



UW Faculty of Management
Working Paper Series
No 1 / February 2015

The Approach of CoVaR in Estimating Systemic Risk

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JEL classification: G01, G10, G20, G28, G38

Keywords: Systemic Risk, Value at Risk, Risk Spillovers, Banking Sector

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Faculty of Management Working Paper Series No 1/ 2015

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Publisher: University of Warsaw, Faculty of Management Press

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Str.: Szturmowa 1/3; 02-678 Warsaw, Poland

Telephone: +48 22 55 34 164

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ISSN 2300-4371 (ONLINE)

What kind of systemic risks do we face in the European banking sector? The approach of CoVaR measure

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Abstract

We measure a systemic risk faced by European banking sectors using the *CoVaR* measure. We propose the conditional value-at-risk (*CoVaR*) for measuring a spillover risk which demonstrates the bilateral relation between the tail risks of two financial institutions. The aim of the study is to estimate the contribution systemic risk of the bank i in the analyzed banking sector of a country in conditions of its insolvency. The study included commercial banks from 8 emerging markets from Europe, which gave a total of 40 banks, traded on the public market, which provided a market valuation of the bank's capital. The conclusions are that the *CoVaR* seems to be a better measure for systemic risk in the banking sector than the *VaR*, which is more individual. And banks in developing countries in Europe do not provide significant risk for the banking sector as a whole. But it must be taken into account that some individuals that may find objectionable. Our results hence tend to a practical use of the *CoVaR* for supervisory purposes.

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1. Introduction

During financial crises, losses tend to spread across the financial system more than average. The situation of crises gives rise to systemic risk. We define the systemic risk as the event in which spillovers across financial institutions can arise from liquidity spirals, fire-sales of assets and counterparty credit risk in financial sector. Systemic risk measures try to capture the potential spread of financial distress across sector. As a result, the correlation between the assets and liabilities of financial institutions tends to rise above the level excusably based on fundamental analysis. Therefore, it seems that the measures evaluating systemic risk should capture the potential spread of the difficult financial situation of the institution where deviation from the mean is higher (what is commonly referred to as extreme, "tail" part of the distribution of rates of return).

Recently MES, the so-called Marginal Expected Shortfall, of a financial institution, has been adapted as the systemic risk measurementⁱ. The measure is defined as the expected equity loss per sum invested in the institutions if the whole market declines by a certain amount (a "tail event" in the system). In turn, Brownlees and Engleⁱⁱ proposed a multi-step modeling approach based on GARCH, Dynamic Conditional Correlations (DCC). Acharya et al. found that the MES of a large sample of US financial institutions was a good predictor of the total decline in equity valuation of firms experienced during the crisisⁱⁱⁱ.

Lastly, the most common measure of risk used by banks is the value at risk (*VaR*), which estimates the risk of an individual institution. This proposed by the bank JP Morgan focuses mainly on the risks of individual institutions. The value of α -*VaR* is the maximum loss for a confidence level α , in the accepted interval Kupiec^{iv} and Jorion^v. Note, however, that the measure that estimates the risk of a single institution does not necessarily reflect systemic risk or threat to the stability of the financial system as a whole. According to the classification adopted by the Brunnermeier's⁷, Crocket, Goodhart, Perssaud and Shin^{vi}, a measure of systemic risk should determine the risk of the system by the individual systemically important institutions, which are connected to each other and so large that in case of a crisis may cause negative consequences for the other participants in the system, as well as the institutions that make up the system as a whole - "systemic as part of herd". The group of combined financial institutions that act as clones can be as dangerous to the system, as big systemically important entities Brady^{viii}, Rubin, Greenspan, Levitt and Born^{viii}, Brunnermeier^{ix} and Adrian and Shin^x. Second, risk estimates should take into account that the risk usually is the result of speculative bubbles and imbalances of the past, and materializes only in times of crisis.

Therefore, measures of risk, based on the high frequency data, which are based mainly on the current price movements are potentially confusing them and build regulatory requirements

appear to be at risk of pro-cyclicality. The following study aims to present the use of *VaR* measures for the verification of systemic risk, and the measurement of their value in the banking systems of 8 countries of developing Europe (Bulgaria, Latvia, Lithuania, Poland, Romania, Turkey, Ukraine, Hungary) in the period 2000-2012.

Measuring systemic risk to individual banks and national banking systems will be verified using the *CoVaR* method. Thus, the estimates will be made conditional on the selected institutions measure and relative to the entire financial system. *VaR* calculations will apply to the entire financial system, provided that the institution *i* is in a crisis situation. The aim of the study is to estimate the contribution of systemic risk of the bank *i* in the analyzed sector of the country, in crisis conditions of bank *i*. The study has adopted the following hypotheses:

1. Evaluation of the banking system, closely based on the principles of valuation of individual financial institutions, i.e. as a static set of assets, ignores interactions arising from systemic risks.
2. Systemic risk is characterized by individualized nature, requiring a separate monitoring and management in each banking sector.

The rest of the paper is organized as follows. In section 2 we describe the *CoVaR* methodology. In section 3 we present our bank balance-sheet dataset. In section 4, we estimate of the contribution of European banks to the instability of the banking sector. Finally, section 5 concludes.

2.CoVar methodology

For the state of financial failure of a financial institution *X*, *VaR* at probability level *p* is defined by:

$$P(X > VaR(p)) = p \quad (1)$$

We can say that the bank is in a crisis situation *X*, which access *VaR* (*p*) with a very low *p* level.

In order to assess risk-taking by individual institution macro-prudential regulations adopt the level of probability *p* equal to 1%. However, imposing the same *p* level restriction dedicated to the definition of banking crises for all banks, may not be the best solution. Due to the fact that a uniform level of losses in the definition of a crisis can not fit into a diversified financial situation of individual institutions.

Adrian and Brunnermeier^{xi} propose a risk measure based on *VaR*, but with contingencies - *CoVaR*, where "Co" is an abbreviation of "comovement" (the correlation), "contagion" (contagion effect), "conditional" (conditionality). They focus on the estimates of the conditional measure *CoVaR* where *CoVaR* is for selected institution *i* relative to the entire financial system. Therefore, *VaR* calculations apply to the entire financial system, provided that the institution *i* is in a crisis situation.

Risk measure can be defined as the VaR institution j (the entire financial system), provided the incident and crisis institutions. Other words, can be expressed as q -quantile distribution of conditional probability:

$$Pr\left(X^j \leq CoVaR_q^{j|C(X^i)} | C(X^i)\right) = q \quad (2)$$

The contribution of the institution i to the institution's risk j we denote the change:

$$\Delta CoVaR_q^{j|i} = CoVaR_q^{j|X^i=VaR_q^i} - CoVaR_q^{j|X^i=Median^i} \quad (3)$$

Adrian and Brunnermeier^{xii} in their estimations of measure $CoVaR$ studied the market changes in the value of assets of financial institutions, using the market value of equity and leverage of financial sector institutions, defining the distribution of changes in assets for institutions i at time t as:

$$X_t^i = \frac{ME_t^i * LEV_t^i - ME_{t-1}^i * LEV_{t-1}^i}{ME_{t-1}^i * LEV_{t-1}^i} = \frac{A_t^i - A_{t-1}^i}{A_{t-1}^i}, \quad (4)$$

where $A_t^i = ME_t^i * LEV_t^i$, and $A_t^i = ME_t^i * LEV_t^i = BA_t^i * (ME_t^i / BE_t^i)$.

BA_t^i – book value of assets of institution i in time t ,

ME_t^i – market value of equity of institution i in time t ,

LEV_t^i – leverage, measure as assets to equity of institution i in time,

BE_t^i – book value of equity of institution i in time t .

In order to estimate the size of $CoVaR$ quantile regression was used for the financial sector due to changes in the rate of return financial institution i , for quantile q .

$$X_q^{system,i} = \alpha_q^i + \beta_q^i X^i, \quad (5)$$

Directly using the assumptions of VaR can be determined VaR_q for the entire financial system on condition X_i as quantile q :

$$VaR_q^{system} | X^i = X_q^{system,i} \quad (6)$$

3. Financial Institutions Data

The analysis was carried out in banks, for which the number of observations exceed a period of five years and which are available on the websites of banks, Bankscope database, and the service of Thomson Reuters. The study was conducted in a period of 12 years, i.e. 2000-2012. The choice of research sample was dictated by the availability of data relating to individual commercial banks and the desire to take into account periods of market conditions and the financial crisis from 2008 to 2009. Characteristics of individual banking units is presented in Annedix I. The rate of return used in the calculations was calculated according to the model of Adrian and Brunnermeier (see Eq.4).

4.Estimates of the contribution of European banks to the instability of the banking sector – study

Based on an earlier literature review and recommended methods for assessing systemic risk, *CoVaR* calculations were made for the banking sector (previously defined as the *VaR* of the financial system provided under crisis event of institution *i* occurs). The aim of the study is to estimate the contribution of systemic risk by bank *i* in country *j* to the banking sector of country *j*. In addition, it will be created a ranking list of banks, which are a source of instability in the financial sector in developing countries of Europe. The study included commercial banks, only traded on the public market, which provided a market valuation of equity capital of the 40 largest commercial banks from 8 countries of developing Europe (Bulgaria, Latvia, Lithuania, Poland, Romania, Turkey, Ukraine, Hungary)².

The analysis was carried out in banks, for which the number of observations exceed a period of five years and be made available on the websites of banks, Bankscope database, and application of Thomson Reuters. The study was conducted in a period of 12 years, ie. 2000 to 2012. The choice of the survey sample was dictated by the availability of data relating to individual commercial banks and willingness to take into account periods of market trends of the financial crisis 2007-2009.

Characteristics of individual banking units is presented in Appendix I. The rate of return used in the calculations was calculated according to the model of Adrian and Brunnermeier'a (see Eq.4).

The study was conducted in two steps:

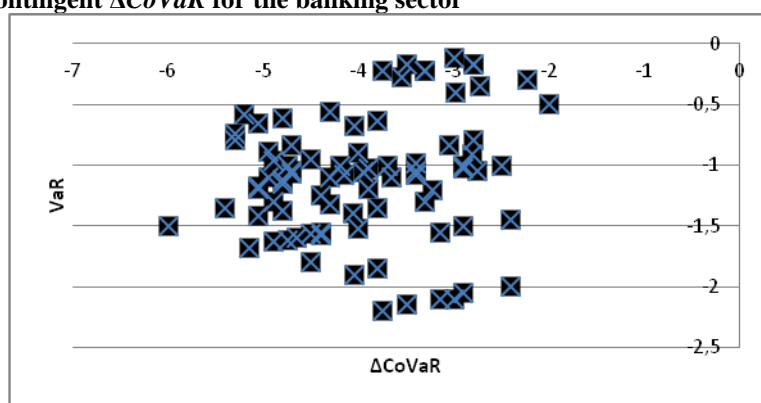
1. The first, *CoVaR* - the conditional value at risk for the banking sector was estimated, and the value of *VaR* for individual banks using the Algorithm (Eq. 2). Then the calculation of $\Delta CoVaR$ - the contribution of risk of the institution *i* to the banking system. The change in the value under distress conditions of bank *i* and the median value was specified as:

² THE STUDY ALSO INCLUDED TURKISH BANKS, DUE TO TURKEY'S ASPIRATIONS TO JOIN THE EUROPEAN UNION, A SIGNIFICANT SHARE OF THE BANKING SECTOR IN THE SAMPLE AND THE LOCATION OF BANKS IN ISTANBUL.

$$\Delta CoVaR_q^{System|i} = CoVaR_q^{System|X^i=VaR_q^i} - CoVaR_q^{System|X^i=Median^i} \quad (7)$$

The condition of bank i failure were determined by VaR at confidence level $q = 1\%$. Comparison of individual risk values of VaR and changes in the value of $\Delta CoVaR$ under distress conditions of bank i (see Eq. 7) is used to estimate the difference between the valuation of systemic risk based on the contribution of all banking institutions to the total risk of the sector, and estimates based on traditional risk measures - VaR focus only on the risks of individual institutions. The results are illustrated in Figure 1.

Figure 1 The difference in the risk evaluation VaR for the individual bank and the estimates of changes in the value of contingent $\Delta CoVaR$ for the banking sector



Source: own study

There is no close relationship between the VaR and the estimates $CoVaR$, which confirmed earlier suspicions about the discrepancies in the estimates of these two measures and the advantage $CoVaR$. Therefore we consider different countries, the VaR and changes on $CoVaR$ are nominal terms in local currencies. We change these calculation into Euro. The results show that the contribution of the institution to the instability of the banking sector measured by $CoVaR$ is larger than the size VaR loss. Estimates $\Delta CoVaR$ for estimated European banks ranged $[-1.9; -6.2]$, but the VaR values of $[-0.05; -2,7]$. It can therefore be concluded that the measure VaR for individual institutions does not bring complete information about the scale of the risk, hence the VaR values are lower than $CoVaR$. The size of $\Delta CoVaR$ shows the potential contribution of the financial institution (in the event of its insolvency) to the risk of the entire banking system.

The next step has been a detailed calculation of the impact of each of the analyzed financial institutions to systemic risk in the banking sector in each country. For this purpose the measurement of: VaR_q^{system} for the banking sector of the country, on condition the occurrence of an incident on the entity X^i :

$$VaR_q^{system|X^i} = X_q^{system,i},$$

and the VaR for the following institutions X^i .

We used quantile regression model for $q=1\%$, where VaR for each bank X^i is the independent variable, whereas the dependent variable is a conditional value $VaR_q^{system}|X^i$ for the banking system. In Romania, Latvia and Hungary we could consider only 2 banks, because of data availability. This is not a good example for test equation, but we decided to show the results.

The quantile regression equation takes the following form:

$$X_q^{system,i} = \alpha_q^i + \beta_q^i X^i. \quad (8)$$

$$CoVaR_q^{system|X^i=VaR_q^i} = VaR_q^{system}|VaR_q^i = \alpha_q^i + \beta_q^i VaR_q^i. \quad (9)$$

The estimation results are presented in Table (1).

Table 1 The impact of the VaR of the bank's risk on the whole national system. The estimation results of regression (Eq. 9) for the developing countries of Europe.

No	Bank(i)/Country	β coefficient (influence of $VaR(i)$ on $CoVaR$ (system))	P- value	No	Bank(i)/Country	β coefficient (influence of $VaR(i)$ on $CoVaR$ (system))	p- value
1	Bulgaria			6	Turkey		
	Bulgarian-American Credit	0.0996	**		Akbank	0.06614	***
	Central Cooperative Bank	0.1376	***		Albaraka Turk Katilim	0.9581	**
	Corporate Commercial	0.1163	*		Alternatifbank	0.87554	*
	First Investment Bank	0.0822	*		Asya Katilim Bankasi	0.37534	*
2	Poland				Denizbank	0.11455	
	Bank PEKAO	0.0366	*		Finansbank	-0.00943	**
	BRE Bank	0.0175	**		Sekerbank	0.10883	*
	ING Bank	0.6410	***		Tekstil Bankasi	-0.00385	
	Millenium	0.8478	**		Turk Ekonomi Bankasi	0.0885	**
	PKO BP	0.0136	*		Turkiye Garanti Bankasi	0.08832	***
	Bank Handlowy	0.8034	**		Turkiye Halk Bankasi	0.01031	*
	BOS Bank	0.5541	*		Turkiye Is Bankasi	0.01144	*
	Bank BPH	0.7822	*		Turkiye Sinai Kalkinma	0.01996	
3	Lithuania				Turkiye Vakiflar Bankasi	-0.00165	*
	Bankas Snoras	0.0156	*		Yapi ve Kredi Bankasi	0.09665	**
	Siauliu Bankas	-0.0059	**	7	Ukraine		
	Ukio Bankas	0.0824	**		Bank Forum	0.08065	**
4	Romania				Raiffeisen Bank Aval	-0.0093	**
	Banca Comerciala Carpatica	0.0478	**		Rodovid Bank	0.02207	**
	Banca Transilvania	0.2423	*		Ukrsotsbank	0.06666	**
5	Hungary						
	FHB Jelzalogbank	0.9744	***				
	OTP Bank	0.8864	**				

*, **, *** - respectively denote the level of significance of 1%, 5% and 10%. Characteristics of the banks participating in the survey in terms of size and risk taken are in Appedix I

Source: own study

In the developing countries of Europe, the impact of risk measured by *VaR* of individual banks to the risk of the whole system is not large (see. Table 1). The size of the beta coefficient is mostly positive values adopted in the majority in the interval [0; 0.5], which would indicate a low influence of listed commercial banks to the instability of the banking system in the event of a crisis. The group of the most influential includes: banks from Poland - Millenium and Bank BPH, from Hungary - FHB Jelzálogbank and OTP Bank, and Turkey - Albaraka Turk Katilim Bankasi. However, this situation is not optimistic if we take into account the significant share of foreign banks systemically important, which are present in the countries of Central and Eastern Europe. The effect of impact and the contagion systemic risk may be greater. The dominance of foreign banks in some Eastern and Central European countries is very important. However, this requires a broader analysis and research for the developed countries.

5. Conclusion

The results of studies using the *CoVaR* indicator for measuring systemic risk confirmed earlier suspicions that the assessment of the banking system, closely based on the principles of valuation of individual financial institutions on the basis of the book value of assets, ignores interactions arising from systemic risks. The models proposed by Adrian and Brunnermeier^{xiii} based on the conditional *VaR*, called by them the *CoVaR* have advantages in the form of: concentration on the contribution of individual institutions to the total systemic risk, while the traditional risk measures focus only on the risk level of a single institution. This is particularly important in view of the applicable prudential standards, showing significant deficiencies in the monitoring of risks in the system size. An important advantage of risk measures *CoVaR* is also its universal nature, which allows the verification of the mutual influence between institutions across the financial network. The study pointed to the importance of the impact of selected commercial banks to the instability of the banking system in the event of an emergency (eg. insolvency).

The regulator should be more inclined to monitor the *CoVaR* of banks because it can help identify before a crisis which institutions are more likely to suffer the most severe losses ex post. Our results hence tend to a practical use of the *CoVaR* for supervisory purposes.

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Appendix I

Characteristics of the banks participating in the survey in terms of size and risk taken. Calculations for selected developing countries in Europe

Country / Bank	No obs.	Equity book value	Asset book value	Market capitalisation	Value of systemic risk	Leverage	Ratio of systemic risk to equity	Capital ratio
Bulgaria								
Bulgarian-American Credit Bank	1600	181.88	735.11	194.59	-65.39	4.32	-0.36	0.25
Central Cooperative Bank	1856	228.8	1 700.80	135.32	-160.63	8.49	-0.7	0.13
Corporate Commercial Bank	1344	279.3	2 123.85	450	80.65	9.12	0.29	0.13
First Investment Bank	1344	402.9	4 270.80	261.8	-206.01	11.75	-0.51	0.09
Total		1 092.88	8 830.56	1 041.71	-351.38	8.42	-0.32	0.12
Czech republic								
Komerční Banka	1600	2 123.66	23 160.57	4 723.75	2 609.25	11.39	1.23	0.09
Total		2 123.66	23 160.57	4 723.75	2 609.25	11.39	1.23	0.09

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Poland

Bank PEKAO	1600	2 997.33	23 483.30	9 771.56	5 066.85	8.16	1.69	0.13
BRE Bank	1600	897.03	13 391.28	2 627.41	383.74	16.55	0.43	0.07
ING Bank	1600	974.02	11 841.53	2 406.85	313.96	11.55	0.32	0.08
Millenium	1600	638.87	7 772.16	1 395.08	71.58	11.68	0.11	0.08
PKO BP	1600	3 615.12	32 329.99	11 464.97	6 025.09	9.62	1.67	0.11
Bank HANDLOWY	1600	1 466.79	9 424.69	2 613.19	555.73	6.27	0.38	0.16
BOS Bank	1600	207.08	2 479.23	301.27	-74.45	11.88	-0.36	0.08
Bank BPH	1600	1 182.94	10 609.36	702.41	-1 579.67	8.81	-1.34	0.11
Total		11 979.18	111 331.55	31 282.75	2 690.71	10.18	0.22	0.11

Latvia

Latvijas Krajbanka	1600	36.4	513.9	32.78	-25.28	14.4	-0.69	0.07
Total		36.4	513.9	32.78	-25.28	14.4	-0.69	0.07

Lithuania

Bankas Snoras	960	552	8 997.00	440.18	-380.09	16.6	-0.69	0.06
Siauliu Bankas	1920	257.25	2 076.70	214.92	-59.04	9.04	-0.23	0.12
Ukio Bankas	1984	429	4 225.00	297.71	-174.89	9.72	-0.41	0.1
Total		1 238.25	15 298.70	952.81	-614.02	11.79	-0.5	0.08

Romania

Banca Comerciala Carpatica	1856	221.9	2 309.50	366.28	-205.43	10.21	-0.93	0.1
Banca Transilvania	2112	1 422.00	15 807.00	2 026.44	512.96	10.82	0.36	0.09
Total		1 643.90	18 116.50	2 392.72	307.53	10.51	0.19	0.09

Turkey

Akbank	3456	6 217.50	52 677.00	12 565.45	-834.64	7.1	-0.13	0.12
Albaraka Turk Katilim Bankasi	1344	711	6 415.00	1 141.87	-251.88	9.02	-0.35	0.11
Alternatifbank	3136	157.8	1 765.20	318	-211.97	10.65	-1.34	0.09
Asya Katilim Bankasi	1600	1 545.00	9 876.00	1 746.00	-441.12	7.25	-0.29	0.16
Denizbank	1984	2 261.00	22 576.00	2 950.33	-885.29	10.14	-0.39	0.1

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Finansbank	3712	1 279.50	14 867.50	2 058.78	1 302.60	9.09	1.02	0.09
Sekerbank	3200	324	3 543.00	570.53	-603.98	10.75	-1.86	0.09
Tekstil Bankasi	3456	165.7	1 792.25	193.2	-237.33	8.03	-1.43	0.09
Turk Ekonomi Bankasi	2176	1 070.00	15 306.50	1 337.93	-1 014.64	12.09	-0.95	0.07
Turkiye Garanti Bankasi	3200	4 146.00	48 510.50	8 828.85	-2 708.46	9.71	-0.65	0.09
Turkiye Halk Bankasi	1344	5 770.00	60 783.00	12 195.63	738.86	10.53	0.13	0.09
Turkiye Is Bankasi	3712	7 928.50	50 475.00	9 812.60	-6 926.15	7.48	-0.87	0.16
Turkiye Sinai Kalkinma Bankasi	3200	548	3 564.50	440.95	-450.2	6.99	-0.82	0.15
Turkiye Vakiflar Bankasi	1728	6 064.00	58 503.00	7 976.53	-2 894.54	9.56	-0.48	0.1
Yapi ve Kredi Bankasi	3712	3 589.50	25 843.00	3 987.98	-4 077.67	8.66	-1.14	0.14
Total		41 777.50	376 497.45	66 124.65	-19 496.40	9.14	-0.47	0.11

Ukraine

Bank Forum	1088	1 591.59	15 426.94	1 512.98	-1 244.76	8.62	-0.78	0.1
Raiffeisen Bank Aval	640	6 351.30	53 181.70	8 718.53	-3 558.84	8.45	-0.56	0.12
Rodovid Bank	1408	1 862.32	10 179.00	1 092.25	-3 597.90	7.7	-1.93	0.18
Ukrsotsbank	1472	4 494.76	35 389.93	6 405.20	-1 376.53	8.81	-0.31	0.13
Total		14 299.97	114 177.58	17 728.96	-9 778.04	8.39	-0.68	0.13

Hungary

FHB Jelzalogbank	2240	36 061.00	630 738.00	68 429.78	-6 191.39	18.14	-0.17	0.06
OTP Bank	2944	717 759.50	6 636 079.50	1 349 272.30	134 015.22	9.51	0.19	0.11
Total		753 820.50	7 266 817.50	1 417 702.08	127 823.83	13.83	0.17	0.1

Legend: (1) leverage ratio = volume of assets / equity of the bank, (2) the value of systemic risk = market value of assets, calculated on the basis of option pricing model - the book value of assets, (3) the systemic risk to equity = risk value system / equity of the bank, (4) capital ratio = equity / book value of assets.

Source: own study

Notes

ⁱ Tasche, (2000).

ⁱⁱ Brownlees, Engle, (2010).

ⁱⁱⁱ Acharya et al. (2010).

^{iv} Kupiec, (2002).

^v Jorion, (2006).

^{vi} Brunnermeier's', Crocket, Goodhart, Perssaud & Shin, (2009).

^{vii} Brady, (1988).

^{viii} Rubin, Greenspan, Levitt & Born, (1999).

^{ix} Brunnermeier, (2009).

^x Adrian & Shin, (2010).

^{xi} Adrian & Brunnermeier, (2011).

^{xii} *Ibidem.*

^{xiii} *Ibidem.*