USING STRESS TESTING METHODOLOGY IN EVALUATING BANKING INSTITUTION'S EXPOSURE TO RISK

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1. Introduction

In recent years, the management policies of banking institutions faced a welcomed change. Banks started to rely more and more on econometric models for the management of banking risks, like market risk, credit risk, operational risk or liquidity risk. These methods gained increasing credibility because they offer a comprehensive framework for identifying, analyzing and controlling of risks. Even so, these models can't account for every possible risk effect, because of its unpredictable nature.

Trying to solve this problem, banks have started to develop stress testing methods which in time became an important element in the bank supervision process. Also more and more supervisory authorities started using techniques for evaluating capital adequacy.

Due to the importance that this methodology has at the international level, we wish to present in the following paragraphs the notion of stress testing and then to describe the methods by which it could be implemented by banks while also presenting the effect that modifying the interest rate has on bank revenues as well as on their capital market value.

2. Literature review

Econometric models are used in estimating the future value of a banking portfolio depending on several factors as the variation of the interest rate or the quality of a credit portfolio. The distribution estimated in this way indicates the probability that the portfolio value of a bank reaches a certain value. Most models have the drawback that they can't account for sudden, atypical and major changes that take place in the market. This was confirmed with the outbreak of the present financial crisis. In order to solve this problem, the risk managers developed stress tests through which they study the potential impact on a portfolio value, the effect of sudden changes of various financial variables while providing information of a potential gain or loss over a certain period of time. Also, stress testing now is completing the standard econometric methods such as Value at Risk (VaR).

The literature offers a series of studies related to stress testing. Neu and Matz (2007) developed a practical approach of stress testing the liquidities on the banking system. First off, the tolerance level and cash-flow predictions are estimated for each bank over a given period of time. Then these cash flows are subjected to stress testing under various scenarios. Persaud (2003) tested the vulnerabilities of portfolios to market risk by simulating a decrease in liquidity on the FX market, the market of fixed income and credit transfers.

Chorofas (2002) raised a series of problems that can appear while constructing stress testing models out of

which we like to recall: approximating non-linear and linear phenomena, estimating the term structure of the of-balance sheet positions and communicating the hypothesis to the upper level management of banks. Also he discovered a link between the superior order elements in the results of the stress tests and the evolution of liquidities in banks. Perdersen and Brunnermeier (2007) and Adrian et al. (2007) integrated these links into the models developed by them. Zeransky (2006) incorporated into his test an econometric method of estimating of extreme events, namely the exceeding of a peak-over-threshold limit. Brevas (2006) also supports the application of extreme value theory for the evaluation of rare scenarios by estimating the distribution that the extreme values may have. Fiedler (2002) was for the construction of extreme liquidity deficit scenarios, proposing the indicator Value-Liquidity-at-Risk for the estimation of additional capital costs necessary for the financing of the GAP in stress conditions. The VLaR indicator is given by the difference between the adequacy costs of capital under normal conditions and those calculated under stress condition under various liquidity evolution scenarios. Fender et al. (2001) underlined the importance of stress testing for the credit portfolios of banks, by simulating various scenarios considering the estimations of the probability of default. For the market risk, Martin (2007) demonstrated the necessity of adding stress testing to the VaR method.

The supervisory authorities developed their own tests for the evaluation of the vulnerabilities to exposure of the national banking system at the systemic level, becoming an important component of the FSAP program initiated by the International Monetary Fund in 1990. This applied two methodologies: one studies the vulnerability of the financial sector from a country to various changes of macroeconomic variables and another one that test in an integrated form the sensitivity of the financial sector by simulating several scenarios for aggregated portfolios. Hoggarth et al (2004) in a study for the Bank of England underlined the fact that it uses its own economic model for implementing the tests for the 10 largest banks in the UK. One of the stress scenarios took into account a decline of 35% in the global price index and another a drop of 12% in real estate prices. In France the market and credit risk interaction as well as the contagious effect on the inter-bank market are tested. This is realized by taking into consideration certain scenarios that predict the decrease of 20% in aggregated demand, a decline in investment rate and a depreciation of the USD/EUR rate. In order to reflect most accurately the market and credit risk, in Spain, scenarios test the effect of increasing bankruptcy and decrease of the GDP.

In the accord between Romania and the IMF, the National Bank of Romania (NBR) carried out some stress tests that were based in IMF methodology. The goal was the prediction of possible loses that banks could face. In order to fundament the maximum levels admitted by the NBR for the indebtedness grade it would be used the great increase of the interest rate, due to the NBR's statistics regarding the medium interest rates practiced by the credit institutions for the new loans and also, form case to case, the maximum level of the appreciation of the loan exchange rate in comparison with the national exchange rate and also the great increase of the commissions and credit administration expenses.

3. Stress testing methodology and its use in the banking surveillance context

Stress testing includes two major categories: sensitivity tests and scenarios tests. ***Sensitivity tests*** evaluate the

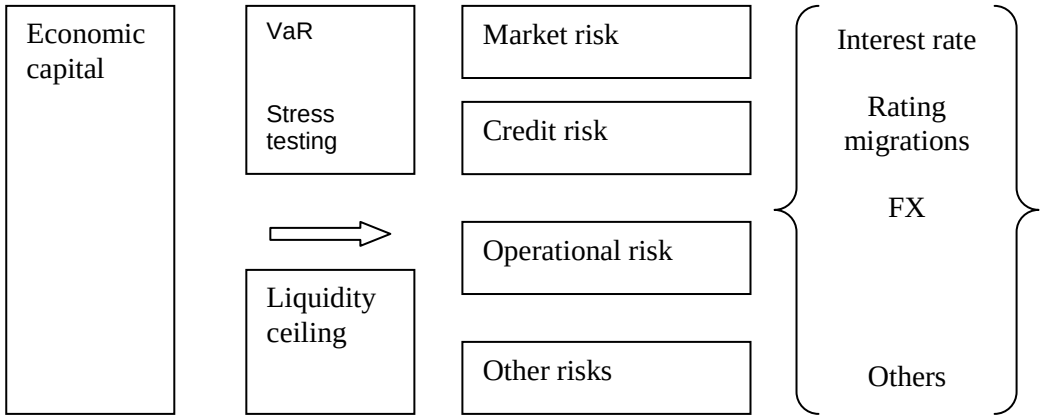
impact that major changes of financial variables have on portfolios without specifying the exact causes of these changes. A typical example is the change with 10 unit points in interest rate or in the revenue generated by certain asset or the reduction by 10% of the prices in a certain portfolio. These tests present the advantage that they can be implemented quickly and easily, being usually used in the approximation of the initial impact that a certain financial variable has on a portfolio. The limitations of these tests are the lack of certain past events that might lead to a false assumption in the future and thus to wrong decisions of banking institutions.

Scenario based tests are constructed based on the particularities of a portfolio or of certain past events that had a significant impact on the financial markets. Risk managers of a portfolio identify key financial elements that are most susceptible to risk in a portfolio and based on these scenarios they study the future evolution of the variables. Choosing one of the two upper scenarios depends on the relevance of the past historic events relative to that particular bank and the resources that can be allocated for the research. Scenarios based on historic events are more widely used because they reflect a segment of the market that is exposed to vulnerabilities which may be studied in detail without making any assumptions. But in case past events are not relevant, then key elements that are capable of influencing the portfolio value need to be determined. Most often a compromise has to be made between comprehensibility and reality because the more sophisticated a scenario, the more difficult it is to interpret.

In order to maintain constantly an adequate level of capital, the Basel Committee on Banking Supervision recommends that banks should use rigorous stress testing programs on a regular basis in order to identify events that may have a negative impact on the bank capital. Stress tests should reflect quantity as well as quality. Quantity criteria should identify possible stress scenarios that may appear while quality criteria should target the evaluation of a banks capacity of absorbing large losses as well as the measures that could be taken to reduce risk. The steps required by stress testing methodology are presented in Grunung and Bratanovic (2004):

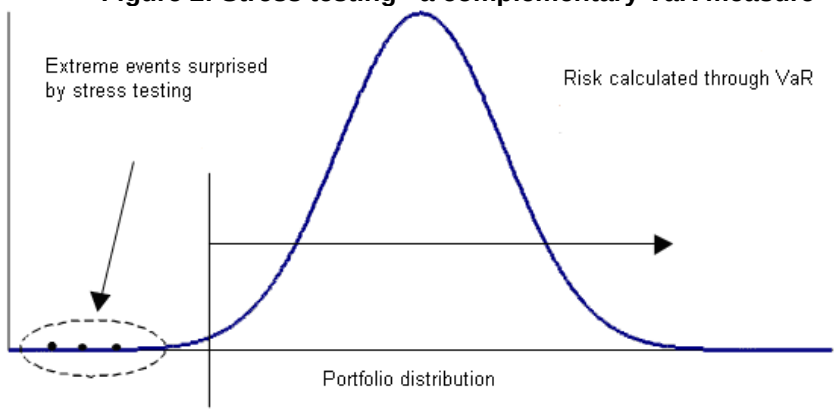
- the revision of information on the largest registered losses during a certain period compared with the estimated level of losses with the help of the bank's internal model for risk analysis;
- the simulation of extreme stress scenarios by incorporating a large price variation as well as a reduction of the liquidities associated to these events;
- the evaluation of the sensitivity degree of a bank's exposure to market risk relative to the modification of the assumptions regarding volatility and the correlations;
- retesting the stress scenarios specific to a bank that take into account the characteristics of the transaction portfolios of a bank in the most adverse conditions.

Figure 1: The capital allocation through the stress testing method



A great number of banks use stress testing in order to verify the minimum limits necessary for the capital adequacy, also dividing these limits for their portfolios. While the VaR based on Historical Simulation methodology is used for the initial allocation of the economic capital, stress testing is used in order to maintain the capital at the adequate level, due to the shocks forecasting to appear on the markets.

Figure 2: Stress testing –a complementary VaR measure



In order to successfully manage the **credit risk** banks use stress tests for simulating the impact of the credit ratings attributed to the debtors on the credit portfolio value. Moreover, there are often tested the impact of the collateral value modification, recovery rates, non-performing loans, or the clients' ratings on the credit portfolio and also the movement of the credit products' value which are traded (credit default swaps, credit linked notes or credit spread options). With all these, the effort to introduce the stress testing methodology at the credit portfolio level and at the trading portfolio level is difficult, due to the different accounting treatment for these two portfolios and also due to the lack of trading with most credit instruments.

Regarding the **market risk**, the stress testing methodology applies to the

trading portfolio of the bank, by simulating different scenarios of the price evolution for the next financial assets:

- spot, FX-forward and FX-swap transactions on the interbank market ;
- attracting and placing deposits transactions on the interbank market;
- treasury bills transactions on the primary and secondary market;
- spot, FX-forward and FX-swap transactions made by clients;
- positions resulting from the treasury activities;
- spot, forward and swap operations made by dealers on the interbank marketing order to equilibrate the real exchange structure.

A study of BCBS highlights that more than 80% of the stress tests are made on the trading portfolio of banks and interest rates movements are the most used in order to quantify their influence of the both on the banks' revenues and on the banks' level of capital that should be allocated in order to satisfy the Basel II Accord requirements. The Federal System from USA uses a validation model based on duration, taking into consideration interest rates increases up to 200 basis points in order to detect the most vulnerable banks to the interest rate movement.

The stress tests used for the liquidity risk asses the possible impact of some extraordinary stress scenarios, but possible on the liquidity level of a bank. The obtained results help banks to determine the level of the liquid assets, capable of absorbing liquidity shocks. Most banks use a combination of adverse market factors, cointegrated, which could affect the liquidity level, taking into account the contamination effect on the whole banking system. Even though it is difficult to implement such a methodology it is preferred in front of an approach which considers that the risk factors are independent and don't have conjugated effects. Most often, scenarios are based on the following evolutions: the reduction of financing to the individual clients, a decrease in the assets pricing, a transfer to the balance sheet of the off balance sheet items, withdrawal the deposits before maturity, an increase in the exposure a group.

4. Simulating interest rate movement scenarios and determine their impact on the bank's revenue and portfolio value

At 31.11.2009 the Romanian Commercial Bank has the following assets and liabilities portfolio sensitive to the interest rate:

Table 1: The structure of the portfolio through the maturity

Maturity	Sensitive assets	Sensitive liabilities	GAP	t_j
0 - 1 months	41.070.264	23.723.644	17.346.620	0,5
1 - 3 months	195.099	6.486.398	-6.291.299	2,0
3 - 6 months	169.993	3.035.322	-2.865.329	4,5
6 - 12 months	61.372	1.085.171	-1.023.799	9.0
Total	41.496.728	34.330.535	7.166.193	-

Where, t_j represents the mid of the residual maturity interval.

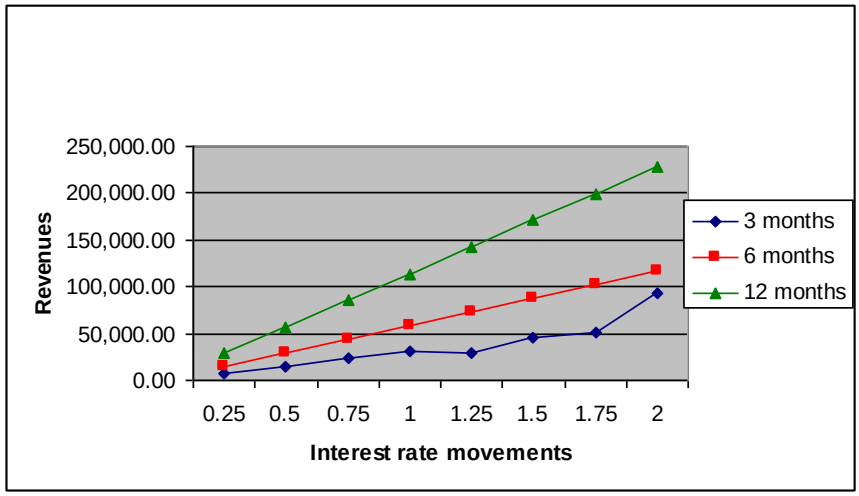
The effects of modifying the interest rates on the net revenues are the following:

Table 2: The effects of modifying the interest rates on the portfolio net revenues

An increase in the interest rates with the following basis points	The estimation of modifying the net revenues from interest rates at the following terms		
	3 months	6 months	12 months
0,25	7.724,01	14.633,59	28.452,74
0,5	15.448,02	29.267,18	56.905,48
0,75	23.172,03	43.900,76	85.358,21
1	30.896,04	58.534,35	113.810,95
1,25	28.965,04	73.167,94	142.263,69
1,5	46.344,06	87.801,53	170.716,43
1,75	50.688,82	102.435,11	199.169,16
2	92.688,13	117.068,70	227.621,90

We observe that even though the bank has a positive GAP in the first residual maturity month, its great value and the long application horizon of the medium effect on the interest rates results in a positive aggregate effect, for all residual maturity horizons. If the market will register an upward trend of the interest rates, the net interest revenues obtained by the bank would increase. The greater the interest rate risk increase, the greater the interest revenues. If the interest rates have an downward trend the net revenues of the bank would decrease.

Figure 3: The portfolio revenues sensitivity to the interest rate modification



At 31.12.2009 the assets and liabilities' duration and convexity calculated through the Macauly indicator was the following:

Table 3: The duration and convexity of the banking portfolio

Elements	Maturity	Face value	Interest	Duration	Convexity
Balances with central bank	1	13433218	0.07	0.080	0.045
Placements with credit institutions	7	3876212	0.02	0.550	0.567
Public effects	5	68004	0.06	0.395	0.344
Bonds and other fixed income titles	5	1013878	0.11	0.395	0.344
Loans and advances to customers	10	24389999	0.14	0.601	0.661
Other assets	0	2399427	0.00	0.000	0.000
Total assets	**-**	**45180738**	**-**	**0.410**	**0.043**
Due to credit institutions	6	11399105	0.17	0.464	0.463
Due to customers	8	26935854	0.06	0.646	0.745
Due through titles	3	1933677	0.07	0.246	0.183
Other liabilities	0	593249	0.00	0.000	0.000
Total liabilities	**-**	**40861885**	**-**	**0.570**	**0.063**

The duration calculation for the portfolio's titles was made through the following formulae:

$$D = \frac{\sum_{t=1}^{n} t \times F_t \times e^{-r \times t}}{P}$$, where:

P- the present value of the balance sheet / off balance sheet items;

F_t – the cash-flow generated by the balance sheet / off balance sheet items at moment t;

r – the interest rate on the market;

t – the time horizon.

For bonds and other fixed income titles the indicator has been calculated through the following formulae:

$$D = \frac{1 \cdot 111.526{,}58 \cdot e^{-0{,}11 \cdot 1} + 2 \cdot 111.526{,}58 \cdot e^{-0{,}11 \cdot 2} + 3 \cdot 111.526{,}58 \cdot e^{-0{,}11 \cdot 3} + 4 \cdot 111.526{,}58 \cdot e^{-0{,}11 \cdot 4}}{1.013.878} +$$

$$+ \frac{5 \cdot 111.526{,}58 \cdot e^{-0{,}11 \cdot 5}}{1.013.878} = 0{,}344$$

The result shows that are necessary 125,56 days for the bonds and other fixed income titles to reach the maturity.

The duration of the entire portfolio has been obtained through weighting the individual values of the Duration indices with each title's weight in the portfolio market value.

- for assets: $D_A = \sum_{i=1}^{n} D_{Ai} \times x_i$;
- for liabilities: $D_P = \sum_{j=1}^{m} D_{Pj} \times y_j$,

where

D_{Ai} –Duration indicator for asset i, $i = \overline{1,n}$

D_{Pj} – Duration indicator for liability j, $j = \overline{1,m}$

x_i, y_j – the market value weight for asset i / liability j in the total assets / liabilities.

The duration indicator calculates as a report between assets and liabilities is 0,719, being lower that 1, which means that the bank has a sensitive assets balance sheet, the assets reaching the maturity before the liabilities. In the case that the interest rates will increase, than

the interest revenues would increase and vice versa.

The convexity has been obtained through the development of the second order Taylor series, based on the second derivate of the price to the interest rate:

$$\frac{\partial P}{P} = -D \cdot (\partial r) + \frac{1}{2} \cdot C \cdot (\partial r)^2$$

It is observed that both the assets portfolio and the liabilities portfolio have a positive convexity. If the interest rates would modify than the market value of the portfolio would increase with a higher value than the absolute value which could be obtained in the moment of decrease, due to the Duration method.

The Duration GAP indicator (DGAP) calculated through the following formulae:

$$DGAP = -(DA - DP \cdot Liabilities / Assets)$$

is 0,1055 and it highlight the existence of the interest rate risk, due to the fact that the assets mature rapidly than the liabilities. If the interest rate on the market would increase than the bank's portfolio would register a deterioration of the market value.

In order to eliminate this risk it is indicated for the bank to immunize its portfolio and bring it to a DGAP=0, through the decrease of the liabilities portfolio's indicator. So, the duration of the liabilities portfolio should reach 0,4533 in order for the bank to protect against the interest rate risk and for the capital invested by the shareholders to remain uninfluenced by the interest rates movements.

Simulating different scenarios of the interest rates movements on the market through Matlab, we have found the next modifications for the assets and liability portfolio.

Tabel 4: Scenarios regarding the portfolio value modification

Interest rate movements	Assets Duration	Assets portfolio modification	Liabilities Duration	Liabilities portfolio modification
-0.0020	45,217,786.21	37,048.21	40,908,467.55	46,582.55
-0.0015	45,208,524.15	27,786.15	40,896,821.91	34,936.91
-0.0010	45,199,262.10	18,524.10	40,885,176.27	23,291.27
-0.0005	45,190,000.05	9,262.05	40,873,530.64	11,645.64
0.0005	45,180,738.00	0.00	40,861,885.00	0.00
0.0010	45,171,475.95	-9,262.05	40,850,239.36	-11,645.64
0.0015	45,162,213.90	-18,524.10	40,838,593.73	-23,291.27
0.0020	45,152,951.85	-27,786.15	40,826,948.09	-34,936.91

So, the modification of the structure of interest rates for the next time horizon would generate different movements of the assets and liabilities market portfolio of the bank.

5. Conclusion

Stress tests represent a very important tool, through which the banks quantify the impact of the adverse effects which could appear both at the credit portfolio and at the trading portfolio. Depending on the tests' results banks take decisions regarding the liquidity risk management, the credit risk management or the market risk management in order to maintain an adequate level of capital due to the Basel II Accord requirements. Taking into consideration their advantages, the supervisory authorities have developed their own tests for evaluating the vulnerabilities caused by the exposure of the banking system to the systemic risk.

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