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# INSTABILITY IN THE CEE BANKING SYSTEM. EVIDENCE FROM THE RECENT FINANCIAL CRISIS

Renata Karkowska\*

**Abstract:** Sparked by the recent great recession and the role of financial markets, considerable interest exists among researchers within both the academic and public community in measuring and modeling systemic risk. This article introduces a new framework for measuring systemic risk by using a risk-adjusted balance sheet approach. In this regard, the analysis of 21 largest commercial banks operating in 7 countries from Central and Eastern Europe, shows potential risk which could threaten all the financial system. The paper concludes new directions for measuring systemic risk by using Merton model. It shows how risk management tools can be applied in new ways to measure and analyze systemic risk in European banking system.

**Keywords:** systemic risk; Merton model; financial crisis; banking system **JEL Classification**: G1; G11; G10; E44

### **INTRODUCTION**

The banking sector is by far the 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, which are forward-looking. Therefore, in the first step of this article author 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. The study is a continuation of previous studies carried CCA method for the Polish banking sector.

<sup>\*</sup> PhD Renata Karkowska, Institute of Financial Systems of Economy, Faculty of Management, University of Warsaw, Szturmowa 1/3, post code 02-678 Warsaw, Poland, e-mail: rkarkowska@wz.uw.edu.pl.



The main hypothesis is: Central and Eastern European banking systems are not devoid of systemic risk. The threat of a systemic crisis is ever-present.

Merton's model has been used to measure banking systemic risk. The approach was applied to the 21 commercial banks covered by Central and Eastern Europe during the period from December 2006 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.

The paper is structured as follows: Section 1 surveys the relevant literature on systemic risk and its reasons. Section 2 presents the data sample and methodology applied. Section 3 presents the results of the investigation. Section 4 concludes.

### **1. LITETERATURE 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. In the literature review we have found a few specific approaches for assessing systemic risk along with different kind of data and models.

The survey 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).

CES Working Papers – Volume V, Issue 4

The second approach is network models of the financial system. The information about financial firm network is very useful in prediction turbulences, 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 survey 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 (2011), 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 author 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 we 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).

Author decided to use CCA method to calculate systemic risk in banking of European emerging markets.

#### 2. DATA AND METHODOLOGY

The survey was based on systemic risk calculation in selected European banking systems, using Contingent Claims Analysis (CCA).

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 2006 - December 2012, because of limited availability of banking variables, which are listed on stock exchange.

It was conducted for the selected 21 largest commercial banks from seven Central and Eastern European countries: Bulgaria, Czech Republic, Hungary, Lithuania, Latvia, Poland, Romania. Data on the size of selected assets and liabilities come from the banks' financial statements, and market data were obtained from Reuters Eikon. Because of the attention to the most accurate results, the variables are related to quarterly periods. General characteristics of the data used to calculate systemic risk are presented in Table 1 (Annex).



#### 2.1. 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" 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  $A \le B$ ).

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).

$$E_T = max[A_T - B, 0]$$

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 (2.1) (Gray, Malone, 2011).

$$E_T = A_T N(d_1) - Be^{-rT} N(d_2)$$



(2.2)

(2.1)

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,

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

$$d_{I} = [ln(A_{T}/B) + (r + \sigma_{A}^{2}/2)T](\sigma_{A}\sqrt{T})^{-1}$$
$$d_{2} = d_{I} - \sigma_{A}\sqrt{T}$$

 $\sigma_A$  – 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 ( $\sigma A$ ) 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.

$$\sigma_E E = N(d_I) \ \sigma_A A,$$

where:

 $\sigma_E$  – volatility of the bank equity.

With equations (2.2) and (2.3) we can calculate the market value of bank assets (*A*) and its volatility  $(\sigma A)$  by successive iterations by comparing the two equations to zero.

$$A_T N(d_1) - Be^{-rT} N(d_2) - E_T = 0$$
(2.4)

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

(2.5)

(2.3)



Minimizing the value of the expression (2.6) estimate the value of assets and volatility:

$$[A_{T} N(d_{1}) - Be^{-rT} N(d_{2}) - E_{T}]^{2} + [(N(d_{1}) \sigma_{A} A - \sigma_{E} E]^{2} \rightarrow min$$
(2.6)

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<sub>def</sub> we get:

$$P_{def} = \Pr\left[V \le V_{def}\right] = \Pr\left[\ln V \le V_{def}\right]$$

$$(2.7)$$

When estimating the probability of losing the ability to pay in the KMV model defined by (2.7), 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:

$$P_{def} = \Pr[\ln A_0 + [(\mu - \frac{\sigma_A^2}{2}t + \sigma_A \sqrt{t} Z_t \le \ln A_{def}]]$$
(2.8)

After the appropriate transformations we can determine the probability as:

$$P_{def} = \Pr\left[\frac{\ln\left(\frac{v_0}{v_{def}}\right) - \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}} \ge Z_t\right] = \Pr[Z_t \le -\frac{\ln\left(\frac{v_0}{v_{def}}\right) - \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}}] = N(-d_2)$$
(2.9)

where:

 $P_{def}$  – probability of the bank failure,

 $V_0$  – market assets value,

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

 $\sigma_A$  – asset volatility,

 $\mu_A$  – the actual expected rate of return on assets,

t – time to option expiration.

The algorithm (2.9) 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. The calculation of the assets market value is based on Merton's model and were calculated by means of Microsoft Excel Solver.

#### **3. EMPIRICAL RESULTS**

In this paper, we advocate a methodology to measure the systemic risk of banking systems in selected CEE countries. We applied this methodology to the 21 banks covered by largest commercial banks listed on stock exchange. The results are presented in Table 2 (Annex).

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.

#### CONCLUSIONS

The aim of our study was to calculate the systemic risk in CEE banking systems and identify its changes. We also try to investigate the determinants of these banking instability using panel regression models. Our results present interesting conclusions. Firstly, we do support to the recent economist survey on the increased systemic risk complexity and heterogeneity. Our results show that banking instability is changing across countries and time. Models provide measurement frameworks and facilitate communication and criticism. Our 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. The survey could be the step to expanded new regulation and put pressures on banking supervision to develop useful measurements of systemic risk. Secondly, we create the map of the most and least instable banking systems in Central and Eastern Europe and confirm instability of CEE banking systems still yet. 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.

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## ANNEX

## Table 1 - Model CCA data description

Country	Bank	Median of equity value (EUR mln)	Average book value of assets (EUR mln)	Average market capitalisation (EUR mln)	Average systemic risk (EUR mln)
ulgarian banking system	Bulgarian-American Credit Bank	93,27	376,98	99,79	-33,53
	Central Cooperative Bank	117,33	872,21	69,40	-82,38
	Corporate Commercial Bank	143,23	1089,15	230,77	41,36
	First Investment Bank	206,62	2190,15	134,26	-105,65
	Bulgarian summary	560,45	4528,49	534,21	-180,20
	Banca Comerciala Carpatica	49,97	520,04	82,48	-46,26
	Banca Transilvania	320,20	3559,33	456,30	115,51
Romanian banking system	Romanian summary	370,16	4079,37	538,78	69,25
	Latvijas Krajbanka	51,83	731,74	46,68	-36,00
Latvian banking system	Latvian summary	51,83	731,74	46,68	-36,00
Lithuanian banking system	Bankas Snoras	159,90	2606,24	127,51	-110,10
	Siauliu Bankas	74,52	601,58	62,26	-17,10
	Ukio Bankas	124,27	1223,89	86,24	-50,66
	Lithuanian Summary	358,69	4431,71	276,01	-177,87
	FHB Jelzalogbank	120,37	2105,41	228,42	-20,67
	OTP Bank	2395,89	22151,28	4503,88	447,34
Hungarian banking system	Hungarian summary	2516,26	24256,68	4732,30	426,68
	Komercni Banka	2123,66	23160,57	4723,75	2609,25
Czech banking system	Czech summary	2123,66	23160,57	4723,75	2609,25
Polish banking system	Bank PEKAO	2997,33	23483,30	9771,56	5066,85
	BRE Bank	897,03	13391,28	2627,41	383,74
	ING Bank	974,02	11841,53	2406,85	313,96
	Millenium	638,87	7772,16	1395,08	71,58
	PKO BP	3615,12	32329,99	11464,97	6025,09
	Bank HANDLOWY	1466,79	9424,69	2613,19	555,73
	BOS Bank	207,08	2479,23	301,27	-74,45
	Bank BPH	1182,94	10609,36	702,41	-1579,67
	Polish summary	11979,18	111331,55	31282,75	2690,71

Source: own calculation



Bank	Dec'	Jun'	Mar'	Dec'	Sep'	Jun'	Mar'	Dec'	Sep'	Jun'	Mar'	Dec	Sep'	Jun'	Mar'	Dec'	Sep'	Jun'	Mar'	Dec'	Sep'	Jun'	Mar'	Dec
	12	12	12	11	11	11	11	10	10	10	10	09	09	09	09	08	08	08	08	07	07	07	07	05
Bylgarian-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	105	103	118	117	101
Banca <u>Transilvania</u>	-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
<u>Ukio Bankas</u>	-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	-	-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	2050	2377	1209	227	1479	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	105	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	6	1456	1004	5594	8694	7177	3720	-3645	-8883	-3688	8611	1059	151/	2085	2124	25/4	19/8	1098

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

>0 =[ 0 - 1000 ] =[ -1001; -2000 ] <-2000