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MAIN ROMANIAN COMMERCIAL BANKS' SYSTEMIC RISK DURING FINANCIAL CRISIS: A COVAR APPROACH

GABRIELA ANGHELACHE AND DUMITRU-CRISTIAN OANEA

Abstract. This paper aims to estimate the effects of contagion on the three Romanian commercial banks during financial crisis period, by using the CoVaR methodology. The motivation in choosing this topic is represented by the fact there is little research on systemic risk and contagion in the Romanian banking sector. The results of this paper highlight that the largest contribution to the daily losses of the most important commercial banks is given by Carpatica, while the lowest contribution is given by Transilvania. Moreover, we obtained that the Carpatica has the highest impact on both BRD and Transilvania, while Transilvania has the smallest impact.

1. Introduction

Our world and society is in a permanent changing, and these changes are affecting the financial world too. If we refer strictly to financial markets, we see that there are several crises which affect the companies and financial institutions. The recent one, the financial crisis from 2008, had a high impact on financial markets volatility. The main actors which were affected by the financial crisis were represented by financial institutions, which recorded significant losses during this period. Moreover, infallible banks as Lehman Brothers had bankruptcy during this financial meltdown, event which released high risk on financial market, risk which is known as systemic risk.

This was a signal for financial regulators to interfere in the market and strictly regulate all the activities in order to prevent such situations. At the European level, Basel III regulated the capital requirements for financial institutions, starting from 2013. Romania was affected too: the lending went down, unemployment increased, the Government cut people's wages from public sector, and Romania borrowed money from International Monetary Fund.

Over the time, many researchers tried to evaluate and estimate the risk for financial market in order to be able to predict it, and prevent future crisis. Until this point, none of existing methodologies was able to do this, but few of them were close to succeed. The most used tool in risk management is represented by Value at Risk, which computes the maximum portfolio's loss, based on assumptions regarding the probability and time-horizon. Even if this tool had become a landmark for risk management, it is not able to provide information regarding the systemic risk, but rather individual risk estimation for each financial institution as a unique entity.

There are several authors which tried to solve this limitation of Value at risk, among which are Adrian and Brunnermeier (2008), who proposed a new tool, CoVaR, in order to measure

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Gabriela Anghelache, Ph.D., is Professor at the Bucharest University of Economic Studies, Romania. Email: anghelache@cnvmr.ro.

Dumitru-Cristian Oanea is Ph.D. Student at the Bucharest University of Economic Studies, Romania. Email: oanea.cristian@gmail.com.

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the systemic risk, by taking into account the co-movement of financial institution's assets and liabilities.

Among the most important systemic risk measures are included Systemic Risk Measure which computes the expected capital shortfall (Acharya et al., 2012; Brownlees and Engle, 2012) and Marginal Expected Shortfall which computes the expected equity loss, based on a certain threshold over a given horizon.

This paper aims to estimate the effects of contagion on the Romanian commercial banks by using the CoVaR methodology, because we consider that this tool is capturing the risk spill over effect that an institution causes to another institution. The motivation in choosing this topic is represented by the fact there is little research on systemic risk and contagion in the Romanian banking sector. In Romania, there are only three banks which are listed on stock exchange: Carpatica Commercial Bank, Transilvania Commercial Bank and BRD Commercial Bank, so we were able to use the data only for these banks.

The paper is organized as follows: section 1 presents a literature review regarding the previous research on systemic risk; section 2 briefly presents the methodology and the data used in the analysis; in section 3 are presented the main results of the paper and the last section concludes the paper and underlines the limitations and further research directions.

2. Literature review

Risk management history dates back to 1945, when Leavens (1945) suggested a quantitative example for quantifying the risk. Along the time, several researchers proposed some improvements, but the financial institutions wanted to develop more complex tools in order to capture the risk, one of them being JP Morgan, which in 1994 brought in the financial industry a new model for estimating the risk: RiskMetrics.

Due to several crises encountered on financial markets, the financial regulators became aware about the risk management, that's why Basel Committee imposed to banks to use Value at Risk methodology for regulatory capital calculations.

In the literature there is a lot of debate regarding the best methodology in estimating the Value at Risk. Lambadiaris et al. (2003), Sollis (2009) and Davis et al. (2004) showed that if we compare the three methods of estimating VaR, namely historical simulation, variance-covariance and Monte Carlo simulation, we are not able to identify the best of them. Moreover, for estimating Value at Risk, we have to estimate the volatility. The first model used for volatility estimation was AutoRegressive Conditional Heteroscedasticity model, suggested by Engle (1982), and which was generalized by Bollerslev (1986) into a Generalized AutoRegressive Conditional Heteroscedasticity model. Going further, we were able to identify a controversy regarding the comparison of the models used for volatility estimation. While, So and Yu (2006) and McMillan and Kambouroudis (2009) find that the GARCH models over perform the EWMA models, Tse and Tung (1992), Galdi and Pereira (2007) and Patev et al. (2009) bring evidence in the favour of the EWMA model.

Researchers realized that VaR is not enough for estimating the systemic risk, which can be sudden and unexpected. Researchers were able to identify a procyclicality in the financial sector, due to fact that risk estimation tend to be low in boom periods and high during the crisis. Moreover, the spills over and externalities can increase the risk.

When you are micro prudential it does not necessary means you are macro prudential. This is true in the bank case too. Even if, a bank is taking into account the micro risk, sometimes, it forgets to take into account the macro risk.

The importance of measuring the systemic risk of financial institutions was highlighted by researchers as Huang et al. (2009), who tried to develop an indicator which measures the price of insurance against systemic financial distress. Going further, Acharya et al. (2010) proposed a simpler model for estimating the systemic risk, namely systemic expected shortfall (SES). Another index proposed by Brownlees and Engle (2012) is SRISK index, which shows the expected capital shortage of a firm on a period of substantial market meltdown.

The systemic risk measure used in this paper is represented by the risk measure proposed by Adrian and Brunnermeier (2008): CoVaR. Based on their methodology we are able to identify each financial institution contribution to systemic risk. As it is emphasized by Adrian and Brunnermeier, CoVaR is focusing on tail distribution, being an equilibrium measure, and this measure is directional, meaning the fact that CoVaR of a financial institution to the financial system is not equal to the CoVaR of financial system to the same financial institution.

This methodology was applied by many researchers until this point. It is worth mentioning the paper of Roengpitya and Rungcharoenkitkul (2011) which showed that a bank size is not necessary a variable which influences the systemic risk. Going further Lopez-Espinosa et al. (2012) highlights the fact that short-term wholesale funding is a key determinant for systemic risk. Recently, Bernardi et al. (2013) tried to use Bayesian inference for CoVaR and they were able to show that the model is able to sharply estimate marginal and conditional quintile.

If we are referring to the European banking system, there are several authors (Borri et al., 2012 and Mutu, 2012) who applied this methodology to estimate systemic risk. Based on this, it was pointed out that the highest contribution to the systemic risk comes from Belgium, Germany, Greece, Ireland and Spain (Mutu, 2012).

3. Methodology

Through this paper we want to analyse which bank had the higher contribution to systemic risk during financial crisis. In order to achieve this we will use Adrian and Brunnermeier (2008) methodology: CoVaR.

The first step is represented by computing the market value of each bank i total assets based on formula (3.1):

$$A_t^i = \left(N_t^i \cdot P_t^i\right) \cdot \frac{Asset_t^i}{E_t^i}, \tag{3.1}$$

where N – the number of shares; P – market price per share; $Asset_t$ – book value of total assets at time t and E_t – book value of total equity at time t. Based on formula (3.1), we will compute further the growth rate of the market value of bank assets, and for the entire system (the asset value of the system is the sum of the assets of all three banks), as follows:

$$R_t^i = \frac{A_t^i - A_{t-1}^i}{A_{t-1}^i} \tag{3.2}$$

Further, we will compute Value a Risk for each bank i and the entire system with α confidence probability according to formula (3.3):

$$\Pr(R_t^i < VaR_{1-\alpha}^i) = 1 - \alpha \tag{3.3}$$

CoVaR computation means the estimation of quantile $1-\alpha$ for the distribution function of R_t, based on formula (3.4):

$$\Pr(X_t^{sys} \leq CoVaR_{1-\alpha,t}^{sys|R_t^i = VaR_{1-\alpha,t}^i} \left| R_t^i = VaR_{1-\alpha,t}^i \right.) = 1 - \alpha \tag{3.4}$$

where sys – the values computed for the system and i – the value computed for each bank i.

For each bank we will estimate the parameters of the following quantile regression:

$$R_t^i = \beta_0^i + \beta_1^i \cdot BET_{t-1} + \beta_2^i \cdot ROBOR6M_{t-1} + \varepsilon_t^i \tag{3.5}$$

Using the estimators computed based on equation (3.5) we can estimate the VaR as:

$$\hat{VaR}_t^i = \hat{\beta}_0^i + \hat{\beta}_1^i \cdot BET_{t-1} + \hat{\beta}_2^i \cdot ROBOR6M_{t-1} \tag{3.6}$$

Going further, we have to estimate the CoVaR for system, based on the parameters obtained based on formula (3.7):

$$R_t^{sys|i} = \beta_0^{sys|i} + \beta_1^{sys|i} \cdot BET_{t-1} + \beta_2^{sys|i} \cdot ROBOR6M_{t-1} + \beta_3^{sys|i} \times R_t^i + \varepsilon_t^{sys|i} \tag{3.7}$$

CoVaR is computed according to formula (3.8), based on the estimations obtained above:

$$\hat{CoVaR}_{AP,t}^{sys|i} = \hat{\beta}_0^{sys|i} + \hat{\beta}_1^{sys|i} \cdot BET_{t-1} + \hat{\beta}_2^{sys|i} \cdot ROBOR6M_{t-1} + \hat{\beta}_3^{sys|i} \times \hat{VaR}_t^i \tag{3.8}$$

The risk that a bank propagates it in banking system is defined according to formula (3.9):

$$\Delta CoVaR_{1\%/5\%}^{sys|i} = CoVaR_{1\%/5\%}^{sys|i\,(1\%/5\%)} - CoVaR_{1\%/5\%}^{sys|i(50\%)} \tag{3.9}$$

The quantile regression is the methodology which it is used in our analysis, in order to estimate systemic risk for each bank. There are some advantages of this type of methodology over the ordinary least square regression. The main advantage is that the estimators are more robust against outliers in the response measurements.

After we compute the VaR and CoVaR, we have to test the models, in order to see the accurateness of them. As we showed in a previous research (Anghelache et al., 2013; Oanea et al., 2013; Zugravu et al., 2013), a frequently test used for this purpose is represented by the conditional coverage proposed by Christoffersen (1998). This test is a joint test such that $LR_{CC} = LR_{UC} + LR_{IND}$, being $\chi^2_{(2)}$ distributed. The indicator variable – I_t is defined as:

$$I_t = \begin{cases} 1 & R_t < VaR_t \\ 0 & R_t \geq VaR_t \end{cases} \tag{3.10}$$

The conditional coverage test is given by formula (3.11):

$$LR_{CC} = -2\ln\left(\frac{(1-\alpha)^{n_0}\alpha^{n_1}}{(1-\hat{\pi}_{01})^{n_{00}}\hat{\pi}_{01}^{n_{01}}(1-\hat{\pi}_{11})^{n_{10}}\hat{\pi}_{11}^{n_{11}}}\right) \sim \chi^2_{(2)} \tag{3.11}$$

where, n_{ij} is the number of observations with value i followed by j, $\pi_{ij} = \Pr(I_t = i | I_{t-1} = j)(i,\, j{=}0{,}1)$,$\hat{\pi}_{01} = \frac{n_{01}}{n_{00}+n_{01}}$, $\hat{\pi}_{11} = \frac{n_{11}}{n_{10}+n_{11}}$.

This kind of test is rather a theoretical one, being used extensively in the research papers, while banks are using the Basel test. Using this test, we can classify banks based on the sum of the indicator variable corresponding to one year (250 trading days), as follows:

1. If $\sum I_t \leq 4$, then the bank is in the low risk group;
2. If $5 \leq \sum I_t \leq 9$, then the bank is in the medium risk group;
3. If $\sum I_t \geq 10$, then the bank is in the high risk group.

4. Data and descriptive statistics

Even if the Romanian Banking System is composed by 41 commercial banks, we are able to analyse the systemic risk only for three of them, which are listed to Bucharest Stock Exchange: Transilvania Commercial Bank (TLV), Carpatica Commercial Bank (BCC) and Romanian Bank for Development (BRD). Despites this, these three banks are very important in Romanian banking system, due to fact that, these three banks have approximately 25% market share, as states the information available on National Bank of Romania official site.

The moment when Lehman Brothers filed for Chapter 11 bankruptcy protection (September 15th 2008) is the official moment when financial crisis started. Despite this, in Romania, the early effects of financial crisis were felt at the end of 2008, when the GDP decreased by 0.1%. Based on the GDP evolution presented in figure 1, we were able to separate the crisis period between last quarter of 2008 and last quarter of 2012, more exactly October 1st, 2008 – December 31st, 2012.

The data regarding the asset value and equity value are from the banks' quarter financial reports and transformed in daily data by linear interpolation, while the stock daily prices were taken from the Bucharest Stock Exchange official site.

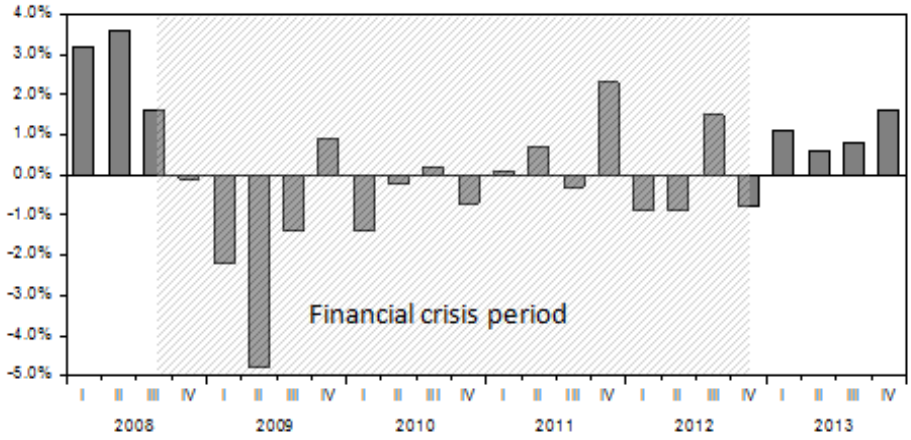

FIGURE 1. Romania GDP growth rate

Following the Mutu (2012) methodology, we choose for CoVaR computation the following state variables: BET index (we didn't choose BET FI because this index contains investment funds, which doesn't reflect the banking system features) and interbank offering rate (ROBOR for 3 months).

Table 1. Descriptive statistics for changes in market value of banks' assets and state variables

Variable	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis
BCC	0.0000	-0.0002	0.3818	-0.1504	0.0313	2.49	32.38
BRD	-0.0006	-0.0004	0.1490	-0.1866	0.0278	-0.39	11.12
TLV	0.0008	0.0000	0.4003	-0.8266	0.0391	-7.75	205.28
SYST	-0.0001	-0.0001	0.1313	-0.1193	0.0228	-0.20	8.61
BET rate	0.0021	0.0633	10.5645	-13.1168	2.0555	-0.71	9.63
ROBOR 3m rate	-0.0008	-0.0007	0.5062	-0.4278	0.0320	3.39	147.66

Note: BCC – Carpatica Commercial Bank, BRD – Romanian Bank for Development, TLV – Transilvania Commercial Bank, SYST – Romanian banking system (formed by BCC, BRD and TLV).

Descriptive statistics for the variables used in the analysis are presented in table 1. Based on presented values, we can see that the standard deviation is similar for all banks, recording values between 0.0228 (banking system) and 0.0313 (BCC). In the same time the highest volatility is recorded for BET rate evolution over the financial crisis period. TLV has a negative skewness, which means that a longer left tail shows more losses for Transilvania Commercial Bank. Moreover the highest kurtosis for TVL highlights the fact that the market asset ratio for this bank is declining rapidly.

Table 2. Correlation matrix for the Romanian banking sector

Correlation	BCC	BRD	TLV	SYST	BET rate	ROBOR 3m rate
BCC	1.0000					
BRD	0.0957	1.0000				
TLV	0.0340	0.0009	1.0000			
SYST	0.1344	0.9649	0.2317	1.0000		
BET rate	-0.0205	0.0447	0.0250	0.0414	1.0000	
ROBOR 3m rate	0.0006	0.0583	-0.0021	0.0512	0.0126	1.0000

Source: authors' calculation.

The strongest correlation of 0.9649, as is presented in table 2, it is recorded between the assets return of BRD and the change of total assets of the banking system, which means that either BRD has a great impact on the system or system has a great impact on BRD.

Table 3. Stationary test results

Augmented Dickey Fuller Test[a]	
Variable	H0: I(1)
BCC	-21.2402*
BRD	-28.8120*
TLV	-32.1368*
SYST	-28.2366*
BET rate	-30.4997*
ROBOR 3m rate	-14.3130*

[a] - The 5 percent critical value for the Augmented Dickey Fuller statistic is -3.83.

* - Indicates significant at the 0.01 level.

Before we start to analyze and compute the systemic risk for each bank, we apply the Augmented Dickey Fuller test to check if the time series are stationary. Based on the results presented in table 3 we can see that all variables are stationary.

5. Results

We want to compute the systemic risk for the three Romanian commercial banks mentioned above, and moreover to see the contagion between each of them, based on CoVaR methodology.

In the analysis for BET rate and ROBOR 3 months rate, we used the lag(1) values, due to fact that changes in the financial and monetary market does not affect immediately the bank's assets.

All the quantile regressions for Value at Risk and CoVaR at 1% and 5% confidence level are presented in the tables from appendix (table 9 to table 14).

The descriptive statistics of Value at Risk and CoVaR for both levels of confidence 1% and 5%, is presented in table 4. One can notice that in Value at Risk case, the highest risk is recorded for BRD for both confidence level (-8.03% at 1% confidence level and -4.43% at 5% confidence level). In CoVaR case, the situation is changing at 1% confidence level, when the highest risk is recorded for Carpatica Commercial Bank.

Table 4. Descriptive statistics for Value at and CoVaR

Risk measurement		Mean	Median	Max.	Min.	St. Dev.	Skewness	Kurtosis
BCC	VaR 1%	-0.0801	-0.0795	0.0133	-0.1966	0.0183	-0.70	9.58
BRD		**-0.0803**	-0.0799	-0.0054	-0.1739	0.0147	-0.70	9.58
TLV		-0.0780	-0.0779	0.0000	-0.1616	0.0064	-1.18	86.39
BCC	VaR 5%	-0.0393	-0.0391	0.0017	-0.0899	0.0080	-0.69	9.63
BRD		**-0.0443**	-0.0442	-0.0021	-0.0869	0.0070	-0.30	10.19
TLV		-0.0380	-0.0380	0.0000	-0.0720	0.0026	2.02	118.72
BCC	CoVaR 1%	**-0.0968**	-0.0965	-0.0421	-0.1421	0.0073	-0.26	14.07
BRD		-0.0763	-0.0760	-0.0144	-0.1538	0.0122	-0.67	9.54
TLV		-0.0702	-0.0699	-0.0274	-0.1227	0.0083	-0.66	9.62
BCC	CoVaR 5%	-0.0407	-0.0405	-0.0149	-0.0733	0.0052	-0.58	9.53
BRD		**-0.0428**	-0.0427	-0.0075	-0.0779	0.0058	-0.29	10.24
TLV		-0.0390	-0.0389	-0.0078	-0.0643	0.0043	-0.01	11.76

Note: BCC – Carpatica Commercial Bank, BRD – BRD Commercial Bank, TLV – Transilvania Commercial Bank.

Based on the estimation of VaR and CoVaR, we were able to compute the average impact of each bank on the system formed by those, which is presented in table 5. When we choose the restrictive confidence level, which is 1%, we obtain that the largest contribution to the daily losses of the three banks is given by Carpatica Commercial Bank (8,648,151 RON), while the lowest contribution is given by Transilvania Commercial Bank, with an average of 6,246,338

RON. The situation is a little bit changing, when we select 5% confidence level. In this case, the largest contribution to banking system loses is given by BRD Commercial Bank (3,791,326 RON), while the lowest contribution is given by Transilvania Commercial Bank, with a value of 3,466,954 RON.

Table 5. Average banks contribution to systemic risk 2008-2012 (RON)

Interconnexion	ΔCoVaR				
	Average	Median	Minimum	Maximum	St. dev.
1% confidence level					
BCC ⟶ Romanian system	-8,648,151	-8,628,870	-2,022,725	-15,043,464	689,803
BRD ⟶ Romanian system	-6,784,130	-6,748,962	-1,271,957	-13,615,212	1,070,944
TLV ⟶ Romanian system	-6,246,338	-6,216,436	-1,717,901	-10,688,638	733,005
5% confidence level					
BCC ⟶ Romanian system	-3,641,369	-3,625,927	-1,576,424	-6,147,438	401,671
BRD ⟶ Romanian system	-3,791,326	-3,777,401	-1,348,989	-6,841,168	479,059
TLV ⟶ Romanian system	-3,466,954	-3,456,779	-1,844,919	-5,478,343	315,267

Note: BCC – Carpatica Commercial Bank, BRD – BRD Commercial Bank, TLV – Transilvania Commercial Bank.

The highest impact associated with the Carpatica Commercial Bank is logical, due to fact that during the analyzed period, this bank recorded only losses so it seems that the activity conducted was associated with a high degree of risk and uncertainty. In the same time BRD even if it is the biggest bank from these three analyzed, it has the higher risk at 5% confidence level. This can be explained through the major impact that financial crisis had over the banking sector. In the same time, Transilvania Commercial Bank has a stable activity which it is focused more on the retail activity. This stability helped this bank to maintain a low risk profile for the activity performed.

Table 6. Contagion direction between banks 2008-2012 (% of market value of total assets)

Interconexion	ΔCoVaR				
	Average	Median	Minimum	Maximum	St. dev.
1% confidence level					
BRD ⟶ BCC	-9.96%	-9.92%	-2.39%	-19.38%	1.48%
TLV ⟶ BCC	-9.76%	-9.69%	0.87%	-22.90%	2.06%
BCC ⟶ BRD	-10.16%	-10.10%	-2.41%	-19.60%	1.51%
TLV ⟶ BRD	-7.03%	-6.99%	0.69%	-16.62%	1.50%
BCC ⟶ TLV	-9.25%	-9.22%	-2.36%	-15.71%	0.79%
BRD ⟶ TLV	-8.12%	-8.11%	1.68%	-18.94%	0.77%
5% confidence level					
BRD ⟶ BCC	-4.97%	-4.95%	-2.06%	-8.50%	0.57%
TLV ⟶ BCC	-4.14%	-4.11%	0.19%	-9.42%	0.84%
BCC ⟶ BRD	-4.89%	-4.86%	-0.88%	-9.82%	0.78%
TLV ⟶ BRD	-4.39%	-4.37%	-1.11%	-8.45%	0.64%
BCC ⟶ TLV	-3.77%	-3.77%	0.00%	-7.17%	0.26%
BRD ⟶ TLV	-4.02%	-4.03%	-2.33%	-5.72%	0.16%

Note: BCC – Carpatica Commercial Bank, BRD – BRD Commercial Bank, TLV – Transilvania Commercial Bank.

In the same time we can see easily, that by choosing a more restrictive confidence level, the estimated contribution of each bank to the whole system is increasing.

The contagion direction between the analysed banks is presented in table 5, and is shown as percentage of the market value of total assets of each mentioned bank. Based on the presented results, we are able to see that Carpatica commercial Bank has the highest impact on both BRD Commercial Bank and Transilvania Commercial Bank. In the same time Transilvania commercial Bank has the smallest impact on the others banks.

Again at 1% confidence level, the measured impact is higher compared to the 5% confidence level. So we can see that in the first case, the impact of the banks one of each other is around 9% from the market value of total assets, while in the second case, when we choose 5% confidence level, the impact is around 4%.

Until this point, we were able to see the results obtained based on the estimated quantile regressions for Value at Risk and CoVaR, but further we want to see how reliable are the models, and how much we can trust the presented results. In order to achieve this, we computed the conditional coverage test for the last 250 observations and 99% confidence level (■=0.01). For this test, the null hypothesis stated that the model is correctly specified. The results are presented in table 7.

Table 7. Conditional coverage test for VaR and CoVaR models

Bank	VaR (1%)	VaR (5%)	CoVaR (1%)	CoVaR (5%)
	H_0	H_0	H_0	H_0
BCC	1.20*	5.92*	1.21*	3.87*
BRD	5.05*	0.18*	5.04*	4.91*
TLV	5.04*	7.36*	5.04*	3.87*

Note: The critical values for $\chi^2_{(2)}$ are 4.605 (90%), 5.991 (95%) and 9.210 (99%).

* - Indicates that the model is accepted (the probability of failure is equal with the desired significance level – α).

Based on the results presented in table 7, we are able to see that the models used to estimate the Value at risk and CoVaR for the three Romanian commercial banks are valid.

Table 8. Basel test for VaR and CoVaR models for 2009 and 2012

Bank	VaR (1%)		VaR (5%)		CoVaR (1%)		CoVaR (5%)	
	Exceptions	Risk	Exceptions	Risk	Exceptions	Risk	Exceptions	Risk
2009								
BCC	6	*Medium*	21	**High**	1	*Medium*	21	**High**
BRD	7	*Medium*	30	**High**	7	*Medium*	28	**High**
TLV	6	*Medium*	24	**High**	10	**High**	25	**High**
2012								
BCC	1	Low	7	*Medium*	1	Low	6	*Medium*
BRD	0	Low	3	Low	0	Low	4	Low
TLV	0	Low	7	*Medium*	0	Low	6	*Medium*

Further, based on Basel test, we classify the banks in three categories of risk: low, medium and high, for the first year of crisis (2009) and the last year (2012). Based on table 8, we can see the impact of financial crisis on existing risk in banking sector. Regarding this, we are able to see that in 2009 all three banks were included in medium and high category of risk, while 3 years later, the risk decreased considerably, that's why all the banks are included in low and few cases in medium category of risk.

6. Conclusion

Generally, the regulations of systemically important financial institutions are intended to prevent financial institutions from becoming "too big to fail". Although the Romanian banking sector was not as negatively affected by financial crisis as the American financial system, there is a possibility, that the future can bring financial crises worse than the last one.

The results of this paper highlight that the largest contribution to the daily losses of the three banks considered is given by Carpatica Commercial Bank due to fact that over the analyzed period this bank recorded loses, meaning that the activity performed was characterized by uncertainty and high risk. In the same time the lowest contribution is given by Transilvania Commercial Bank. It seems that a more stable retail activity helped this bank to maintain a low level of risk for the analyzed period. By comparing with the results obtained for BRD, we are

able to find something interesting. BRD has a more diversified activity, and both retail activity and corporate activity have the same importance in the total activity, while in Transilvania Commercial Bank case this is different. It seems that Transilvania Commercial Bank focuses a little more on retail activity compared with corporate one. By maintaining a good level of deposits from population, and a good portfolio of credits, Transilvania Commercial Bank was able to keep a low risk level for performed activity.

Moreover, we analysed the contagion direction between the three banks. Based on the obtained results, we pointed out that Carpatica Commercial Bank has the highest impact on both BRD Commercial Bank and Transilvania Commercial Bank. In the same time Transilvania commercial Bank has the lowest impact on the others banks. Although it might seem surprising that the bank that has the lowest value of total assets in the selected system of banks, is also the largest contributor to the systemic risk, this finding is consistent with Roengpitya and Rungcharoenkitkul (2010) who argued that the size of a financial institution is not the most influential factor of systemic risk.

Reliability of estimated models was confirmed through estimating conditional coverage test, which validates all the models used in estimating systemic risk.

Further, based on Basel test, we classify the banks in three categories of risk: low, medium and high for 2009 and 2012. Based on this classification, we identify the impact of financial crisis on existing risk in banking sector. Regarding this, we are able to see that in 2009 all three banks were included in medium and high category of risk, while 3 years later, the risk decreased considerably, that's why all the banks are included in low and few cases in medium risk classes.

These results are important for all commercial banks, because based on their typology and comparison with the analyzed banks, they are able to see in which risk profile they are included. The activity performed is the main source for the risk, and the manner in which they perform it, can be a way of influencing the risk profile.

One of the research limitations is represented by the small number of analysed banks, due to fact that only these three banks are publicly listed at Bucharest Stock Exchange. Another limitation can be represented by using only two state variables in the analysis.

Further research is necessary in the direction of finding which characteristics of each institution, like maturity mismatch, leverage, market-to-book, size, and market beta are influencing CoVaR, so that both regulators and banks will have an accurate picture of the systemic risk and contagion effects on the Romanian banking system in order to take the best decisions for the stability of the banking sector.

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Appendix

Tabel 9. Value at Risk results for the Romanian banks

Variable	VaR (5%)			VaR (5%)		
	BCC	**BRD**	**TLV**	**BCC**	**BRD**	**TLV**
Constant	$-.0800^{***}$	-0.0803^{***}	-0.0781^{***}	-0.0393^{***}	-0.0442^{***}	-0.0379^{***}
	$(0.0079)^{a}$	(0.0083)	(0.0100)	(0.0025)	(0.0032)	(0.0025)
BET rate	0.0088^{***}	0.0071^{***}	0.0015^{**}	0.0038^{***}	0.0032^{***}	-0.0004
	(0.0015)	(0.0013)	(0.0007)	(0.0010)	(0.0011)	(0.0005)
ROBOR	0.0259^{**}	0.0240	-0.1752^{***}	-0.0208^{***}	0.0615^{**}	0.0777^{***}
3M rate	(0.0114)	(0.0357)	(0.0267)	(0.0064)	(0.0310)	(0.0086)
Pseudo R^2	0.1094	0.0594	0.0022	0.0223	0.0224	0.0024

Tabel 10. CoVaR results for the Romanian banks

Variable	CoVaR (1%)			CoVaR (5%)		
	BCC	**BRD**	**TLV**	**BCC**	**BRD**	**TLV**
Constant	-0.0751^{***}	-0.0121^{***}	-0.0656^{**}	-0.0347^{***}	-0.0063^{***}	-0.0337^{***}
	$(0.0075)^{a}$	(0.0008)	(0.0184)	(0.0020)	(0.0005)	(0.0025)
BET rate	0.0007	0.0002^{**}	-0.0039	0.0019^{***}	0.0001	0.0019^{***}
	(0.0024)	(0.0001)	(0.0031)	(0.0004)	(0.0001)	(0.0007)
ROBOR	-0.1108^{*}	0.0145^{***}	-0.0209	0.0296	0.0010	0.0379^{**}
3M rate	(0.0577)	(0.0019)	(0.1096)	(0.0181)	(0.0014)	(0.0183)
R $_{\text{assets}}$ ^{BCC}	0.2714^{***}			0.17495^{***}		
	(0.0203)			(0.0257)		
R $_{\text{assets}}$ ^{BRD}		0.7988^{***}			0.8213^{***}	
		(0.0047)			(0.0102)	
R $_{\text{assets}}$ ^{TLV}			0.0586			0.1376^{**}
			(0.3084)			(0.0575)
Pseudo R^2	0.0578	0.7680	0.0537	0.0433	0.8008	0.0327

Tabel 11. VaR(50%) and CoVaR (50%) results for the Romanian banks

Variable	VaR (50%)			CoVaR (50%)		
	BCC	**BRD**	**TLV**	**BCC**	**BRD**	**TLV**
Constant	-0.0001	-0.0002	0.0001	0.0001	-0.0001	-0.0001
	$(0.0005)^{a}$	(0.0006)	(0.0001)	(0.0004)	(0.0001)	(0.0005)
BET rate	0.0002	0.0001	0.0001	0.0003	-0.0001	0.0002
	(0.0002)	(0.0004)	(0.0001)	(0.0003)	(0.0001)	(0.0004)
ROBOR 3m rate	0.0259	0.0604^{***}	0.0001	0.0543^{***}	-0.0063^{**}	0.0504^{***}
	(0.0232)	(0.0192)	(0.0001)	(0.0118)	(0.0029)	(0.0097)
R $_{\text{assets}}$ ^{BCC}				0.0741^{***}		
				(0.0238)		
R $_{\text{assets}}$ ^{BRD}					0.8016^{***}	
					(0.0094)	
R $_{\text{assets}}$ ^{TLV}						0.01563^{***}
						(0.0326)
Pseudo R^2	0.0008	0.0048	0.0001	0.0138	0.7697	0.0461

^{a} - (standard errors in parentheses).

* , ** , *** - Indicates significant at the 0.1 level, 0.05 level and 0.01 level.

Tabel 12. CoVaR (1%) results for the Romanian banks

Variable	BCC		BRD		TLV	
Constant	-0.0779^{***}	-0.0833^{***}	-0.0848^{***}	-0.0773^{***}	-0.0760^{***}	-0.0796^{***}
	$(0.0081)^a$	$(0.0080)^a$	$(0.0114)^a$	$(0.0056)^a$	$(0.0073)^a$	$(0.0111)^a$
BET rate	0.0054^{**}	0.0098^{***}	0.0054^{**}	0.0075^{***}	0.0013^{*}	0.0013
	(0.0026)	(0.0012)	(0.0026)	(0.0011)	(0.0007)	(0.0009)
ROBOR	0.0246^{*}	0.0255^{**}	-0.0244	0.0400^{*}	-0.1508^{***}	-0.1812^{***}
3M rate	(0.0130)	(0.0107)	(0.0842)	(0.0207)	(0.0331)	(0.0351)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BCC}}$			0.2119^{***}		0.2071^{***}	
			(0.0644)		(0.0248)	
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BRD}}$	0.2708^{*}					0.0247
	(0.1446)					(0.1070)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{TLV}}$		0.1850^{***}		-0.0860^{***}		
		(0.0378)		(0.0072)		
Pseudo $\mathbf{R^2}$	0.1386	0.1234	0.0883	0.0633	0.0081	0.0022

Tabel 13. CoVaR (5%) results for the Romanian banks

Variable	BCC		BRD		TLV	
Constant	-0.0408^{***}	-0.0402^{***}	-0.0442^{***}	-0.0443^{***}	-0.03830^{***}	-0.0383^{***}
	$(0.0031)^a$	$(0.0034)^a$	$(0.0036)^a$	$(0.0032)^a$	$(0.0026)^a$	$(0.0026)^a$
BET rate	0.0022^{**}	0.0042^{***}	0.0034^{***}	0.0032^{**}	-0.0003	-0.0006
	(0.0011)	(0.0008)	(0.0010)	(0.0013)	(0.0006)	(0.0004)
ROBOR	-0.0221^{**}	-0.0214^{***}	0.0610^{**}	0.0609^{*}	0.0770^{***}	0.0762^{***}
3M rate	(0.0109)	(0.0068)	(0.0303)	(0.0329)	(0.0093)	(0.0079)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BCC}}$			0.1201^{**}		-0.0179	
			(0.0468)		(0.0629)	
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BRD}}$	0.2025^{***}					0.0487
	(0.0735)					(0.0602)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{TLV}}$		0.0355		-0.0056		
		(0.1079)		(0.1125)		
Pseudo $\mathbf{R^2}$	0.0338	0.0225	0.0330	0.0225	0.0024	0.0033

Tabel 14. CoVaR (50%) results for the Romanian banks

Variable	BCC		BRD		TLV	
Constant	-0.0001	-0.0001	-0.0001	-0.0002	0.0001	0.0001
	$(0.0005)^a$	$(0.0005)^a$	$(0.0005)^a$	$(0.0006)^a$	(0.0001)	(0.0001)
BET rate	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	(0.0002)	(0.0002)	(0.0004)	(0.0004)	(0.0001)	(0.0001)
ROBOR 3m rate	0.0253	0.0286	0.0758^{***}	0.0628^{***}	0.0001	0.0001
	(0.0235)	(0.0222)	(0.0159)	(0.0173)	(0.0001)	(0.0001)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BCC}}$			0.0263		0.0001	
			(0.0239)		(0.0001)	
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{BRD}}$	0.0179					0.0001
	(0.0297)					(0.0001)
$\mathbf{R}_{\mathbf{assets}}^{\mathbf{TLV}}$		0.0153		0.0047		
		(0.0210)		(0.0093)		
Pseudo $\mathbf{R^2}$	0.0012	0.0013	0.0064	0.0050	0.0001	0.0001

^{a} - (standard errors in parentheses).

* , ** , *** - Indicates significant at the 0.1 level, 0.05 level and 0.01 level.