monitored.

Consider an intermediated credit market with two types of entrepreneurs: those with a "good" project and those with a "bad" project. Both projects require an investment of size 1. The return of a "good" project is G with probability Π_G in case of success or 0 otherwise; the return of a "bad" project is B with probability Π_B and 0 otherwise. "Good" projects have a positive net present value, whereas "bad" projects have a negative net present value:

$$G\Pi_G - 1 > 0 > B\Pi_B - 1,\ G < B,\ \Pi_G > \Pi_B \tag{1}$$

Both types of entrepreneurs have no equity and can only finance the project if they receive a bank credit of size 1.

[5] The sample consists of ten CEE countries: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia.

[6] The distinction of two segmented markets for sources of funds is similar to the one in Billet and Garfinkel (2004).

The banking sector consists of two types of banks: one large bank (LB) and n small banks ($SB_i, i = 1,2,...,n$). The large bank has an implicit or explicit deposit guarantee by the government. The deposit rate with the large bank (i_{lb}) is, therefore, equal to the riskless interest rate, considered for simplicity to be zero. That is, the nominal repayment to the depositors, D_{lb}, for a deposited amount of 1 is equal to 1. We assume that the large bank has zero marginal costs of deposit gathering since it has a widespread deposit gathering network. However, it has a competitive disadvantage compared to the small banks in lending to the non-financial private sector. For simplicity, we assume that the large bank does not lend to the non-bank public at all. Thus it invests only in two types of assets: liquid bonds whose net return is normalized to zero and interbank loans which bear an interest rate i_{ib}. The nominal repayment rate that the large bank requires on an interbank loan of volume 1 is denoted by d ($d = 1 + i_{ib}$). Selling bonds, the large bank can supply any demand for interbank loans.

Small banks are modeled as banking institutions with undiversified portfolios and no government protection. They differ among each other in the volume of equity, denoted with E_i. They can refinance their investments in two segmented markets, the market for customer deposits and the interbank market. Small banks have no access to deposit insurance[7]. Denote by i_{sb} the small banks' interest rate on customer deposits. This deposit rate is positive (higher than the one of the large bank, $i_{sb} > i_{lb}$) because depositors are aware that deposits with small banks are not guaranteed and are thus riskier than the ones with the large bank[8]. The amount of nominal repayment of a small bank to its depositors for a deposit in volume of 1 is denoted by D, $D = 1 + i_{sb}$. Denote with α_i the volume of customer deposits that SB_i accumulates. In

[7] We assume that no universal deposit insurance scheme is in force in the market.

[8] We do not explicitly model competition in the deposit market in this model. At the end of this section we provide a proof of the existence of equilibrium in the market for customer deposit in small banks.

addition to interest payments each SB_i incurs increasing marginal costs of deposit gathering $C(\alpha_i)$.[9]

Alternatively, the small banks can refinance their investments in the interbank market. The only provider of funds in the interbank market is the large bank, since it is the only one that can gather deposits at a preferential rate. If SB_i decides to accumulate α_i in the market for customer deposits, it will ask for an interbank deposit in the volume of $1-E_i-\alpha_i$.

Each small bank can only finance the project of one entrepreneur. Small banks can observe the type of the entrepreneur at no cost and set the respective repayment rates R_G and R_B. The expected return on a loan for a "bad" project is negative, whereas the one for a "good" project is positive:

$$R_G\Pi_G - 1 > 0 > R_B\Pi_B - 1,\ R_B > R_G \tag{2}$$

Entrepreneurs and banks have limited liability and are risk neutral.

Because of the limited liability a moral hazard problem emerges: a small bank could have an incentive to finance an investment in a "bad" project, despite its knowledge of the project's negative net present value. This result is formalized in the following lemma:

Lemma 1: Denote by R_i the repayment SB_i owes to its creditors ($R_i = (1-E_i)D + C(1-E_i)$ if SB_i is fully financed by customer deposits and $R_i = (1-E_i-\alpha_i)d + \alpha_i D + C(\alpha_i)$ if it is partly financed by customer deposits and partly by an interbank deposit). The small bank will choose to invest in the "good" project if, and only if:

[9] Small banks in our model are assumed to have no deposit gathering network. They operate with few branches located near to the potential credit users. Thus deposit accumulation beyond the area of operation of these branches is associated with increasing marginal costs since more distant depositors have to be compensated for transportation costs, information asymmetries, etc.

$$R_i \leq R_{C_i} = \frac{\Pi_G R_G - \Pi_B R_B + (\Pi_G - \Pi_B)E_i}{\Pi_G - \Pi_B} \qquad (3)$$

Proof: See Appendix

If $R_{Ci} < 1$, SB_i has an incentive to invest in a "bad" projects for every feasible repayment rate and the credit market collapses, therefore we assume that $R_{C_i} \geq 1$, for now on.

Now, assume a situation of strong moral hazard where $\Pi_G R_{Ci} < 1$ for each $i = 1,2,...,n$. Since otherwise depositors would expect a loss even if all small banks invest in "good" projects, it must be true that $\Pi_G D \geq 1$. This implies that $D > R_{C_i}$ for all SB_i. Therefore, each SB_i will invest in the bad project, if it is fully financed by customer deposits. That is, if all SB_i are fully financed by customer deposits, the credit market will collapse as depositors realize losses in expectations.

A technology for monitoring the small banks exists. At a fixed cost $M > 0$ the creditors of a small bank can screen the type of the project and introduce different interest rates according to the project type.[10] However, in order for monitoring to be conducted the fixed cost of monitoring should be justified by the benefits of it.

Individual depositors have an endowment of size $\varepsilon << 1$, which they choose to deposit in either the large bank or in one of the small banks. We assume $\varepsilon < M$, from which it follows that individual depositors cannot invest in monitoring. Therefore, they cannot distinguish whether SB_i would finance the "good" or the "bad" project. That is why they require a uniform deposit rate for deposits with small banks.

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[10] We adopt a broad concept of monitoring introduced in Hellwig (1991), according to which monitoring includes:

- screening of projects (a priori)
- preventing opportunistic behaviour of the borrower during the realisation of the project (moral hazard)
- punishing or auditing a borrower who fails to meet contractual obligations.

There are two time periods. In period 0, each small bank decides on the structure of its liabilities and finances a "good" or a "bad" project depending on which one bears a higher net expected return. In period 1 the project returns are realized, the small banks get repayment from the entrepreneurs and repay their creditors. To simplify computations we assume that the costs of deposit gathering $C(\alpha_i)$ are incurred by SB_i at time period 1.

The problem of the large bank

If the large bank decides to monitor the investment behavior of the small bank it could set different interbank rates depending on whether the "good" or "the "bad" project would be financed. Moreover, under the assumption of a low interest rate for deposits at the large bank we can prove that the large bank is only interested in investing in "good" projects. This result is formalized in Lemma 2.

Lemma 2: The large bank will maximize its net expected return, if it provides interbank loans only to small banks, which invest in "good" projects.

Proof: See Appendix

However, the large bank as a creditor of the small bank will monitor if, and only if, the benefit of monitoring, that is the difference of the expected repayments, is no lower than the monitoring costs. That is, the volume of the interbank deposit has to be high enough to justify the cost of monitoring. From which the following proposition follows:

Proposition 1: The large bank will supply an interbank deposit if and only if its volume $1-E_i-\alpha_i$ satisfies:

$$1-E_i-\alpha_i \geq \frac{M}{d(\Pi_G-\Pi_B)}. \quad (4)$$

In this case it will invest in the monitoring technology to ensure that the “good” project will be financed.

Proof: See Appendix

The problem of the small bank

Small banks’ decisions on the structure of their liabilities and on which project to finance consider the fact that if they ask for interbank financing they would be monitored and can thus only finance the “good” project. Therefore, they will ask for interbank financing if and only if the “good” project can bring higher net expected return than the “bad” project. The net expected return of the “bad” project is equal to the expected return in case of success net of refinancing costs minus the loss in case of failure (in this case SB_i loses its equity):

$$\Pi_B\left[R_B-(1-E_i)D-C(1-E_i)-E_i\right]-(1-\Pi_B)E_i \tag{5}$$

On the other hand, the net expected return of the good project is a function of α_i and is equal to the expected return in case of success net of refinancing costs minus the expected loss in case of failure (the loss of equity):

$$\Pi_G\left[R_G-(1-E_i-\alpha_i)d-D\alpha_i-C(\alpha_i)-E_i\right]-(1-\Pi_G)E_i \tag{6}$$

Lemma 3: Let us denote with α_i^* the volume of customer deposits at which the net expected return of SB_i has a maximum. Then α_i^* is the solution of:

$$\max_{\alpha_i}\Pi_G\left[R_G-(1-E_i-\alpha_i)d-D\alpha_i-C(\alpha_i)-E_i\right]-(1-\Pi_G)E_i \tag{7}$$

and is equal to the volume of customer deposits, at which the marginal cost of deposit gathering equals the difference between the interest rate on interbank deposits and the interest rate on customer deposits. This volume does not depend on the amount of equity, and $\alpha_1^* = \alpha_2^* = ... = \alpha_n^* = \alpha^*$.

Proof: *See Appendix*

Then SB_i will ask for an interbank loan if and only if the net expected return of the "good" project at α^* is higher than the net expected return of the "bad" project. That is, SB_i will ask for an interbank loan if and only if the following inequation (8) holds:

$$\begin{aligned} &\Pi_G\left[R_G - (1-E_i-\alpha^*)d - D\alpha_i - C(\alpha^*) - E_i\right] - (1-\Pi_G)E_i \geq \\ &\Pi_B\left[R_B - (1-E_i)D - C(1-E_i) - E_i\right] - (1-\Pi_B)E_i \end{aligned} \tag{8}$$

From which the following proposition follows:

Proposition 2: SB_i will accumulate α^* as customer deposits and demand $1-E_i-\alpha^*$ in the interbank market, if and only if:

$$E_i \in S = ((-\infty, \underline{E}) \bigcup (\overline{E}, +\infty)) \bigcap (-\infty, E_m) \bigcap [0,1], \tag{9}$$

where $E_m = 1 - \alpha^* - \dfrac{M}{d(\Pi_G - \Pi_B)}$ is the critical value below which the large bank will extend an interbank loan, and $E_i \in (-\infty, \underline{E}) \bigcup (\overline{E}, +\infty)$ denotes the set of $E_i s$ for which the highest feasible net expected return of the "good" project is higher than the one of the "bad" project.

If $E_i \notin S$, then either SB_i does not demand or the large bank reject to supply an interbank loan. In this case SB_i refinances only in the market for customer deposits.

Proof: See Appendix

Proposition 2 formalizes the intuition that interbank borrowing takes places if both the small bank has an incentive to ask for an interbank deposit and the large bank has an incentive to supply it. In this case the small bank invests in a “good” project. If $E_i \notin S = ((-\infty, \underline{E}) \bigcup (\overline{E}, +\infty)) \bigcap (-\infty, E_m) \bigcap [0,1]$, then SB_i does not borrow from the large bank. This is either because SB_i does not ask for an interbank deposit because the “bad” project is always more profitable for it than the “good” one. Or because the large bank rejects to provide the interbank deposit since its volume is too small to justify monitoring costs. In this case SB_i is fully financed by customer deposits and since $D > R_{C_i}$ it invests in the “bad” project.

Existence of equilibrium in the market for customer deposits

In the next step we derive the existence of equilibrium of the market for customer deposits in small banks under conditions (a) strong moral hazard ($\Pi_G R_{C_i} < 1, i = 1,2,...n$) and (b) a proportion of small banks are monitored. Thus, we have to derive the existence of an equilibrium repayment rate on customer deposits in small banks D, such that for the population of small banks as a whole $D\Pi_D = 1$, where Π_D denotes the probability of repayment to the depositors.

We pool together “monitored” and “unmonitored” small banks, as individual depositors are not able to distinguish among them, and charge a uniform repayment rate. We assume that without investing in monitoring the individual depositors are not able to gather any information about small banks’ balance sheet[11].

Assume the distribution of E_i is such that for a proportion β of the n small banks $E_i \in S$. As a result βn small banks receive interbank loans and finance the “good” project, whereas $(1-\beta)n$ small banks are fully financed by customer deposits and finance the “bad” project. Therefore, the amount deposited by customer depositors in the monitored banks equals $\alpha^* \beta n$.

[11] This assumption is crucial for the existence of an equilibrium rate on deposits in small banks. If depositors are able to observe interbank borrowing and associate it with lower risk, then they will require higher interest rate from small banks which are not interbank borrowers, at this rate all small banks will finance the “bad” project and depositors will realize losses in expectation.

The amount deposited by customer depositors in banks, which are not monitored equals $(1-\beta)n\gamma$, where $\gamma = \left[\sum_{i=k}^{k+(1-\beta)n} (1-E_i) \right] / [(1-\beta)n]$ denotes the average amount of customer deposit of small banks which do not borrow in the interbank market. The expected repayments by both groups of banks are expressed by $\alpha^* \beta n \Pi_G D$ and $(1-\beta)n\gamma\Pi_B D$, respectively. Existence of competitive equilibrium for deposits in small banks requires that the sum of expected repayments equals the amounts deposited, that is:

$$\alpha^* \beta n \Pi_G D + (1-\beta)\gamma n \Pi_B D = \alpha^* \beta n + (1-\beta)\gamma n, \tag{10}$$

from which follows:

$$D = \frac{\alpha^* \beta + (1-\beta)\gamma}{\alpha^* \beta \Pi_G + (1-\beta)\gamma \Pi_B} \tag{11}$$

β belongs to the interval (0, 1] and γ belongs to the interval (0, 1), D is limited in the interval $[1/\Pi_G, 1/\Pi_B]$. Therefore, for all feasible β and γ there exists a deposit rate D for which a competitive equilibrium in the market for customer deposits in small banks exists. If $\beta = 1$ (all small banks receive interbank financing and are therefore monitored), then $D = 1/\Pi_G$ (all financed projects are good). $\beta = 0$ is not a feasible option as it means none of the small banks is monitored, and therefore they all finance a bad project and the credit market collapses.

To recapitulate, in the case of strong moral hazard equilibrium in the market for customer deposits is only possible if a monitoring technology is introduced and some of the small banks are monitored, provided that individual depositors cannot distinguish between monitored and unmonitored small banks. In this case, whether a bank will invest in a "good" or a "bad" project depends on whether it is financed by interbank deposits. The small bank will have a lower risk level if it receives an interbank deposit from a large bank. The volume of the interbank deposit should be sufficiently large to justify monitoring costs.

3 Data sources

Our sample covers banking institutions from ten CEE countries, Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, and Slovenia. For the macro level variables we use data provided by IMF in the International Financial Statistics CD-ROM issues. Micro level data stem from banks' financial statements provided by BankScope[12]. Our sample includes 296 banks, of which 28 are Bulgarian, 35 Czech, 12 Estonian, 36 Hungarian, 28 Latvian, 14 Lithuanian, 56 Polish, 34 Romanian, 24 Slovakian, and 29 Slovenian. In each of the sample countries, BankScope covers 70-90% of the banks calculated as percentage of banking assets. We have restricted the analysis to the period of 1994-2001. Data for some of the banks are available for only some of the years, which results in an unbalanced panel dataset.

4 The two-tier banking system

To measure the magnitude of interbank transfers of funds on the interbank market, we use two variable. The first one is the ratio of large banks' net interbank assets to customer deposits. ($NIA_{lb}/CD_{lb,}$ where NIA denotes net interbank assets, calculated as the difference between deposits with banks and deposits from banks, CD denotes customer deposits, and the subscript lb stands for large banks). This ratio, which we call large banks' lending ratio, is closest to the phenomenon we study and represents the share of deposits of the large banks that are passed on to other banks. If this ratio is positive, large banks are net lenders in the interbank market.

[12] BankScope is a database created by IBCA and Bureau van Dijk

Since the large banks' borrowers might be institutions located abroad rather than domestic institutions, we also look at the net interbank position of small banks relative to their loans to nonbanks. We call this the small banks' borrowing ratio, NIA_{sb}/L_{sb}, where L denotes loans.It is an indicator of the extent to which small banks rely on interbank funds for the financing of their loans. A large negative ratio results from the small banks' relative strong reliance on interbank funds.

The construction of these variables is based on a distinction between large and small banks. We choose to treat as "large" those institutions, which individually gather at least 20% of the total amount of customer deposits in their banking systems[13]. All other banks are considered to be small. The values of the transfer of funds variables by country and year are presented in Table 1and Table 2.

As shown in Table 1 Bulgaria, the Czech Republic, Hungary, Poland and Slovakia have persistently high positive values of large banks' lending ratio, whereas Lithuania, Romania and Slovenia have very low (mostly negative) values of this variable. The values for Estonia and Latvia fluctuate over the years. The countries with high values of the large banks' net interbank assets variable are countries with strong incumbent banks, whereas the countries with low values of this variable are countries where no incumbent banks exist. [14]

As shown in Table 2, the small banks' borrowing ratio is close to zero in Bulgaria (after 1995), Estonia (for most of the observed periods), Latvia, Lithuania, Romania, and Slovenia, indicating that small banks do not depend in their credit activity on funds gathered on the interbank market. In contrast, the Czech Republic, Hungary, Poland and Slovakia show very large negative values of this variable (even below -30% in the early years), suggesting that in

[13] The banks that have at least 20% share in the respective deposit market and year are listed in Table A.2 in the Appendix

[14] Estonia, Latvia, Lithuania and Slovenia are newly independent countries which do not have inherited institutions from pre-transition time; Romanian incumbent banks lost customer confidence in the early transition period when the first periods of distress were observed; later on one of the major incumbent banks went insolvent.

these countries a large proportion of the small banks heavily depend on interbank funds for the financing of their credit activities.

Table 1: Large banks' lending ratio

	1994	1995	1996	1997	1998	1999	2000	2001
Bulgaria	n.a.	0,17	-0,50	0,29	0,47	0,44	0,66	0,49
Czech Republic	0,20	0,13	0,06	0,16	0,20	0,34	0,53	0,51
Estonia	0,29	0,20	0,00	-0,14	-0,12	-0,13	-0,05	0,06
Hungary	0,00	0,02	0,22	0,10	0,14	0,15	0,11	0,17
Latvia	0,29	0,12	0,13	0,09	-0,11	0,00	0,07	-0,09
Lithuania	0,04	0,04	0,00	0,01	-0,04	-0,03	0,09	0,09
Poland	0,15	0,10	0,10	0,09	0,07	0,08	0,10	0,12
Romania	0,60	0,35	-0,27	-0,61	0,08	-0,07	0,07	0,06
Slovakia	0,16	0,15	0,09	0,07	0,06	0,11	0,12	0,17
Slovenia	-0,21	0,26	0,24	0,10	-0,02	-0,04	-0,07	-0,11

Source: Own calculations based on Bankscope and IFS

Table 2: Small banks' borrowing ratio

	1994	1995	1996	1997	1998	1999	2000	2001
Bulgaria	-0,66	-0,24	1,60	1,03	0,76	0,73	0,76	0,66
Czech Republic	-0,38	-0,33	-0,31	-0,22	-0,09	-0,04	0,05	-0,12
Estonia	0,43	0,10	0,03	-0,16	-0,25	-0,09	0,22	0,07
Hungary	-0,42	-0,26	-0,17	-0,25	-0,17	-0,11	-0,12	-0,07
Latvia	0,50	1,10	1,56	1,02	0,16	0,38	1,08	0,83
Lithuania	-0,10	-0,17	0,04	0,27	-0,05	-0,03	-0,06	0,00
Poland	0,05	-0,11	-0,19	-0,08	-0,19	-0,11	-0,04	-0,06
Romania	0,37	0,18	0,11	0,52	0,33	0,32	0,30	0,37
Slovakia	-0,41	-0,34	-0,29	-0,36	-0,30	-0,32	0,00	-0,01
Slovenia	0,05	0,10	0,17	0,07	0,07	0,01	0,05	0,05

Source: Own calculations based on Bankscope and IFS

To sum up, in all the countries where incumbent banks still have dominant position in the market for customer deposits, except Bulgaria, we observe significant flows of funds through the interbank market from the incumbent banks to the rest of the banking sector. In the countries where, due to historical reasons, incumbent banks no longer exist or have lost customers' confidence in the early transition, banks dominating the deposit market do not channel significant amounts of funds to the rest of the banking system. In some of the sample countries we even observe the contrary case where large banks are net receivers of funds but the magnitude of this transfer is much lower and could be associated with the classical motivation of interbank borrowing, namely covering of short term liquidity.

5 Comparison of banks' risk characteristics: empirical evidence

The theoretical model in Section 2 derives the hypothesis that interbank borrowing can reduce the level of risk undertaking of a bank. We test this hypothesis by empirically estimating the impact of interbank borrowing on bank risk characteristics. In addition we test whether banks operating in two-tier banking systems have lower risk levels on average.

5.1. Econometric models

To test the hypothesis of the risk effects of interbank borrowing we use the following Model 1:

$$BR_{ijt} = \beta_1 + \beta_2 * NIP_{ijt} + \beta_3 * X_{ijt} + \beta_4 * Y_{jt} + \beta_5 * C_j + \beta_6 * T_t + \varepsilon_{ijt}, \tag{12}$$

where:

BR_{ijt} denotes a measure of the risk incurred by bank i in country j in time t;

NIP_{ijt} denotes the net interbank position of bank i in country j in time t;

X_{ijt} is a vector of control variables at the level of the individual bank;

Y_{jt} is a vector of control variables at the level of country of operations, and

ε_{ijt} is the error term.

To test the impact of a two-tier structure of the banking system on the level of risk, we use the following Model 2:

$$BR_{ijt} = \eta_1 + \eta_2 * TS_{jt} + \eta_3 * X_{ijt} + \eta_4 * Y_{jt} + \eta_5 * C_j + \eta_6 * T_t + \nu_{ijt}, \tag{13}$$

where, in addition to the notations in equation (12), we introduce:

TS_{jt} as the vector of variables describing the type of the banking system;

ν_{ijt} as the error term.

We perform the regressions on a sample consisting only of the banks that are regarded as small by the construction of the transfer of funds variables, since for large banks the relation between interbank borrowing and interbank monitoring could be hampered by moral hazard and too-bog-to-fail concerns and thus be different from what our model predicts.

Dependent variable

We use four variables that have been widely used in the literature to measure the riskiness of a bank's business[15]: loan loss reserves to gross loans (LLR), loan loss provisions to gross loans (LLP), net-charge offs to gross loans (NCO), and non-performing loans to gross loans (NPL)[16].

The ratio of loan loss reserves to gross loans expresses what proportion of the total loan portfolio has been provided for but not charged off. Loan loss reserves are an entry on the liability side of the balance sheet and represent accumulated provisions for expected loan losses. Assuming similar accounting policy and regulations of provisioning, higher LLR ratio would imply that banks expect losses on higher proportion of their loans and is thus an indicator for riskier loan portfolio of the bank[17].

The ratio of loan loss provisions to gross loans expresses the proportion of total loans that have been provided for during the current period. Loan loss provisions are expenses against current earnings in the income statement. They represent allocations in the current period to the loan loss reserves and should reflect estimated losses for specifically identified loans as well as estimated probable credit losses inherent in the remainder of the portfolio at the

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[15] See Martin (1977) and Gonzales-Hermosillo, et al (1996)

[16] The use of more sophisticated market based measures of bank risk, e.g. interest rate on certificates of deposits, bank bond prices, etc., is not possible for the sample of CEE banks since such instruments were not used in most of the CEE countries during the period we study.

[17] Cavallo and Majnoni (2001)

balance sheet date[18]. Again, assuming similar accounting policy and regulations of provisioning, higher LLP ratio implies riskier loan portfolio.

The ratio of net charge-offs to gross loans (NCO) illustrates the proportion of written-off loan losses[19] in the amount of the gross loan portfolio. The lower the NCO ratio, the lower the level of risk undertaking of a bank, as long as the write-off policies are consistent across comparable banks. Since charge-offs illustrated in current financial statements reflect the risk of loans distributed in previous balance periods, we use as dependent variables the values of the NCO ratio for one year ahead (one-year lead NCO). In other words, we regress the values of the NCO ratio in period t on the lagged values of the explanatory variables (from period t-1).

Non-performing loans to gross loans represent the proportion of impaired (doubtful) loans in the loan portfolio[20]. A high value of this ratio indicates that a large proportion of a bank's loans have not been served according to the repayment schedule. Thus, it suggests that defaults on a high proportion of a bank's loans are expected[21].

Following Demsetz (1996) we use the logarithmic form of all dependent variables in the econometrical estimations.

Explanatory variables

To measure the impact of interbank borrowing on bank risk levels, we include as an explanatory variable the net interbank position of a bank as measured by the ratio of net interbank assets to total assets (NIA/TA). If this ratio has negative values, the bank borrows

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[18] Cavallo and Majnoni (2001)

[19] Net charge-offs are defined as the amount written-off from loan-loss reserves minus recoveries (see BankScope: "Ratio definitions")

[20] see BankScope: "Ratio definitions"

[21] We regress current values of NPL rather than leads, because most of the loans are short-term and thus potential repayment delays are already reflected in the year of loan extension.

on the interbank market. On the other hand, positive values of the ratio indicate that the bank is a net provider of interbank funds. However, an one-stage OLS estimation of the effect of a bank's net interbank position on a bank's risk may suffer under simultaneity, because as described in the theoretical model, the interbank position variable will be an outcome of the same equilibrium that determines a bank's level of risk undertaking. To deal with the simultaneity problem, we choose to instrument a bank's net interbank position (NIA/TA) with a bank's current ratio of loans to total assets (Loans/TA), and two transfer of funds variables (NIA_LB and NIA_SB) equal to the ratios of large banks lending (NIA_{lb}/CD_{lb}) and small bank borrowing (NIA_{sb}/L_{sb}), respectively. Each of these instruments can be considered as exogenous with respect to current risk, but is correlated with a bank's current interbank position. The ratio of loans to total assets is closely correlated with a bank's current interbank position and indicates a bank's specialization in credit supply. The transfer of funds variables indicate the country average interbank positions of large and small banks and are significantly correlated with individual small banks' interbank position (see Table A.3 in the Appendix for the reduced form estimations of NIA/TA).

In the estimation of the type of the financial system's impact on bank risk (Model 2) we include as regressors the variables measuring the interbank transfer of funds, defined in Section 4 as indicators for the existence of a two-tier banking system. Thus, the vector TS_{jt} consists of two variables measuring the transfer of funds (NIA_LB and NIA_SB) equal to the ratios of large banks lending (NIA_{lb}/CD_{lb}) and small bank borrowing (NIA_{sb}/L_{sb}), respectively. A high value of NIA_LB shows that large banks have high net interbank assets. A high value of NIA_SB implies that small banks have high net interbank assets. Therefore, in a two-tier banking system, where large banks lend and small banks borrow substantial amounts in the interbank market, the values of NIA_LB are high and those of NIA_SB are low.

Several control variables are included in the estimations of both econometric models. On the individual bank level we introduce bank size, capitalization level, and foreign ownership as control variables. We proxy a bank's size by the ratio of its total assets to the median bank's total assets in the respective sample country. The normalization aims at a better comparability across banks with different countries of origin and neutralizes the effects of exchange rate deviations. In addition, we use the squared bank size term to control for non-linear form of the dependence between bank's size and risk undertaking. Capitalization is measured by the ratio of equity to total assets. Foreign ownership is measured by a dummy variable equal to one if at least 50% of a bank's equity is owned by an institution based abroad and to 0 otherwise. We include this variable to account for the possibility that foreign-owned banks have better technology for assessment of credit worthiness and are thus less likely to generate non-performing loans.

On the level of country of operations we include the following macroeconomic variables as controls: inflation, per capita GDP, and the growth rate of GDP[22]. Inflation is defined as the percentage change in the GDP deflator. Per capita GDP is used as a general index of economic development and is measured in ten thousands of US dollars. GDP growth is used to measure cyclical effects on bank risk and is measured as the growth rate of real per capita GDP. Time and country fixed effects are introduced in the regressions to capture other unobserved variables.

5.2. Estimation technique

As mentioned above, in order to deal with the endogeneity of the net interbank position variable we estimate Model 1 using instrumental variable panel data approach. The estimations are performed by generalized two-stage least squares random effects[23] technique.

[22] Using these variables as controls for bank risk has been proposed by Demsetz et al (1996)

[23] Hausman test rejects the hypothesis of fixed effects in both model 1 and model 2.

It estimates the predicted value of NIA/TA using the instrumental variables described above and plugs this predicted value of NIA/TA into the structural model.

The estimations of the impact of the type of financial system on the level of bank risk undertaking (Model 2) are performed by standard (one-stage) random effects panel data estimation.

5.3. Estimation results

Table 3 illustrates the results of the regressions of the different proxies for bank risk undertaking on the measure of bank's net interbank position. For all measures of bank risk the net interbank position of a bank as measured by the ratio of net interbank assets to total assets (instrumented by the ratios of loans to total assets (Loans/TA) and the transfer of funds variables (NIA_LB and NIA_SB)) has a significant positive coefficient.

Table 3: Two-stage panel regressions of bank risk on interbank position

	LLR	LLP	LNCO	NPL
net interbank assets/total assets	**3.308** ***	**3.512** ***	**4.647** ***	**4.382** ***
	0.479	0.533	1.780	1.079
bank size	**0.002**	**-0.037**	**-0.120**	**0.017**
	0.031	0.034	0.215	0.052
bank size squared	**-0.001**	**0.001**	**0.024**	**-0.001**
	0.001	0.001	0.022	0.002
equity/total assets	**-0.027** ***	**-0.026** ***	**-0.009**	**-0.005**
	0.004	0.005	0.018	0.009
foreign	**-0.529** ***	**-0.621** ***	**-0.469** *	**-0.536** **
	0.132	0.144	0.315	0.246
inflation	**0.001** *	**0.001** **	**0.001**	**-0.002** ***
	0.000	0.000	0.001	0.001
per capita GDP	**-0.001**	**-0.001**	**-0.003**	**-0.002**
	0.000	0.000	0.004	0.002
GDP growth	**-3.181** **	**-9.704** ***	**-2.495**	**-7.522** ***
	1.376	1.781	5.271	2.678
const	**3.039** ***	**-1.706**	**0.350**	**4.182** **
	1.117	1.358	3.672	1.852
country dummies	yes	yes	yes	yes
time dummies	yes	yes	yes	yes
R2	0.15	0.21	0.51	0.15
Observations	968	999	243	365
Groups	223	245	84	120

Note: Coefficients in bold, standard errors below coefficients. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

These results indicate that a higher share of net interbank assets in total assets implies higher risk levels of the loan portfolio, as measured by the LLR, LLP, lead NCO, and NPL ratios. Therefore, net interbank borrowing, which necessary implies negative net interbank assets, is associated with a lower level of risk undertaking: banks borrowing on the interbank market have on average lower LLR, LLP, lead NCO and NPL ratios than banks fully financed through customer deposits. The values of the coefficients indicate that the effect is at strongest when LNCO is used as risk proxy.

The results of the estimations of the impact of the type of banking system are illustrated in Table 4. The level of net interbank assets of small banks (NIA_SB) has a significant positive coefficient in all, but the lead NCO, regression specifications. This result implies that in systems where small banks are the providers of interbank funds, the risk levels of the small banks are generally higher than in systems where small banks receive interbank funds (have negative net interbank assets).

Net interbank assets of large banks (NIA_LB) have negative coefficients in all but the lead NCO specifications, but these are all statistically insignificant. The insignificance of the NIA_LB coefficients can be explained by the fact that since borrowers of interbank funds are not necessary domestically located banks, high net interbank assets of large banks do not necessary imply that domestic small banks are interbank borrowers (see, for example, the values of the transfer of funds variables for Bulgaria, 1997-2001 and Latvia, 1994-1997).

In general, the estimations of the impact of the structure of the banking system present evidence on the importance of the source of interbank financing. If interbank funds are provided by small banks, the level of risk undertaking is on average higher for the whole population of small banks. This result supports the argument that free rider issues and too-big-to-fail concerns could hamper lending banks' incentives to monitor the borrowing banks in a system where numerous small banks provide credit to a few larger banks.

Table 4: Panel regressions of bank risk on the type of banking system

	LLR	LLP	LNCO	NPL
net interbank assets LBs (NIA_LB)	**-0.171**	**-0.059**	**0.711**	**-0.243**
	0.213	0.283	0.963	0.588
net interbank assets SBs (NIA_SB)	**0.688** ***	**0.718** ***	**0.013**	**0.659** **
	0.145	0.216	0.623	0.283
bank size	**0.001**	**-0.014**	**-0.008**	**0.023**
	0.029	0.031	0.205	0.042
bank size squared	**0.000**	**0.001**	**0.012**	**0.000**
	0.001	0.001	0.021	0.001
equity/total assets	**-0.005** **	**-0.004**	**0.014**	**0.005**
	0.003	0.003	0.015	0.007
foreign	**-0.516** ***	**-0.589** ***	**-0.527** *	**-0.450** **
	0.126	0.137	0.330	0.196
inflation	**0.001**	**0.001** **	**0.001**	**-0.002** ***
	0.000	0.000	0.001	0.001
per capita GDP	**-0.001**	**-0.001**	**-0.001**	**-0.002**
	0.000	0.000	0.000	0.001
GDP growth	**-3.486** ***	**-9.003** ***	**-3.673**	**-9.809** ***
	1.226	1.713	5.147	2.251
const	**2.484**	**-1.804**	**-1.450**	**3.237** **
	0.960	1.223	3.554	1.605
country dummies	yes	yes	yes	yes
time dummies	yes	yes	yes	yes
R2	0.27	0.36	0.46	0.3
Observations	999	1036	234	375
Groups	227	251	85	121

Note: Coefficients in bold, standard errors below coefficients. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.

To summarize, small banks in two-tier systems, where small banks have low net interbank assets, have lower levels of risk than small banks in one-tier systems.

Control variables

Bank size and bank size squared have insignificant coefficients in all regression specifications, indicating that within the sample of small banks, the relative size of a bank is not a determinant of its levels of risk undertaking. Equity to total assets has a significant negative impact on LLR and LLP (only in the estimation of the impact of the interbank position), which is compliant with the theoretical notion that banks with higher proportion of own capital invest in less risky projects. The coefficients of equity to total assets are insignificant in the specifications using lead NCO and NPL as proxy for risk. The foreign ownership dummy has significant negative coefficients in all regression specifications, presenting evidence for lower levels of risk undertaking by banks owned by foreign entities.

This result supports similar findings in the literature on foreign bank entry in transition and developing countries (Clarke et al, 2003).

Concerning the macroeconomic variables higher inflation is associated with higher levels of LLR and LLP, indicating that banks reckon with higher risk of their portfolio in high inflation periods. The negative significant coefficients in the NPL regressions indicate that the de facto loan defaults are lower in high inflation times, which is an intuitive result as long as loans are contracted to pay a fixed interest. Per capita GDP has a negative but insignificant coefficient in all regression specifications. GDP growth significantly reduces bank risk as measured by LLR, LLP, and NPL indicating the cyclical impact on bank risk.

To summarize, we find empirical evidence supporting the hypothesis that interbank borrowing is associated with lower levels of risk undertaking, which is an indicator that interbank-borrowing banks are being monitored. This result implies that interbank-lending banks feel responsible for losses they incur on interbank transactions.

Furthermore, the estimates of the impact of the type of the financial intermediation system indicate that in two-tier systems banks undertake less risk on average. Such a result is consistent with our notion that interbank monitoring is mostly feasible when few institutions lend large amounts.

6 Conclusion

In this paper we provide evidence on the risk alleviating role of long-term interbank borrowing in the absence of too-big-to-fail concerns.

In the theoretical part we present a model based on information asymmetries and moral hazard. In the setting of the model monitoring the investment strategy of the banks is necessary to prevent the credit market from a collapse, but since it is costly only the large creditors of a bank can perform it. Therefore, banks that are financed by large interbank deposits are monitored, whereas those that are fully financed by customer deposits are not. As a result, the model shows that banks which borrow in the interbank market engage in less risky lending activities than banks that finance themselves predominantly in the deposit market.

The empirical part consists of two steps. First, we propose a methodology for measuring the flow of funds from the large banks to the rest of the banking system. We use this methodology to determine those countries where the interbank flow of funds is high enough to claim that the banking system consists of two tiers of banks. The banks from the first tier (large incumbent banks) dominate the deposit market but are very inactive in the loan market with private borrowers, while the banks from the second tier engage in lending but have only small shares of the deposit market.

Second, we provide econometric evidence about the existence of risk alleviating effects of interbank borrowing. We test the impact of interbank borrowing and the existence of a two-tier banking structure on different parameters used as proxies for bank's level of risk undertaking. The results show a significant effect of both interbank borrowing and the two-tier structure. Banks which borrow on the interbank market undertake less risky projects. Furthermore, small banks in countries with a two-tier structure of the banking system are characterized by lower risk levels than small banks in one-tier structure countries.

In general, large incumbent banks adopt monitoring functions over those of the new entrant banks, which finance themselves through interbank deposits. In an environment of inefficient banking regulation and undiversified portfolios of the new entrant banks, monitoring by the large banks could play essential role for the establishment of prudent investment behavior.

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Appendix

Proof of Lemma1:

SB_i will choose to invest in the "good" project if, and only if, the expected net return from a "good" project is not lower than the one from a "bad" project. Therefore, SB_i will invest in a good project if, and only if:

$$\Pi_G(R_G - R_i) - (1-\Pi_G)(1-E_i) \geq \Pi_B(R_B - R_i) - (1-\Pi_B)(1-E_i) \Leftrightarrow$$
$$R_i \leq \frac{\Pi_G R_G - \Pi_B R_B - (\Pi_G - \Pi_B)E_i}{\Pi_G - \Pi_B} \quad \text{(A.1)}$$

Denote $\frac{\Pi_G R_G - \Pi_B R_B - (\Pi_G - \Pi_B)E_i}{\Pi_G - \Pi_B} = R_{C_i}$. Then, R_{C_i} is a critical value of the repayment above which SB_i will choose to invest in a "bad" project. That is, a bank will invest in a good project if, and only if:

$$R_i \leq R_{C_i} \quad \text{(A.1')}$$

Q.E.D.

Proof of Lemma 2:

Assume that the large bank can invest in monitoring and screen the projects that the small banks intend to finance. Then the large bank will require different interest rates on its interbank deposits depending on the type of project that is to be financed. If the large bank can assure that the small bank will invest in a "good" project, it will require a repayment of d_G. If a bad project will be financed then the required repayment is set at d_B.

$$d_G \Pi_G - 1 > 0 > d_B \Pi_B - 1 \quad \text{(A.2)}$$

$d_G < d_B$

Denote by δ the share of the large bank's portfolio that is invested in projects, which are screened as "good"; $(1-\delta)$ is the share of projects screened as "bad". Assume the large bank has a total volume of interbank assets equal to m. Then δm denotes the total volume of investment in good projects, whereas $(1-\delta)m$ denotes the volume of investment in bad projects. Table A.1 illustrates the net expected return (NER) of the large bank.

Table A.1: Expected net returns of the large bank

Bad / **Good project**	**Succeeds** Probability: Π_B	**Fails** Probability: $1-\Pi_B$
Succeeds Probability: Π_G	All (both good and bad) projects succeed Probability: $\Pi_G \Pi_B$ $NER =$ $(\delta d_G + (1-\delta) d_B - D_{lb}) m \Pi_G \Pi_B$	Bad projects fail, good projects succeed Probability: $\Pi_G (1-\Pi_B)$ $NER =$ $\max((\delta d_G - D_{lb}) m, 0) \Pi_G (1-\Pi_B)$
Fails Probability: $1-\Pi_G$	Good projects fail, bad projects succeed Probability: $(1-\Pi_G)\Pi_B$ $NER =$ $\max((1-\delta) d_B - Dlb) m, 0)(1-\Pi_G)\Pi_B$	All projects fail Probability: $(1-\Pi_G)(1-\Pi_B)$ $NER = 0$

It is obvious that the large bank will be solvent and has to repay D to its depositors if all projects succeed. Similarly, if all projects fail, no repayment to depositors will be made and the bank's net return is 0. Whether the large bank's returns will be sufficient to cover repayments to depositors in the cases where only "good" ("bad") projects succeed depends on the relation between δ, d_G, d_B and D. The net return in these cases equals the return from "good" ("bad") projects net of repayments to depositor. But since we assume limited liability, the bank can repay only what it has. Therefore, this net return cannot be negative. Summarizing the information from Table A.1, we derive the following expression for the large bank's NER:

$$NER = (\delta d_G + (1-\delta)d_B - D_{lb})m\Pi_G\Pi_B + \max((\delta d_G - D_{lb})m,0)\Pi_G(1-\Pi_B)$$

$$+\max((1-\delta)d_B - D_{lb})n,0)(1-\Pi_G)\Pi_B + 0 \qquad \text{(A.3)}$$

The large bank will choose δ so that it maximizes its NER.

$$\max_\delta NER = (\delta d_G + (1-\delta)d_B - D_{lb})n\Pi_G\Pi_B + \max((\delta d_G - D_{lb})n,0)\Pi_G(1-\Pi_B)$$

$$+\max((1-\delta)d_B - D_{lb})m,0)(1-\Pi_G)\Pi_B + 0 \qquad \text{(A.4)}$$

To solve the maximization problem we have to define the values of $\max((\delta d_G - D_{lb})m,0)$ and $\max((1-\delta)d_B - D_{lb})m,0)$, that is to study whether the bank will be solvent if:

(i) only the "good" projects succeed: the bank will be solvent, $(\delta d_G - D_{lb})m > 0$, if

$$\delta > \frac{D_{lb}}{d_G}$$

(ii) only the "bad" projects succeed: the bank will be solvent , $(1-\delta)d_B - D_{lb})m > 0$, if

$$\delta < 1 - \frac{D_{lb}}{d_B}$$

We restrict the analysis to the case where both d_G and d_B are smaller than 2 (d_G< d_B < 2), therefore

$$1 - \frac{D_{lb}}{d_B} < \frac{D_{lb}}{d_G}. \qquad \text{(A.5)}$$

Then we have to study the following three cases for δ:

(1) $\frac{D_{lb}}{d_G} < \delta \leq 1$.

In this case the bank is solvent if all projects succeed and if only the “good” projects succeed and is insolvent if only the “bad” projects succeed. The NER has the following form:

$$NER = (\delta d_G + (1-\delta)d_B - D_{lb})m\Pi_G\Pi_B + \max((\delta d_G - D_{lb})m, 0)\Pi_G(1-\Pi_B) \quad \text{(A.6)}$$

The first derivative is:

$$\frac{\partial NER}{\partial \delta} = (d_G\Pi_G - (d_B\Pi_B)\Pi_G)m\,, \quad \text{(A.7)}$$

which is always positive, since $d_G\Pi_G > d_B\Pi_B$ and $0 < \Pi_G < 1$. Therefore, NER is increasing in δ and the local maximum for the interval $(\frac{D_{lb}}{d_G}, 1]$ is at 1.

(2) $1 - \frac{D_{lb}}{d_B} \leq \delta \leq \frac{D_{lb}}{d_G}$.

In this case the bank is only solvent if all projects succeed. The NER has the following form:

$$NER = (\delta d_G + (1-\delta)d_B - D_{lb})m\Pi_G\Pi_B \quad \text{(A.8)}$$

The first derivative is:

$$\frac{\partial NER}{\partial \delta} = (d_G\Pi_G - (d_B\Pi_B)\Pi_G)m\,, \quad \text{(A.9)}$$

which is always negative, since $d_G < d_B$. Therefore, NER is a decreasing function of δ and the local maximum for the interval $[1 - \frac{D_{lb}}{d_B}, \frac{D_{lb}}{d_G}]$ is at $1 - \frac{D_{lb}}{d_B}$.

(3) The bank is solvent if all projects succeed and if only the "bad" projects succeed. The NER has the following form:

$$NER \quad = (\delta d_G + (1-\delta)d_B - D_{lb})m\Pi_G\Pi_B +$$

$$\max((1-\delta)d_B - D_{lb})m, 0)(1-\Pi_G)\Pi_B \qquad \text{(A.10)}$$

The first derivative is:

$$\frac{\partial NER}{\partial \delta} = (d_G\Pi_G\Pi_B - d_B\Pi_B)m = (d_G\Pi_G - d_B)m\Pi_B\,, \qquad \text{(A.11)}$$

which is always negative, since $d_G < d_B$ and $0 < \Pi_G < 1$. Therefore, NER is decreasing in δ and the local maximum for the interval $[0;\ 1 - \frac{D_{lb}}{d_B}]$ is at 0.

It remains to compare the local maximums at the three cases by plugging the NER maximizing values of δ into (A.6), (A.8) and (A..10), respectively.

If $\delta = 1$, then

$$NER = \Pi_G(d_G - D_{lb})m \qquad \text{(A.6')}$$

If $\delta = 1 - \frac{D_{lb}}{d_B}$, then

$$NER = \Pi_G\Pi_B(d_G - D_{lb}\frac{d_G}{d_B})m \qquad \text{(A.8')}$$

If $\delta = 0$, then

$$NER = \Pi_B(d_B - D_{lb})m \qquad \text{(A.10')}$$

Then the NER in the case of $\delta = 1 - \frac{D_{lb}}{d_B}$ is smaller than the NER in the case $\delta = 0$, since because $\Pi_G \frac{d_G}{d_B}$ is smaller than 1 (both Π_G and $\frac{d_G}{d_B}$ are in the interval (0; 1)), the expression in (A.8) is smaller than the one in (A.10).

Since we assume that deposits with the large bank are riskless and thus bear zero interest $D_{lb} = 1$ and therefore

$$D_{lb} < D_C = \frac{\Pi_G d_G - \Pi_B d_B}{\Pi_G - \Pi_B}. \tag{A.12}$$

Therefore, if $\delta = 1$ (investment only in good projects) the NER is larger than the one in the case of $\delta = 0$ (investment only in bad projects). Therefore, in order to maximize its net expected return the large bank will choose $\delta = 1$ (invest only in "good" projects). Q.E.D.

Proof of Proposition 1:

The large bank will monitor if and only if the benefit of monitoring measured by the difference of expected repayment in the case of a "good" and a "bad" project, $(1 - E_i - \alpha_i) d(\Pi_G - \Pi_B)$ is not lower than the fixed costs of monitoring M. That is

$$(1 - E_i - \alpha_i) d(\Pi_G - \Pi_B) \geq M \tag{A.13}$$

Which is equivalent to:

$$1 - E_i - \alpha_i \geq \frac{M}{d(\Pi_G - \Pi_B)} \tag{1}$$

If inequation (4) does not hold (SB_i asks for a too small interbank loan), the large bank reckons with the small bank's opportunistic behavior and will prefer not to provide the interbank loan. Q.E.D.

Proof of Lemma 3:

SB_i maximizes its net return from the "good" project if it accumulates α_i^* as customer deposits and borrows $1-E_i-\alpha_i^*$ from the large bank. Then α_i^* is the volume of customer deposits at which expression (6) has a maximum. Therefore, α_i^* is determined as the solution of (7):

$$\max \Pi_G\left[R_G-(1-E_i-\alpha_i)d-D\alpha_i-C(\alpha_i)-E_i\right]-(1-\Pi_G)E_i\,. \qquad (7)$$

Since Π_G, R_G and E_i are independent of α_i (7) is equivalent to:

$$\min f(\alpha_i)=(1-E_i-\alpha_i)d+D\alpha_i+C(\alpha_i)\,. \qquad (A.14)$$

The first order condition of the minimization problem (A.14) is:

$$\frac{\partial f(\alpha_i)}{\partial \alpha}=-d+D+C'(\alpha_i)=0 \qquad (A.15)$$

Equivalent to:

$$C'(\alpha_i)=d-D \qquad (A.16)$$

Since $\dfrac{\partial^2 f(\alpha_i)}{\partial \alpha_i}=C'(\alpha_i)>0$, $f(\alpha_i)$ has a minimum at α_i^*, where α_i^* is the solution of the first order condition defined in (A.16)[24]. It follows from (A.16) that at α_i^* the marginal costs of deposit gathering equal the difference between the interest rate on interbank and on customer deposits. Furthermore, α_i^* is derived as the solution of (A.16) which does not depend on E_i. From which it follows that $\alpha_1^*=\alpha_2^*=...=\alpha_n^*=\alpha^*$.

[24] The first order condition has an unique solution because from $\dfrac{\partial^2 f(\alpha_i)}{\partial \alpha_i}>0$ it follows that $\dfrac{\partial f(\alpha_i)}{\partial \alpha_i}$ is monotonically increasing.

Proof of Proposition 2:

SB_i will choose to demand an interbank deposit and invest in the "good" project if and only if condition (8) holds:

$$\begin{aligned}&\Pi_G\left[R_G-(1-E_i-\alpha_i)d-D\alpha_i-C(\alpha_i)-E_i\right]-(1-\Pi_G)E_i\geq\\&\Pi_B\left[R_B-(1-E_i)D-C(1-E_i)-E_i\right]-(1-\Pi_B)E_i\end{aligned}\qquad(8)$$

(8) can be simplified to:

$$\begin{aligned}&(\Pi_G d-\Pi_B D)(1-E_i)-\Pi_B C(1-E_i)\leq\\&\Pi_G R_G-\Pi_B R_B+\Pi_G\alpha^*(d-D)-\Pi_G C(\alpha^*)\end{aligned}\qquad(\text{A.17})$$

Denote $\Pi_G R_G-\Pi_B R_B+\Pi_G\alpha^*(d-D)-\Pi_G C(\alpha^*)=A$ (A does not depend on E_i) and $(\Pi_G d-\Pi_B D)(1-E_i)-\Pi_B C(1-E_i)=F(E_i)$. Then inequation (8) takes the following form:

$$F(E_i)\leq A$$

Since $\frac{\partial^2 F(E_i)}{\partial E_i}=-\Pi_B C''(1-E_i)<0$, $F(E_i)$has an unique maximum at E^*, which is the solution of:

$$\frac{\partial F(E_i)}{\partial E_i}=-(\Pi_G d-\Pi_B D)-\Pi_B C'(1-E_i)=0.$$

Therefore there exist two solutions of the equation

$$F(E_i)=A,\qquad(\text{A.18})$$

which we denote with $\underline{E}$ and $\overline{E}$. $\underline{E}$ and $\overline{E}$ are functions of Π_G,Π_B,R_G,R_B,d,D and α^*.

Inequation (8) will then be fulfilled if and only if

$$E_i \in (-\infty, \underline{E}) \bigcup (\overline{E}, +\infty). \qquad \text{(A.19)}$$

Therefore, SB_i will demand an interbank loan if and only if $E_i \in (-\infty, \underline{E}) \bigcup (\overline{E}, +\infty)$.

On the other hand, the large bank will supply the interbank deposit if and only if monitoring is worthy, that is if inequation (4) as derived in Proposition 1 holds. Condition (4) holds if and only if:

$$E_i \leq 1 - \alpha^* - \frac{M}{d(\Pi_G - \Pi_B)} = E_m \qquad \text{(A.20)}$$

Taking into consideration the fact that E_i as equity is bounded in the interval $[0,1]$ and combining (A.19) and (A.20) we can conclude that SB_i will choose the "good" project if and only if:

$$E_i \in S = ((-\infty, \underline{E}) \bigcup (\overline{E}, +\infty)) \bigcap (-\infty, E_m) \bigcap [0,1] \qquad (9)$$

If the set S is empty than there exists no E_i so that SB_i will choose to invest in the "good" project. As a result all SB_i choose not to borrow in the interbank market and finance the "bad" project. Q.E.D.

Table A.2: Large banks list [1)]

Country	Banks dominating the deposit market
Bulgaria	up to 1995 only DSK, 1996-2001 DSK and Bulbank
Czech Republic	up to1999 only Sporitelna and Komercni, 2000-2001 Sporitelna, Kommercni and Obchodni
Estonia	up to 1994 Savings and Uhis, 1995-1996 Savings, Uhis and Hansa, 1997-2001 only Hansa and Uhis
Hungary	1994-2001 OTP
Latvia	up to 1997 Uni and Parekss, 1998-2001 Uni, Parekss and Hansa
Lithuania	1994 Commercial and Agricultural, 1995-1996 Commercial, Agricultural and Hansa, 1997-2001 Hansa and Vilniaus
Poland	1994-2001 PKO BP
Romania	1994-1997 Bancorex, 1998-2001 Banca Kommerziala
Slovakia	1994-2001 Sporitelna and Vseoshta Uverova
Slovenia	1994 Nova Matibor and Nova Ljubljanska, 1995-2001 only Nova Ljubljanska

1) Large deposit gathering institutions (large banks) are the those banking institutions each of which gathers at least 20% of the total volume of customer deposits in the banking system

A.3: First-stage estimation (NIA/TA on instruments)

	net interbank assets/total assets	
loans/total assets	**-0.588**	***
	0.035	
net interbank assets LBs (NIA_LB)	**0.066**	**
	0.029	
net interbank assets SBs (NIA_SB)	**0.063**	***
	0.021	
bank size	**0.009**	**
	0.004	
bank size squared	**0.000**	
	0.000	
equity/total assets	**0.005**	***
	0.000	
foreign	**0.003**	
	0.019	
inflation	**-0.010**	**
	0.004	
per capita GDP	**0.011**	
	0.016	
GDP growth	**-0.146**	
	0.175	
const	**0.128**	
	0.134	
country dummies	yes	
time dummies	yes	
R2	0.36	
Observations	1411	
Groups	276	

Note: Coefficients in bold, standard errors below coefficients. *, **, *** indicate significance at the 10%, 5% and 1% level, respectively.