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Bank panics in transition economies

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Contents

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Juha-Pekka Niinimäki *

Bank panics in transition economies

Abstract

This paper discusses recent bank runs in seven transition economies (Russia, Bulgaria, Estonia, Hungary, Latvia, Lithuania and Romania), comparing them against the older US experience and theoretical research. Bank runs seem to usually be information based. For example, improvements in bank transparency such as new accounting rules can reveal a bank's insolvency and trigger a run. However, bank runs, as seen a few years ago in East Asia, Bulgaria and Russia, may also be accompanied by runs on national currencies.

We include a bank run model that shows a bank may issue liquid demand deposits and avoid runs without deposit insurance as long as it also issues less liquid time deposits. Self-fulfilling runs are prevented through elimination of the maturity mismatch. The well-known Diamond & Dybvig (1983) model is modified to account for depositors' risk affinities, whereby high-risk depositors hold their savings as demand deposits and low-risk depositors prefer time deposits. These deposit choices transfer liquidity optimally from low-risk to high-risk depositors who value liquidity. By exploiting these choices, a bank can improve its intertemporal risk-sharing by issuing deposits of varying degrees of liquidity. This maturity transformation does not necessarily raise the economy's total liquidity.

Key words: Transition Economies, Bank Panics, Bank Regulation, Financial Crises

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Juha-Pekka Niinimäki

Bank panics in transition economies

Tiivistelmä

Tässä tutkimuksessa kuvataan talletuspakoja (pankkipaniikkeja) seitsemässä siirtymätaloudessa (Venäjä, Bulgaria, Latvia, Liettua, Romania, Unkari ja Viro) ja verrataan niiden tapahtumia sekä teoreettiseen tutkimukseen että kokemuksiin Yhdysvalloista. Talletuspako syntyi tavallisesti pankin taloudellisten ongelmien paljastuttua. Usein jokin pankin taloudellisen tilan arviointia helpottanut muutos – esimerkiksi paremman tilinpitojärjestelmän käyttöönotto – paljasti pankin ongelmat tallettajille käynnistäen talletuspaon. Aivan kuten Aasian talouskriisienkin tapauksessa talletuspakoihin liittyi joissakin maissa, esim. Bulgaria ja Venäjä, pako valuutasta.

Maakatsauksen lisäksi esitämme teoreettisen mallin talletuspaoista. Malli osoittaa ilman talletusvakuutusta toimivan pankin kykenevän välttämään talletuspaot, vaikka pankki tarjoaa likvidejä käteistalletuksia, jos se samanaikaisesti kerää riittävän osuuden rahoituksestaan määräaikaistalletuksin, joilla on alhainen likvidisointiarvo. Tähän tulokseen pääsemiseksi laajennamme tunnettua Diamond & Dybvig (1983) mallia olettamalla tallettajille toisistaan poikkeavat riskit tarvita säästöjään lähitulevaisuudessa. Osoitamme että korkeariskiset tallettajat, jotka todennäköisesti tarvitsevat varojaan pian, suosivat likvidejä käteistalletuksia. Vastaavasti vähäriskiset tallettajat, jotka tuskin tarvitsevat varojaan lähitulevaisuudessa, sijoittavat pitkäaikaisiin määräaikaistalletuksiin. Nämä talletusvalinnat tarjoavat likviditeettiä juuri niille tallettajille, jotka sitä eniten kaipaavat. Pankki pystyy parantamaan talouden riskinjakoa tarjoamalla eri likviditeetin omaavia talletuksia, vaikka talletusten keskimääräinen likviditeetti ei muutu.

Asiasanat: siirtymätaloudet, talletuspaot, pankkipaniikit, pankkisäätely, rahoituskriisit

1 Introduction

Bank runs or bank panics are among the most serious challenges faced by bank regulators.[1] This paper reviews recent bank runs in the transition economies and compares them with the older US experience and theoretical research. We also propose a bank-run model that shows banks may avoid runs without deposit insurance by issuing liquid demand deposits and time deposits with low liquidation value.

The classic bank run follows a familiar pattern. Depositors have saved their funds in a bank, and the bank has invested the bulk of these funds in illiquid, long-term assets. The bank holds the remainder as reserves. Depositors with confidence in the bank rarely withdraw deposits. If there are withdrawals, the bank can normally cover them with its reserves. Panicked depositors, in contrast, rush *en masse* to the bank to withdraw their deposits. The run quickly depletes the bank's reserves and forces it to start liquidating long-term assets. Assets with low liquidation values such as real estate and loans may be dumped at fire-sale prices. In the end, the cash raised from the liquidation of assets is often insufficient to pay off all depositors.

Bank runs bring financial injury to many people. There is the immediate bank failure, the wiping out of individual depositor savings and the impairment of the payment system. Productive projects are halted as banks call in their loans and the monetary authorities face problems such as an increase in the currency-deposit ratio, which reduces the amount of money in the economy.

To avoid runs, banks can hold excess reserves in anticipation of a run. They may also close their doors temporarily when a run hits, then use the respite to attract liquid funds from the money market and attempt to calm panicking depositors by providing information on the bank's financial condition. Governments can prevent runs through implementation of a credible deposit insurance scheme.

Recent bank run experiences in transition countries include Bulgaria in 1995 and 1996-1997, the Czech Republic in 1996-1997, Hungary in 1997, Macedonia in 1994, Estonia in 1994, Latvia in 1995, Lithuania in 1995-1996, Georgia in 1995-1997 and Kazakhstan in 1996 (Tang et al 2000). Bulgaria experienced full-scale simultaneous runs on its currency and banking sector in mid-1996. People withdrew their lev deposits, converted them to dollars, then shied away from banks. A third of the country's banks closed their doors for good (Tsantis, 1997).

Bank runs in transition economies merit study for several reasons. First, these particular runs inflicted heavy damage on national banking systems and hampered economic development. Study of these runs may thus help reveal the shortcomings of national banking systems and suggest ways to deal with the threats of future runs.

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[1] Calomiris & Gorton (1991, p.112) see little difference in the usage of the terms bank panic and bank run. "A banking panic occurs when bank debt holders at all or many banks in the banking system suddenly demand that banks convert their debt claims into cash to such an extent that the banks suspend convertibility of their debt into cash or, in the case of the United States, act collectively to avoid suspension of convertibility by issuing clearing-house loan certificates. Several elements of this definition are worth discussing. First, the definition requires that a significant number of banks be involved. If bank debt holders of a single bank demand redemption, this is not a banking panic, though such events are often called bank runs. The term banking panic is often used simultaneously with bank run that there is no point attempting to distinguish between the two terms."

Second, they provide relatively fresh information. US deposit insurance ruled out large-scale runs after 1933, so bank run study in the US concerns itself with old data. For example, Dwyer and Hafer (2001) investigate bank runs in the 1860s and Rolnick et al. (1998) examine a run in 1837.

Finally, given the negative incentives associated with deposit insurance (e.g. Merton, 1977), it is important to investigate how well a banking system might operate without deposit insurance. Since many transition economies lack deposit insurance schemes, their experiences provide interesting information.

The paper is structured as follows. Section 2 reviews theoretical analysis on bank runs and surveys existing empirical evidence. Bank runs in transition economies are described in section 3. Runs are examined in the context of banking theory and existing empirical evidence in section 4. Section 5 presents a model showing how a bank can prevent runs by issuing both demand deposits and time deposits. The model is also shortly compared with the transition experience. A short empirical test is presented in section 6. Section 7 concludes with an overview of banking problems of transition economies.

2 Bank-run theory and empirical evidence

2.1 Theory

Bank runs are commonly explained by one of three theories. The earliest theory, *random withdrawal*, is based on the model of Diamond & Dybvig (1983). The basic thesis is that depositors favor liquid assets for saving as they are uncertain about future consumption. Banks can offer this by issuing demand deposits, but they then run the risk that the total face value of demand deposits may exceed the liquidation value of their assets. Obviously, a bank will be unable to pay off all depositors if they attempt to withdraw their deposits simultaneously. Thus, a bank run occurs as soon as depositors have reason to believe that other depositors are preparing to withdraw their deposits. This forces the bank into a costly liquidation of its assets. Fear of being last in the line motivates depositors to attempt recovery of their savings. This theory sees bank runs as random, self-fulfilling, "mass hysteria" events, which are impossible to predict. Anything that causes depositors to anticipate a run, leads to a run.

Jacklin & Bhattacharya (1988) propose the *information-based bank run*. According to this theory, a bank avoids runs as long as it is solvent. The run occurs when depositors get negative signals about the bank's solvency and understand that an insolvent bank cannot pay off all deposits. They rush to the bank to rescue their savings.

The *seasonal bank run theory* (Champ et al., 1998) suggests that seasonal fluctuations in liquidity demand generate bank runs. For example, the seasonal cycle of agriculture causes fluctuations in the need for liquidity in rural economies. Farmers need extra funds at harvest time and they receive returns when they later sell their products. Thus, the high local liquidity demands at harvest time may trigger a run.

Theory suggests the government can eliminate runs by introducing a credible deposit insurance scheme so that depositors can trust their deposits are safe and have no reason to panic (Diamond & Dybvig, 1983). A bank can also deal with a run-in-progress by suspending convertibility of deposits to cash by closing its doors temporarily or allowing depositors to withdraw only a certain fraction of their deposits (Diamond & Dybvig, 1983;

Wallace, 1988). Other banks and authorities can also provide liquidity assistance to a bank threatened with a run (Smith, 1984).

Some theoretical studies (e.g. Bryant, 1980) argue that a bank runs are inherently unfair as depositors with good abilities to observe the bank's insolvency may recover their deposits while the slow-to-learn may lose all or part of their savings. The expected return on a bank deposit is thus higher for an informed depositor (e.g. a business firm) than an uninformed depositor.

2.2 Econometric evidence from US bank runs

We next review the econometric evidence from bank runs in the United States in 1814, 1819, 1837, 1839, 1857, 1861, 1873, 1884, 1890, 1893, 1907, 1914 and 1929-1933.

In examining seven bank runs between 1873 and 1914, Gorton (1988) argues that runs represent depositors' systematic responses to new macroeconomic information that changes their risk perceptions. He shows that whenever the variable predicting recession exceeds a threshold level, a panic occurs. Gorton offers an intuitive interpretation: rational depositors realize banks tend to fail during recessions. When they expect a recession, they withdraw their deposits.

Calomiris & Gorton (1991) find that the bank runs of the National Banking Era (1873-1914), in contrast to the runs of the Great Depression, tended to occur after business cycle peaks. Their results indicate that a run occurred when depositors received adverse information concerning bank stability. Notably, this information tends to be macroeconomic rather than bank specific, so that, e.g., a stock price decline accompanied with the increase of commercial failures well predicts a run. During the period studied, banks often attempted to stop runs by suspending convertibility of deposits to cash.

Donaldson (1992) investigates US bank runs during the period 1867-1933. The results may be interpreted according to any of the three bank-run theories mentioned above. He argues that the different theories are not really in conflict, but merely emphasize different aspects. Donaldson notes that the exact starting time of a run may be random, but it is possible to identify circumstances where the probability of a run is high. Market liquidity also strongly determines the length and severity of a run. Interest rates rise during a run, while stock prices, bank deposits and bank cash reserves fall. Donaldson further explains that the 1933 run departs from this pattern because it began as a run on the US dollar rather than a run on commercial banks.

Calomiris & Mason (1996) explore the June 1932 Chicago bank run. Asymmetric information between depositors and banks caused a general run on all banks. Depositors were unable to distinguish between solvent banks and insolvent ones. Banks, on the other hand, knew each other's financial condition. Solvent banks thus could help each other during the run by providing liquidity assistance when insolvent banks were unable to attract liquidity. As a result, only the most distressed banks failed during the run.

Dwyer & Hafer (2001) confirm the findings of Calomiris & Mason (1996). Using data from 1860s, they find that the *ex ante* risk of a bank's portfolio helps predict which banks fail during bank runs. The riskiest banks are the most likely to fail.

By examining the runs of the Great Depression, Saunders & Wilson (1996) find evidence consistent with insolvent bank deposit withdrawals being re-deposited locally in solvent banks in 1929 and 1933. In contrast, the 1931-1932 evidence points to contagion, i.e. depositors withdrew their savings from both solvent and insolvent banks. The evidence also indicates that some depositors were more informed than others about the solvency of individual banks.

Wicker (2000) investigates panics in the Great Depression. He concludes e.g. that Chicago bank runs in 1931 were mainly information based as most runs were directed against weak banks. By 1932, however, most depositors had lost confidence in the banking system, so runs were directed against all banks. The following year, statewide suspension of convertibility of deposits was used to stop runs. By the end of the day on March 4, 1933, banks were temporarily closed in 33 states and partial restrictions on deposit withdrawals were used in ten states.

Kaufman's (1994) survey concludes, "Such an analysis suggests that bank contagion is largely firm-specific and rational, as it appears to be in other industries, and that the costs are not as great as they are widely perceived to be. Bank runs also appear to be bank-specific and rational. The evidence also suggests that, compared to non-banks, bank failure contagion appears faster; is more likely to spread to a larger proportion of industry; is likely to lead to a larger percentage of failures, although runs do not appear to drive solvent banks into insolvency; and is more likely to spill over to other sectors." (Kaufman, 1994, p.143).

Even if the econometric evidence is a bit conflicted, we can make the following observations. Bank runs tend to be information based. They occur at certain times and under certain conditions, and they are mostly directed against distressed banks. Given depositors' insufficient ability to evaluate bank risk, depositors often base their decisions on macroeconomic information, and not on bank-specific information. When this happens, runs may also be directed against solvent banks. There is also evidence that better-informed depositors sometimes successfully withdraw their deposits from the failing banks before less-informed depositors, and that mutual liquidity assistance among banks, official liquidity assistance, and suspension of convertibility all can help restrict runs.

3 A survey of bank panics in transition economies

At the start of transition, the banking systems in the seven transition economies considered here were quite similar. Each country had its own mono-bank system with specialized state banks serving specific branches of the economy. By restructuring the banking system (e.g. by splitting large branches into small banks and then privatizing them), a first wave of commercial banks was established. New commercial banks formed next. In Latvia, for example, over sixty new banks were licensed in 1993, although it was quickly apparent most of these new entrants to the banking industry were unprepared for the risks. They failed to deliver basic banking services, and were generally small, unprofessionally managed, undercapitalized, and poorly supervised. Some inherited loans (typically non-performing) from state banks, adding a costly burden. The authorities often worsened this bad situation by ordering banks to grant new loans to unprofitable firms. "Wildcat banks," or pocket banks, were established by firms to raise cheap finance for their owners. These banks never bothered with standard banking services and were high risk. In the end, the established banking sector failed at a basic function of banks – transforming small, short-term deposits into large, long-term loans for entrepreneurs.

3.1 Russia

The Russian economy showed numerous positive signs in 1997. Inflation was low, exchange rates were stable, and economic growth – after years of contraction – was finally positive. Unfortunately, severe problems also existed: a large budget deficit, rising government indebtedness, growing reliance of money surrogates, a poorly functioning tax system, and low investment levels.

The fiscal deficit in 1996 and 1997 was financed by piling up government debt. The high interest rates on government bonds attracted foreign funds. Large Russian banks, instead of granting investment loans, invested increasingly in government bonds so that the total bank investments in these bonds more than tripled in 1996-1997.[2] Foreign investors invested in bank liabilities and in the stock market, which drove up stock prices. Indeed, the Russian stock market was the world's best-performing equity market in terms of percentage gain in both 1996 and 1997. Then export prices fell and investment dried up. The stock market collapsed in October 1997. As confidence in the banking system declined, banks could only attract deposits by issuing foreign-denominated liabilities or by supplying forward contracts for hedging exchange rate risk. This exposed the banks to an exchange rate risk that materialized.[3] The drop in government bond prices by 17-30% at the beginning of 1998 caused banks severe losses, which mounted as the stock market fell over 40% in May 1998. Numerous borrowers were unable to repay their loans and the relative solvency of banks (ratio of liquid assets to deposits) decreased about 25% between January and September. However, even after several banks defaulted on their forward contracts with foreign investors, the banks retained their deposits. Indeed, while deposits in business accounts decreased, deposits in public accounts rose up to the end of August. At that point, the government defaulted on its bonds and declared a restructuring program. Many banks suffered huge losses. Meanwhile, the exchange rate system collapsed and the rouble depreciated sharply. This drove the banks that had issued forward contracts into insolvency (Bernstam & Rabushka, 1998; Sutela, 1999; Komulainen 1999; Astaphovich & Syrmolotov, 2000).

Depositors began to withdraw their deposits during August 1998. The fall of rouble excited the run. When the volume of bank deposits declined about 20%, banks suspended convertibility of deposits to cash by setting limits on maximum daily withdrawals, by paying off currency deposits only in roubles (at an unfavorable exchange rate), and by transforming deposits into long-term obligations (Astapovich & Syrmolotov, 2000). The authorities stepped in to eliminate runs by stopping deposit services in six large commer-

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[2] Werner (1998) looks at the profits of the Russian banks in 1992-1998 and finds that profits resulted from a bank's ability to attract cheap liabilities. During 1992-1994, the central bank granted loans to firms through banks. It lent these loans to banks at a nominal annual rate of interest of 10%. With inflation over 800%, the banks could mediate these loans to firms at a much higher loan rate. Second, banks also succeeded at attracting zero-interest rate deposits. In 1995, the fraction of non-interest bearing deposits was over 70% of all liabilities. For example, public pension funds and social security funds were often deposited in local banks in zero-interest deposits. Third, even if demand deposits bore interest, the spread between lending rates and deposits rates was wide. For an extensive review of the Russian banking sector, see Rautava (1996).

[3] At several banks, the volume of obligations under futures contracts exceeded both the magnitude of the bank's equity capital and the magnitude of the bank's assets (Aleksashenko, 2000).

cial banks.[4] Depositors with these banks were compelled to transfer their deposits to the state-owned Sberbank at an unprofitable exchange rate. This scheme, together with public loans to Sberbank, the state-owned bank's implicit deposit insurance, and its ability to fulfill its obligations to the public, succeeded in stopping bank runs and restored confidence in the banking system. Sberbank played a dominant role in calming the situation as it possessed the lion's share of public rouble deposits. By the next year, 1998, the volume of bank deposits began to increase (OECD 2000).[5]

While the financial crisis sorely damaged the Russian economy (numerous banks failed, the payment system went into gridlock, the rouble collapsed, and industrial output nose-dived), the recovery was rapid. Deposits reverted to the banks and industrial output grew. The rapid recovery reflected the minor role of bank finance in Russia. Since bank lending to industry was minor, the destruction of the banking sector did little to hinder industrial recovery.

Russia's banking sector remains in weak financial condition. The Central Bank of Russia estimated the aggregate capital of the banking system to be zero in 1999. The World Bank estimated that in 1999 the top 30 banks had negative equity of $10-15 billion (Thomson, 2000). Although the central bank pulled the licenses of many banks after the crisis, the restructuring of the largest insolvent banks has been extremely slow due to loopholes in Russian bankruptcy law and the weak statutory power of regulatory authorities. The absence of bank competition also constitutes a big problem. In the deposit market, Sberbank continues to dominate, holding almost 90% of retail rouble deposits. The role of foreign banks remains marginal.

3.2 Bulgaria

Major bank runs rocked Bulgaria during 1994-1996. In 1994, the liquidity crises of Economic Bank and Mineral Bank triggered a withdrawal of deposits. In June 1995, adverse rumors and the publication of troubling financial statements precipitated a run on First Private Bank. In December 1995 and March 1996, the National Bank of Bulgaria took over two small private banks after they failed to stem runs (Dobrinsky, 1997).

The National Bank of Bulgaria attempted to stabilize the situation with a limited deposit insurance scheme. Instead, the scheme disappointed depositors and triggered runs on the five other banks and the currency in general. To limit pressure on the currency, the National Bank raised its basic rate in February 1996. The banks reacted to the high interest rate by converting their foreign currency holdings to levs to gain from the wide interest rate spread. The conversion created currency risk as banks were attracting considerable foreign currency deposits while their assets were lev-denominated. The risk materialized and banks were unable to repay their deposits. This result was a simultaneous full-scale run on the currency and the banking system in mid-1996. People withdrew their lev deposits, converted them to dollars then shied away from the banking system altogether.[6] About a

[4] Distressed banks turned to asset stripping. They moved their profitable assets to other banks held by the same owners and paid back some deposits at the expense of other depositors (OECD, 2000).

[5] The Bank of Russia attempted to improve the liquidity of the banking system in several ways. First, reserve requirements were decreased. Second, the reserve funds used to operate the payment system. Third, the Bank granted loans to banks.

[6] In March 1996, the Bulgarian National Bank abandoned its defense of the lev. In the second quarter of 1996, the lev depreciated by 100% and by over 200% in the second half of a year. It ended 1996 down almost 600% for the year (Balyzov, 1999). Due to the instability in the demand

third of banks ceased operations and entered bankruptcy proceedings (OECD, 1997; Dubrinsky, 1997).

Depositors lost confidence in the Bulgarian banking sector for several reasons. First, Bulgarian banks had plenty of non-performing loans.[7] The share of non-performing assets rose rapidly in 1995, so that the net worth of the banking sector became negative. At the end of the year, over 70 % of commercial loans were classified as problematic. The main reason for the high fraction of problem loans was the use of the bank credits as implicit subsidies to loss-making state-owned firms. Second, many banks had exchange rate risk exposure. They invested in lev-denominated assets and issued hard currency deposits. When the return on the lev-denominated assets fell, banks could no longer repay their deposits. Third, confidence in Bulgarian financial institutions was shaken by the collapse of financial pyramid schemes in mid-1995. Finally, bank formation was initially easy, capital requirements low, and financial supervision of banks weak (OECD, 1997).[8]

3.3 Hungary

In February 1997, the second largest retail bank of Hungary, Postabank, was hit by a run. Depositors reacted to a rumor that large-scale deposits had been withdrawn from the bank. This triggered a run lasting two days. Although over 15 % of bank deposits were withdrawn, the bank emerged from the run without suspending the convertibility of deposits to cash. The run, however, revealed severe problems in Postabank's operations and considerable state funds were later been spent on the consolidation of the bank. The state is now filing a lawsuit against few auditing companies arguing that the auditors obscured Postabank's actual financial position during 1994-1996.

The run did not threaten the stability of the banking sector as a whole and macroeconomic development was favorable before the run.

3.4 Romania

In spring 1996, two Romanian banks, Dacia Felix SA and Credit Bank SA, were troubled by the withdrawal of deposits and had to suspend convertibility of deposits to cash. The National Bank of Romania spent huge amount on supporting the banks before July 3, 1996, when it announced it would stop refinancing.

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of money, monthly inflation varied considerably. In late 1995 and in early 1996, monthly inflation was about 3%, but in June and July inflation was over 20%. The financial crisis had a strong negative effect on GDP. GDP, although up in 1994-1995, dropped 11% in 1996. For the period 1991-1998, the cost of the government assistance to the banking sector amounted to 26.5% of GDP (Tang et al., 2000).

[7] In 1991, the Bulgarian government announced it would pay 25% of non-performing loans. In 1992-1993, the government again paid bad loans. This created the expectation of an all-forgiving policy. The outcome was that practically all state-owned firms stopped repaying their loans (Dobrinsky, 1997). Even if the rate of non-performing loans was very high, 70%, the rate was even higher in Kyrgyz Republic, where over 92% of bank loans were non-performing (Tang et al., 2000).

[8] Moral hazard was present in banking operations. Banks generously granted insider loans and risky loans, as well as violated banking regulations. Easy access to refinancing from the central bank eliminated financial discipline.

The banks' financial difficulties were known for a long time. Credit Bank had been under special surveillance from 1994 and Dacia Felix bank from 1995. National Bank's supervision team found several violations of bank regulations at Dacia Felix. Many of the bank's statements were false. The bank reported profits for 1994 and 1995, for example, when in fact the supervisors found enormous losses. Moreover, the bank granted large insider loans. Dacia Felix suffered from liquidity problems for some time. Its assets were sold off at fire-sale prices to pay high interest on deposits and receive liquidity support from the National Bank (Tsantis, 1997).

3.5 Estonia

Estonia experienced two banking crises in the early 1990s. The first occurred in late 1992, when the three largest commercial banks of Estonia faced financial difficulties. Two of these, North Estonian Bank and Union Baltic Bank, had invested in Vneshekonom Bank. In early 1992, the Moscow headquarters of Vneshekonom Bank froze all assets of non-Russian banks. The freeze made the two Estonian banks illiquid and insolvent. Banking problems were worsened by the Bank of Estonia, which changed its banking policy by stopping cheap lending to banks. North Estonian Bank and Union Baltic Bank were allowed to operate until November 1992, when the Bank of Estonia finally closed them. The closure did not trigger a run on other healthy banks. Instead, there was a shift to the remaining solvent banks (IMF, 1993).

The second banking crisis in 1994 was culminated in the insolvency of Social Bank, which managed the government funds. The government decided to withdraw a large share of its funds and reinvest the funds in several banks. The withdrawal caused serious liquidity problems for Social Bank and drove it into insolvency.

3.6 Latvia

The Latvian banking crisis broke out in 1994 when five small banks and two medium-sized banks were declared insolvent. Two-thirds of banks reported losses in 1994 and more than ten banks were unwilling to provide required financial statements eroded public confidence in banking system, and the volume of deposits in Latvian banks declined during the spring of 1995 (Hansson & Tombak, 1999).

Two mid-sized banks had serious financial difficulties exposed in February and May 1995. Worsening banking problems became a full-blown crisis with the closure of Baltija Bank.

Baltija Bank, formed in 1989, had grown rapidly, increasing its assets from $25 million in 1993 to $242 million in 1995 – a real annual growth rate of over 600%. Baltija Bank funded its growth by paying high interest on deposits. The rapid growth made Baltija Bank the largest bank in Latvia with over 16 % of total assets and over 30% of deposits. The bank invested in risky assets, e.g. trade loans, and gambled with the exchange rate risk by funding its foreign currency assets with lat deposits. The move meant the bank would have reaped high profits in the event of a lat devaluation. Instead, the lat appreciated gradually causing severe losses to the bank. The losses grew with revelations of unprofitable insider loans and fraudulent activities. The Bank of Latvia attempted to bail out the bank with a restructuring plan. During negotiations, however, Baltija Bank transferred 60%

of its loan portfolio to the third parties at low prices. Baltija Bank was finally declared insolvent on 23 May (Brabco et al., 1996; Fleming, 1995; Hansson & Tombak, 1999).

During the first seven months of 1995, fifteen banks (holding some 35-40% of the country's banking assets) closed. Entrepreneurs were the first to withdraw their deposits. Households, in contrast, were slow to understand the threat of bank insolvency. Hence, mostly small deposit holders lost their deposits (Fleming et al., 1996). When the crisis began to subside, public confidence in the banking sector was eroded, foreign deposits were withdrawn from Latvia, and the total amount of deposits fell. Yet, large bank runs were avoided because deposits withdrawn from banks with financial difficulties were resaved in solvent banks. The overall decrease in deposits was moderate. Depositors apparently could distinguish the risk differences among banks (Brabco et al., 1996).

3.7 Lithuania

Lithuania's banking crisis started in early 1995. Bank returns had shrunk for several reasons. The introduction of the currency board in 1994 and the drying up of the metal trade lowered bank returns. The government had also pressed some banks to finance unprofitable borrowers in e.g. the energy sector (Fleming et al., 1996). By the end of June 1995, ten small banks were under public administration. The crisis erupted in December with the publication of the on-site examination results for Innovation Bank and Litimpeks Bank. The publication triggered a run on both banks and they were closed. Steady bank deposit withdrawals spread to other banks. Foreign funds outflow and bank reserves dwindled away. The banking system lost about 15% of its lit deposit base; deposits in foreign currencies decreased 19%. Rumors incited runs on better banks, which attempted to calm panicking depositors by publishing information, for example, on the size of their corresponding balances abroad. The panic was mainly curbed, however, by public intervention. In the state banks, deposits were risk-free and in the other banks partial deposit insurance reduced the risk. The government also promised to guarantee inter-bank lending. Some banks were even able to increase their deposit base during the crisis (Fleming, 1996).

4 Comparing econometric evidence

As in the US, bank runs in transition economies have typically been information based. A disclosure of negative bank-specific information (say, an accounting report) might trigger a run, but the run did not spread to solvent banks. In Russia and Bulgaria, where runs ravaged the banking system, runs were often directed against the currency. Depositors withdrew their deposits to convert them into foreign currency on the rational fear that the domestic currency would depreciate.

During the bank runs in Latvia and Estonia, depositors withdrew their deposits from insolvent banks and re-deposited them in other banks. This evidenced that depositors were able to evaluate risk differences among banks. Arguably, the "creative destruction" wrought by such a bank run may have positive impacts. The run forces the weak bank into bankruptcy and moves deposits into solvent banks capable to productive lending. Since the total deposits of the economy are essentially unchanged, the transfer of deposits generates only slight changes in the money stock. Given the excessive number and small size of banks, the exit of banks is likely to have a salubrious effect on the banking sector.

There is also evidence from Latvia and Russia that some depositors had an information advantage over others and withdrew their deposits from failing banks earlier.
Transition countries relied on traditional methods to stop runs: convertibility of deposits to cash was suspended, the authorities provided financial support to distressed banks or promised to guarantee the safety of deposits.

Nevertheless, there are also important differences between the US experience and that of transition countries. US bank runs occurred either following an economic boom or at the deepest depression. In the transition economics, macroeconomic development was not essential. Instead, the improvements in bank transparency – for example, the introduction of the new accounting system – often revealed bank insolvency and triggered a run. Russia was the only country where a bank run occurred after a stock market crash. Given that the crash combined a run on the currency, the Russian crisis closely resembles the financial crises of East Asia. Another important element of the Russian crisis – the collapsed value of government bond – closely parallels US banking history. The bank runs of 1814 and 1861 in the US followed precipitous exogenous declines in the value of government securities during wartime. Adverse rumors regarding the probability of government repayment lowered bond values, threatening the solvency of banks (Calomiris & Gorton, 1991).

5 Modifying the Diamond & Dybvig model

5.1 Background

The fundamental cause of self-fulfilling bank runs is the maturity mismatch. The combination of illiquid assets and liquid demand deposits makes a bank financially fragile. As long as confidence is maintained, everyone benefits from the maturity transformation. When depositors panic and rush to withdraw their deposits at once, the bank is forced to liquidate its assets at a loss and may fail.[9] Bank runs can be prevented without deposit insurance or other intervention as long as the value of bank deposits matches the liquidation value of bank assets. Using this notion, we design a novel panic-free banking system whereby a bank funds its illiquid assets by issuing deposits of varying degrees of liquidity (demand and time deposits) in such a way that deposit liquidity is on average the same as asset liquidity. Since the face value of demand deposits exceeds the liquidation value of assets, the liquidation value of time deposits must be lower than the liquidation value of assets. Substantial long-term returns make time deposits attractive. Each depositor then chooses the most attractive deposit alternative. We show that when depositors are exposed to different risks, or "preference shocks," high-risk depositors will save with liquid demand deposits, whereas low-risk depositors will favor illiquid time deposits. Liquidity is important to high-risk depositors, who want to be able to get at their money any time. In contrast, low-risk depositors, who are unlikely to need their savings in the near future, appreciate the substantial long-term return of a time deposit. These deposit choices transfer liquidity optimally from low-risk to high-risk depositors, which improves intertemporal risk sharing. Thus, a bank can provide valuable liquidity and risk sharing services, and yet avoid runs, by issuing different kinds of deposits.

[9] The risk of maturity mismatch has been long discussed, e.g. by Adam Smith (1789). Modernly, warnings about maturity mismatch surface in discussions of narrow banking.

We modify the seminal model of Diamond & Dybvig (1983) in two ways. First, we introduce depositors that encounter preference shocks with different probabilities. Second, we explore optimal deposit contracts in the event that runs are possible in the absence of deposit insurance or other intervention. Under the Diamond & Dybvig (1983) model, a bank issues only demand deposits. In our setting, a bank rationally responds to the threat of runs on the liability side by issuing both demand deposits and time deposits. Our study therefore complements the recent analysis of Cooper & Ross (1998) in which banks respond to the threat of runs on the asset side by investing in both liquid reserves and illiquid assets. Our study is also closely related to other suggestions for preventing runs: deposit insurance (Diamond & Dybvig 1983), suspension of convertibility (Diamond & Dybvig 1983, Wallace 1988), bank's equity capital (Gangopadhyay & Singh 2000), and state-contingent deposit payments with priority-of-claims provisions (DeNicolo 1996).[10] Depositors, of course, may prefer some risk of runs to a completely safe bank if it yields higher interest on deposits (Cooper & Ross 1998). Runs may even be optimal (Calomiris & Kahn 1991, Niinimäki 2001a).[11]

Panic, possibly at the international level, also needs to be considered here. Radalet & Sachs (1998), for example, stress the role of panic as a key element in the Asian crises of 1997. They find that short-term foreign debt in excess of foreign exchange reserves made certain Asian countries vulnerable to creditor panic and that the crisis-triggering events involved sudden massive capital outflows from the region. Chang & Velasco (1998) model the panic and argue that disincentives for short-term foreign borrowing may well be justified. Bordo et al (2001) recommend taxes that lengthen the maturity structure of foreign debt and restrict maturity mismatch.[12]

5.2 The Diamond & Dybvig model

The framework presented below is the Diamond & Dybvig (1983) model extended so that agents have differing risks of encountering a preference shock. We consider a three-period economy $(T = 0,1,2)$ with a single consumption good and a continuum of agents of total measure one. Each agent is endowed with one unit of the consumption good at date 0 and

[10] Perhaps the article most closely related to ours is that of Smith (1984), who also extends the Diamond & Dybvig (1983) model via low-risk and high-risk agents. His model differs from ours in two ways. First, he focuses on adverse selection (competition for different deposits may make the banking system unstable), whereas we focus on eliminating runs (different deposits are offered so as to make the bank system stable). Second, under Smith's approach banks compete for deposits, whereas our bank is a monopoly bank (or bank competition takes place only in loan markets).

[11] Von Thadden (1999) surveys the Diamond & Dybvig literature. See Hellwig (1998) for a more extensive discussion of risk- sharing in banking.

[12] This paper relates to Niinimäki (2000, 2001b) in which banks also eliminate runs by issuing different deposits. In Niinimäki (2000) each depositor splits his savings between demand deposits and time deposits. If he later faces a small consumption shock, he withdraws only his demand deposit funds, whereas a big shock also requires liquidation of time deposits. Depositors hit by a small shock benefit from their liquidity. In Niinimäki (2001b), depositors vary in terms of risk aversion. Highly risk-averse depositors favor demand deposits, whereas modestly risk-averse depositors prefer time deposits. These deposit choices transfer liquidity risk from highly risk-averse depositors to slightly risk-averse depositors. On risk aversion, see also Cooper & Ross (1998), Von Thadden (1999) and Gangopadhyay & Singh (2000).

none at any other time.[13] At date 0, an agent is uncertain of his future consumption preferences, but by the start of date 1, he knows his *consumption type.*

- *Impatient agents* value date 1 consumption only.
- *Patient agents* value date 2 consumption only.

An agent's realized consumption type is his private information. At date 0, agents have different risks of being impatient; i.e. there are two *risk types.*

- *Low-risk agents* (identified by L) become impatient with probability t_L.
- *High-risk agents* (identified by H) become impatient with probability t_H, $t_L < t_H$.

At date 0, each agent knows his risk type privately. A fraction h of agents is high risk and a fraction $1-h$ of agents is low risk. Both t_L and t_H are assumed to be non-stochastic and known to all agents so that there is individual uncertainty over tastes, but no aggregate uncertainty. For example, at date 1, $ht_H + (1-h)t_L$ agents become impatient. [14] At date 0, agent i's expected utility is

$$U_i = t_i u(c_1^i) + (1-t_i)u(c_2^i), \quad i \in \{L, H\}. \qquad (1)$$

Here c_T^i represents agent i's consumption in period T and $u()$ represents utility from consumption. Assume that $u()$ is strictly increasing and strictly concave, $u'(0) = \infty$ and $u'(\infty) = 0$. Moreover, agents are relatively risk-averse, $-cu''(c)/u'(c) > 1$.

Two infinitely divisible production technologies are available. The long-term technology yields $R > 1$ units of output at date 2 for each unit of date 0 investment, but if the production process is interrupted at date 1, only 1 unit can be obtained. The storage technology transfers the good without cost from one date to another. If the agents live in *autarky*, the risk types' expected utilities are

$$\overline{U}_L = t_L u(1) + (1-t_L)u(R), \qquad \overline{U}_H = t_H u(1) + (1-t_H)u(R). \qquad (2)$$

These utilities represent agents' *reservation utility levels*.

5.3 Optimal allocation with deposit insurance

In this section, we analyze the provision of liquidity under deposit insurance with only high-risk agents. To simplify the analysis considerably, a bank is assumed to have market

[13] See Champ et al (1996) for a Diamond & Dybvig model with currency. Liquidity provision in the overlapping generations version of the Diamond & Dybvig model is examined by Qi (1994), Bhattacharya & Padilla (1996), Bhattacharya et al (1998) and Fulghieri & Rovelli (1998). For discussion of corporate demand for liquidity, see Holmström & Tirole (1998,2000).

[14] Several types of aggregate risk have been studied with the Diamond & Dybvig (1983) model. For a stochastic fraction of impatient agents, see Diamond & Dybvig (1983), Wallace (1988), DeNicolo (1996) and Gangopadhyay & Singh (2000). Interest rate risk is investigated by Hellwig (1994) and production risk by Jacklin & Bhattacharya (1988) and DeNicolo (1996).

power: it offers such small deposit payments to high-risk agents that the agents receive their reservation utility,

$$t_H u(c_1^{DI}) + (1-t_H)u(c_2^{DI}) = \overline{U}_H . \qquad (3)$$

Here c_1^{DI} denotes the deposit payment to impatient agents and c_2^{DI} denotes the payment to patient agents under deposit insurance. The bank selects deposit payments so that its expected profit

$$\left[1 - t_H c_1^{DI}\right]R - (1-t_H)c_2^{DI} \qquad (4)$$

is maximized subject to the agents' participation constraint, (3). In (4), $t_H c_1^{DI}$ denotes the bank's total payments to impatient agents and $(1-t_H)c_2^{DI}$ denotes payments to patient agents. The optimal deposit payments satisfy

$$\frac{u'(c_1^{DI}*)}{u'(c_2^{DI}*)} = R . \qquad (5)$$

Just as in Diamond & Dybvig (1983), the bank provides liquidity insurance, $1 < c_1^{DI}* < c_2^{DI}* < R$; the variance of agents' expected income is smaller than in autarky. Since agents receive their reservation utility, the bank can keep the returns on improved risk sharing and earns a positive profit. Because the face value of deposits exceeds the liquidation value of assets, $c_1^{DI}* > 1$, the bank is vulnerable to runs without deposit insurance. The bank cannot provide liquidity and avoid runs without deposit insurance when there is only one agent type.

5.4 Optimal allocation without deposit insurance

Now we show that the bank can provide liquidity and avoid runs without deposit insurance when there are both low-risk and high-risk agents. Self-fulfilling bank runs can be prevented when a patient agent knows that he will receive a higher income by waiting for date 2 than by joining an anticipated run at date 1. This is possible only with matching maturity structures of bank assets and liabilities.[15] The m*aturity matching constraint* determines that at date 1 the total value of the bank's deposits is 1, i.e.

$$hc_1^H + (1-h)c_1^L = 1 , \qquad (6)$$

[15] If the maturity matching constraint is not satisfied, the bank cannot repay all deposits in the event of a run and a rational agent would join an anticipated run.

where c_T^i denotes the deposit payment in period $T \in \{1,2\}$ to an agent whose risk-type is $i \in \{L, H\}$. Recall that h is the fraction of high-risk agents.

Next, we derive the bank's profit function. At date 1, there are ht_H impatient high-risk agents who withdraw a total of $ht_H c_1^H$, as well as $(1-h)t_L$ impatient low-risk agents who withdraw $(1-h)t_L c_1^L$. The sum total of withdrawals at date 1 is thus $ht_H c_1^H + (1-h)t_L c_1^L$ and at date 2 the production income is

$$\left[1 - ht_H c_1^H - (1-h)t_L c_1^L\right]R. \tag{7}$$

At date 2, there are $h(1-t_H)$ patient high-risk agents and $(1-h)(1-t_L)$ patient low-risk agents. Hence, total deposit payments to patient agents at date 2 are

$$h(1-t_H)c_2^H + (1-h)(1-t_L)c_2^L. \tag{8}$$

Subtracting deposit payments from the bank's production income (7) gives the bank's profit

$$\pi = \left[1 - ht_H c_1^H - (1-h)t_L c_1^L\right]R - h(1-t_H)c_2^H - (1-h)(1-t_L)c_2^L. \tag{9}$$

The bank must offer payments on deposits that satisfy agents' participation constraints so that agents reach their reservation utility levels. The participation constraint for high-risk agents is

$$t_H u(c_1^H) + (1-t_H)u(c_2^H) \geq \overline{U}_H \tag{10}$$

and for low-risk agents

$$t_L u(c_1^L) + (1-t_L)u(c_2^L) \geq \overline{U}_L. \tag{11}$$

Thus, the bank maximizes its profit (9) subject to the agents' participation constraints, (10) and (11), and the maturity matching constraint, (6). To simplify the maximization problem, we first solve for the deposit payment, c_1^L, from the maturity matching constraint,

$$c_1^L = \frac{1 - hc_1^H}{1-h}, \tag{12}$$

and then substitute this deposit payment into the bank's profit function (9) and into the low-risk agents' participation constraint, (11). After the substitution, the bank's maximization problem can be expressed as

$$Max \quad \left[1-t_L-hc_1^H(t_H-t_L)\right]R - h(1-t_H)c_2^H-(1-h)(1-t_L)c_2^L \qquad (13)$$
$$-\lambda_L\left\{\overline{U}_L-t_Lu(\frac{1-hc_1^H}{1-h})-(1-t_L)u(c_2^L)\right\}$$
$$-\lambda_H\left\{\overline{U}_H-t_Hu(c_1^H)-(1-t_H)u(c_2^H)\right\}.$$

The top line represents the bank's profit, the second line the low-risk agents' participation constraint and the third line the high-risk agents' participation constraint. Here, λ_L (λ_H) is the Lagrange multiplier associated with low-risk (high-risk) agents' participation constraint. The bank selects payments on deposits so that

$$\frac{d\pi}{dc_1^H}: -h(t_H-t_L)R - \lambda_Lt_Lu'(c_1^L)\frac{h}{1-h}+\lambda_Ht_Hu'(c_1^H)=0. \qquad (14)$$
$$\frac{d\pi}{dc_2^H}: -h(1-t_H)+\lambda_H(1-t_H)u'(c_2^H)=0 \quad \leftrightarrow \quad \lambda_H=\frac{h}{u'(c_2^H)}.$$
$$\frac{d\pi}{dc_2^L}: -(1-h)(1-t_L)+\lambda_L(1-t_L)u'(c_2^L)=0 \quad \leftrightarrow \quad \lambda_L=\frac{1-h}{u'(c_2^L)}.$$

It is now straightforward to show that both participation constraints are binding, $\lambda_L,\lambda_H>0$ (appendix B). Intuitively, if a participation constraint were not binding, the bank could boost its profits by lowering deposit payments. After some manipulation, the optimal conditions simplify to

$$\frac{d\pi}{dc_1^H}: t_H\frac{u'(c_1^H*)}{u'(c_2^H*)} - t_L\frac{u'(c_1^L*)}{u'(c_2^L*)} - (t_H-t_L)R=0. \qquad (15)$$

We first explore whether the autarky allocation $(1,R)$ is optimal. Inserting the autarky payments $c_1^L*=c_1^H*=1,\ c_2^L*=c_2^H*=R$ into the left-hand side of the optimal condition (15), we obtain

$$\frac{d\pi}{dc_1^H}: (t_H-t_L)\frac{u'(1)}{u'(R)} - (t_H-t_L)R>0, \qquad (16)$$

since $u'(1)/u'(R)>R$ (recall Diamond & Dybvig 1983). Hence, the autarky allocation is not optimal: the bank can increase its profits by raising the payment to impatient high-risk agents above the autarky level, $c_1^H* > 1$. Since $c_1^H* > 1$ and since the high-risk agents' participation constraint is binding, a patient high-risk agent can consume less than in autarky, $c_2^H* < R$. Moreover, because $c_1^H* > 1$ and because the maturity matching constraint is binding, an impatient low-risk agent can consume less than in autarky, $c_1^L* < 1$. Given that $c_1^L* < 1$ and given their participation constraint, low-risk agents are willing to put their savings in the bank only if a patient low-risk agent can consume more than in autarky, $c_2^L* > R$. We summarize this as

Lemma 1: *The optimal allocation without deposit insurance satisfies* $c_1^L* < 1 < R < c_2^L*$ *and* $1 < c_1^H*$, $c_2^H* < R$.

In the context of Lemma 1, we next examine whether high-risk agents' allocation under deposit insurance $(c_1^{DI}*, c_2^{DI}*)$ is now optimal for them. By inserting $c_1^H = c_1^{DI}*$, $c_2^H = c_2^{DI}*$ into the left-hand side of the optimal condition (15), we obtain

$$\frac{d\pi}{dc_1^H}: \; t_H \frac{u'(c_1^{DI}*)}{u'(c_2^{DI}*)} - t_L \frac{u'(c_1^L*)}{u'(c_2^L*)} - (t_H - t_L)R. \qquad (17)$$

Given $u'(c_1^{DI}*)/u'(c_2^{DI}*) = R$ (recall (5)), we obtain

$$\frac{d\pi}{dc_1^H}: \; -t_L\left(\frac{u'(c_1^L*)}{u'(c_2^L*)} - R\right), \qquad (18)$$

which we know to be negative, since in Diamond & Dybvig (1983) $u'(c_1^L*)/u'(c_2^L*) > R$ when $c_1^L* < 1 < R < c_2^L*$. Hence, the optimal allocation under deposit insurance $(c_1^{DI}*, c_2^{DI}*)$ now provides too much liquidity insurance to high-risk agents: we must have $c_1^H* < c_1^{DI}*$. Given that $c_1^H* < c_1^{DI}*$ and given the high-risk agents' participation constraint, it must be that $c_2^{DI}* < c_2^H*$. Thus, $c_1^H* < c_2^H*$, i.e. an impatient high-risk agent can consume less than a patient one. This can be summarized as

Lemma 2: *The optimal allocation without deposit insurance provides less liquidity insurance to high-risk agents than the optimal allocation with deposit insurance, i.e.* $u'(c_1^H*)/u'(c_2^H*) > u'(c_1^{DI}*)/u'(c_2^{DI}*) = R$. *Impatient high-risk agents can consume less than patient high-risk agents, so that* $c_1^H* < c_2^H*$.

Combining lemmas 1 and 2, we see that the optimal panic-free deposit payments satisfy

$$c_1^L * < 1 < c_1^H * \quad < \quad c_2^H * < R < c_2^L * .$$

An impatient high-risk agent can consume more than an impatient low-risk agent, i.e. $c_1^H * > c_1^L *$, but a patient high-risk agent can consume less than a patient low-risk agent, so that $c_2^H * < c_2^L *$.

Proposition 1: *Without deposit insurance, the bank makes such deposit payments that the variance of high-risk agents' income is less than in autarky,* $1 < c_1^H * < c_2^H * < R$*, but the variance of low-risk agents' income is greater than in autarky,* $c_1^L * < 1 < R < c_2^L *$*. These deposit payments transfer risk from high-risk agents to low-risk agents.*

The bank system operates as follows. At date 0, the bank supplies two deposit contracts. We label the more liquid contract $(c_1^H *, c_2^H *)$ as a demand deposit and the less liquid contract $(c_1^L *, c_2^L *)$ as a time deposit. Thus, demand deposits in each period yield a positive return, $1 < c_1^H * < c_2^H *$. Time deposits yield a substantial long-term return, $R < c_2^L *$, but their liquidation value is lower than the initial deposit, $c_1^L * < 1$. A high-risk agent prefers to save in the form of demand deposits, whereas a low-risk agent favors time deposits.[16] Intuitively, liquidity is important to a high-risk agent, who knows that he will likely consume soon. In contrast, a low-risk agent is unlikely to consume for a long while. Therefore, the low-risk agent values the substantial long-term return on a time deposit and is willing to bear the low-probability risk of becoming impatient and liquidating his time deposit. At date 1, there are ht_H impatient high-risk agents who withdraw demand deposits totaling $c_1^H *$ and $(1-h)t_L$ impatient low-risk agents, who liquidate time deposits totaling $c_1^L *$. Hence, the early withdrawing of a demand deposit is more likely than the early liquidation of a time deposit, $t_H > t_L$. We regard this situation as realistic. At date 2, all $h(1-t_H)$ patient high-risk agents withdraw demand deposits totaling $c_2^H *$ and $(1-h)(1-t_L)$ patient low-risk agents withdraw time deposits totaling $c_2^L *$. The optimal panic-free allocation is thus achieved by offering different kinds of deposits. Since $c_1^H * < c_2^H *$ and $c_1^L * < c_2^L *$, the incentive constraints are satisfied, i.e. patient agents maximize their consumption by waiting for date 2, whereas impatient agents withdraw their deposits at date 1.

In the next section we show that runs are avoided when time deposits are subordinated to demand deposits.

Note that the bank could offer the autarky allocation (1,R) to agents, but it would then earn no profit. By transforming the given liquidity of assets to different deposits, the bank can provide desired liquidity and risk sharing services. The agents who value liquidity most (high-risk agents) obtain liquidity insurance against a preference shock, while the

[16] In Appendix A we show that a high-risk (low-risk) agent maximizes his expected utility by saving in the form of demand (time) deposits. Hence, both risk types prefer their own deposit contract to the other type's optimal contract.

agents less concerned with liquidity (low-risk agents) stabilize the bank system by saving in time deposits.[17] Since agents receive their reservation utility, the bank can keep the returns on improved risk sharing and earn a positive profit.

We emphasize that the bank can provide less liquidity than under deposit insurance. First, as we have seen above (lemma 2), high-risk agents obtain less liquidity without deposit insurance than with it. Moreover, without deposit insurance low-risk agents, who would also like to obtain liquidity insurance, receive less liquidity than in autarky. Hence, the bank could provide more liquidity if the regulator insured deposits (see Smith 1984).

5.5 Subordination prevents runs

We will indicate that bank runs are avoided when time deposits are subordinated to demand deposits. The proof takes two steps.

Step 1: A patient high-risk agent does not panic when low-risk agents do not panic. Suppose that some high-risk agents panic and that the realized fraction of early withdrawn demand deposits is $\tilde{t}_H$, $\tilde{t}_H \geq t_H$. The withdrawals of demand deposits thus amount to $h\tilde{t}_H c_1^H *$. Since low-risk agents do not panic, the early withdrawals of time deposits amount to $(1-h)t_L c_1^L *$. Hence, the total early withdrawals add up to $h\tilde{t}_H c_1^H * + (1-h)t_L c_1^L *$ and at date 2, the production income is $R\left[1 - h\tilde{t}_H c_1^H * - (1-h)t_L c_1^L *\right]$. This income covers demand deposit payments of $c_2^H *$ to each of the $h(1-\tilde{t}_H)$ non-panicking high-risk agents if

$$R\left[1 - h\tilde{t}_H c_1^H * - (1-h)t_L c_1^L *\right] \geq h(1-\tilde{t}_H)c_2^H *. \tag{19}$$

Some manipulation gives

$$R\left[1 - (1-h)t_L c_1^L *\right] \geq hc_2^H * + h\tilde{t}_H (c_1^H * R - c_2^H *). \tag{20}$$

Since $c_1^H * R > c_2^H *$, the right-hand side is maximized when $\tilde{t}_H = 1$. When $\tilde{t}_H = 1$, the condition (20) simplifies to $R\left[1 - hc_1^H * - (1-h)t_L c_1^L *\right] \geq 0$, and further to

$$R\left[1 - hc_1^H * - (1-h)c_1^L *\right] + R(1-h)(1-t_L)c_1^L * \geq 0. \tag{21}$$

The maturity matching constraint (6) implies that $1 - hc_1^H * - (1-h)c_1^L * = 0$. Since $R(1-h)(1-t_L)c_1^L * > 0$, the bank can make the promised payment of $c_2^H *$ to each non-panicking high-risk agent. Hence, senior demand deposits are risk-free and high-risk agents have no reason to panic.

[17] There is ongoing discussion, e.g. Von Thadden (1998,1999), on the possibility of offering liquidity insurance.

Step 2: A low-risk agent never panics. We will show that a low-risk agent does not panic even when his upcoming income of date 2 is at the minimum; that is, all high-risk agents panic, $\tilde{t}_H = 1$ (recall (21)). When $\tilde{t}_H = 1$ the production income is $R(1-h)(1-t_L)c_1^L*$ at date 2 (see (21)) and each of the $(1-h)(1-t_L)$ patient low-risk agents receives Rc_1^L*, compared to the c_1^L* he can get if he panics. Hence, a low-risk agent does not join a run of high-risk agents. Finally, suppose some low-risk agents also panic and that the realized fraction of early withdrawing low-risk agents is $\tilde{t}_L, \tilde{t}_L > t_L$. The production income is $R(1-h)(1-\tilde{t}_L)c_1^L*$, which is now shared among $(1-h)(1-\tilde{t}_L)$ non-panicking low-risk agents, so that each of them receives Rc_1^L*. Hence, waiting is again more profitable than panicking, ie $Rc_1^L* > c_1^L*$. A low-risk agent never joins a run.

Proposition 2: *When the maturity matching constraint is satisfied and time deposits are subordinated to demand deposits, self-fulfilling bank runs are certainly avoided.*

5.6 Eliminating Moral Hazard

In this section, the analysis is extended to the problem of moral hazard, where the bank has the option of taking excessive risks. It is often argued that moral hazard rules out long-term deposit contracts (e.g. Calomiris & Kahn 1991, Niinimäki 2001). We establish that our proposed bank system can avoid moral hazard even if the bank issues time deposits.

We first consider whether the bank will invest in the safe technology when it pays fixed rates $c_1^H*, c_2^H*, c_1^L*, c_2^L*$ on deposits and when a risky technology is available. The risky technology yields $\overline{R} > R$ with probability p and $\underline{R} < 1$ with probability $1-p$ and has a negative NPV, i.e. $p\overline{R} + (1-p)\underline{R} < 1$ and its liquidation value at date 1 is $l \leq 1$. Since $\underline{R} < 1$, the risky technology provides returns to the bank only when risk-taking succeeds. Bank's expected profit from risk-taking is

$$\pi_r = p\left\{[1-D_1]\overline{R} - D_2\right\}, \tag{22}$$

$$D_1 = ht_H c_1^H* + (1-h)t_L c_1^L*, \quad D_2 = h(1-t_H)c_2^H* + (1-h)(1-t_L)c_2^L*.$$

Here D_1 denotes total deposit payments to impatient agents and D_2 total payments to patient agents. Recall that safe investing yields $\pi = (1-D_1)R - D_2$. Moral hazard is problematic when risk-taking yields higher expected profits than safe investing, $\pi_r > \pi$. We focus on this case and simplify the analysis by assuming that

$$(1-D_1)\underline{R} > h(1-t_H)c_2^H*. \tag{23}$$

The yield on the failed risky investment covers the payments on senior long-term demand deposits. This assumption makes demand deposits risk-free, whereas time deposits are risky.

The bank's investment choice is unobservable at date 0, but publicly observable at date 1. The yield on risk-taking, with success or failure, is known at date 2. In the optimal banking system, no runs occur if the bank invests safety, but a run occurs if the bank takes risk. Bank's total investment is then liquidated, the bank is closed and the banker earns no profit. A rational banker expects at date 0 that risk-taking will cause a run and zero profit, so he invests safely. The threat of a run eliminates risk-taking.

We have seen that a bank can prevent self-fulfilling runs by issuing different kinds of deposits, and moral hazard is avoided if risk-taking triggers a disciplining run. Does risk-taking trigger a run in our setting? We analyze three cases and simplify the analysis via

Assumption 1: *If the maturity matching constraint is not satisfied, a bank run certainly occurs.*

First, suppose that $l<1$. The liquidation value of the risky technology is lower than the liquidation value of deposits, i.e. the maturity matching constraint is unsatisfied under risk-taking, but it is satisfied if the bank invests safety. This seems realistic, given that the NPV of the risky technology is lower than the NPV of the safe technology. Thus, if the bank takes risk, the agents observe risk-taking at date 1, realize the maturity mismatch, and start a run (by assumption 1). A rational banker expects that risk-taking will trigger a run, so he invests safety.

Lemma 3*: If the liquidation value of the risky technology is lower than the liquidation value of the safe technology, i.e. $l<1$, the threat of a disciplining run removes risk-taking.*[18]

Second, suppose that $l=1$ and that the bank takes on risk. The maturity matching constraint is now satisfied. Contrary to the case where $l<1$, maturity mismatch does not trigger a run here. A run occurs only if a patient agent maximizes his expected income by withdrawing his funds at date 1. Since senior demand deposits are risk-free (recall (20)), they are not withdrawn at date 1 until time deposits are withdrawn. Do patient low-risk agents panic and liquidate time deposits? We solve for the expected income on a time deposit at date 1, with risk-taking. With probability p, the risky technology will succeed and the bank will be able to pay the promised return of c_2^L*. With probability $1-p$, the risky technology will fail and the income thereon will be used first and foremost to pay off senior demand deposits (recall (23)). The rest of the returns are then paid against time deposits and a patient low-risk agent receives

$$\hat{c}_2 = \frac{(1-D_1)\underline{R} - h(1-t_H)c_2^H*}{(1-h)(1-t_L)}. \qquad (24)$$

[18] Suppose that assumption 1 is not satisfied. When the bank invests in the risky asset, the maturity matching constraint is not satisfied and a run will occur with some positive probability. If this probability is high, risk-taking is unprofitable; if it is sufficiently low, risk-taking may be profitable.

In contrast, a low-risk agent can obtain c_1^L* by liquidating a time deposit. If $pu(c_2^L*)+(1-p)u(\hat{c}_2) < u(c_1^L*)$, waiting until date 2 results in lower expected utility than does liquidating and hence low-risk agents panic.

Do patient high-risk agents join a run of the low-risk agents and withdraw their demand deposits? Since all low-risk agents and impatient high-risk agents withdraw at date 1, the early withdrawals total $(1-h)+ht_H$. Thus, the bank's ongoing investment amounts to $1-(1-h)-ht_H$ or $h(1-t_H)$. With probability p, risk-taking succeeds and yields $h(1-t_H)\overline{R}$. The bank can then pay the promised c_2^H* to each of the $h(1-t_H)$ patient high-risk agents. With probability $1-p$, risk-taking fails and yields $h(1-t_H)\underline{R}$. Each of the $h(1-t_H)$ patient high-risk agents then receives $\underline{R}$. By waiting until date 2, a patient high-risk agent has expected utility of $pu(c_2^H*)+(1-p)u(\underline{R})$, whereas by joining a run he obtains utility of $u(c_1^H*)$. Since $c_2^H*<\overline{R}$ and the risky technology has negative NPV, we see that $pc_2^H*+(1-p)\underline{R} < p\overline{R}+(1-p)\underline{R} < 1 < c_1^H*$. Hence $pu(c_2^H*)+(1-p)u(\underline{R}) < u(c_1^H*)$ and a patient high-risk agent maximizes his expected utility by joining the run of low-risk agents.[19]

All agents thus panic when risk-taking becomes observable. A rational banker expects that risk-taking will cause a disciplining run and invests safety.

Lemma 4: *When* $l=1$ and $pu(c_2^L*)+(1-p)u(\hat{c}_2) < u(c_1^L*)$ *the threat of the run removes risk-taking.*

Third, when $l=1$ and $pu(c_2^L*)+(1-p)u(\hat{c}_2) \geq u(c_1^L*)$, no disciplining run occurs and the bank optimally takes risk. Rational agents anticipate risk-taking and are unwilling to save in the bank. Moral hazard thus eliminates bank formation. We summarize our findings as

Proposition 3*: If* $l<1$ *or if* $l=1$ *and* $pu(c_2^L*)+(1-p)u(\hat{c}_2) < u(c_1^L*)$*, the threat of the disciplining run removes risk-taking. If* $l=1$ *and* $pu(c_2^L*)+(1-p)u(\hat{c}_2) \geq u(c_1^L*)$ *no runs occur and risk-taking eliminates bank formation.*

Consequently, it is possible for a bank to prevent self-fulfilling runs by issuing demand deposits and time deposits, yet avoid the risk-taking problem.

5.7 Discussion

In the model presented above, we used the banking environment setup suggested by Diamond & Dybvig (1983) to examine the use of optimal deposit contracts to prevent self-fulfilling bank runs without relying on deposit insurance. We find that banks can issue liq-

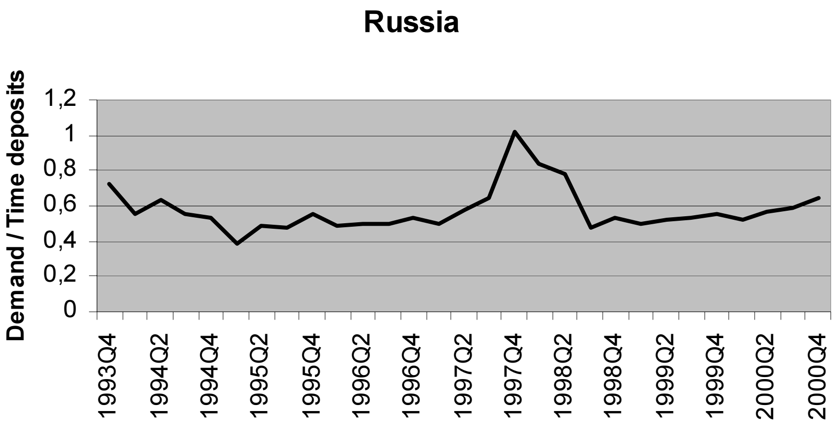
[19] The panicking of high-risk agents can be seen more easily from the maturity matching constraint. After a panic of low-risk agents, the bank has only high-risk agents. The value of their demand deposits at date 1 is $c_1^H*>1$. Hence, the maturity matching constraint is no longer satisfied. Given assumption 1, patient high-risk agents join a run of low-risk agents.

uid demand deposits, yet avoid runs, if they issue less liquid time deposits. By issuing deposits of varying degrees of liquidity, banks improve intertemporal risk sharing between depositors, even when banks do not increase the economy's total liquidity (i.e. the liquidity of bank assets matches the average liquidity of deposits). Moreover, the banking system avoids the risk-shifting problem.

Does, however, this model match with the experiences of the transition countries? Certainly, the model better suits liquidity-based bank runs than information-based runs, and the bank runs of the transition economies have tended to be information based, i.e. directed towards distressed banks. If the banks of these countries had issued more time deposits, the banking sectors of these countries might have been more stable, i.e. the number and magnitude of the bank runs had been smaller. The authorities had then had more time to react to runs. However, since the banks faced fundamental solvency (not liquidity) problems, even the wide use of time deposits would not had prevented the runs.

6 Empirical evidence

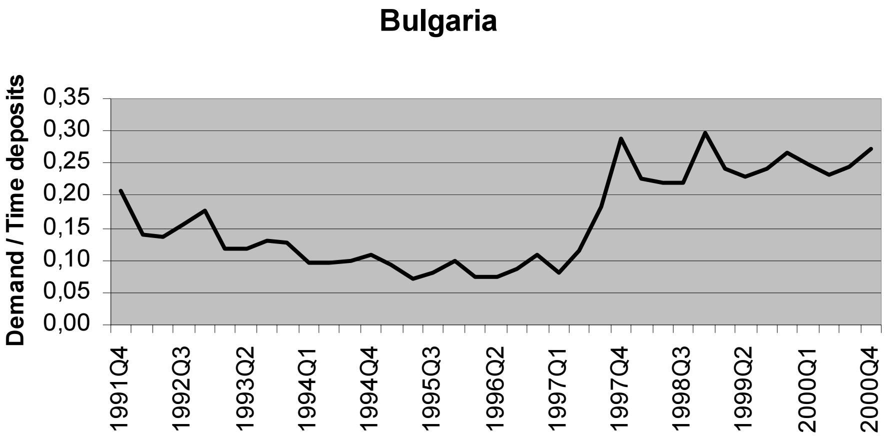
We next shortly examine the empirical evidence for bank runs in the transition economies using IMF data. We investigate how the deposit ratio (the ratio of demand deposits to time deposits) varied in these countries during 1990s. How did the financial crises affect on the ratio? Did the countries with the high deposit ratio be relatively vulnerable to bank runs?



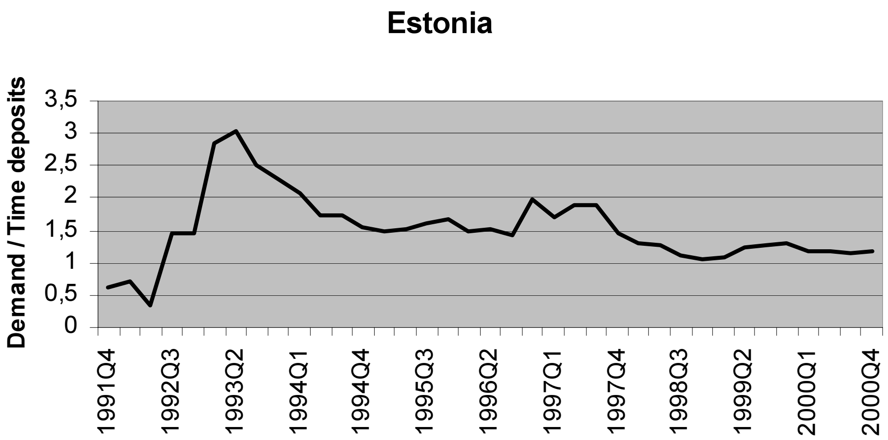
In Russia, the deposit ratio soared at the second half of 1997, peaked at the end of the year and fell back to the initial level at the end of 1998.

The Russian stock market crashed in October 1997 and the main financial crises followed in August 1998. Apparently, the deposit ratio rose just after the stock market crash and dropped back to its initial level when the financial crisis was over.

In Bulgaria, the deposit ratio decreased gradually until the end of 1996, then soared to a higher level it has since maintained.



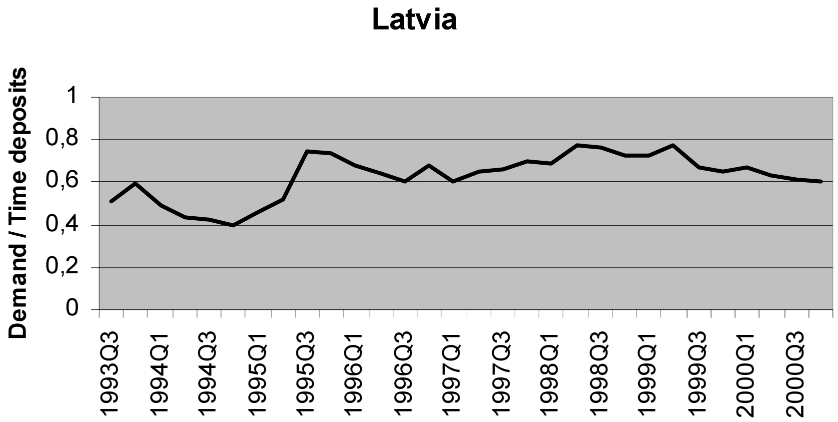
In 1994 – 1996, the Bulgarian economy was hit by a worsening banking crisis, which culminated to a full-scale bank run in mid-1996. The deposit ratio was very low before and during the crisis, so banks funded their investments mostly by attracting time deposits. As a result, excessive deposit liquidity did not trigger bank runs. Instead, it appears the deposit ratio rose after the crisis when depositors had lost their confidence in the banking system and were unwilling to commit to long-term deposit contracts.



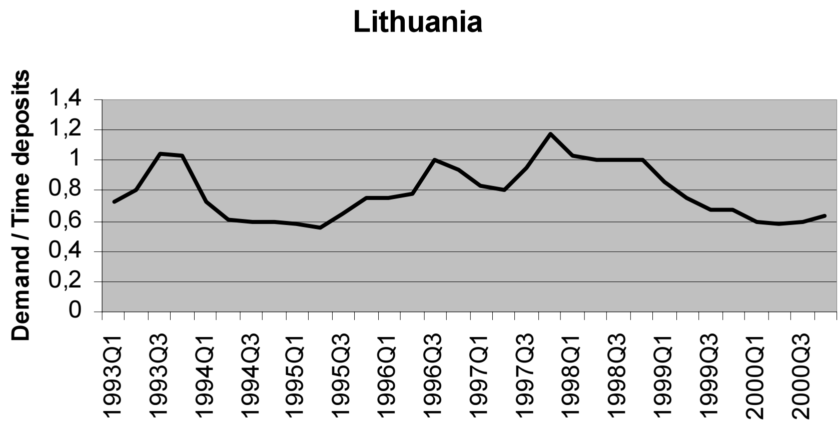
In Estonia, the initially low deposit ratio rocketed up at the beginning of 1993, peaked in mid-1993 and then subsided slowly.

Since the first Estonian banking crises occurred in 1992, the deposit ratio rose after the crisis.

In Latvia, the deposit ratio rose in 1995 peaking in autumn. Since the peak the ratio has held at a relatively high level.

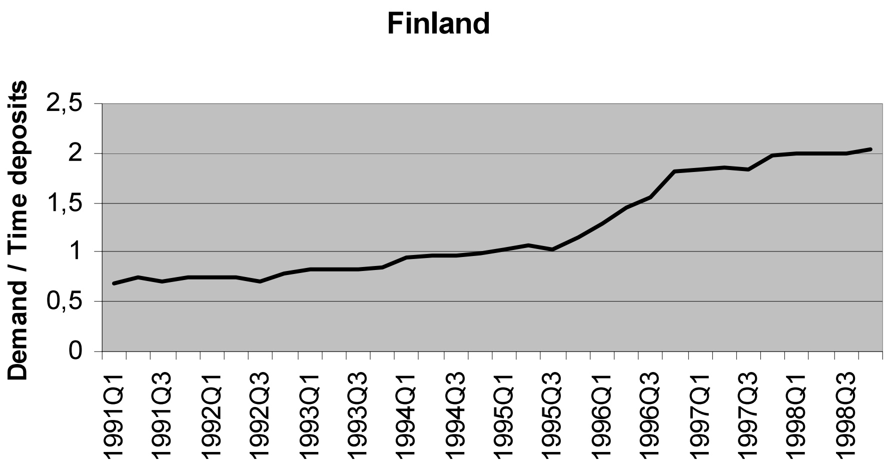


The Latvian banking sector was hit by the severe crisis in the first half of 1995. During the first seven months of that year, 15 banks possessing 35-40% of banking sector assets were closed. It seems that the deposit ratio rose after the crisis and has since remained at this higher level.



In Lithuania, the deposit ratio has varied considerably.
The ratio rose in the second half of 1995 after the Lithuanian banking sector was hit by a serious banking crisis.

Just to compare the transition countries with the other countries, we investigate the development of the deposit ratio in Finland. It is easy to see that the deposit ratio has continuously increased.



These results do not support the assumption that a low deposit ratio, i.e. a low fraction of demand deposits, helps prevent bank runs. In Finland, for example, the deposit ratio has steadily increased, so the bank runs might have been expected in the late 1990s. In practice, Finland only experienced two small-scale runs on deposits, and they occurred in the first half of 1990s (E-säästökassat in 1993, Elanto in 1995). In Bulgaria, a large-scale bank run occurred in 1996 despite the fact that the deposit ratio had continuously decreased before the run and the ratio was very low (0,1) just before the crisis. In Russia, the deposit ratio was also relatively low ahead of the financial crisis. In general, it seems that a high fraction of time deposits does not prevent bank runs. Instead, in many transition countries the deposit ratio rose during or after a financial crisis. The intuition seems to be obvious. Under unstable economic circumstances, depositors are unwilling to commit to long-term deposit contracts. In addition, under unstable circumstances declining stock prices motivate investors to transfer savings from stocks to demand deposits.

7 Conclusions

Before investigating bank runs in transition economies, we reviewed theoretical analysis on bank runs and empirical evidence from the US. Next, we provided an overview of bank runs in Bulgaria, Estonia, Hungary, Latvia, Lithuania, Romania, and Russia. Bank runs strongly impacted these countries, destroying their banking sectors and slowing their economic development. The runs were often information based. Thus, improvements in bank transparency (say, the introduction of a new accounting regime) revealed bank insolvency and triggered runs. The authorities typically reacted to these runs by providing liquidity support, even though the main problem of the banks was not illiquidity, but insolvency due to the high fraction of non-performing loans. Just as in the context of the East Asian crises, the bank runs often occurred in concert with a run on currency.

While it is beyond dispute that bank runs damaged the transition economies, the main problems of their banking sectors seem to lie elsewhere. In Russia, for example, the banking sector remains chronically underdeveloped. Of all capital formation in Russia in 1999, only 4% was financed by bank loans. In comparison, the share of budgetary resources was 17% and the share out-of-pocket financing by firms was possibly 53% (OECD, 2001). The following is a list of problems facing Russia's economy.

1. Poor protection of minority shareholders

A bank may pay excessive interest on its majority shareholders' deposits at the expense of other shareholders or grant advantageous loans to its major shareholders (Alfa Capital, 1998).

"Attempts have been directed towards pushing out individual minority shareholders into new companies in a less favorable financial situation or transferring valuable assets to other entities leaving only impaired assets in the original shareholder structure, (OECD, 2001, p.17)."

2. Lack of information on borrowers' true financial condition.

Russian accounting standards provide insufficient information for lenders. Tomson (2000, p.616) offers interesting examples. "The valuation of securities and other investments at historic costs and the case with which bad debts may be under-recorded make the Russian accounting standards particularly problematic when banks are concerned. The results reported by Inkombank for 1998, for example, show a healthy profit of $422 million on Russian accounting standards (despite the fact that the bank was clearly insolvent), but a loss of $355 million on International Accounting Standards." Increased non-monetary payments and varying inflation have further worsened the reliability of the accounting information. In addition, rapid changes in the economic environment erode the value of the historical accounting information (Tomson, 2000).

3. Low usefulness of collateral

4. Poor protection of depositors

Depositors have suffered several losses during the last decade due to bank failures and hyperinflation. Banks take excessive risks and are heavily involved in insider lending. Credit given to shareholders make up to half of the top banks' portfolios (Alfa Capital, 1998). Moreover, the managers of insolvent banks often engage to asset stripping, i.e. they transfer the assets of insolvent banks to new structures, leaving the liabilities in the shell of the old bank. Oneximbank, for example, created Rosbank. Menatep Bank established Menatep St. Petersburg. SBS Agro set up the Soyuz Group and the First Mutual Credit Society (Alfa Capital, 1998). Given the transfer of the valuable assets, nothing is left over for depositors after the bankruptcy process. Due to these shortcomings, depositors have lost their confidence in the banking system. The magnitude of retail bank deposits is small and almost 90% have been deposited in Sberbank operating under implicit deposit insurance.

5. Weak enforcement of laws

Investors encounter a multitude of administrative barriers and obstacles – mostly at the regional level and often in contravention of federal regulation. These kind of barriers are, for example, unforeseen licensing or permission requirements, license fees, tax payments that are negotiable rather than statutory, "voluntary" contributions to extra-budgetary funds, etc. (OECD, 2001). There is no security of private property rights and contracts are difficult to verify and enforce. Moreover, local political authorities can influence law enforcement. Foreign investors are particularly exposed to the potential interference of authorities in support of local entrepreneurs (OECD, 2001).

6. Corruption

"Further estimates show some 70-80% of privatized firms and banks paying various forms of tribute to criminal groups, racketeers and public officials. Commercial companies are said to allocate 30-50% of profits to ensure special relations with representatives of the authorities (OECD, 2001)."

Appendix A: Self-selection constraints are not binding

Both risk types prefer their own deposit contract to the other types optimal contract, i.e. high-risk agents favor demand deposits and low-risk agents prefer time deposits. Recall that demand deposits offer high-risk agents their reservation utility (autarky allocation):

$$t_H u(c_1^H *) + (1-t_H)u(c_2^H *) = t_H u(1) + (1-t_H)u(R). \qquad \text{(A.1)}$$

In contrast, low-risk agents receive their reservation utility by saving in time deposits:

$$t_L u(c_1^L *) + (1-t_L)u(c_2^L *) = t_L u(1) + (1-t_L)u(R) \;. \qquad \text{(A.2)}$$

Wel first show that a high-risk agent prefers demand deposits to time deposits. The low-risk agents' participation constraint (A.2) yields

$$t_L\left[u(c_1^L *) - u(1)\right] + (1-t_L)\left[u(c_2^L *) - u(R)\right] = 0\,. \qquad \text{(A.3)}$$

A high-risk agent prefers demand deposits to time deposits if he prefers his autarky allocation to time deposits (recall (A.1)):

$$t_H u(c_1^L *) + (1-t_H)u(c_2^L *) < t_H u(1) + (1-t_H)u(R), \qquad \text{(A.4)}$$

which can be rewritten as

$$t_H\left[u(c_1^L *) - u(1)\right] + (1-t_H)\left[u(c_2^L *) - u(R)\right] < 0\,. \qquad \text{(A.5)}$$

We know that $u(c_1^L *) - u(1) < 0$ and $u(c_2^L *) - u(R) > 0$. Comparing (A.3) and (A.5), we see that (A.5) is true since $t_L < t_H$. A high-risk agent prefers his autarky allocation and demand deposits to time deposits.

Second, we show that a low-risk agent prefers time deposits to demand deposits. We can rewrite high-risk agents' participation constraint (A.1) as

$$t_H\left[u(c_1^H *) - u(1)\right] + (1-t_H)\left[u(c_2^H *) - u(R)\right] = 0\,. \qquad \text{(A.6)}$$

A low-risk agent prefers his autarky allocation and time deposits to demand deposits if

$$t_L u(c_1^H *) + (1-t_L)u(c_2^H *) < t_L u(1) + (1-t_L)u(R), \quad \text{(A.7)}$$

which can be rewritten as

$$t_L \left[u(c_1^H *) - u(1)\right] + (1-t_L)\left[u(c_2^H *) - u(R)\right] < 0, \quad \text{(A.8)}$$

where $u(c_1^H *) - u(1) > 0$ and $u(c_2^H *) - u(R) < 0$. Comparing (A.6) and (A.8), we see that (A.8) is true, since $t_L < t_H$. A low-risk agent prefers his autarky allocation and time deposits to demand deposits. *Consequently, both risk types prefer their own deposit contracts to the other type's optimal contract, i.e. self-selection constraints are not binding.*

Appendix B: Participation constraints are binding

Participation constraints are binding, i.e. all agents receive their reservation utility level. We rewrite bank's maximization problem as

$$Max \quad \left[1 - ht_H c_1^H - (1-h)t_L c_1^L\right]R \; - \; h(1-t_H)c_2^H - (1-h)(1-t_L)c_2^L \quad \text{(B.1)}$$
$$- \lambda_L\left\{\overline{U}_L - t_L u(c_1^L) - (1-t_L)u(c_2^L)\right\}$$
$$- \lambda_H\left\{\overline{U}_H - t_H u(c_1^H) - (1-t_H)u(c_2^H)\right\}$$
$$- \beta\left\{hc_1^H + (1-h)c_1^L - 1\right\}.$$

The top line is bank's profit, the second line is the low-risk agents' participation constraint, the third line is the high-risk agents' participation constraint, and the forth line is the maturity matching constraint. We do not know whether the participation constraints are binding. The Lagrange multipliers associated with all constraints are non-negative. The first order conditions are

$$\frac{d\pi}{dc_1^H} : \; -ht_H R + \lambda_H t_H u'(c_1^H) - \beta h = 0 \quad \text{(B.2)}$$

$$\frac{d\pi}{dc_2^H} : -h(1-t_H) + \lambda_H(1-t_H)u'(c_2^H) = 0$$

$$\frac{d\pi}{dc_1^L} : \; -(1-h)t_L R + \; \lambda_L t_L u'(c_1^L) - \; \beta(1-h) = 0$$

$$\frac{d\pi}{dc_2^L} : -(1-h)(1-t_L) + \lambda_L(1-t_L)u'(c_2^L) = 0 .$$

Suppose that the high-risk constraint is not binding, i.e. $\lambda_H = 0$. Since $\beta \geq 0$, we obtain from (B.2)

that

$$\frac{d\pi}{dc_1^H} : \; -h(t_H R \; + \beta) < 0 , \qquad \frac{d\pi}{dc_2^H} : -h(1-t_H) < 0 . \quad \text{(B.3)}$$

Deposit payments to high-risk agents are minimized in both periods. This is impossible given their participation constraint. *The high-risk agents' participation constraint must be binding, i.e.* $\lambda_H > 0$.

Suppose that the low-risk agents' constraint is not binding, $\lambda_L = 0$. We get from (B.2)

$$\frac{d\pi}{dc_1^L}: -(1-h)(t_L R + \beta) < 0, \qquad \frac{d\pi}{dc_2^L}: -(1-h)(1-t_L) < 0, \qquad \text{(B.4)}$$

since $\beta \geq 0$. Hence, the payments to low-risk agents are minimized in both periods, which is impossible given their participation constraint. *Thus, the low-risk agents' participation constraint must be binding.* Consequently, both participation constraints are certainly binding.

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