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IS THE CENTRAL AND EASTERN EUROPEAN BANKING SYSTEMS STABLE? EVIDENCE FROM THE RECENT FINANCIAL CRISIS

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ABSTRACT

Systemic risk is a very important but very complex notion in banking and how to measure it adequately is challenging. We introduce a new framework for measuring systemic risk by using a risk-adjusted balance sheet approach. The measure models credit risk of banks as a put option on bank assets, a tradition that originated with Merton. We conceive of an individual bank's systemic risk as its contribution to the potential sector-wide net. In this regard, the analysis of public commercial banks operating in 7 countries from Central and Eastern Europe, shows potential risk which could threaten all the financial system. The paper shows how risk management tools can be applied in new ways to measure and analyze systemic risk in European banking system. The research results is a systemic risk map for the CEE banking systems. The study finds also instability of systemic risk determinants.

JEL classification: G1, G11, G10, E44

Keywords: systemic risk, banking system, instability, emerging markets, Merton option model

1. INTRODUCTION

During the past two decades, the Central and Eastern European financial systems experienced changes, including the opening to attract foreign investments, mainly big banking group, the deconcentration of their banking sectors and the privatization of financial institutions. Such reforms during the early 1990s were expected to increase investment in the region and produce high profits by banking sector.

The stability of CEE banking sectors should be examined in the context of high foreign ownership by Western European banks in CEE. The aggregated CEE exposure of Western European banks remained more or less high in recent years. By year-end 2012, the aggregated CEE exposure of the three most important banking sectors for the region (Austria, Italy and France, representing some 50% of the total regional exposure of European banks or 45% of global cross-border CEE exposure)[1]. On the other hand given the systemic presence of Western European banks in the CEE there had been an extensive debate among academics and policy-makers about the efficiency of CEE comparing to Western European banks in recent years. Is it also a question if deleveraging of Western European banks within a short period of time might have disruptive effects for the CEE economies?

Definition of systemic risk is related to the probability that a given size shock will generate a particularly severe and undesirable outcome. Systemic risk may be due to common exposures or from systemic interdependence due to information contagion, domino effects through contracts, fire sales and asset prices, and the breakdown of market making functions.

Banking sector is by far the most central part of the financial system in most of the emerging economies and is, therefore, also the main source of risk for financial stability. Traditional banking models do not adequately measure risk position of financial institutions and cannot be used to understand risk within and between balance sheets in the financial sector. A fundamental subject is that accounting balance sheets do not indicate risk exposures,

[1] According to the OECD data base

which are forward-looking. Therefore, in the first step of this article we proposes the use of Merton's model, which is mainly used for option pricing as a way to assess the risk of insolvency of the company. The essence of this method is the connection of information coming from the company's balance sheet and market data, containing part of future expectations of market participants. In particular, it seems important to use option pricing methodology, which takes into account the information contained in the market prices about the increasing risks in the financial system. In the second step of research there will be investigating analysis whether systemic risk of banks operating in Central and Eastern Europe (CEE), is affected by bank size, risk taking, market determinants or country specific variables, like banking concentration and competition. The study is a continuation of previous studies carried CCA method for the Polish banking sector (Karkowska, 2012).

Main hypothesis is: (1) Central and Eastern European banking systems are not devoid of systemic risk. The threat of a systemic crisis is ever-present. (2) Systemic risk has not pro-cyclical determinants. It depends on market risk, the banking system specific conditions and risk taken by individual banks.

The paper shifts focus from the country specific variables to financial institutions and the possible causal links between market variables and systemic risk changes. It was consider a set of CEE countries during a period of last seven years that enhanced financial prosperity and slump. It was examined whether country specific variables affects risk in banking system. To the best of ours knowledge, there is no work considering explicitly such a research of systemic risk in European countries and its determinates.

To measure banking systemic risk it was using Merton's model. And to test our main hypothesis and determinants of systemic risk it was employed a panel data framework using the generalized methods of moments (GMM).

The approach was applied to the 21 commercial banks covered by Central and Eastern Europe during the period from December 2004 to December 2012. The findings suggest that the systemic risk indicator stood at its peak in March 2009, but in Hungarian banking system is still high. Finally, it was find that the increase in systemic risk of the CEE banking sector during the 2007-09 financial crisis was initially driven mainly by bank specific risk premiums and later by the market determinants, like volatility and stock exchange capitalization.

The paper is structured as follows. Section 2 shows the relevant literature on systemic risk and its reasons. Section 3 outlines model specification and describes dependent and independent variables used in the analyses. Section 4 presents the data sample and methodology applied. Section 5 presents the results of the investigation. Section 6 concludes study.

2. LITERATURE REVIEW

The problem of increasing systemic risk in the economy is again widely presented in the literature. Especially a lot on this subject can be read in the IMF reports (IMF, 2008; IMF 2009).

The wide scope of research about systemic risk show that there is not a single and agreed approach to this measurement. It suggests that measurements tools should support the understanding of linkages between financial institutions and the macroeconomy. The problem of systemic risk is complex and requires multiple measurements. The literature review finds a few specific approaches for assessing systemic risk along with different kind of data and models.

The study of Brownlees and Engle (2011), Adrian and Brunnermeier (2008) and Acharya et al. (2010) presented how to use tail-risk measures to estimate solvency of the

financial system. It measures interdependence in the tails of equity returns to financial institutions. MES measures the expected loss to each financial institution conditional on the entire set of institution s' poor performance; CoVaR measures the value-at-risk (VaR) of financial institutions.

Estimation of tail dependence is problematic because of limited historical data of a financial crisis. The tail measurement helps to identify large aggregate shocks. This approach is interesting but has some critical questions – how equity returns transmitted disturbance to the macroeconomy? How big crisis could be expected? The tail measures is based on big public financial institutions. What about so-called shadow banking sector that are not publicly traded? The study of systemic risk measures based on analysis of equity returns emphasized also Billio, Getmansky, Lo, and Pelizzon (2010).

The second approach is network models of the financial system. The information about financial firm network is very useful in prediction disturbulances, but much more difficult to collect in dynamic financial system. Last time, Cont (2010) and Kim and Giesecke (2010) presented a network-based systemic risk measure.

Smets and Wouters (2007) suggested dynamic and macroeconomic equilibrium models. This econometric estimation measures the transition mechanisms of shocks and its consequences for macroeconomy. The study remains a question how important is the model? And how to identify consequences of shocks that are very large but infrequent?

The other research apply Gray and Jobst (2009), Gapen (2009) known as contingent claims analysis. It based on the use of option pricing theory for financial institutions where there is an underlying stochastic process for the value of their assets. This approach using investors market expectations in conjunction with equity-based measures of debt obligations uncertainty. The advantages of model is connection of market risk appetite with balance sheets statements.

The concept of credit risk measurement methods using CCA has a wide range of applications. American studies Gray and Malone (2011) used by central banks to support the analysis and management of financial risk management. The main analytical tool is the risk-adjusted balance sheet, which shows the sensitivity of the company's assets and liabilities to external "shocks" on the national and international level. Traditional approaches may have a problem with the analysis of how risks can accumulate gradually and then suddenly erupt in times of crisis. The CCA model approach is designed to overcome any "non-linearity" in the assets and liabilities, and between institutions. Simulations and stress tests, using risk-adjusted balance sheets are managing systemic risk.

Along Chan-Lau and Gravelle (2005), Lehar (2005) and Avesani, Pascual, and Li (2006) show alternative systemic risk indicators - default probabilities based on the credit default swap (CDS), equity , or option market.

Overview of the theoretical and empirical aspects of systemic risk measurement and management has enabled we to determine what was missed in previous studies and is the structural default risk modeling reasonable in CEE financial system? However, the using of multitude of methods caused unequivocal conclusions. There is no doubt, that the cause of it is the randomness of economic phenomena that can’t be properly described by statistical model.

According to Schuermann, Pesaran, Treuler and Weiner, (2006) accounting balance sheets do not indicate risk exposures, which are forward-looking and express market risk. He has worked on linking the default risk of corporations with macroeconomic models. He underline that the main risk is frequently left out of our models default risk in the financial sector. Gray and Jobst, (2009:128-131) pointed out that study of financial volatility has not been well served by economic theory.

To manage and mitigate risk in financial sector there are needed new analytic tools and additional regulatory. Recent work has shown that financial sector risk indicators, such as the systemic expected losses or system default risk from Merton model, have big predictive power for GDP and the output gap Garcia, Gray, Luna and Restrepo, (2010).

In view of the above literature review, we decides to use CCA method to calculate systemic risk in banking of European emerging markets.

3. DETERMINANTS OF SYSTEMIC RISK

The section describes the explanatory variables which will be use to analyze determinants of systemic risk scope and size, calculated using CCA method. of in commercial bank.

Assessment of financial stability in general is made on a broad-spectrum of risk factors developing outside and inside the financial system respectively. Recent research on systemic risk has identified three main determinants for systemic crises: (1) Market and macroeconomy variables widespread financial imbalances that unravel with adverse effects on both intermediaries and markets, (2) Banking systems specific variables caused interbank contagion arising from the interconnectedness of banks through the interbank loan market, (3) Individual risk taking by commercial banks.

3.1 Market and macroeconomy determinants

Market and macroeconomy determinants are widely considered as one of the key indicators of financial instability (Demirguc¸ -Kunt et al., 2006). we focus on four such determinants: *ON interbank rate spread* as liquidity indicator, *VIX - volatility index*, *stock exchange capitalization to GDP*, *central bank base rate*, *money market rate*, *real GDP growth.* The choice of merket variable as *ON interbank rate spread* as liquidity indicator, *central bank base rate*, *VIX - volatility index*, *stock exchange capitalization to GDP* as the primary determinants of banking systems stability has been justified in the literature, which I

have mentioned above. Perhaps the typical source of financial instability is market dysfunction mostly due to liquidity problem. The liquidity ratio of the banking market is liquidity in the interbank market, where banks finance their investments. Narrow BID ASK spread of ON transaction means liquid market and access to money. In contrast wide indicates lack of transaction and bottlenecks in payments. Interbank loans granted to other financial institutions in the interbank market: the risk adjusted pricing of these loans takes into account the funding costs of the granting bank as well as the expected and unexpected loss. The funding of commercial banks is largely through interbank market credits, which appear to be inelastic in the liquidity crisis. related volatility in the market.

The other indicator of risk appetite in stock exchange, measures by capitalization and volatility in stock exchange market. In my study it is emphasize by changes in VIX index and capitalization measures. Falls of return on assets can occur when a shock is experienced. Several studies establish the significance of volatility as an important measure of financial soundness of the banking system, because of short sell problem. Bank threat liquidity problem when they can't sell assets of its investment portfolio. Risk affecting by liquidity can effect banking sector banking instability. Each bank can issue and repurchase stocks at current market prices to optimise the capital structure.

Economic cycle measure as *GDP growth* impacts on systemic risk by lending activity and by credit quality. The improvement in macroeconomic conditions increases demand for credit by enterprises and households so has a positive effect on the banks profitability but cause taking additional risk Albertazzi and Gambacorta (2009). On the other hand, poor macroeconomic conditions can worsen the quality of the banking loan portfolio and consequently generate credit losses and increase banks default probability. Such conditions will result in increasing systemic risk in banking sector. The question is whether the systemic risk has procyclicality?

An environment of low interest rates in economy results in bigger competition among banks. It could cut the opportunity for banks to get appropriate prices for lending and deposits activity. It puts pressure on the margin and consequently negatively influences bank stability. On the other hand, high interest rates could result in the debt repayment difficulty among borrowers. Consequently, rising interest rate payments may lead to a higher number and volume of non-performing loans Karkowska, Chodnicka, Olszak (2013), García-Herrero et al. (2009) and Staikouras and Wood (2003).

3.2 Banking sector specific variables

Causal link between concentration or competition and stability in the financial sector can be found in theory and data. Into consideration there were taken five variables: *Z-score* as the ratio of return on assets plus capital-asset-ratio to the standard deviation of return on assets. It is an indicator of banking stability. A higher Z-score indicates that the bank is more stable. *HHI* (Herfindahl–Hirschman Index) as market concentrations across banking markets, *CR5* is asset share of 5 largest banks, *NPL* - bank nonperforming loans to total gross loans.

The relationship between competition/concentration and stability is ambiguous in the academic literature. It can be distinguished two opposing views: the first one points to a negative relationship between competition and stability. The second one instead to a positive influence of competition on stability. If we consider systemic risk as the situation, when banks are unable to fulfill their intermediation function, the typically measures is market concentration, such as HHI. But market contestability is also important for evaluating competition in financial markets. The existence of entry barriers must be taken into account in evaluating financial system in a dynamic sense. A study using cross-country data set on 134 countries for the period 1993-2004 provides evidence of a positive relationship between competition and stability (Boyd, De Nicolò and Jalal, 2006). On the other the study of

Berger, Klapper and Turk-Ariss (2009) measures competition with the Herfindahl-Hirschmann index and stability with various measures of the probability of bank failure such as the z-score and the NPL, finds that institutions with a higher HHI are more likely to fail.

3.3 Bank's individual risk taking

As banking sector specific determinants of bank efficiency it was used five variables: *bank capital to assets ratio*, *leverage as* bank equity to total assets measure, *liquidity gap* measured as customer lending less customer borrowing normalized by customer lending, *ROA* - Average Return on Assets (Net Income/Total Assets) and *ROE* - Average Return on Equity (Net Income/Total Assets).

It was used *capital to assets* ratio as a measure of solvency risk. Anticipating the effect of changes in this variable is complex. Too high as well as too low values of capital ratio are not desirable in terms of bank operating efficiency. Sufficiently high capitalized banks are safer and remain profitable even in times of economic difficulties. Such banks benefit from both reduced funding costs and reduced need for external financing, which may have a positive effect on their stability.

Large changes in the *liquidity* of banks may perhaps indicate a crisis. As a result, liquidity risk may turn into solvency risk. Solvency risk can thus be affected by both asset return risk and liquidity risk. Further, banking crises indicator was employed by Demirguc¸-Kunt and Detragiache (2008) in which liquidity and solvency is a significant factor in analysis of banking instability.

There are two basic channels of propagation financial crisis — leverage and liquidity gap. Excessive leverage and funding gap make the real economy more fragile to adverse shocks. They act as amplifying mechanisms, increasing the effects of solvency and liquidity crisis on the wider economy (BoE, 2009:14, 16; Brunnermeier, Pedersen, 2009). Both

leverage, as a measure of solvency risk of a bank, and funding gap, as a measure of liquidity risk, can become excessive. Negative values for liquidity gap suggest low liquidity risk. The higher the positive value of liquidity gap the higher is liquidity risk. Excessively negative value of liquidity gap may be a proof of bank's inability to convert deposits into income earning assets. But extremely large positive values of this measure indicate excessive dependence of banks on retail money markets, which may bring about vulnerability of banks to financial crises. The recent global financial crisis is mostly attributed to build-up of excessive leverage. The study was focus on two measures of bank efficiency: ROA and ROE, to investigate whether systemic risk of banks operating in Central and Eastern Europe is affected by profitability. In order to test the hypotheses it was implemented the quantitative measures presented in Table 1 to capture above mentioned dimensions of stability in a comparative static analysis.

Table 1 Systemic risk determinants

Target complex/ variables:		**Measure(s):**	**Expected effect on systemic risk:**
Market and macroeconomy:	LIQUIDITY	ON BID ASK spread	Positive
	MONETARY	central bank base rate	???
	VIX	VIX volatility index	Positive
	CAP	indicator of stock exchange capitalization to GDP	Positive
	MMR	money market rate	???
	GDP	real GDP growth	Negative
Banking sector specific variables:	HHI	Herfindahl–Hirschman Index as market concentrations	???
	NPL	bank nonperforming loans to total gross loans	Negative
Bank's individual risk taking:	CAPITAL	bank capital to assets ratio	Positive
	LEVERAGE	bank equity to total assets	Negative
	LIQUIDITY GAP	liquidity gap (customer lending - customer borrowing) customer lending	negative

	ROA	Average Return on Assets (Net Income/Total Assets)	Positive

Source: own study

4. DATA AND METHODOLOGY

The study was divided into two part: the first one, in which it was calculated systemic risk in selected European banking systems, using Contingent Claims Analysis (CCA); the second one, in which it was estimated systemic risk determinants.

In the first step - CCA method of systemic risk measures has been used to estimate the market value of the assets of European commercial banks listed on stock exchange. In the study it was applied quarterly data from a period of December 2004 - December 2012, because of limited availability of banking variables, which are listed on stock exchange.

Bank-level data from 2004 through 2012 (49 quarterly periods) are constructed from two sources. Stock prices and returns are obtained from Eikon Thomson Reuters. Quarterly balance sheet accounting data come from Bankscope. Macroeconomic data are downloaded from the website maintained by the OECD. It was conducted for the selected 21 largest commercial banks, listed on stock exchange from seven Central and Eastern European countries: Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland, Romania. They were choosen only 21 banks, because that is all, that are traded in a public market (for which data were available). General characteristics of the data are presented in Table 3.

4.1 CCA method description

In order to understand the individual institutional exposure to systemic risk in times of crisis, the method of the CCA and its technique of using risk-based balance sheets of financial institutions are worth analyzing. The CCA method assumes that the total market value of bank assets at any time T is equal to the sum of the market value of equity E and its "risky" debt D at time T. The term of "risky debt" is due to the fact that there is always a chance of

company insolvency. The regulation of payment of "risky debt" depends on the quality of bank assets, therefore being a claim against the assets of uncertain value. This type of claim is known as a conditional claim. The methodology of the study has been presented previously by Karkowska (2012).

At the time of bankruptcy shareholders receive payment in the amount of A-B, if $A > B$, or do not receive anything if $A < B$, where A is the market value of the assets, B – the liabilities (without equity). Similarly, we can compare the situation of a shareholder to that of a holder of a call option on the assets of the company. Exercise of the option occurs when it is in-the-money, which means $A > B$, while in the opposite situation, when the option is out-of-the-money, the shareholder does not exercise it (the situation of loss of the ability to pay where $A \leq B$).

The CCA method describes the relation between the value of assets and the capital of the analyzed subject, derived from the theory of Black-Scholes option pricing model (Hull, Nelken, White, 2003).

$$E_T=\max[A_T-B, 0] \tag{4.1}$$

where:

E_T - value of equity at the time T,

Assets take a random distribution and may fall below the value of liabilities which is equal to the level of a bank failure B (often referred to as the "default point" or "distress barrier"). Using the Black-Scholes-Merton model, the value of equity can be expressed as an implied call option on the bank assets with an exercise price equal to the level of B, which is expressed by the formula (4.1) (Gray, Jobst, Malone, 2011).

$$E_T=A_T\, N(d_1) - Be^{-rT}\, N(d_2) \tag{4.2}$$

where:

E_T – option value equal to the value of the bank capital at the time T,

A_T – value of the underlying bank assets at the time T,

B – exercise price equal to the value of liabilities,

r – risk free rate,

T – time to maturity option,

$N(d_i)$ – value of the distribution function for a standardized normal distribution equal to the argument d_i, where i=1, 2

$N(d_2)$ – probability of exercising a call option,

$1\text{-}N(d_2) = N(-d_2)$ – probability of losing the ability to pay,

$$d_1=[\ln(A_T/B) + (r+\sigma_A^2/2)T](\sigma_A\sqrt{T})^{-1}$$

$$d_2=d_1 - \sigma_A\sqrt{T}$$

σ_A – bank assets volatility.

In the model, the variables E, B, T, r are directly observable, but the market value of bank assets (A) and its volatility (σA) are not directly observable. Therefore, in order to estimate the market value of the asset and its variability the relationship (Hull, 2003) was used as well.

$$\sigma_E E = N(d_1)\, \sigma_A A, \tag{4.3}$$

where:

σ_E – volatility of the bank equity.

With equations (4.2) and (4.3) we can calculate the market value of bank assets *(A)* and its volatility *(σA)* by successive iterations by comparing the two equations to zero.

$$A_T N(d_1) - Be^{-rT} N(d_2) - E_T = 0 \quad (4.4)$$

$$N(d_1)\, \sigma_A A - \sigma_E E = 0 \quad (4.5)$$

Minimizing the value of the expression (4.6) estimate the value of assets and volatility:

$$[A_T N(d_1) - Be^{-rT} N(d_2) - E_T]^2 + [(N(d_1)\, \sigma_A A - \sigma_E E]^2 \rightarrow \min \quad (4.6)$$

The estimated value is a market asset value, as assessed by investors. Let us assume that the relevant bank has a simple structure of financing (equity and foreign liabilities with maturity T). The bank's loss of the ability to pay occurs when at the time T the value of the assets is smaller than the liabilities. It follows that the loss of solvency is a function of the capital structure, the volatility rate of return on assets and the current market value of assets. When marking the probability to lose the ability to pay by the bank P_{def} we get:

$$P_{def} = Pr\,[V \leq V_{def}] = Pr\,[\ln V \leq V_{def}] \quad (4.7)$$

When estimating the probability of losing the ability to pay in the KMV model defined by (4.7), we assume that the random variable – the return on assets adopts normal distribution, and therefore can be represented as a cumulative normal distribution of P_{def}. Which means that we can find the value of a normally distributed variable Z, that decline in the value of assets below this level will mean the bank loss of the ability to pay:

$$P_{def} = Pr[\ln A_0 + [(\mu - \frac{\sigma_A^2}{2}t + \sigma_A \sqrt{t} Z_t \leq \ln A_{def}] \quad (4.8)$$

After the appropriate transformations we can determine the probability as:

$$P_{def} = Pr\left[\frac{\ln\left(\frac{V_0}{V_{def}}\right)-\left(\mu-\frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}} \geq Z_t\right] = Pr\left[Z_t \leq -\frac{\ln\left(\frac{V_0}{V_{def}}\right)-\left(\mu-\frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}}\right] = N(-d_2) \quad (4.9)$$

where:

P_{def} – probability of the bank failure,

V_0 – market assets value,

V_{def} – limit of the assets value resulting in bankruptcy,

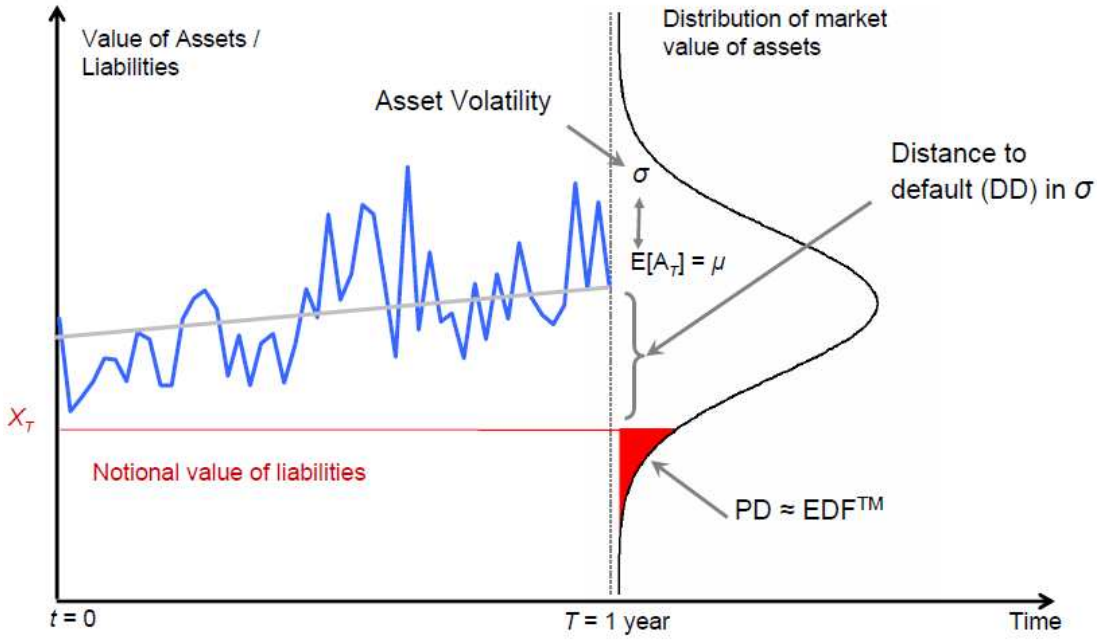
σ_A – asset volatility,

μ_A – the actual expected rate of return on assets,

t – time to option expiration.

The algorithm (4.9) is defined in literature as a DtD - Distance to Default, the number of standard deviations between the expected value of assets and the level of causing the loss of ability to pay. Use the process of estimating the likelihood of using KMV estimator turns out to be a better credit risk than the actual statistics of rating agencies - such conclusions were reached in the studies by (Kealhofer, McQuown and Vasicek, 2007). The distribution of assets at time T of the selected barrier solvency is presented in the Figure 1.

Figure 1 Distribution of assets and the process of finding the probability of default



As the risk-free rate is the central bank's reference rate, while the market value of equity is adopted as the capitalization of individual banks on the stock exchange. Finally we find the market value of banking assets, based on market participants' expectations. The calculation of the market assets value is based on Merton's model and were calculated by means of Microsoft Excel Solver. As the indicator of systemic risk is difference between calculated market value of banking sector assets and the book value. Positive values indicate that there is a surplus of the market value of bank assets over book value (there is no systemic risk). On the other hand, negative values suggest that market participants assessed the value of bank assets below book value and the bank may have problems with solvency. Differences in asset values are presented in Table 2 for each bank individually and for the whole banking sector in each country.

4.2 Systemic risk determinants panel model

Because the results showed a large discrepancy we decided to look for reasons for the different phenomena. In the second step it has been investigated determinants of calculated systemic risk in banking systems of CEE country. It was applied the 21 banks covered by

largest commercial banks listed on stock exchange. As the estimation model was used one – step Arellano – Bond (1991) GMM difference estimator for panel data with lagged dependent variable. The model data sources and descriptions are preseted in Table 3. The final version of the model is given by equation (4.10) below:

$$y_{i,t} = \sum_{k=1}^{2} \alpha_k y_{j,t-k} + \sum_{k=0}^{2} \beta_k x_{j,t-k} + \theta_t T_t + \mu_j + \varepsilon_{j,t} \quad (4.10)$$

where:

$y_{i,t}$ is the income statement component examined, i.e. systemic risk $SRISK_{j,t}$;

$x_{j,t}$ is a vector of explanatory variables, i.e. :

$x_{i,j} = [\ln LIQUIDITY_{j,t}, MONETARY_{i,j}, \ln VIX_{i,j}, \ln CAP_{i,j}, MMR_{i,j}, GDP_{i,j}, HHI_{i,j}, NPL_{i,j}, CAPITAL_{i,j}, LEVERAGE_{i,j}, LGAP_{i,j}, ROA_{i,j},]$

, where: $LIQUIDITY_{i,j}$ is log of ON spread, $MONETARYi,j$ is central bank base rate, $VIX_{i,j}$ is log of CBOE VIX volatility index, $CAP_{i,j}$ is indicator of stock exchange capitalization to GDP, $MMR_{i,j}$ – money market rate, $GDP_{i,j}$ is the GDP growth. $HHI_{i,j}$ (Herfindahl–Hirschman Index) as market concentrations across banking markets, *NPL* - bank nonperforming loans to total gross loans, $CAPITAL_{i,j}$ - bank capital to assets ratio, $LEVERAGE_{i,j}$ is bank equity to total assets, $LGAP_{i,j}$ is the liquidity gap measured as customer lending less customer borrowing normalized by customer lending, $ROA_{i,j}$ - Average Return on Assets (Net Income/Total Assets), , T_t is a vector of year-dummies; μ_j is an unobservable time-invariant country effect. Panel model determinantes descriptive statistics are presented in Table 4.

Due to the fact that the consistency of GMM estimator depends on the validity of instruments applied in the model (4.10), it was consider two specification tests suggested by Arellano and Bond (1991). The first, is a Sargan test of over-identifying restrictions, which

checks the overall validity of the instruments. The other, examines the hypothesis of absence of second-order serial correlation in the first-difference residuals.

5 EMPIRICAL RESULTS

In this paper, it was used CCA methodology to measure the systemic risk of banking systems in selected CEE countries. It was applied this methodology to the 21 banks covered by largest commercial banks listed on stock exchange. The study finds the estimation of market assets value in individual commercial banks and total in CEE coutries. The indicator of systemic risk is difference between calculated market value of banking assets and the book value. Positive values indicate that there is a surplus of the market value of bank assets over book value (there is no risk systemic risk). On the other hand, negative values suggest that market participants assessed the value of bank assets below book value and the bank may have problems with solvency. The results of the 2006-2012 period of time are presented in Table 2. It was creating a map of risk in CEE banking systems.

The highest values of systemic risks shall cover the period of the financial crisis (September 2008 - June 2009) in the banking system Polish and Hungarian. In the individual analysis most threatened were: BRE Bank, Bank BPH, OTP Bank. The period before the crisis, most of it can be assumed to be safe, with the exception of individual units: ING Bank, Bank BPH and Latvijas Krajbanka. Wonder and anxiety can raise the fact that there is still a danger systemic risk in the CEE countries that are considered safe. The study showed that even in December 2012, the analysis showed worrying developments in Hungary, where the underestimation of OTP Bank's assets fall below EUR 3 000 million. Also questionable situation is in: the Bulgarian, Romanian, Lithuanian and Latvian banking system. Risk map shows that only individual banks, such as the Czech Komercni Banka, Bulgarian Corporate

Commercial Bank, the Polish Bank Pekao and PKO BP did not show systemic risk threat throughout the research.

The second step of research finds systemic risk determinants. Results suggest that the systemic risk in the banking sector is driven initially by mainly by bank specific risk premiums and later by the market determinants, like volatility and stock exchange capitalization. Table 6 reports the results of analysis of three groups of factors: 1/ market and marco determinants, 2/ banking sector specific variables, 3/ risk taking by individual banking. The first part of Table 5 reports the results of market and macro determinants. SRISK is significantly affected by only market specific variable, i.e. negative by stock exchange capitalization CAP and positive by volatility VIX. The positive impact of VIX on SRISK suggests that with rising volatility in the market, the banking systems instability. The negative impact of CAP is probably connected with a decrease in the possibility of liquidity regulating by banks during periods of downturn. In the regression (No1) a significant influence also proved to be LIQUIDITY in the interbank market. It is the results of traditional activity in CEE banking systems - the interbank market is used as a source of money loans and deposit for banks. Lack of liquidity in this market raises a number of instability risks. Liquidity is a significant factor in analysis of banking instability employed by Demirguc¸ -Kunt and Detragiache (2008).

Marco determinants, as GDP, monetary policy and interest rates proved to be no significant impact on the variability of systemic risk in CEE countries. The interactions between the value of GDP growth and the changes in banks stability are mostly negative but not significant. Our lagged dependent variable, which measures the degree of persistence of our systemic risk is statistically significant across all models, indicating a high degree of persistence of bank instability and justifying the use of a dynamic model.

In the second part of Table 5 (regression No2) it was estimated also the impact of banking sector specific variables. Systemic risk is mostly dependent on variables specific to the banking sector. Variable significantly affecting the volume of systemic risk is change in the banking systems concentration - more concentrated market improved probability of systemic crisis. In each of the models important and positive factor is non-performing loans NPL. It suggests a significant impact of credit risk and solvency on the stability of the CEE banking systems.

The last final model (regression No3) include also individual banks factors. Taking into account the liquidity (LGAP) and solvency (LEVERAGE) risks taken by individual commercial banks, it should be noted that although the effect is statistically significant but it is the smallest. The results are not in line with Brunnermeier and Pedersen (2009). Without affecting the increase of systemic risk is banks efficiency - ROA. Another words raising banking systems profitability, the systemic risk is not increasing. Similar results we obtained by analyzing the equity to assets indicator.

6. CONSLUSION

The aim of the study was to calculate the systemic risk in CEE banking systems and identify its changes. Also it was investigated the determinants of these banking instability using panel regression models. Our results present interesting conclusions. Firstly, the study supports to the recent economist study on the increased systemic risk complexity and heterogeneity. The results show that banking instability is changing across countries and time. There is still a problem of systemic risk in CEE banking systems. The measures is not perfect, as was mentioned in the introduction has flaws, but it seems to be considered to support policy discussion and analysis. May be as CEE banking early warning indicators, such as in the stress testing exercise. Models provide measurement frameworks and facilitate

communication and criticism. The study could be the step to expanded new regulation and put pressures on banking supervision to develop useful measurements of systemic risk. Secondly, it was created the map of the most and the least instable individual bank and banking systems in Central and Eastern Europe. The above-mentioned decomposition could be used to examine to what degree the CEE banking instability can be explained by the risk premium versus default risk component. In the third, banking systemic risk dependent on many factors, as: banking systems specific variables, market volatility and liquidity. A decomposition analysis shows that the individual banks factors are marginal contributions to the systemic risk. The indicators are determined mostly by outside determinants, consistent with the banking systems concentration and correlation. Primary risk management of the financial system came down to the concept of a central bank as a lender of last resort before releasing domino effect. This concept has proved ineffective. Research has shown limited possibilities for monetary policy. And finally, the study finds negative relation between banking system stability and GDP cycle, which confirm hypothesis that systemic risk in CEE banking is not procyclical. It partly explain why different commercial banks had distinct contribution to the global crisis.

Nevertheless, confronting the various analysis of uncertainty with some measurability will help us to use models in meaningful ways.

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Table 2 Systemic risk map in CEE banking systems during the period December 2012 - December 2006 (in mln EUR)

Bank	Dec' 12	Jun' 12	Mar' 12	Dec' 11	Sep' 11	Jun' 11	Mar' 11	Dec' 10	Sep' 10	Jun' 10	Mar' 10	Dec' 09	Sep' 09	Jun' 09	Mar' 09	Dec' 08	Sep' 08	Jun' 08	Mar' 08	Dec' 07	Sep' 07	Jun' 07	Mar' 07	Dec' 06
Bulgarian-Amer Credit Bank	-12	-46	-51	-53	-65	-56	-39	-32	-35	-42	-11	2	15	-40	-59	-35	157	305	362	442	462	470	370	
Centr. Cooper. Bank	-98	-145	-137	-129	-112	-94	-76	-105	-92	-88	-77	-78	-73	-86	-111	-107	-8	73	124	302	254	254	205	196
Corp. Comer. Bank	21	18	20	48	45	49	80	29	21	43	38	27	20	34	42	40	134	169	158					
First Invest.Bank	-87	-171	-143	-139	-107	-62	-40	-104	-113	-109	-95	-88	-65	-121	-174	-148	32	157	220					
Bulgaria Total	**-176**	**-344**	**-311**	**-274**	**-238**	**-162**	**-75**	**-212**	**-219**	**-196**	**-146**	**-138**	**-102**	**-214**	**-303**	**-250**	**315**	**705**	**864**	**744**	**716**	**724**	**575**	**196**
Banca Carpatica	-128	-165	-120	-137	-91	-61	-64	-49	-46	-52	-49	-84	-73	-85	-76	-16	-6	5	7	106	103	118	117	101
Banca Transilvania	-345	-472	-402	-478	-368	-246	-236	-310	-210	-212	-86	-197	-310	-514	-667	221	203	248	442	760	389	402	324	298
Romania Total	**-473**	**-638**	**-522**	**-615**	**-459**	**-307**	**-299**	**-359**	**-256**	**-264**	**-135**	**-282**	**-383**	**-599**	**-744**	**205**	**197**	**253**	**449**	**865**	**492**	**521**	**441**	**399**
Latvijas Krajbanka								-49	-65	-74	-82	-125	-94	-134	-146	-232	-115	-86	-41	-31	-12	6	27	-8
Latvia Total								**-49**	**-65**	**-74**	**-82**	**-125**	**-94**	**-134**	**-146**	**-232**	**-115**	**-86**	**-41**	**-31**	**-12**	**6**	**27**	**-8**
Bankas Snoras								18	-39	-81	-48	-69	-48	-193	-161	-255	-215	-140	-139					
Siauliu Bankas	-12	-34	-26	-32	-30	-18	-12	-8	-18	-21	-17	-19	-21	-63	-52	-60	-34	2	23	39	62	45	30	26
Ukio Bankas	-5	-79	-74	-88	-92	-53	-40	-24	-57	-75	-47	-56	-68	-136	-114	-170	-122	-52	-4	10	83	72	68	59
Lithuania Total	**-17**	**-114**	**-100**	**-120**	**-122**	**-71**	**-52**	**-14**	**-114**	**-177**	**-112**	**-144**	**-137**	**-393**	**-327**	**-485**	**-372**	**-189**	**-120**	**49**	**145**	**117**	**98**	**85**
FHB Jelzalogbank	-287	-260	-232	-256	-246	-144	-123	-149	-51	-80	21	-34	-52	-234	-279	-211	-111	-65	-22	110	180	212	158	132
OTP Bank	-3476	-3363	-3018	-3742	3346	-585	-834	-1309	-978	1523	-675	-669	-1112	-3087	-5049	-3630	-383	393	888	3178	4151	5354	3538	3876
Hungary Total	**3763**	**3623**	**-3250**	**-3998**	**3592**	**-729**	**-956**	**-1458**	**1029**	**1603**	**-696**	**-704**	**-1164**	**-3321**	**-5328**	**-3841**	**-493**	**328**	**867**	**3288**	**4331**	**5566**	**3696**	**4007**
Komercni Banka	1598	1702	2025	1587	1734	3012	3256	3433	2622	2119	2609	2959	2377	1209	227	1429	2596	2451	2650	3670	4013	3453	2824	2105
Czech R. Total	**1598**	**1702**	**2025**	**1587**	**1734**	**3012**	**3256**	**3433**	**2622**	**2119**	**2609**	**2959**	**2377**	**1209**	**227**	**1429**	**2596**	**2451**	**2650**	**3670**	**4013**	**3453**	**2824**	**2105**
Bank PEKAO	2584	2942	3107	2437	2210	4243	4707	5434	5118	4292	4919	4815	4407	2191	294	2729	5514	5469	7119	9074	6944	7645	7427	6336
BRE Bank	3109	2922	-184	-445	-398	591	972	633	276	10	87	216	-1176	-1913	-2757	-1128	365	760	958	2159	2304	2634	2308	1384
ING Bank	-924	-847	370	159	106	610	1171	940	761	604	592	801	298	-926	-1367	-747	-1279	-1425	-1189	-190	378	713	145	447
Millenium	-852	-559	-294	-495	-216	89	356	83	158	-58	-23	-95	-820	1558	-1873	-1200	68	312	664	1423	1518	1814	1524	868
PKO BP	3598	2964	2628	2361	2831	5917	6420	6588	6479	4391	5726	5320	3427	1614	551	3721	5583	6442	6299	8545	9401	9594	8046	7916
Bank HANDLOWY	142	528	-803	-2862	-2228	-1543	-1837	1104	927	557	688	431	99	-333	-719	-418	213	774	942	1354	1824	2310	1344	1122
BOS Bank	-276	-292	-248	-289	-187	-157	-125	-141	-97	-82	-40	-12	-93	-97	-71	-17	-66	-68	-40	-27	4	-9	33	28
Bank BPH	-543	-701	-640	-841	-549	-332	-29	-74	3582	4120	-3256	-4300	2423	2623	-2941	-6628	-1786	-1667	-1576	-1501	-1133	-953	-1047	-1119
Poland Total	**6838**	**6956**	**3937**	**26**	**1568**	**9418**	**1163 6**	**1456 7**	**1004 1**	**5594**	**8694**	**7177**	**3720**	**-3645**	**-8883**	**-3688**	**8611**	**1059 7**	**1317 7**	**2083 7**	**2124 0**	**2374 7**	**1978 0**	**1698 1**

Table 3 Panel data sources and descriptions

Variable	Source	Kind of observation
SRISK	Own calculation (BS- model) based on bank's balance	Yearly observation from each CEE banking systems
LIQUIDITY	Reuters Eikon data	Yearly observation from each CEE money market
MONETARY	Reuters Eikon data	Yearly observation from each CEE central banks
VIX	Reuters Eikon data	Yearly observation from Chicagi Board Options Exchange CBOE
CAP	WORLD BANK data base	Yearly observation from each CEE stock exchanges
MMR	Reuters Eikon data	Yearly observation from each CEE money markets
GDP	OECD data base	Yearly observation from each CEE countries
HHI	WORLD BANK data base	Yearly observation from each CEE banking systems
NPL	WORLD BANK data base	Yearly observation from each CEE banking systems
CAPITAL	WORLD BANK data base	Yearly observation from each CEE banking systems
LEVERAGE	Own calculation (BS- model) based on bank's balance	Yearly observation from selected commercial banks
LIQUIDITY GAP	Own calculation (BS- model) based on bank's balance	Yearly observation from selected commercial banks
ROA	WORLD BANK data base	Yearly observation from each CEE banking systems

Table 4 Panel model determinantes descriptive statistics

Variable	Average	Median	Min	Max	Standard deviation
SRISK	-0,2536	-0,2088	-4,8356	2,8034	1,3545
LIQUIDITY	0,5353	0,4000	0,0800	2,0000	0,4211
MONETARY	-0,2402	-0,0897	-2,7081	0,5577	0,6438
VIX	0,0573	-0,0432	-0,6125	0,6660	0,4376
CAP	-0,0825	-0,0408	-1,2174	0,8219	0,4924
MMR	0,0404	0,0486	-0,1249	0,2036	0,0541
GDP	-0,3776	-0,0770	-3,6938	1,6983	1,0512
HHI	0,0985	0,0871	0,0559	0,1913	0,0357
NPL	0,2618	0,1295	-0,3282	1,8214	0,5024
CAPITAL	-0,0110	0,0853	-0,8800	0,2977	0,2947
LEVERAGE	0,3818	0,2495	-0,2082	1,9414	0,6224
LIQUIDITY GAP	0,0897	0,0997	-0,0766	0,2262	0,1544
ROA	-0,0309	-0,1154	-0,9800	1,6650	0,5384

Table 5 Determinantes of systemic risk in CEE coutry commercial banks. Panel model estimations.

DEPENDENT VARIABLE: SRISK							
INDEPENDENT VARIABLES:		***Regression 1 Market & macro model***		***Regression 2 Market & macro + Banking sector specific model***		***Regression 3 FINAL MODEL***	
		Coef.	p-value	Coef.	p-value	Coef.	p-value
Market & macro variables	***SRisk(-1)***	-0,216614	*	-0,00663602	*	0,0371537	*
	SRisk(-2)	-0,307965	***	-0,00476545	**	-0,019684	*
	CONST	0,494863	*	0,477856	**	0,526591	*
	LIQUIDITY	0,989835	*	0,27472		0,255186	
	MONETARY	0,180512		0,0563186		0,333324	
	VIX	1,2212	*	0,95078	*	1,29886	*
	CAP	-0,972679	**	-0,979241	***	-1,31744	***
	MMR	0,0036472	*	0,0010831		0,0089161	
	GDP	-0,107193		-0,129886		-1,4097e-06	
Banking sector specific variables	***HHI***			0,431	**	0,8568	***
	NPL			0,08496	*	0,44014	**
Bank individual specific variables	***CAPITAL***					0,113202	
	LEVERAGE					0,0091452	*
	LIQUIDITY GAP					0,0001523	*
	ROA					0,435684	
Tests	***MA1***	0.0123		0.0190		0.0000	
	MA2	0.2205		0.1931		0.1628	
	Sargan test	0.0752		0.0907		1.0000	

Source: own study