THE 14 D. E. C.

The Fourteenth Dubrovnik Economic Conference

The Fourteenth Dubrovnik Economic Conference

Organized by the Croatian National Bank

HNB

Lana Ivičić, Davor Kunovac and Igor Ljubaj

Measuring Bank Insolvency Risk in CEE Countries

Hotel "Grand Villa Argentina",
Dubrovnik
June 25 - June 28, 2008

Draft version

Please do not quote

CROATIAN NATIONAL BANK

Measuring Bank Insolvency Risk in CEE Countries*

Lana Ivičić Davor Kunovac Igor Ljubaj†

Abstract

This paper investigates the impact of various macroeconomic and bank-specific variables on bank insolvency risk in 7 CEE countries from 1996 to 2006. Estimating separate pooled regression for each country we provide an empirical evidence of considerable heterogeneity among countries with respect to estimated relationship between bank stability and various macro and bank specific variables. Bank insolvency risk is measured by *z-score*, our distance to default indicator. Although different in size, *z-scores* among countries follow similar dynamics and underlying insolvency probabilities in the later period were on average much lower compared to the 1990s.

*We are grateful to Ivana Herceg for her invaluable data assistance. We also thank to Martin Cihak for useful comments. The views expressed in this paper are those of its authors and do not necessarily reflect the view of the Croatian National Bank. All remaining errors are ours.

†Email: lana.ivicic@hnb.hr, davor.kunovac@hnb.hr, igor.ljubaj@hnb.hr

1 Introduction

Healthy and sound banking system plays the crucial role in good functioning of an economy. Since the late 1970s bank insolvencies have become increasingly common. Where these insolvencies and failures are systemic and result in large losses, final consequence is misallocation of resources and slower growth in the whole economy. This is one of the reasons for which bank insolvency risk has been extensively examined in the literature.

Stability of the banking system seems to be of even greater importance in Central and Eastern European (CEE) countries whose financial systems are *bankcentric* and largely dominated by commercial banks. Taking into account remarkable development of these banking sectors since the beginning of the transformation from centrally planned to market economies, a question arises what are the factors affecting bank stability in CEEC.

The key points of the CEE banking sector reforms were the introduction of a two-tier banking system, privatisation of state-owned banks and establishment of a strong legal framework and efficient bank supervision. Consolidation was predominantly conducted through entrance of foreign, mainly EU-15 banks into national banking industries which facilitated integration and rapid credit expansion in the context of catching-up and convergence. However, restructuring proceeded at different paces among countries, which resulted in significant country-specific differences in the development of the banking sectors. Furthermore, macroeconomic environment in CEE countries was sometimes also diverse as different cycles in economies had diverse influence on banks performance.

In this paper we explore macro and micro affecting bank insolvency risk measured by *z-score*. Taking into account differences among countries we analyze each country separately in order to explore insolvency risk and determinants that affect banks' stability country by country, rather than pooling them all in one single group. Finally, we try to sum up the results and conclude at the aggregate level how is the insolvency risk influenced by determinants.

Extending beyond the existing literature, we adopt an intuitive feature of *z-score* as a probability of default indicator, in addition to distance to default type measure often used by other authors. This paper formally defines probability of default of CEE banks given the employed explanatory variables. Next, it investigates the impact of various factors on bank insolvency risk in CEE and describes the stability of established relationships in time by employing *moving window regressions*. Finally, we tested the predictive power of our model in forecasting the one-step-ahead *z-score* of each bank and banking sectors.

Using extensive knowledge of Croatian banking sector, this paper further investigates whether the usage of more detailed and higher frequency data allows for more precise measure of bank insolvency risk. In the case of Croatia, *z-score*, macro environment and banking sector characteristics showed us the evidence of strong correlation between real economy and financial stability.

The rest of the paper is organized as follows. Section 2 discusses methodology. Section 3 summarises data and provides a historical decomposition of insolvency risk in CEEC. Section 4 concludes.

1.1 Z-score literature

Previous work on the topic of bank insolvency risk measured by the *z-score* is based on Roy (1952), who shown that the probability that current losses would exceed bank equity is less than or equal to $\frac{1}{z^2}$, so that higher level of z implies lower upper bound of insolvency probability.

Some of the earliest research studies on bank insolvency risk include Hannan and Hanweck (1988) who empirically investigated the relationship between large certificates of deposits rates and insolvency risk for various maturities in the US market and confirmed the hypothesis that market for large certificates exacts a price for bank risk taking. De Nicolo (2000) documents the relationship between bank size and measures of charter value and insolvency risk in a sample of publicly traded banks in 21 industrialized countries. With some exceptions, charter values decrease in size and insolvency risk increase in size for most banks in countries considered. He also found that banks operating in countries with more developed financial markets exhibit lower insolvency risk, while (absent future structural changes in banking markets of developed countries) bank consolidation is likely to result in an average increase in banks' insolvency risk.

Cihak and Hesse (2006) extended the research on the cooperative banks in 29 OECD countries, analyzing their role in financial stability using the *z-score*. They found that cooperative banks are on average more stable than commercial banks, mainly due to the lower volatility of their returns, which more than offsets their lower profitability and capitalization. Using the regression analysis, they also found that a higher share of co-operative banks increases stability of an average bank in the same banking system. The same authors empirically assessed the relative financial strength of Islamic banks covering individual Islamic and commercial banks in 18 banking systems with a substantial presence of Islamic banking (Cihak and Hesse, 2008). Measuring individual bank risk by *z-score*, the paper found that small Islamic banks tend to be financially stronger than small commercial banks while the opposite is true for large commercial banks that tend to be financially stronger than large Islamic banks. Boyd, De Nicolo and Al Jalal (2006) explored relationship between concentration and banks' risk of failure, using *z-score* as an empirical risk measure. Using two large bank samples with different properties (cross-section sample of 2,500 banks in US in 2003 and an international panel data set of 134 industrialized countries from 1993 to 2004), their results revealed a positive association between market concentration and risk of failure, driven primarily by a positive association between concentration and volatility of the rate of return on assets. Most studies on modelling default probabilities are focused on individual financial institutions, while links between individual institution defaults and system-wide crises are still much less understood. Cihak (2007) argues that analysis of the distribution of systemic loss can lead to a clearer differentiation of cases of stability and instability than some of the existing measures such as distance to default and *z-score*. In addition, he found that although these indicators tend to indicate correctly increased instability in crises periods, measurement can be improved significantly by taking into account the loss given default in individual institutions and correlations across failures in institutions. Maechler, Mitra and Worrel (2007) focused the analysis on the emerging Europe, investigating banks in ten countries – new members of the EU and eight neighbouring countries. The paper assessed how various types of financial risk affect banking stability and how the quality of supervisory standards may have mitigated the vulnerabilities arising from these risk factors. The study found substantial variation in the impacts of financial risks, the macroeconomic environment and supervisory standards on banks' risk profile across different country clusters.

2 Methodology

This section introduces technical framework we follow throughout the paper. First, our insolvency risk measure, namely the *z-score* of individual institution (bank) is defined and its key properties as well as several interpretation issues are discussed in details. After that we attempt to link *z-score* based bank stability and a number of macro and bank-specific indicators. For this purpose, as in Machler et al. (2007), standard cross-sectional regressions are estimated for each CEE country. Furthermore, we take advantage of both the latter regression representation and the fact that the *z-score* is monotonically (i.e. negatively) related to (*the upper bound of*) bank's insolvency probability in order to estimate this probability as a function of a number of both macro and micro indicators. Finally, after the estimation of individual banks' *z-scores* we discuss the problem of aggregation and define our measure for systemic insolvency risk.

2.1 Z-score definition

We wish to determine the probability that bank losses, that is negative profits, exceed bank's equity. In other words our objective is to estimate individual bank's probability of insolvency - $P\{r \leq -K\}$ where $K = \frac{k}{A}$ and $r = \frac{\pi}{A}$ denote bank's equity capital to asset and return to asset ratios respectively.

Assuming that returns follow a distribution with (finite) first two moments μ and σ_r^2, one can estimate[1] *the upper bound of probability of insolvency*:

$$P\{r \leq -K\} \leq \frac{\sigma_r^2}{(\mu + K)^2}. \tag{1}$$

With definition of our insolvency risk measure *z-score:* $z = \frac{\mu+K}{\sigma_r}$, inequality (1) reduces to:

$$P\{r \leq -K\} \leq \frac{1}{z^2}. \tag{2}$$

Two relations above present adopted insolvency risk measure as an extremely conservative one in the sense that it is being related to the *worst case* scenario. Although (2) provides a fairly rough estimate of bank's probability of insolvency, it is very mild conditioned (see footnote 1) and therefore presents quite an appealing indicator from practitioners point of view.

Regarding its interpretation *z-score* can be considered as a version of bank's *distance to default* type measure. More precisely z measures the *lower bound* for number of standard deviations returns have to drop in order to exhaust the bank's equity:

$$P\{r \leq -K\} = P\{\frac{r-\mu}{\sigma_r} \leq \frac{-K-\mu}{\sigma_r}\} = P\{\frac{r-\mu}{\sigma_r} \leq -z\} = P\{r \leq \mu - z\sigma_r\} \tag{3}$$

Let us note that terms (2) and (3) ensure the negative relation between *z-score* and probability of bank's failure. Higher z implies a decrease in failure probability and hence more stability for corresponding bank.

[1] By Chebyshev theorem for $\mu \geq -K$ we have $\frac{\sigma_r^2}{(\mu+K)^2} \geq$(Chebyshev)$\geq P\{\mid r - \mu \mid \geq \mu + K\} = P\{r \leq -K\} + P\{r \geq 2\mu + K\} \geq P\{r \leq -K\}$.

So far we have not presumed returns r to follow any specific probability distribution in which case though the exact default probability could be determined:

$$P\{r \leq -K\} = (3) = P\{\frac{r-\mu}{\sigma_r} \leq -z\} = \Phi_r(-z), \tag{4}$$

where Φ_r denotes distribution function of bank's standardised returns.

In practice when analysing banking system stability using z indicies several technical issues arise. Firstly, although the moments μ and σ_r^2 present *true* parameters they need to be replaced with sample estimates in practice. Accordingly the reliability of estimated *z-based* bank's stability heavily depends on their precision. This can be particularly important when dealing with short transition countries data sets which often contain many structural breaks. As will be shown later in the paper the data frequency (quarterly vs annual data) used may also strongly affect the results. Finally, one faces a *trade-off* when needs to choose between the approximate (inequality (2)) and the exact (equality (4)) set-up of the insolvency probability estimation. Here we adopted the more robust one and restricted the analysis to the estimation of upper bound of probability (2) only.

2.2 Country regressions

Motivated by de Nicolo (2000), Cihak and Hesse (2007) and Machler et al (2007) we also attempt to set a relation between *z-score* based bank stability and a number of relevant macro and bank-specific indicators. For that purpose we estimate a pooled regression[2] for each CEE country:

$$\ln(z_{it}) = \alpha + \beta_0 \ln(z_{it-1}) + \sum_{j=1}^{J} \beta_j X_{jt} + \sum_{k=1}^{K} \gamma_k Z_{ikt} + \varepsilon_{it},\ i = 1, \ldots, N,\ t = 1, \ldots, T, \tag{5}$$

where $i = 1, \ldots, N$ indexes banks, X_j, $j = 1, \ldots, J$, denote macroeconomic variables which are identical across banks and affect all the banks in the same fashion through β_j, while Z_{ik}, $k = 1, \ldots, K$, denote bank-specific variables with corresponding pooled effects γ_k. We also include lagged z into our specifications as an attempt to capture capital reserves built in previous period.

Furthermore, by projecting z onto lagged predictors:

$$\ln(z_{it}) = \alpha + \beta_0 \ln(z_{it-1}) + \sum_{j=1}^{J} \beta_j X_{jt-1} + \sum_{k=1}^{K} \gamma_k Z_{ikt-1} + \varepsilon_{it},\ i = 1, \ldots, N,\ t = 1, \ldots, T, \tag{6}$$

we aim to define an insolvency forecasting model.

All the specifications are estimated applying the ordinary least squares with robust errors.

[2] For all the countries under consideration possible significance of individual banks' fixed effects are tested. The null hypothesis of fixed effects redundancy could not be rejected.

2.3 Conditional Probability of Insolvency

Combining regression fit from (5) and relation (2) it is possible to estimate *macro and micro indicators implied upper bound of probability of insolvency*:

$$\begin{aligned}
P\{r_t \leq -K_t | X_t, Z_t\} &\leq \frac{1}{z(X,Z)^2} = \\
&= \left(\frac{1}{e^{\alpha+\beta_0 \ln(z_{it-1})+\sum \beta X_t+\sum \gamma Z_t+\varepsilon_{it.}}}\right)^2 = \\
&= \left(\frac{1}{e^{\alpha+\beta_0 \ln(z_{it-1})+\sum \beta X_t+\sum \gamma Z_t}}\right)^2 \left(\frac{1}{e^{\varepsilon_{it.}}}\right)^2 \approx \\
&\approx \left(\frac{1}{e^{\alpha+\beta_0 \ln(z_{it-1})+\sum \beta X_t+\sum \gamma Z_t}}\right)^2, \text{ for } \varepsilon_{it.} \textit{ close to } 0.
\end{aligned}$$

Similarly, by using panel (6) a forward-looking version of above implied probability can be estimated - $P\{r_{t+1} \leq -K_{t+1} | X_t, Z_t\}$.

Related literature generally ignores the calculation of conditional probabilities of failures mainly due to the strong underlying requirements when one needs to derive the exact insolvency probability. On the other hand, if the upper bound of insolvency probability is sufficient for the analysis and if actual z is well approximated by equation (5), there is no reason to ignore the above relation.

2.4 Systemic risk

Another important question we address here concerns the link between the individual banks' risks and likelihood for overall banking sector to experience insolvency problems.

In this paper we employ simple aggregation strategy: systemic indicator is defined as weighted average of individual banks *z-scores* where weights correspond to bank's share in total banking system assets.

As it is documented in Cihak (2007), any measure of systemic stability should incorporate three elements: probabilities of failure in individual financial institutions, loss given default in financial institutions, and correlation of defaults across institutions. He also notes that all the standard measures of financial stability have not proven to be fully successful regarding these requirements. Thus, our systemic risk measure are exposed to Cihak's critique where the inability to deal with the contagion properly is perhaps the most important in this context.

The literature on bank contagion risk in CEE countries is not abundant. To the best of our knowledge, this type of risk has been empirically explored only in Croatia (Krznar, 2008) and Hungary (Lubloy, 2005). Both studies found that bank contagion risk is very low due to the relatively small size of interbank market with bilateral exposures significantly lower than bank tier I capital. These results are not unexpected since majority of banks in both countries is owned by large foreign groupations which are their main market counterparts. As high ratio of foreign ownership is common characteristics of all CEE banking sectors that we investigate in our paper, we assume that ignoring correlations across banks in each country should not significantly alter our results.

3 Empirics

3.1 Data

In this paper we use two separate datasets. The first dataset comprises commercial banks from 5 CEE and 2 Baltic countries. Time span observed is 9 years (1998-2006). Dependent variable, *z-score* of bank i at time t, is given by:

$$z_{it} = \frac{E(roaa)_{it} + \frac{eq_{it}}{ta_{it}}}{\sigma(roaa)_{it}}$$

where $E(roaa)_{it}$ stands for expected return on average assets, estimated as 3-year average of realized $roaa$ in time t, $t-1$ and $t-2$, $\sigma(roaa)_{it}$ denotes corresponding standard deviation, eq_{it} is bank's equity and ta_{it} is bank's assets. The *z-score* as a measure of bank stability has several limitations, perhaps the most important being that it is based on accounting rather than on market data. Market data for CEE banks are unreliable even if the bank's shares are publicly traded, since the free float is rather small and turnover is usually insignificantly low.

We calculated *z-scores* for commercial banks in 7 countries, namely: Bulgaria, Czech Republic, Croatia, Hungary, Latvia, Lithuania and Slovakia[3]. Across the whole sample we obtained 820 observations of z-score, most of them falling within the 10-100 range. There are some extreme observations, resulting in the total sample range being from 0.14 to 2760, with an average of 52. To assess the robustness of our results with respect to the outliers, we have done all the regressions both for the full sample and for a sample that excludes the most extreme outliers. As we found no difference in main results for both approaches, we decided to eliminate only two most extreme observations (*z-score*>2000).

Z-scores across the countries are fairly similar in size. Bank stability is on average increasing in all countries in our sample. This upward trend is a direct consequence of higher average profitability and lower return volatility that more than offset the decline in capitalization ratios (see Appendix A2).

Table 1. Descriptive statistics of *z-score* across the countries

	Hu	Bu	Cz	La	Li	Sk	Cro
Mean	39.3	33.0	51.7	28.9	68.5	41.8	64.1
Median	26.6	26.8	27.0	21.2	32.2	21.2	35.4
Maximum	532.3	201.4	542.4	185.3	675.1	311.0	888.5
Minimum	0.57	0.88	1.03	0.31	1.85	0.14	0.29
Observations	158	142	119	93	65	76	166

The list of explanatory variables used in regressions incorporates a number of possible risks and banks' characteristics discussed in the literature. Explanatory variables in this paper are proxied by three groups of variables: 1. bank specific variables from banks' balance sheets and profit and loss accounts, 2. national banking sectors data and 3. macroeconomic variables. Descriptive statistics of explanatory variables is given in Appendix A3.

[3]Poland and Romania are not included in our sample since we noticed that Bankscope database's coverage of banks and data in these two countries was too incomplete to represent their banking sectors, especially in 1990s. Slovenia and Estonia are not included due to a small number of banks.

Bank specific variables from balance sheets and profit and loss accounts Our balance sheets and profit and loss accounts data stem from Bureau van Dijk's Bankscope database. As there was no complete set of data available for some of the variables used, our country by country data sets were reduced to unbalanced panels. Banks' size is captured by the total assets (ta), whereas share of loans to assets describes banks' asset structure (l_a). Banks' credit risk is measured by the annual growth rate of private non-financial sector loans (chg). We had no *a priori* assumptions on the signs of coefficients on these three variables as they can all affect banks' solvency positively or negatively, depending on the quality of assets and loan portfolio. Additionally, credit risk is captured by the ratio of loan loss provisions to net interest income (llp) and we expected that higher ratio would increase the banks' insolvency risk. However, this sign might be ambiguous too as higher loan loss provisions could reflect banks' precautionary reserve building as well as high non-performing loans. Liquidity risk is measured as a ratio of liquid assets to deposits and short-term funding (liqa). In general, liquidity reserves promote banks' financial soundness; on the other hand, excess liquidity undermines banks' efficiency and profitability. In addition, we use the lagged *z-score* as a proxy for profit and capital buffers built up in advance, reflecting bank's credit risk policies.

National banking sectors data Concentration level is measured by the Hirschman Herfindahl index for each county (hhi). We would expect that following the financial liberalization of CEE banking markets increase in concentration in first couple of years in our sample positively affected banks' soundness (since it reflected consolidation and market exit of weaker banks); in the later stage of development this impact is more ambiguous since the existing empirical evidence on this topic is mixed and, theory, too, has produced conflicting predictions.

Macroeconomic variables Macroeconomic environment plays an important role in banking sector performance. We choose several macro variables: real GDP growth rate (gdp) where we expect higher growth reflects better conditions for financial stability. However, in countries where credit and real economy cycles are highly correlated the opposite might occur. Next, we use inflation rate (cpi) where we assume that price stability contributes to the profitability and stability of the banking sector. Finally, interest rate risk is measured by LIBOR 6-months rate (libor) with an a priori assumption that lower interest rates decrease banks' insolvency risk.

The second dataset comprises only Croatian banks in the period from 1996 to 2007 obtained from the central bank's monetary statistics. Here we could benefit from our more in-depth knowledge on developments of domestic banking sector and availability of more detailed data. We confined our sample to 24 banks that were active during the whole period analyzed, which resulted in total of 360 observations. This made our sample biased towards more solid banks, as others that have left the market were either acquired by another bank, liquidated or went bankrupt. In addition, there are some banks that only appeared later; however, we did not have sufficient observations on these banks to include them in the sample.

We calculated new *z-score* for Croatia (z*) using annualized data from banks' quarterly reports. Expected return on average assets was proxied by 12-quarters moving average of annualized ROAA, and standard deviation of ROAA is calculated on the basis of 12 quarterly observations and than annualized. This procedure takes into account intra-annual variation in returns and gave us significantly higher standard deviation of ROAA than the former formula where we used only annual data. As a consequence, new *z-score* for Croatia is substantially lower. Although dynamics are quite similar, according to our knowledge of Croatian banking sector in the time period analyzed, new *z-score* implies more realistic probabilities of default.

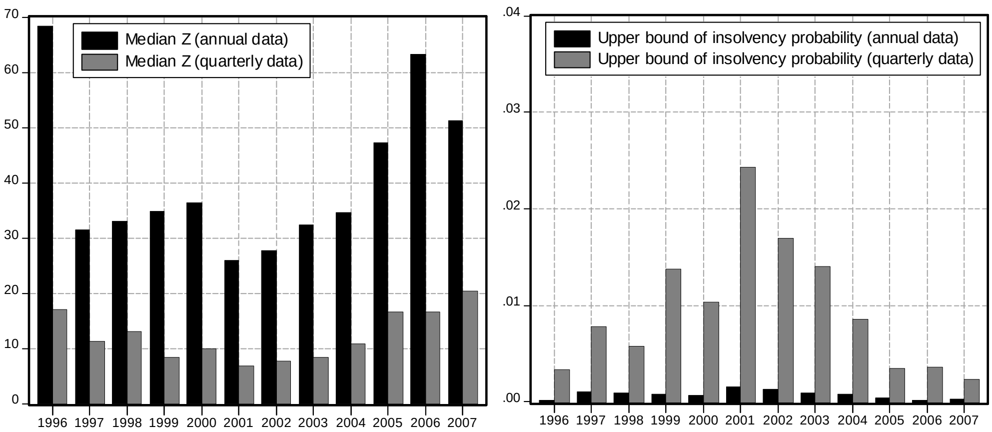


Figure 1: Comparison between *z-scores* and corresponding insolvency probabilities for Croatia calculated from quarterly and annual data.

Explanatory variables again belong to the one of the following three groups: banks-specific variables, banking sector variables and macroeconomic variables. Having in mind that Croatia is the most euroised country in our sample we study the impact of nominal exchange rate depreciation on bank stability. On the other hand due to frequent changes of exchange rate regimes in other countries in our sample, this variable was not included in pertaining specifications. In addition to bank-specific variables used in CEEC sample, we employed some new indicators: credit risk is alternatively measured by non-performing loans as a percent of total loans (npl) and dependency on the foreign sources of financing is measured by the ratio of foreign liabilities to total assets (open). We disaggregated credit growth into growth of households' loans (yoy_h) and growth of loans to corporate (yoy_c) as we assume that financing of different sectors might have different impact on banks' insolvency risk. However, it is difficult to judge in advance whether financing households vs. financing corporates should improve or worsen bank's stability. Finally, we constructed a set of dummy variables describing bank ownership through time (government owned - gd, domestic private banks – dd and foreign owned banks - fd) and bank's primary business orientation (on households financing, dom_h or on corporate lending, dom_c).

3.2 Historical decomposition of insolvency risk in CEEC

As an initial step in our analysis we study to what extent insolvency risk in CEEC measured by *z-scores* can be captured through dynamics of various macroeconomic and bank-specific variables. For each of the CEE countries in our sample we estimate a separate pooled regression (see (5)). This approach to risk decomposition is well known in recent literature. In their studies Maechler et al. (2007) and de Nicolo (2000) adopted similar strategies in order to identify main determinants of bank insolvency risk. Although estimated linear relations do not allow us to draw strong conclusion on causal relations between insolvency risk and various indicators we used, they can still provide us with a useful information on their eventual co-movements.

Another important issue we pay attention here concerns *the stability* of estimated relations. For comparison purpose beside the estimates based on the whole sample data (1996 -2006) we also report results from *rolling regressions* based on *moving windows* of fixed length of 5 years. While many of our specifications suggest certain level of instability (see Appendix A4), the analysis of rolling coefficients might provide us with additional useful information on possible changing nature of estimated relations between the insolvency in CEEC banks and both macro and micro environment.

Country regression estimates of both the whole sample and moving windows specifications can be summarised as follows.

Z-index is characterised by strong persistence as reflected in high coefficients on its first lag, ranging among the countries between 0.47 and 0.77. As lagged z depicts bank's capital buffers built in the past this result, as expected, confirms its significant positive relationship with present z in all countries observed.

Banks credit risk measured by the annual growth rate of total loans is on average associated with lower stability, which is additionally confirmed with the rolling regression. This way rapid credit growth as one of the main characteristics of CEE banking sectors exposed banks to higher insolvency risk despite the higher returns derived from such expansion. Comparing to Maechler et al. (2007), who found positive relation with credit growth and negative with credit growth acceleration (measured as growth rate squared), we find no explanatory power of quadratic effect of credit growth, while coefficients with credit growth rate remained negative.

Without any assumptions on causality, the results for relationship between real output growth and bank insolvency risk are somewhat mixed. Looking at the whole time span, if there exists significant relationship, it is negative as we find for four countries in our sample. However, the results of rolling regression with 5-year time intervals undermine this finding: negative relationship between real GDP growth and bank insolvency risk was confirmed during the whole period in only two countries with one being significant only in the later period (Bulgaria and Czech Republic). In Slovakia, the significant negative association between real economic activity and bank insolvency risk disappeared after 2004. In Latvia, previously negative relationship became and remained significant and positive after year 2000 when banking stability indicator and real economy started to move in opposite directions. In other countries real output growth proved to be insignificant in explaining bank stability. However, among these countries in three out of four rolling regression with 5-year time intervals showed that in earlier years real economic activity was positively related to bank insolvency risk. This result, as well as the one for Latvia, may be explained by the positive correlation between output and credit cycles in these countries, where credit growth contributed to higher insolvency risk.

Bank's size proxied by its total assets appears to be associated with greater bank stability in Bulgaria until 2002 and in Czech Republic after 2002. On the contrary, larger banks were in some period less stable in Slovakia (until 2002). Regarding other countries, it is possible that more precise measure of size effects would provide better results. However, due to the Bankscope's limited coverage of banks in earlier years of observed time interval we were not able to cluster banks by their share in total sector assets.

Bank's asset structure, captured by share of loans in total assets can be interpreted as credit risk (since loans in CEE banks are on average the riskiest form of banks' assets) as well as the profitability potential (as the return on loans is in general higher than on the other investments, such as government bonds or deposits). We find that higher share of loans contributed to bank insolvency risk in Bulgaria and Hungary, while the opposite is true for Croatia. Rolling regression confirmed these results and in addition, suggests that higher share of loans after the first couple of years started to contribute to bank stability in Slovakia and Czech Republic. In Lithuania it only gained some importance in the middle of the time span observed when higher loans share negatively influenced bank stability, and later became insignificant.

Ratio of loan loss provisions to net interest income illustrates quality of bank loan portfolio (in a sense that higher reserves reflect lower loan quality and higher non performing loans). On the other hand, higher reserves might mirror good risk management practices where building reserves has precautionary character. However, if we look at the moving window of 5-year periods, in last five years loan loss provisions to net interest income became positively connected to bank stability in Czech Republic and Hungary.

Liquidity risk doesn't explain much variation in *z-index*, so we cannot clearly conclude anything about the association between banks liquidity and stability[4]. Based on the rolling regression we still found that until 2003, higher liquidity contributed to bank stability in Bulgaria, while in Slovakia and Hungary this effect appeared only after 2002.

Although relation is not uniform in all countries, concentration in banking sectors is on average negatively associated with the stability. This is specially pronounced in Lithuania and Bulgaria. All countries, except Hungary and Croatia, recorded a substantial decrease of concentration in banking sectors during the last decade. Together with improved financial stability, it seems that lower concentration with stronger competition contributed to lower insolvency risk. This is in line with some other studies that were exploring same relation on much broader sample of the banks (Boyd et al. 2006). Nonetheless, looking at the movements in rolling coefficients, we found out that in the first period higher concentration contributed to banking sector stability in some countries such as Hungary and Latvia. Although not in line with results of similar researches, this could be explained with the fact that increase in concentration at the end of the 1990s, related to the process of consolidation and restructuring with falling number of banks, actually increased the banking sectors stability. However, as concentration later decreased this relation finally became negative in all countries observed, suggesting that stability goes in line with more strong competitors at the market.

Our assumption that price stability contributes to the stability of banking sector is confirmed for most of the countries. Lithuania is the only exception. Although level of inflation was not uniform in all the countries, and also not always low and stable, negative coefficient with change in CPI implies that price stability contributes to financial stability.

Interest rate risk measured by 6-months LIBOR rate, which was included in the

[4] Choice of liquidity indicator was constrained as it was the only uniform indicator available in the Bankscope database, so perhaps alternative measure would gain more insight in the relation between liquidity risk and insolvency.

model to control for the cost of foreign financing, has somewhat puzzling effect on bank stability. Its significance among countries is very diverse, as well as the direction of relation, where even estimated rolling coefficients are changing in both directions.

There is a remarkable degree of heterogeneity among banks in different countries with respect to the relationship between bank stability (*z-score*) and explanatory variables. Although relatively high homogeneity is found in bank stability-credit growth and bank stability-loan loss provisions relationships, we believe that given the diverse relationships among other variables, pooling all banks in one sample would provide less precise estimates than country by country regressions.

In order to get more insight into insolvency risk developments in CEEC four systemic z measures are constructed for each individual country. Firstly we look at *true z-scores* calculated by using individual banks' accounting data. In addition, the fact that *z-score* dynamics is *well* approximated (in MSE sense) by a simple regression equation leads us to calculate historical systemic risk of insolvency implied by various macro and micro economic indicators. The second index thus takes advantage of regression representation of insolvency risk (see (5)) and *z-scores* are estimated as fitted values from these regressions. Furthermore, as we provide evidence of parameters instability in estimated relations (see Appendix) we also estimate macro and micro indicators conditioned *z's* by using moving (fixed length) window regressions[5]. Finally, by regressing *z-scores* onto lagged explanatory variables we define a suitable insolvency forecasting tool. Thus together with three already defined z-measures we also construct one-year-ahead forecasts[6] for the period from 2004-2006.

Figure 2 summarises insolvency risk developments in CEE Countries in the period 1998 -2006. As a common trend among countries we note a steady growth of banking sector's stability measured by *z-scores*. The beginning of observed period is mostly characterised by early stage of transition process - fairly low GDP growth rates, banking sector clean-up programmes while first foreign banks were entering the CEE markets. Under these conditions banks were having relatively low and volatile returns which according to its definition resulted in low *z-scores.* On the other hand more stability was recorded in CEEC during the latter period observed when all the systems experienced substantially better broader economic conditions followed by the rapid development of banking sectors (see Appendix for details).

Regarding the reliability of two regression based alternative indicators of insolvency risk, figure 2 suggests that both of them capture dynamics of actual z fairly well[7]. In contrast to actual z these indicators directly link insolvency risk with actual broader economic and bank - specific environment which might be of great importance.

Related literature (de Nicolo (2000), Cihak and Hesse (2007) and Machler et al. (2007)) almost exclusively exploits *distance-to-default* property of *z-score* only and thus ignores underlying probabilities. Such practice is motivated by several reasons. The

[5] When calculating z-scores from moving window specifications, the estimate z_t is constructed by using relation (5) on the period from $t-4$ to t.

[6] All the forecasts were produced by using parsimonius specifications where we excluded the variables which do not explain much variation in z (such as LIBOR or total assets).

Due to small amount of available data we could not produce reliable forecasts for Lithuania.

[7] Employing the root mean squared error statistics, we measured the distance between actual z and two regression based estimates of z index. For four out of seven countries in our sample the moving window specifications outperformed the whole sample counterpart. The gain was most significant in Bulgaria (around 20%).

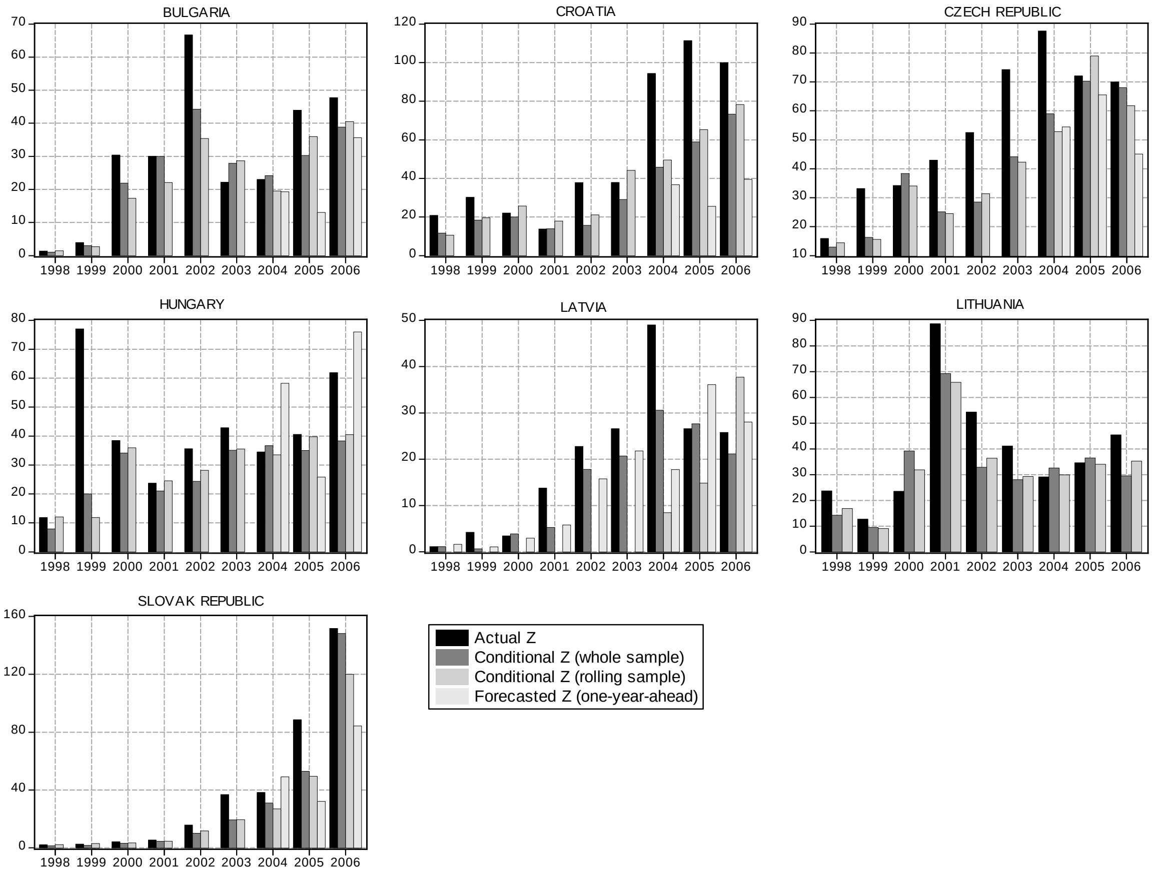


Figure 2: Z-scores for seven CEE Countries (1998 -2006). Conditional *z-indicies* are fitted values from panel regressions (5). The country aggregate is defined as weighted average of individual bank's *z-scores* weighted by corresponding bank's share in total assets.

most important one concerns a very strong requirement that probability distribution for returns needs to be defined explicitly. Yet this is neccesary only when exact probability of insolvency is of interest while relaxing this condition enables us to estimate conservative or *safety first* version of insolvency probability, i.e its upper bound. In context of measuring insolvency risks in transition economies we do not find conservativity property to be (too) restrictive. Let us note that if distance to default, i.e. z drops bellow unity, Chebyshev theorem only ensures probability of insolvency to be less than one which is of very limited help in this context. Nonetheless we favour *probability of default* interpretation over *distance to default* one as former seems to be more intuitive.

Probabilities on figure 3 reflect differences in *z-scores* among CEE Countries. Although quite different in size, *z-score* time series in CEEC show similar dynamics. At the beginning of the observed period estimated upper bounds of insolvency probabilities were on average much higher than they were in the later period.

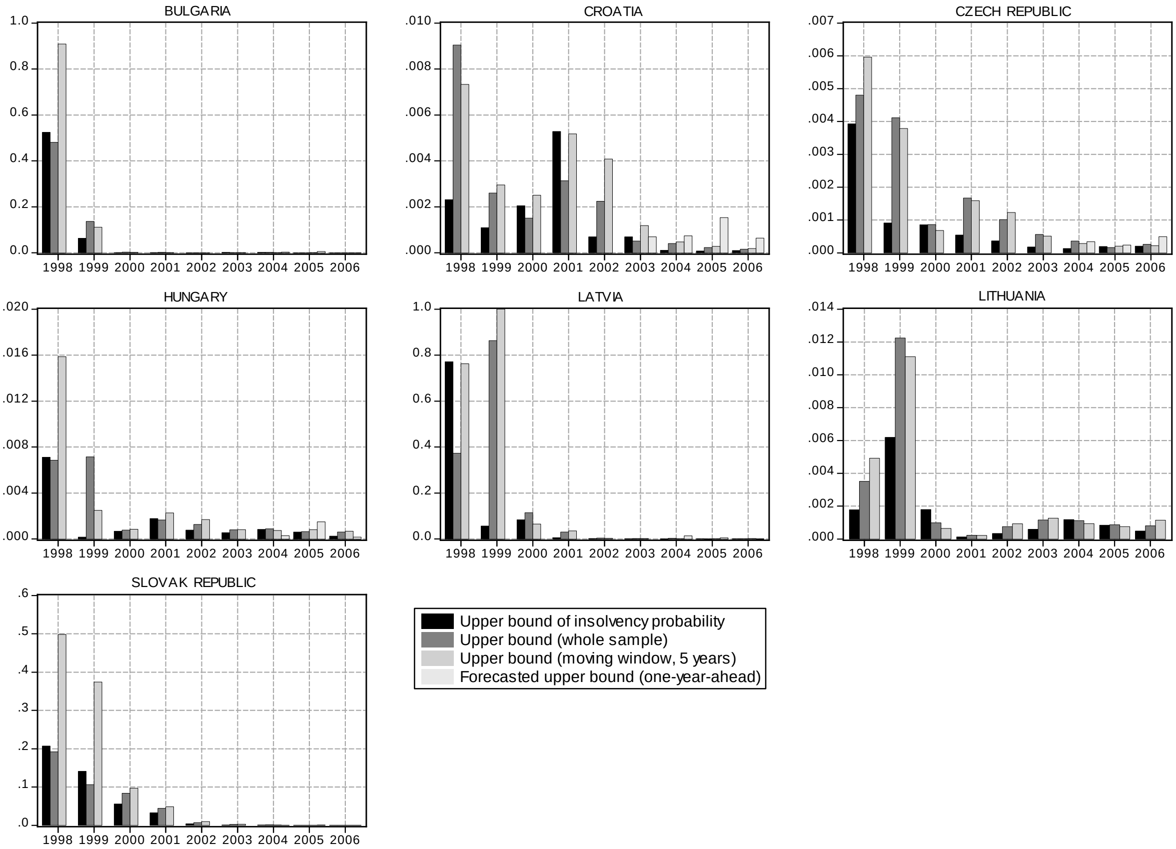


Figure 3: Upper bounds of insolvency probabilities for seven CEE Countries (1998 - 2006).

3.3 Case study: Croatia

Motivated by the availability of more detailed and reliable accounting and supervisory bank data we decided to investigate the bank insolvency risk in Croatia in more details. Our dependent variable is *z-score* based on quarterly data described in Section 3.1, which exhibits similar dynamics in time as the one used in previous analysis thus at significantly lower levels. In addition, our time span is 3 years longer as we included year 1996, 1997 and 2007.

The evidence of strong cyclic co-movements of real economic activity, credit growth, bank stability and non-performing loans gave us further motivation for exploring interrelations between Croatian banking sector and its environment. Closer look at these series reveals that present negative relationship between output gap and bank stability measured by *z-score* appeared only after 1999 which justifies the use of moving window regression.

As illustrated in Figure 4, coefficients on real output growth were positive and significant in first couple of 5-year periods analysed. At that time bank stability indicator moved in line with output gap and credit growth. After economic recovery and banking system restructuring and consolidation, credit growth became negatively related to bank

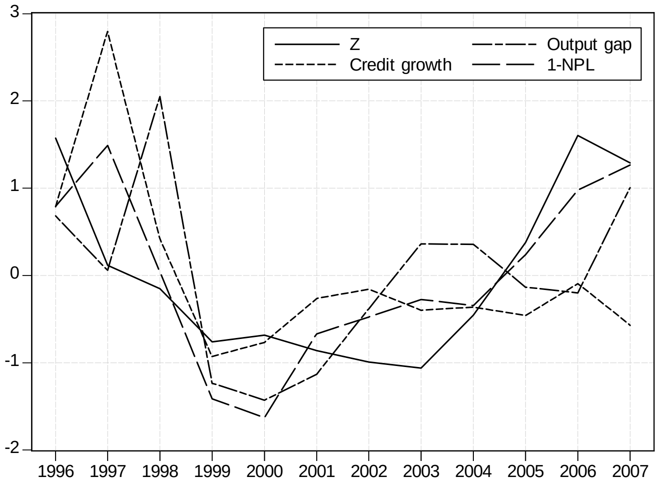


Figure 4: Average z, output gap, credit growth and *performing loans* (1-NPL) in Croatia (1996 - 2007)

stability. Since credit and output growth continued to move simultaneously, this alludes a negative relationship between bank stability and output which is confirmed by significant negative coefficients on real GDP growth in moving window regressions after 2001. Although whole sample estimation of real output growth relationship to bank stability was not significant, having in mind substantial change in economic environment since 1998, one should pay more attention on the rolling regression estimates.

As widely documented in literature, bank stability decreases in consumer prices inflation. This relation was confirmed in Croatia too. Exchange rate stability in context of high level of eurisation plays a particularly important role in financial stability. In general, domestic currency depreciation leads to lower bank stability as shown by its significant negative coefficient on the whole sample. Given the high level of eurization in Croatia, this is an expected result since depreciation exposes banks, whose FX positions are on average balanced, to indirect credit risk arising from possible higher proportion of loan defaults.

Higher level of concentration in Croatia is positively associated with stability. This result is opposite with findings in other CEE countries, but it is not unexpected. While in other CEE countries in our sample concentration with time decreased, in Croatia it recorded sharp increase during 1999 and 2000 after which it remained relatively stable in the following years. Initial increase in HHI in Croatia was primarily driven by market exit of numerous (usually small) unsound banks that contributed to the higher stability of the more consolidated and healthier banking sector.

Share of loans in total assets over the whole sample does not affect bank stability, which is the same result we obtained in previous regression. On the other hand moving window regression coefficients became positive and significant after 2004 to present. This result is probably driven by higher profitability of loans in comparison to other forms of assets. Whereas this relationship in earlier model was unclear, here we find that bank stability increases in size (measured by total assets).

As a measure of credit risk, instead of ratio of loan loss provisions to net interest income that has an ambiguous impact on bank stability, we use non-performing loans (NPL) ratio. As oppose to the first measure whose impact on bank stability in Croatia was not significantly different from zero, bank stability is decreasing in NPL ratio over the whole sample. However, moving window regression coefficients and their significance are decreasing over time, suggesting that the negative impact of NPLs on bank stability is weakening.

In addition to these variables, we investigated the impact of dependency on foreign financing, business orientation and ownership. We find that bank insolvency risk increases with higher share of foreign liabilities in total assets, especially after 2003. Banks oriented towards corporate lending as oppose to household financing are on average less stable than the other banks, which is not surprising taking into account that households loans in Croatia have on general higher interest margins while bad loans ratio to total loans is lower. Finally, we find that domestic banks tended to be more stable than foreign and government owned banks until 2004, when this relationship became insignificant. This result is direct consequence of higher capitalization rates of domestic, mainly smaller, banks.

Overall, this model better explains variations in z compared to the model described in Section 3.2. We gained from the studious choice of banks included in the sample based on the availability and reliability of their historical data, as well as from the adding additional explanatory variables. In addition, determinants of bank stability used in both regressions have better explanatory power in this model.

4 Conclusion

In this paper we studied banking sector stability in Central and Eastern European countries. Despite the considerable degree of heterogeneity among countries, we provide evidence of some common features. We show that bank stability is on average increasing since 1998, mainly as a consequence of more favourable macroeconomic environment and banking sector consolidation that resulted in higher and less volatile bank returns. Bank stability in CEE countries is on average decreasing in credit growth. This result emphasizes the problem of rapid credit expansion associated with a number of micro (loosening of credit policies and underestimation of risks) and macro (building of domestic and external imbalances) risks. Higher loan loss provisions are negatively associated with bank stability mainly through lower profitability indicators. This might imply that building loan loss provisions in CEE banks during the period observed was more a reflection of the loans quality than a precautionary risk management. We also documented a negative impact of inflation on bank stability.

We employed *z-score* as our distance to default measure. In addition to analysing the actual (accounting data based) *z-score*, we propose the estimation of conditional *z-scores* that we find to capture observed *z-score* dynamics fairly well. In contrast to the actual z, these conditional indicators directly link bank insolvency risk with broader macro and micro environment. Thus, conditional *z-scores* might be useful in identifying the impact of possible shocks on banking sector stability. This is especially interesting in the context of recent global financial turmoil and rising inflation pressures.

In this analysis when aimed to estimate the relation between bank stability and economic environment, we employed the same regression specification for all countries. However, for practical purposes more attention should be paid to individual country specifics.

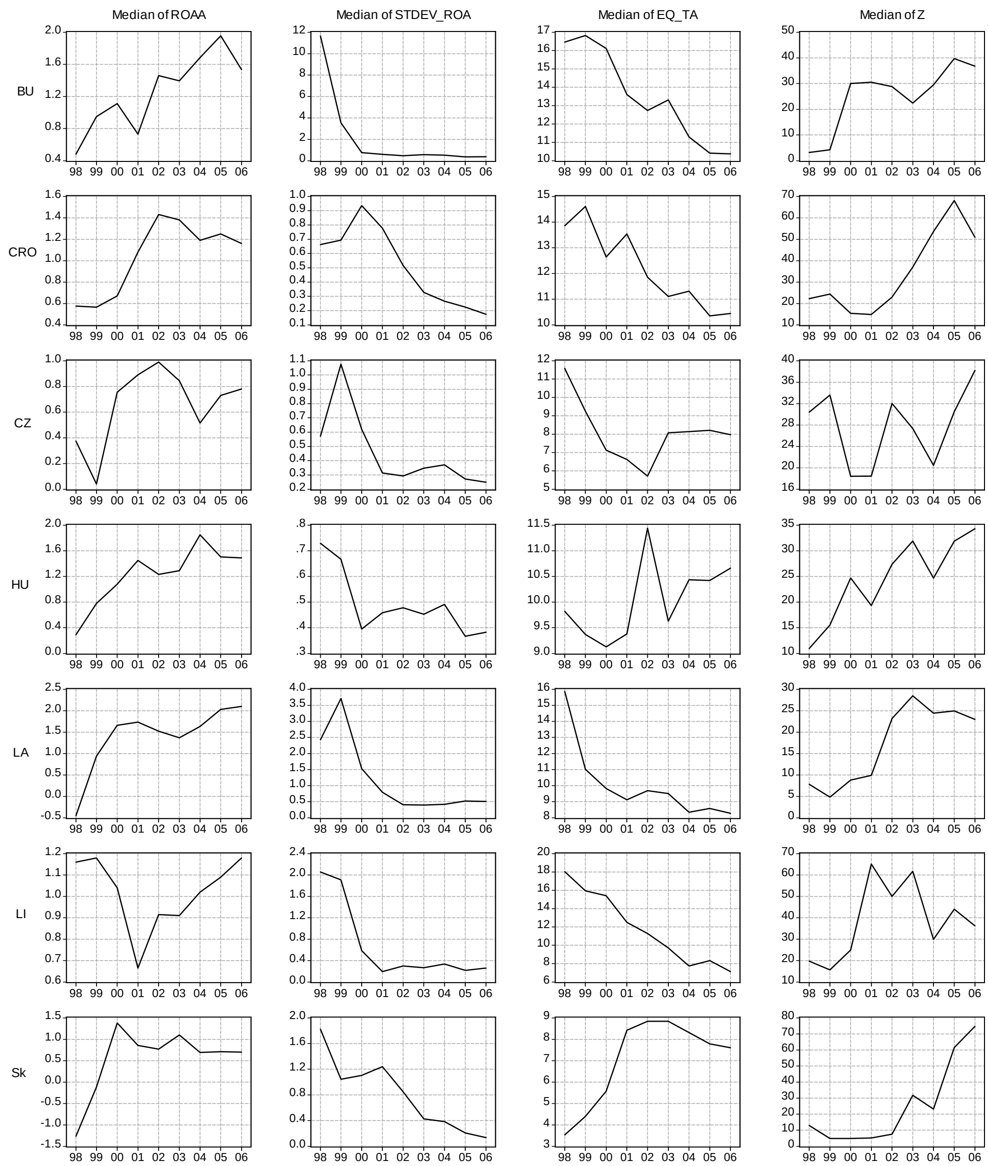
A Appendix

A.1 Data description

Variables		**Name**	**Description**	**Source**
Dependent variable				
	z-score	log(z)		Bankscope
	z-score*	log(z*)	Calculatation based on quarterly data	CNB
Explanatory variables				
Bank specific	Credit growth	chg	Annual percentage change in total credits	Bankscope, CNB
	Total assets	ta	Total bank assets, in USD mil	Bankscope, CNB
	Credit growth to households*	chg_h	Annual percentage change in total credits to households	CNB
	Credit growth to corporates*	chg_c	Annual percentage change in total credits to corporates	CNB
	Assets structure	l_a	Share of total credits in bank assets	Bankscope, CNB
	Credit risk	llp	Loan loss provisions to net interest income	Bankscope
	Non performing loans*	npl	Non performing loans in percent of total loans	CNB
	Liquidity risk1	liqa	Liquidit assets as percentage of customer and short term funding	Bankscope
	Liquidty risk2*	liq	Liquid assets as percentage of short term liabilities	CNB
	Foreign financing*	open	Ratio of foreign liabilities to total assets	CNB
Macro variables	Output growth	gdp	Annual rate of change in real output	IFS, CBS
	Inflation	cpi	Average annual rate of change in consumer price index	IFS, CBS
	Interest rate risk	libor6	6-months LIBOR	Bloomberg
	Exchange rate risk*	hrkeur	Average annual exchange rate of HRK/EUR	Eurostat, CNB
Banking sector	Concentration	hhi	Hirschman-Herfindal index	Bankscope, CNB
Dummy variables*	Bank ownership	dd fd gd	Private domestic banks Foreign owned banks Government owned banks	CNB
	Credit structure	dom_h dom_c	Share of credits to households > 55% Share of credits to corporates > 55%	CNB

*variables used only in Section 3.3 Case study: Croatia

A.2 Z - score components over time



A.3 Mean values of explanatory variables over time

Bulgaria	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	4.0	17.11	0.177	180,988	0.30	-7.86	22.51	103.07
1999	2.3	2.55	0.186	146,915	0.38	19.46	18.51	15.64
2000	5.4	9.82	0.160	151,829	0.41	27.55	15.14	40.25
2001	4.1	7.10	0.147	164,878	0.40	22.87	52.29	55.50
2002	4.5	5.65	0.121	234,291	0.47	35.66	25.34	92.31
2003	5.0	2.13	0.112	347,985	0.54	9.01	21.40	92.93
2004	6.6	6.15	0.106	607,661	0.57	16.63	26.09	63.85
2005	6.2	4.92	0.095	757,194	0.55	11.74	23.69	27.23
2006	6.3	7.01	0.096	1,170,187	0.54	-1.45	19.26	50.42

Czech Republic	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	-0.8	10.10	0.286	5,448,951	0.38	60.64	14.89	15.60
1999	1.3	2.12	0.254	3,298,618	0.29	69.74	22.26	22.62
2000	3.6	3.83	0.233	4,110,290	0.31	8.95	17.17	126.06
2001	2.5	4.60	0.227	4,679,935	0.36	19.50	17.60	79.40
2002	1.9	1.77	0.217	6,363,683	0.37	5.91	15.26	62.13
2003	3.6	0.09	0.220	7,560,156	0.45	14.94	20.09	76.24
2004	4.5	2.80	0.210	7,741,083	0.45	3.14	12.91	54.07
2005	6.4	1.82	0.217	8,751,003	0.48	31.75	25.92	11.53
2006	6.4	2.51	0.213	11,259,602	0.51	7.69	36.41	40.89

Latvia	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	4.7	4.56	0.503	97,539	0.43	-17.90	13.71	377.75
1999	3.3	2.34	0.303	119,603	0.43	28.58	11.39	82.53
2000	6.9	2.61	0.238	175,337	0.30	95.30	14.61	-12.53
2001	8.0	2.46	0.189	284,208	0.34	-10.57	8.65	91.05
2002	6.5	1.92	0.176	460,283	0.39	6.16	22.64	180.49
2003	7.2	2.88	0.143	633,454	0.41	13.40	21.83	39.62
2004	8.7	6.01	0.142	837,322	0.42	21.83	26.55	57.29
2005	10.6	6.54	0.164	1,014,180	0.48	-0.15	28.44	32.80
2006	12.2	6.35	0.184	1,862,201	0.57	5.19	31.29	69.19

Lithuania	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	7.5	4.95	0.471	231,075	0.45	-2.28	26.90	23.50
1999	-1.5	0.75	0.559	336,478	0.47	23.45	24.75	27.52
2000	4.1	1.01	0.464	329,008	0.47	29.69	25.27	48.20
2001	6.6	1.29	0.391	371,389	0.44	20.72	23.70	25.47
2002	6.9	0.30	0.361	444,631	0.53	18.87	21.12	88.61
2003	10.3	-1.19	0.258	706,408	0.53	-1.94	20.21	69.63
2004	7.3	1.19	0.238	1,274,225	0.58	9.45	13.74	61.74
2005	7.9	2.62	0.223	1,695,332	0.61	10.85	17.50	44.20
2006	7.7	3.76	0.222	2,675,187	0.66	11.73	16.89	74.77

Hungary	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	4.8	13.31	0.136	2,614,547	0.41	13.77	20.48	32.53
1999	4.2	9.53	0.150	2,484,260	0.46	21.92	18.30	31.70
2000	5.2	9.34	0.158	2,473,057	0.57	4.82	16.20	32.10
2001	4.1	8.82	0.159	2,316,934	0.59	7.22	11.24	21.66
2002	4.4	5.13	0.196	2,825,696	0.67	5.51	17.67	83.84
2003	4.2	4.53	0.216	3,358,255	0.67	5.89	8.54	49.85
2004	4.8	6.56	0.228	5,108,780	0.72	11.54	35.24	64.87
2005	4.1	3.49	0.315	5,148,624	0.74	11.21	72.66	0.02
2006	3.9	3.81	0.332	7,804,021	0.72	16.19	51.47	31.05

Slovak Republic	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	4.4	6.47	0.247	1,558,586	0.45	111.83	12.94	5.34
1999	0.0	10.06	0.270	1,425,614	0.39	160.10	19.15	-16.07
2000	1.4	11.36	0.279	1,265,801	0.42	-42.29	21.92	-12.44
2001	3.4	7.07	0.227	1,302,672	0.37	9.55	31.73	-8.48
2002	4.8	3.27	0.220	1,661,436	0.39	8.90	24.32	89.06
2003	4.8	8.20	0.214	1,913,712	0.43	7.98	30.06	45.27
2004	5.2	7.28	0.206	2,629,704	0.39	3.52	18.96	31.78
2005	6.6	2.67	0.201	2,548,109	0.47	8.88	16.20	25.20
2006	8.5	4.38	0.204	3,433,220	0.48	13.99	18.27	42.67

Croatia	gdp	cpi	hhi	ta	l_a	llp	liqa	chg
1998	2.8	5.54	0.102	676,521	0.55	71.48	15.34	21.40
1999	-0.9	3.92	0.119	551,495	0.51	91.24	18.01	-23.02
2000	2.9	4.50	0.136	638,265	0.47	36.55	14.84	-4.60
2001	4.4	3.73	0.130	748,427	0.48	2.05	14.77	25.84
2002	5.6	1.69	0.124	1,063,001	0.53	25.36	10.02	57.29
2003	5.3	1.78	0.127	1,448,483	0.55	14.16	9.43	36.00
2004	4.3	2.08	0.136	1,533,306	0.57	15.46	13.21	28.00
2005	4.3	3.25	0.136	1,409,316	0.56	8.33	11.88	13.70
2006	4.8	3.15	0.130	2,307,614	0.59	5.17	10.36	57.83

A.4 Regression results

These tables provide regression coefficients from both whole sample and moving window specification. In first five rows of the table for each country the results from moving window regressions are reported where given year denotes a final observation in the window (2002 row is related to 1998 - 2002 window, 2003 with 1999 - 2003 and so on). The first table summarises results from section 3.3 while results for seven CEE countries are reported in second table. For both tables (*) i (**) denote significance at 10% and 1% respectively.

Croatia	z*(-1)	gdp	cpi	hrkeur	hhi	chg	npl	open	l_a	ta	dom_c	dd
2002	0.67(**)	22.02(**)	0.36(**)	28.57(**)	-5.84(**)	-0.18(**)	-2.75(**)	0.13	-0.26	0.00	0.04	0.31(**)
2003	0.58(**)	5.60(**)	-0.47(**)	17.86(**)	2.41(**)	0.07	-1.68(*)	-0.43	0.02	0.05	-0.03	0.4(**)
2004	0.55(**)	44.45(**)	-1.20(**)	32.8(**)	17.61(**)	0.09	-1.52(*)	-1.17(**)	0.97(*)	0.15(**)	-0.01	0.27(**)
2005	0.63(**)	36.67(**)	-0.11(**)	-4.43(**)	9.98(**)	-0.04	-0.61(*)	-0.69(*)	1.66(**)	0.17(**)	-0.05	0.15
2006	0.63(**)	-38.94(**)	-0.07(**)	-1.29(*)	-1.38	-0.49(**)	-0.41	-0.89(**)	1.29(**)	0.15(*)	-0.19(*)	0.01
2007	0.61(**)	-12.59(**)	-0.14(**)	-4.51(**)	2.44(**)	-0.53(**)	0.07	-0.74(**)	1.37(*)	0.13(*)	-0.15(*)	-0.08
1996-2007	0.70(**)	1.86(*)	0.19(**)	-6.74(**)	1.90(**)	-0.32(**)	-1.41(**)	-0.07	0.43	0.03	-0.10(*)	0.04

Bulgaria	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.51(**)	67.37(**)	-12.63(**)	-0.11	15.67	0.13(**)	-0.81(*)	-0.49(**)	1.12(*)	-0.17
2003	0.5(**)	13.36(**)	-1.78	-3.8(**)	21.87(*)	0.05	-0.82(**)	-0.53(**)	1.02(*)	-0.20(**)
2004	0.72(**)	11.05(**)	-2.75(*)	-3.73(**)	36.37(**)	0.01	-0.99(**)	-0.37(**)	0.00	-0.19(**)
2005	0.52(**)	27.26(**)	3.99(*)	-5.00(**)	-25.63(*)	0.01	-0.45(*)	-0.27(*)	0.75	-0.26(**)
2006	0.51(**)	3.48	5.42(*)	-2.49(**)	0.59	0.03	-0.55(**)	-0.20(**)	0.11	-0.29(**)
1998-2006	0.54(**)	6.49(*)	-8.96(**)	-4.22(**)	36.61(**)	0.03	-0.58(**)	-0.25(**)	0.48	-0.24(**)

Czech Republic	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.85(**)	14.64	-4.04	-2.58	-7.88	-0.10	-0.56	0.01	-0.75	0.01
2003	0.80(**)	11.51	-4.77(*)	0.60	-5.22	0.02	-0.11	0.28	-0.33	0.10
2004	0.73(**)	7.43(**)	-4.26(*)	2.11	0.84	0.12	0.21	0.31	-0.16	0.08
2005	0.65(**)	12.04(**)	-0.60	-1.77	-33.37(**)	0.17(*)	0.98(*)	0.23	-0.42	0.14
2006	0.57(**)	10.92(*)	-5.75	-4.14	-27.23(**)	0.27(**)	1.43(**)	0.44(**)	0.30	0.16
1998-2006	0.77(**)	6.60(*)	-6.57(**)	0.01	-3.66	0.02	-0.35	0.14	-0.25	0.09

Latvia	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.34(*)	16.03(**)	-64.03(**)	2.87(**)	-3.90	0.03	0.72	-0.43(*)	-0.34	-0.05(*)
2003	0.35(*)	-1.24	47.35	5.54(*)	-17.6(**)	-0.05	0.69(*)	-0.47(**)	-0.33	-0.07(*)
2004	0.43(**)	-7.03	-2.79	2.33(**)	-22.69(*)	0.03	0.37	-0.37(**)	-0.40(*)	-0.04(**)
2005	0.40(*)	-23.18(**)	5.07	0.64	7.83	0.00	0.34	-0.13	-0.29	-0.04(**)
2006	0.27(*)	-13.62(**)	3.70	-0.39	20.60(*)	-0.03	-0.03	-0.14	-0.53(**)	-0.04(**)
1998-2006	0.48(**)	14.45(*)	-24.2(*)	1.66(*)	-26.11(**)	0.04	0.29	-0.29(**)	-0.18	-0.07(**)

Lithuania	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.74(**)	-6.70(*)	25.55(**)	-3.71(**)	5.35	0.01	-2.59	-1.01	-0.35	-0.97(**)
2003	0.74(**)	-9.26(*)	28.60(**)	-4.59(**)	0.79	-0.03	-0.97	-0.96	-2.29	-0.99(**)
2004	0.67(**)	24.02(*)	51.30(**)	-2.16(*)	34.69(**)	-0.22(*)	-0.94(*)	-1.18	-0.41	-0.96(**)
2005	0.63(**)	-6.65	23.86(**)	-5.36(**)	74.57(*)	-0.18(*)	-0.31	-0.92	-1.07	-0.93(**)
2006	0.66(**)	-250.25(**)	186.8(**)	-44.50(**)	-31.04(**)	-0.10	-0.15	-1.07	0.20	-0.6(**)
1998-2006	0.65(**)	-3.65	26.37(**)	-3.73(**)	-1.03	-0.06	-0.15	-0.47	-0.64	-0.86(**)

Hungary	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.62(**)	-380.35(**)	33.02(**)	13.68(**)	155.24(**)	0.05	-1.24(*)	-1.95(*)	-2.79(*)	-0.02
2003	0.68(**)	342.12(**)	23.34(**)	3.10(**)	-160.48(**)	0.11	-0.38	-1.85(*)	-3.49(**)	-0.19
2004	0.60(**)	-27.25	-15.11(**)	0.51	31.07(*)	0.03	0.13	2.02(*)	0.18	-0.29
2005	0.62(**)	74.28(**)	-4.38(*)	1.34(*)	-32.65(**)	-0.01	0.04	0.57	0.10(**)	-0.25(**)
2006	0.54(**)	-5.66	4.81	0.50	-7.45(*)	0.04	-0.50	0.97(**)	0.06(*)	-0.21(**)
1998-2006	0.56(**)	22.80	-12.63(**)	0.23	-3.61(*)	0.03	-0.81(*)	-0.76	0.02	0.00

Slovak Republic	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.64(**)	-261.28(*)	-181.03(*)	-13.92(*)	247.74(*)	-0.58(*)	-3.00(**)	-0.97(**)	0.15	-0.24
2003	0.74(**)	50.89(**)	-1.18	1.43	6.19	-0.02	-3.06(**)	-0.63(**)	-2.55(*)	-0.69
2004	0.57(**)	29.58(*)	-4.12(*)	3.56(*)	-11.25	-0.16	-1.96(*)	-0.69	0.34	-0.68
2005	0.56(**)	-7.18	-3.92	5.95(*)	8.73	0.09	0.33	-0.79	1.10	-0.78
2006	0.73(**)	9.91	-0.80	-9.56	23.42(**)	0.12	2.14(**)	2.50(*)	4.20(**)	-0.19
1998-2006	0.69(**)	20.79(*)	-3.14	2.66(**)	-1.74	-0.10	-0.23	-0.80(*)	1.71(**)	-0.35

Croatia	z(-1)	gdp	cpi	hhi	libor	ta	l_a	llp	liqa	chg
2002	0.66(**)	-256.83(**)	-125.64(**)	-63.33(**)	336.67(**)	-0.08	-0.42	-0.32(*)	0.73	-0.27
2003	0.58(**)	0.62	-32.5(**)	1.99(*)	0.47	-0.11(**)	-0.65	-0.34(*)	0.55	-0.18
2004	0.59(**)	-69.12(**)	-74.25(**)	-2.56(**)	-11.46(*)	-0.12(**)	-0.23	0.18	1.07	-0.51(*)
2005	0.47(**)	69.56(*)	22.00	7.41(*)	59.36(*)	-0.03	0.88	0.31	-0.39	-0.22
2006	0.46(**)	-25.44(*)	-20.16(*)	-0.33	12.32(*)	0.07	1.65(*)	0.8(*)	-1.24	-0.35(*)
1998-2006	0.57(**)	2.19	-18.49(**)	-0.12	6.52	0.06	1.24(*)	0.04	-0.75	-0.31(*)

References

[1] Adahl, Martin, (2002), *Banking in the Baltics — The Development of the Banking Systems of Estonia, Latvia and Lithuania since Independence The Internationalization of Baltic Banking (1998-2002)*, Oesterreichische Nationalbank Focus on Transition 2/2002

[2] Arpa, Markus, Thomas Reininger and Zoltan Walko, (2005), *Can Banking Intermediation in the Central and Eastern European Countries Ever Catch up with the Euro Area?*, Oesterreichische Nationalbank Focus on European Economic Integration 2/2005

[3] Backé, Peter and Zoltan Walko, (2006), *Bank Intermediation in Southeastern Europe: Depth and Structure*, Oesterreichische Nationalbank Focus on European Economic Integration 2/2006

[4] Barisitz, Stephan, (2005), *Banking in Central and Eastern Europe since the Turn of the Millennium — An Overview of Structural Modernization in Ten Countries*, Oesterreichische Nationalbank Focus on European Economic Integration 2/2005

[5] Bonello, Michael C., Fabrizio Saccomanni, Claudia M. Buch, Jörn Kleinert and Peter Zajc, (2003), *Securing Financial Stability: Problems And Prospects For New Eu Members*, SUERF – The European Money and Finance Forum Vienna, SUERF Studies: 2003/4

[6] Boyd, John H., Gianni De Nicoló, and Abu M. Jalal, (December 2006), *Bank Risk-Taking and Competition Revisited: New Theory and New Evidence*, IMF Working Paper No. 06/297

[7] Cihák, Martin, (2007), *Systemic Loss: A Measure of Financial Stability*, Czech Journal of Economics and Finance, Vol. 57, Issue 1, pp.5-26

[8] Cihák, Martin and Heiko Hesse, (January 2008), *Islamic Banks and Financial Stability: An Empirical Analysis*, IMF Working Paper No. 08/16

[9] De Nicoló, Gianni, (December 2000), *Size, Charter Value and Risk in Banking: an International Perspective*, Board of Governors of the Federal Reserve System International Finance Discussion Papers No. 689

[10] Hannan, Timothy H. and Gerald A. Hanweck, (May 1988), *Bank Insolvency Risk and the Market for Large Certifikates of Deposit*, Journal of Money, Credit, and Banking, Vol. 20, No. 2

[11] Hesse, Heiko and Martin Cihák, (January 2007), *Cooperative Banks and Financial Stability*, IMF Working Paper No. 07/2

[12] Hilbers, Paul, Inci Otker-Robe, Ceyla Pazarbasioglu, and Gudrun Johnsen, (July 2005), *Assessing and Managing Rapid Credit Growth and the Role of Supervisory and Prudential Policies*, IMF Working Paper No. 05/151

[13] Honohan, Patrick, (January 1997), *Banking System Failures in Developing and Transition Countries: Diagnosis and Predictions*, BIS Working Paper No. 39

[14] International Monetary Fund, (February 2007), *Republic of Croatia: Selected Issues*, IMF Country Report No. 07/82

[15] Jiménez, Gabriel, Jose A. Lopez and Jesús Saurina, (September 2007), *How Does Competition Impact Bank Risk-Taking?*, Federal Feserve Bank of San Francisco Working Paper 2007-23

[16] Jokipii, Terhi and Brian Lucey, (2006), *Contagion and interdependence: measuring CEE banking sector co-movements*, Bank of Finland Research Discussion Papers 15/2006

[17] Krznar, M. (2008), *Rizik bankovne zaraze u Hrvatskoj*, mimeo.

[18] Lublóy, A (2005), *Domino Effect in the Hungarian Interbank Market*, mimeo.

[19] Maechler, Andrea M., Srobona Mitra and DeLisle Worrell, (October 2007), *Decomposing Financial Risks and Vulnerabilities in Eastern Europe*, IMF Working Paper No. 07/248

[20] Racocha, Pavel (2003), *Joining the EU – Impact on The Financial Sector of New Member States*, National Europe Centre Paper No.117

[21] Ramirez, Carlos D. and Philip A. Shively, (June 2005), *Do Bank Failures Affect Real Economic Activity? State-Level Evidence from the Pre-Depression Era*, FDIC Center For Financial Research Working Paper No. 2005-06.

[22] Roy, A. D., (July 1952), *Safety First and the Holding of Assets*, Econometrica, Vol. 20, No. 3, pp. 431-449

[23] Segoviano Basurto, Miguel A., Charles Goodhart, and Boris Hofmann, (September 2006), *Default, Credit Growth, and Asset Prices*, IMF Working Paper No. 06/223

[24] Worrell, DeLisle, (August 2004), *Quantitative Assessment of the Financial Sector: An Integrated Approach*, IMF Working Papers No. 04/153