UNIVERSITY OF LJUBLJANA

FACULTY OF ECONOMICS

MASTER'S THESIS

STRESS TESTING OF MONTENEGRIN BANKING SYSTEM WITH AGGREGATED AND BANK-SPECIFIC DATA

Ljubljana, September 2013 SANJA VUKOVIĆ

AUTHORSHIP STATEMENT

The undersigned Sanja Vuković, a student at the University of Ljubljana, Faculty of Economics, (hereafter: FELU), declare that I am the author of the master's thesis entitled "Stress testing of Montenegrin banking system with aggregated and bank-specific data" , written under supervision of Igor Masten.

In accordance with the Copyright and Related Rights Act (Official Gazette of the Republic of Slovenia, Nr. 21/1995 with changes and amendments) I allow the text of my bachelor thesis / master's thesis / doctoral dissertation to be published on the FELU website.

I further declare

- the text of my bachelor thesis / master's thesis / doctoral dissertation to be based on the results of my own research;
- the text of my bachelor thesis / master's thesis / doctoral dissertation to be language-edited and technically in adherence with the FELU's Technical Guidelines for Written Works which means that I
    - cited and / or quoted works and opinions of other authors in my bachelor thesis / master's thesis / doctoral dissertation in accordance with the FELU's Technical Guidelines for Written Works and
    - obtained (and referred to in my bachelor thesis / master's thesis / doctoral dissertation) all the necessary permits to use the works of other authors which are entirely (in written or graphical form) used in my text;
- to be aware of the fact that plagiarism (in written or graphical form) is a criminal offence and can be prosecuted in accordance with the Criminal Code (Official Gazette of the Republic of Slovenia, Nr. 55/2008 with changes and amendments);
- to be aware of the consequences a proven plagiarism charge based on the submitted bachelor thesis / master's thesis / doctoral dissertation could have for my status at the FELU in accordance with the relevant FELU Rules on Bachelor Thesis / Master's Thesis / Doctoral Dissertation.

Ljubljana, _____ Author's signature: _____

(Month in words / Day / Year)

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

INTRODUCTION

Real economy and financial sector are closely related. On the one hand, financial stability, which is a necessary condition for successful banking system, plays a crucial role in providing an efficient allocation of funds and in fostering economic growth. Similarly, macroeconomic environment affects the stability of the banking sector. The effect of macroeconomic changes on the banking sector will be addressed through the majority of the thesis while in the last part the opposite relation will also be examined, mainly through impulse response functions.

The consequences of the most recent crisis are still being felt, specifically in Europe where the crisis had a profound influence through sovereign debt crisis. In Montenegro, the effects of the crisis came with a delay. Even so, the crisis hit Montenegrin economy hard and major changes in the whole economy were necessary. Recently, the institutions took some actions in order to ensure better coping with the crisis. Central Bank of Montenegro limited the highest lending interest rate, while the Government increased Value Added Tax in order to increase Government revenues. However, banking system was in bad shape since after a credit boom which was present during 2008, the credit crunch took place in light of the crisis. Many banks received capital injunctions from their parent banks and this was crucial for such a small economy as Montenegrin is. If this wasn't the case, there would be much more problems when dealing with the crisis.

When the events of high negative performance and low probability are concerned, it is of crucial importance to be aware that they can happen any moment. If this is the case, there aren't so many extreme and surprising events that couldn't be handled. In order to be aware of the possible negative shocks, European Central Bank (hereinafter: ECB) and other institutions have prescribed a set of regulatory frameworks and practices that each of the EU countries (but also the candidate and acceding ones) should perform on regular basis. One of these practices is stress testing. Banks are obliged to do it by themselves and ECB performed various times EU-wide stress test. Central banks are also advised to perform stress tests regularly since they possess the majority of the necessary data. In Montenegro stress tests are done by the Central bank on a quarterly basis for over than three years.

There are many different approaches to the process of stress testing and in this paper two of them will be investigated. The first one is a stress test performed on aggregated data i.e. on the banking system as a whole. The variable of interest in both exercises is Loan Loss Provision ratio (hereinafter: LLP). The main goal of the thesis is to find an answer to the following question: what are the macroeconomic variables that influence LLP the most and how will LLP, as a variable of interest, behave in a situation when all these variables were to experience negative performance at the same time? The resilience of the banking system to such scenario will be tested through capital adequacy ratio. In order to find out more

about the management practices of the banks, micro-level data on the banks were also used in the analysis. The focus was to see which of the variables are able to explain LLP ratio for each bank individually and how is this information helpful for possible improvements in the banking sector. Hopefully, the relations between these variables will be able to explain some of the banks' losses and some of the banks' practices regarding credit activities. Through the analysis there will be formed some recommendations for the banks but also for the Central bank and its way to influence the practices of the banking sector.

The composition of the paper is the following. In the first chapter the theoretical framework is provided. Some of the main links between financial and economic sector are described in the light of the recent economic crisis. In addition to this, the usual methodological approaches to stress testing practices are presented. In the second chapter an overview of the Montenegrin economic situation along with the stress tests done so far are presented. The following chapters of the thesis are devoted to the empirical analysis. Namely, in the third chapter the stress test is performed on aggregated data. Firstly, the methodology in use is explained after which the necessary steps taken to get the estimation process and at the end the results with the most important findings. In the fourth chapter the stress test is done on the bank-specific variables. The results and the impact of shocks are investigated through impulse response analysis. Finally, the last section concludes.

1 THEORETICAL FRAMEWORK

In the aftermath of the recent global financial crises, it has become obvious what could be direct costs and possible indirect effects of such an extreme negative economic performance. Even though direct costs are undoubtedly high, the indirect ones may be more dramatic and long-lasting. In order for people responsible for the proper functioning of the financial system to be able to address the issues in the most suitable way, they must be aware of the vulnerabilities of the financial system as a whole. Stress testing (or more precisely, macroeconomic stress testing) can help this cause since it is defined as quantitative tool used by banking supervisors and central banks in order to assess the soundness of the financial systems in the event of extreme but plausible shocks.

Stress testing techniques are not as new as they may seem. They have been applied since the early 1990s. However, they were then used only by large and internationally owned banks which, because of the nature of their risks, were the few ones able to understand the usefulness of stress tests. They were used as a complementary analysis of the risk management models such as value-at-risk technique. In contrast to the value-at-risk which gives information only about the level of negative performance, stress tests provided more useful information since they are able to actually explain these extreme events as opposed to merely identify them. Since 1996, banks and investment firms have been required to perform some kind of stress tests as a part of the internal model related to the calculation of capital requirements. However, through many years these practices have become more and

more often and now form a part of the obligatory regulatory tests (Quagliarello, 2009, p. 19).

1.1 Financial stability

In order to perform stress test, financial system has to be assessed and major vulnerabilities have to be identified. This is not a simple process and yet it is essential prerequisite for the stress testing exercise. Moreover, it has been proven difficult to provide an appropriate definition of the term financial stability. According to Schinasi (2004, p. 7) financial stability does not necessarily imply that all its components operate at the top or near top of the performance, but it has the ability to limit and resolve any possible imbalances. It is always defined in terms of ability to enhance and facilitate economic processes as well as to manage risks and absorb shocks. However, there are other definitions like a broad one provided by Financial Stability Board and they believe that the main goal is to coordinate at the international level the work of the financial institutions as well as to develop and implement effective regulatory, supervisory and other financial sector policies. The definition of the term is important because of the ability to build an effective framework, guided by its meaning, through which it will be possible to assess the healthiness of the financial system. Consequently, if the state of the financial stability or instability is known, it is easier to identify the risks and vulnerabilities that make the system weak, the shock that can trigger those vulnerabilities and the mechanisms through which the effect of the crisis or a shock can be amplified (Quagliarello, 2009, p. 9).

1.2 The effect of the financial crisis on the financial system

As it was shown with the sub-prime mortgage crisis, the financial system is likely to be the one mostly affected by the crisis given that it is vulnerable and likely to cause contagion and consequently systemic crises. This is exactly why stress tests are usually performed within, or on financial institutions, mostly banks. Before actually performing stress test it is important to detect the appropriate linkage between the shock related to the (macroeconomic) environment and the financial system. When this relation is established some meaningful results are to be expected in the form of the ability of the system to absorb shocks and resolve them (Quagliarello, 2009, p. 18).

Nowadays, stress tests are more used exactly in the purpose of assessing financial stability at the macroeconomic level. International Monetary Fund (hereinafter: IMF) and World Bank have been using stress tests increasingly. For many authorities the practice of stress testing was introduced as part of the **Financial Sector Assessment Programs** (hereinafter: FSAPs) conducted by International Monetary Fund and World Bank. The FSAP stress tests stimulated widespread research interest in developing new techniques whereas many additional studies are under way. Moreover, in some countries, econometric macroeconomic models have been developed in order to ease this kind of analysis. Basel II and III are form of recommendations regarding banking laws and practices and contain, among the others, recommendations to perform stress test frequently. In euro area, almost every country has done stress tests regularly in order to check for the robustness of its

financial system. According to Čihák (2004, p. 22) more often stress tests brought some benefits for the authorities such as more accurate and detailed data that can then be analyzed even more regularly in the future.

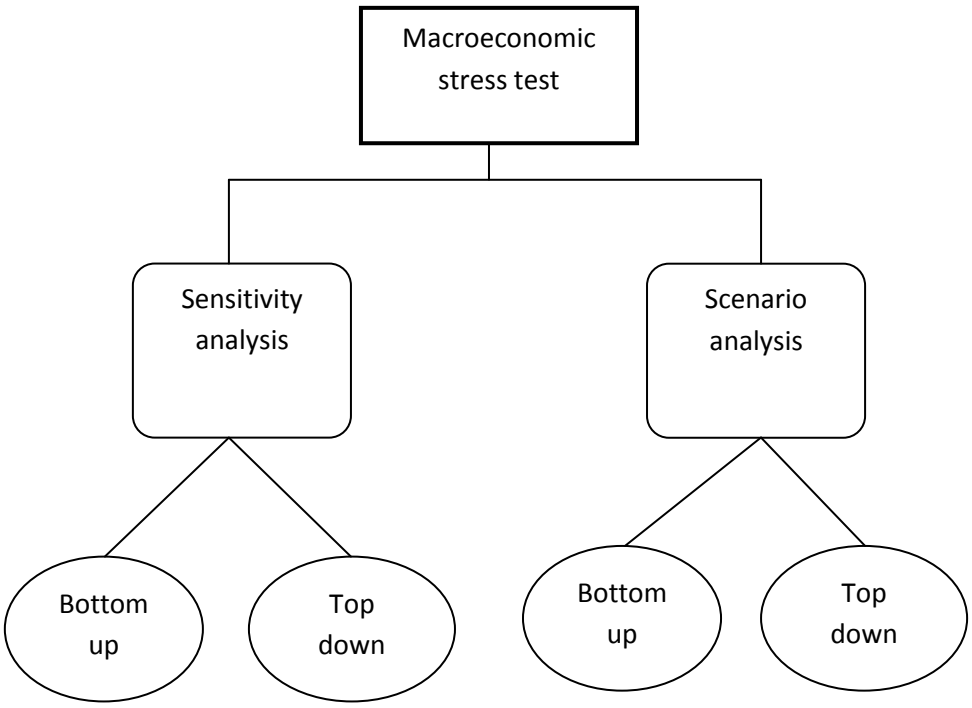
1.3 Stress tests

There are different types of stress tests and consequently various definitions. According to the IMF and from macroeconomic point of view, stress testing is defined as a key element of the macro prudential analysis that can help in monitoring and anticipating potential vulnerabilities in the financial system. Macroeconomic stress test (the one which will be the first performed and analyzed in the paper) is defined as a way of measuring the risk exposure of a relevant set of institutions to stress events. However, stress test is not a single exercise. It actually comprises of the various techniques with a goal to identify the range of extreme but plausible events and the response of the banking sector. Hence, the main outcome of the portfolio is an estimate of the change in value of a portfolio, where by portfolio it can be considered, for instance, the balance sheet or income statement of the particular bank or even more frequently used – **capital adequacy ratio**. Still, it is useful to be aware of the fact that they are not always accurate and in many ways they rely on the judgment of the researcher. Stress test cannot, therefore, be considered a precise tool, it is more of an art, where all of the three ingredients such as quantitative techniques, human judgment and several discretionary assumptions have to be taken into account (Quagliarello, 2009, p. 23).

Stress test can be used to measure the effect of the negative impact of a **single factor** (e.g., decline in house prices) which is defined as sensitivity analysis or to measure an effect of the negative impact of the **various factors**. The latter form of stress tests is called scenario analysis since the negative impact of various factors (decline in GDP together with the increase in unemployment rate and a rise in interest rate) actually form a specific negative scenario to which the reactions of the financial system are then further analyzed. The former type of stress tests is used by the IMF's country FSAP's which look at the impact of a change in one variable (e.g. the exchange rate or the policy interest rate) on banks' balance sheet. However, there is no interaction between the variables like in the case of scenario analysis (Hoggarth, Sorensen, & Zicchino, 2005, p. 7).

As shown in the Figure 1, when the choice of the negative impact (one factor or more) is done, stress test of the whole system can be done in two ways. A first option is called bottom-up approach and is done in a way that authorities define the macroeconomic shock and let the institutions evaluate the impact on their balance sheet. Then all the results are aggregated in order for researcher to be able to inspect about the overall impact on the system as a whole. The other approach is called top-down and it is done in the opposite way, namely the authorities themselves apply the shock either to the aggregated banking system portfolio or on the bank-by-bank data.

Figure 1. Types of stress tests



Source: M. Quagliarello, *Stress testing the banking system*, 2009, p. 23.

As it can be supposed, bottom up approaches are more detailed and done according to the specificities of the particular institution. Hence, this is one of their advantages. However, this advantage becomes immediately disadvantage of this approach since the comparability of these results is very limited, if possible at all. On the other hand, in the top down approach the data that the central institution has are not as rich and detailed as those of each institution individually, but are therefore very easy to compare and to interpret their results. There is a clear distinction between those which are highly understandable and those more complex and realistic ones (Quagliarello, 2009, p. 25).

1.3.1 Ingredients of the stress tests

When it comes to the ingredients of the stress tests and the definition of its parameters it is important to determine what the primary goal of the stress test is. Also, in order to perform stress tests both meaningful and useful it is important to explore the economy and financial system of the country or institutions in which the stress test is performed. Even though the best way is to include all relevant **financial intermediaries**, the banks are mostly the ones on which the tests are performed. However, if the stress test is done in those countries where non-bank intermediaries are more important and account for a significant or bigger portion of the financial system, they should also be included. Still, in most cases the banks are the one included in the exercise as these are usually the most important part of the financial system, through which the majority of the payment system is done and through which the contagion is likely to happen.

1.3.2 Identifying the proper risks

The next important step in this procedure is to identify the **proper risks** of a specific institution on which the stress test is done. Along with the selection of the intermediaries this step is of huge importance, since this is how the tailoring according to a given country or bank can be done, precisely by analyzing its weaknesses and possible cause-effect relations. This way the whole process becomes more realistic and effective and the results become more useful. Making the right decisions regarding the choice of risk types is of huge importance also. Further, what has to be done is **shock calibration** i.e. defining the events which will trigger the shock and the level to which these shocks are to be materialized in the form of the specific stress scenario. In this step it is important to be aware of the fact that these events should be extreme but still plausible. However, they should always be strong enough to produce turbulence (or a stress). There are several ways in which the shock is to be determined; among them are historical events, worst-case scenario, threshold approach etc. When the estimation of the results is done another factor that should be considered are **feedback effects**. The fact is that the shock can usually cause other processes to affect the model and other variables of interest and these should also be analyzed in order to form a complete picture of the stress performed. Feedback effects can provide insight into the reaction of macroeconomy to an increase in financial fragility and it is usually done through Vector Auto Regression. In the case of the stress tests by Hoggarth et al. (2005, pp. 3-7) UK banks' aggregate write-offs, particularly the ones related to the corporate portfolio, are found to be sensitive to an adverse macroeconomic scenario, while household write-offs are found to be more sensitive to changes in income gearing (Quagliarello, 2009, p. 28).

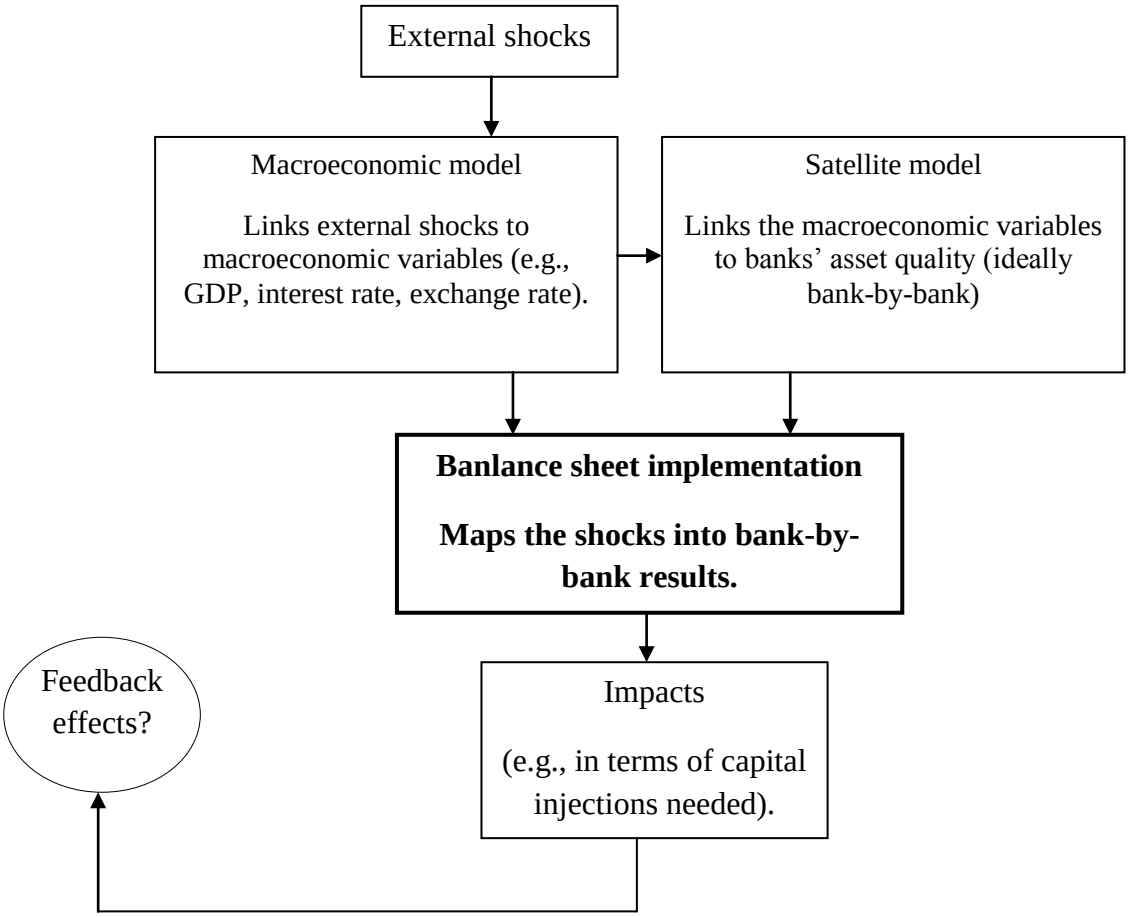
1.3.3 Stress testing as a multi-step process

The stress test has several stages of which all are extremely important for the quality and credibility of the results. The stages and models mentioned in Foglia (2009, p. 11) are used in the empirical part of the thesis regarding the stress test performed on the aggregated data. They are also presented graphically in the Figure 2.

First, the macroeconomic model is to be considered as a coherent stress test scenario. Next, given that this kind of macro econometric model doesn't include financial sector variables, there is a necessity to include the so called satellite model which is used to map macroeconomic variables to some financial variables.

Further, there is a need to map the values provided this way to some measures of bank's asset quality or potential losses. This type of stress testing by formulating macro econometric model whose variables have been forecasted into stresses values and then linking this stressed model to the satellite model (the one containing variables related to the financial sector) has already been used many times.

Figure 2. Stress testing - a multi stage process



Source: M. Čihák, *Introduction to applied stress testing*, 2007, p. 8.

For example, bank of the Netherlands has done similar analysis by performing stress tests using deviations of the macro variable from the baseline scenario (i.e. output of the macroeconomic model) as input in the credit-risk model. French Banking Commission and Bank of France performed similar form of stress tests where the outputs of the macro model (stressed GDP, short-term and long-term interest rates) done with the new version of the macro-econometric forecasting model are the input of the credit-risk model (Foglia, 2009, p. 30).

1.3.4 The design of the macroeconomic stress scenario

The macro econometric model can usually be done in three ways: a structural econometric model, vector autoregressive method (hereinafter: VAR) and pure statistical approach. Many of these macroeconomic models are done with existing econometric model used by Central banks and other authorities for forecasting and policy analysis, in order to get the level of key macroeconomic variables under assumed stressed conditions. VAR model is flexible and has a simple way of producing a set of mutually consistent shocks although they don't incorporate the economic structure like in the macro modeling approach. These models were also used in many stress tests performed by central banks such as: Bank of the

United Kingdom, Bank of Japan, Bank of Spain and the European Central bank (Foglia, 2009, p. 14).

Both the structural and VAR approach need a way to map econometric variables into indicators that can then be further used to estimate the implications of the stress on the banks (either balance sheet, losses, capital adequacy ratio or something else). In this kind of model, loan performance measures are used to link these two models, usually nonperforming loans (hereinafter: NPL) ratio. The assumption behind this practice is that loan quality is sensitive to the economic cycle. Unlike macro econometric model, credit-risk satellite model can be estimated on the individual banks' data and even on the individual borrowers' data. For example, Čihák (2007, p. 49) differentiates between two groups of satellite models: one is based on loan performance data and the other is based on micro-level data like default risk of the households and corporate sector.

1.4 Stress testing in the EU

One of the responsibilities of the European Banking Authority (hereinafter: EBA) is to ensure the proper functioning and integrity of financial markets as well as the stability of the financial system in the EU. It is a part of the European System of Financial Supervision whose primary goal is to rebuild trust in the financial sector.

Regarding this goal, EBA has a responsibility to monitor and recognize market developments but also to identify trends, potential risks and vulnerabilities. One of its most important tools with which it aims at reaching this goal is **EU-wide stress test exercise**. This exercise is done in cooperation with European Systemic Risk Board (hereinafter: ESRB). The resilience of the financial system is being tested against adverse macroeconomic scenario. These stress tests are performed in bottom-up manner using methodologies, scenario and assumptions developed through the work with European Central Bank and the European Commission (European Banking Authority, 2011a, p. 2).

The EU-wide stress test performed in 2011 incorporated some changes according to the lessons learnt through two previous EU-wide stress tests. For example, the definition of the core Tier 1 capital is far more restrictive than the one used in the previous stress tests. For the purpose of the trading book stress test and the inclusion of sovereign risk component a set of stressed market parameters were directly applied on the trading book positions.

The European Banking Authority published the results on EU-wide stress test exercise performed in 90 banks in 21 countries on 15th July 2011. The aim was, as usual, to assess the resilience of the banks covered in the exercise against an adverse but plausible scenario. Banks were incentivized to strengthen their capital position since they were allowed to increase the capital in the first four months of 2011. The results showed that from the test performed at the end of 2010, 20 banks would fall out below the threshold value of 6% in a two year period. The overall shortfall would be equal to 26.8 billion. When capital raisings were taken into account, which happened between January and April of 2011, the results were somewhat different. Namely, eight banks fall below the threshold

over a two-year horizon period with a shortfall of 5.2 billion. Still, 16 other banks display CAR between 5% and 6%. After conducting these tests and analyzing the results, EBA gave recommendation to the national supervisory authorities stating that they should require those banks whose Capital Core Tier 1 (hereinafter: CT1) falls below 5% to improve their capital position. Regarding these recommendations, EBA published a report in July 2012 in which it states that the banks, after following these recommendations, are in much stronger capital position (European Banking Authority, 2011b, pp. 2-4).

On the 27th September, EBA published the results of its second Basel III monitoring exercise in which the results regarding capital, risk weighted assets, leverage and liquidity ratio in EU member states were presented.

Table 1. The timeline of the 2011 EU-wide stress testing process

Date	Description of the step
13/01/2011	The EBA announced a new round of stress tests
02/03/2011	Concrete next steps and timeline of the 2011 EU-wide stress test exercise
18/05/2011	The EBA published details of its stress test scenarios and methodology
08/07/2011	The EBA announced the benchmark to be used in the 2011 EU-wide stress test
08/07/2011	The EBA Announces Stress Test Publication Date
15/07/2011	Results of 2011 EU wide stress testing exercise
02/05/2012	Report on the fulfillment of the EBA Recommendation adopted on 15 July 2011

Source: European Banking Authority, *EU-wide stress testing*, 2011a, p.3.

The 2011 EU-wide stress tests contains an unprecedented level of transparency regarding banks' exposures and capital positions, so that investors, analysts and other market participants can develop a proper and informed view of the resilience of the EU banking sector. Also, on the EBA's website the results of stress tests for all individual banks are published. Other important requirements are also available such as: database of structure, database of results, summary report, the necessary tools etc. This majority of the available data and methodology can motivate other practitioners to perform stress tests as well. If they decide to do so, they have appropriate information and methodology available and are able to provide some new relevant insights into this topic (European Banking Authority, 2011b, p. 3).

Still, the process of performing a stress test has its timeline and the one which was followed when it comes to the EU-wide stress tests performed in 2011 is presented in the table below (European Banking Authority, 2011b, p. 4).

1.4.1 Stress tests in the new EU member states

The stress tests in the EU new member states (hereinafter: NMS) are somewhat specific. These countries experienced rapid credit growth in 2009 and 2010. Among several important common features is their financial system. Most of them are bank-dominated, thus making banks the central focus of financial analysis. Moreover, banks are mostly foreign-owned where parent companies acting as a funding source present another analytical challenge for stress testing financial stability in these countries. If the source of the crisis is in the parent company home country, then the aid that in normal times would be given to the subsidiary would now be decreased or even absent. The problem parent bank is facing can thus be transferred to the sound bank of the subsidiary through, for example, reputation risk. Exactly this is the reason why the authorities, when doing stress testing, are generally conducting it on a stand-alone basis, i.e. assuming no support from the parent bank. On the opposite side, the spillover effects from parent to subsidiary are still rare in stress tests. Despite the obvious problem of data limitation, the stress tests are improving in its sophistication but the main challenge remains the inclusion of the causes and effects of the foreign parent banks (Quagliarello, 2009, p. 262).

1.5 Overview of the methodology

In macroeconomic scenario stress testing the effects of shocks to macroeconomic and financial variables can be estimated through different models. However, they are usually estimated through three different approaches: 1) a structural econometric model, 2) vector autoregressive methods and 3) pure statistical approaches.

1.5.1 The three approaches

Many practitioners use existing **structural models** (those developed and used by central banks for forecasts and policy analysis) to project the levels of key macroeconomic indicators. The use of structural models is good because it can allow for endogenous policy reactions to the initial shock. If there is no such model available or if it is available but isn't feasible to produce consistent and relevant shocks, a second possibility is **VAR** or vector error correction models (VECM). In these models, a set of macroeconomic variables are jointly affected by the initial shock. VAR approaches are convenient because they are flexible and have a relatively simple way of producing mutually consistent shocks. The disadvantage of these models in comparison with the structural models is that they don't incorporate the economic structure present in the previous kind of models. Also, the results of VAR are relatively easy to understand and interpret. According to Foglia (2009, pp. 34-42) and a survey she conducted, this approach is used by Bank of England, Bank of Japan, Bank of Spain, Bank of Netherlands and the European Central Bank. Some of these

central banks use global VAR or GVAR. The third way of conducting stress test has been chosen by the Austrian Central bank in its Systemic Risk Monitor (hereinafter: SRM) and that is a pure **statistical approach** to scenario design. SRM is a model developed by the Austrian Central bank for systemic financial stability and stress test analysis. It includes three different types of risk: credit risk, market risk and interbank contagion risk. Macroeconomic and financial variables are modeled through a multivariate t-copula. This approach is not well suited for policy analysis because it is purely statistical (Foglia, 2008, p. 16).

1.5.2 Credit risk models

Since in both types of empirical analysis (that of aggregated data of the banking sector with VAR approach and the other with bank-specific data with panel VAR approach) the key interest is to estimate and identify major concerns related to the credit risk of the banking sector in Montenegro, a usual way to estimate this type of risk will be explored.

Both the VAR approach and structural econometric approach need a method to map the macroeconomic variables into indicators which will further be used to estimate the implication on the banks' balance sheet. Usually, macro econometric models do not include variables related to the credit risk so there is a need to include another model called satellite model. The satellite models maps shocks of the macroeconomic variables into shocks on the banks' balance sheet. In this credit-quality regression models there are several ways to include variables related to the loan quality. The general assumption of these models is that the loan quality is sensitive to the general economic cycle. For example, Blaschke, Jones, Majnoni, & Peria (2001, p. 25) use $\text{NPL}/\text{total assets}$ ratio as dependent variables which is then regressed against the nominal interest rate, the inflation rate, the change in real GDP rate and the change in the terms of trade. The coefficients of this regression provide an estimate of the sensitivity of loan performance to these macroeconomic indicators (Foglia, 2009, p. 18).

The initial step when analyzing the credit risk is estimating the variables, both macroeconomic and financial that influence the credit risk. As a rule, the interest rate is of key importance and almost always crucial variable since it represents the direct cost of borrowing. The disadvantage of the satellite model that treats macroeconomic variables as exogenous is the fact that it cannot analyze the feedback effect of the worsening banks' balance sheet to the macroeconomic variables i.e. to the environment. There are several reasons why sometimes exactly this approach is necessary. The typical framework through which this analysis of the feedback effects is usually done is VAR approach where macroeconomic and credit risk variables are all endogenous and influencing each other. Marcucci and Quagliarello (2006, p. 22) analyze default rate as the dependent variable and as macroeconomic scenario they include GDP growth, the long-term interest rate, the loan-deposit spread and stock exchange index changes. In order to have a better understanding of these variables, the authors also analyze impulse response functions as feedback effects. The main goal was to verify whether banks' performance is linked to the general

macroeconomic climate and to identify the timing of the banks' reactions to the changes in economy. Nevertheless, the most important fact of the satellite model, which is differentiating it from macroeconomic model, is the fact that it can be analyzed on the data for individual banks and sometimes even for the individual borrowers. Čihák (2007, p. 29) divides these models in two large groups: one based on loan performance data (such as non-performing loans, loan loss provisions, and historical default rates) and the other group based on the micro-level data related to the default risk of the household or corporate sector (Foglia, 2009, p. 18).

- **Model based on loan performance data**

Regarding this approach there are several possibilities for the dependent variable: non-performing loans, loan loss provisions and historical default frequencies. Depending on the availability of the data the exercise can be done on the aggregated type of data, on the industry level and on the individual bank data. The credit-risk models of Lehmann and Manz (2006) and the German Bundesbank use the LLP ratio to measure credit quality at the individual bank level, with static or dynamic panel data estimation. The panel estimation is therefore advantageous since it controls for individual banks characteristics and captures different sensitivities of each banks to certain macroeconomic variable. Loan loss provision used as the dependent variable raises important questions. There are many studies analyzing loan loss provisioning rules of the banks, but the general conclusion is that the loan performance is lagged or retrospective indicator of asset quality. Therefore, loan loss provision may be only partly driven by the bank-specific indicators like credit growth, loan to deposits ratio etc. There is different legislation among different countries regarding the rules about writing-off of the non-performing loans and about their presence in the financial statement (Foglia, 2009, p. 11).

- **Model based on data on individual borrowers**

As mentioned before, credit risk satellite model can also be based on the individual borrower data. The model may and should also include macroeconomic variables which would take into account some of the macroeconomic environment. The probability of default can be related to the borrowers' characteristics like Eklund, Larsen, and Bernhardsen (2001, p. 34) have done it and then compared default with the characteristics such as firm size, age, industry and accounting variables. The forecasted macroeconomic variables are used to estimate the future income statement and with that information individual probabilities of default were calculated. Further, this data is aggregated to generate total loan loss.

1.5.3 Liquidity stress testing

On the other hand, liquidity stress tests are not so common, mainly because of the problem with data limitation. An example of such stress test is the one was done on the Hungarian banking system. Stress liquidity indicator is proposed which is considered to be a percentage of customer deposits that a bank is able to pay out within a period in which it

loses its interbank funding and has no external sources of liquidity except for its portfolio of marketable securities. These stress liquidity indicators for Hungarian banks were fluctuating in the range of 20-30 per cent from 2004 to 2007. The authors also don't allow help from the parent company in their model, because they wanted to address and explore capacity of Hungarian banks on a stand-alone basis. Liquidity risk is connected with the network banks have created so far because the interbank deposit market is a crucial tool for banks day-to-day liquidity management (Quagliarello, 2009, p. 261).

1.5.4 Interbank contagion in stress tests

Similarly, the ability to conduct stress test analysis based on interbank contagion risk very much depends on data availability. However, in the countries where the central banks have data on the interbank exposures this type of analysis is included in the stress tests. The National bank of Poland tried to estimate the scale of interbank contagion risk. This scale is assessed looking at the size of banks which are subject to "secondary default" as well as the value of interbank liabilities that these banks are unable to pay. They found out that the scale of probable interbank contagion is low, since the banks at risk of secondary default have a share at around 6 % in the Polish banking sector. Moreover, the losses because of secondary defaults are only 0,1 % of assets. The performed tests in CEE countries generally do not indicate that risk of interbank contagion is a serious problem.

1.5.5 Methodological challenges

Each research process faces challenges on its way to the implementation and so does the stress testing. These challenges can be summarized into four large groups: data limitation, endogeneity of risk, challenges connected with non-linearities of the stress process and those connected to the distribution of the risk factors.

- **Data limitation**

The usual problems with regard to data limitation are shortness of the time series and the scarcity of extreme observations. This is the reason why it is difficult to efficiently predict future crises and the reason why each of them brings unexpected consequences. There is not enough data regarding the crises in the past and along with the fact that the financial and banking sectors are always changing, the models built cannot keep up well with the constant changes. That is exactly the reason why this is the problem practitioners are constantly facing since the input they have to put in stress test is sometimes not good enough to produce sensible and relevant results (Drehmann, 2008, p. 69).

- **Endogeneity of risk**

Endogenous policy responses and decisions of the central bank and other banks may make exogenous policy shocks disproportionate. (Drehmann, 2008, p. 77) This endogeneity of risk can also be due to the absent feedback effects from banks to other financial institutions and from financial system back to the real economy. Thus, second round effect, so far mostly ignored by the researchers, should also be explored. Central banks have recently

been trying to advance this field of research, usually by including VAR model with impulse responses. Such example is presented in Espinosa and Prasad (2010, p. 3) where they conduct a panel VAR analysis in order to examine non-performing loans in banking system and the effects they produce regarding macroeconomy.

- **Non-linearities**

The problem with possible non-linearities may be exactly in the specificity of the model the stress test is. If in normal circumstances linear relationships can be assumed, in stressed conditions that assumption may not hold. These non-linearities can be a consequence of endogenous behavioral responses (again connected with another possible limitation) or they can respresent a consequence of misspecification of the econometric model. Nevertheless, Drehmann (2008, p. 83) suggests that non-linearity may not be such a huge problem since the main goal of the majority of the stress tests is communication. He believes that the transmission of the shock would remain the way it is.

- **Distribution assumption**

Regarding stress test, an assumption about normal distribution may not be appropriate. Data should be carefully examined even though it is not easy to change the normality assumption when the fundamental logic of the model depends on it. In some cases non-normal distribution with fat tails should be assumed because it implies higher probability of the stress events (Quagliarello, 2009, p. 75).

2 STRESS TESTS IN MONTENEGRO

2.1 Economic environment in Montenegro

As already mentioned, in Montenegro stress tests are done on regularly basis (quarterly frequency) by the Central Bank of Montenegro (hereinafter: CBM). These stress tests are done with top-down approach. The baseline and adverse scenario are developed in CBM according to financial risk indicators. As Montenegro is currently candidate country for joining European Union, stress tests are also done by some regulatory bodies from the EU. For example, in September 2012, European Central Bank (hereinafter: ECB) performed stress tests for the candidate and acceding countries. Before providing some insights into most recent stress test, overview of the Montenegrin economy is presented and stability of its financial system is analyzed.

2.2 Macroeconomic environment in Montenegro

The economic recovery from the recession is in progress, even though the recovery pace is still slow. Some significant growth is experienced during one quarter (for example the 1st quarter of 2013) but this is usually due to some sharp increases which are not sustainable on a long-term basis. After gaining its independence Montenegro experienced a credit boom driven by high (aluminum) exports while construction, financial services and

tourism were the most important branches. Real GDP peaked at 10.7% in 2007 which was a consequence of a high foreign direct investments and domestic demand. After the beginning of the crisis, the economy started to slow down to reach a decrease in 2009 of -5.7%. GDP recovered again in 2010 due to a good tourism season. Slowdown of economic growth was present also during 2011 due to the consequences of euro area sovereign debt crisis. In 2012 the growth began to experience an increase of 3.2% (similar to the estimates of CBM of 3.5%) but is expected to slow down in 2013. (ECB, 2012, p. 62)

Unemployment is still relatively high but is slowly decreasing and has decreased up to 13.5% during the first half of 2013. Montenegro has sizeable external imbalances which are a source of constant concern. Still, in the period of the crisis no aid from the IMF was necessary. The current account deficit in 2008 was 50% of GDP which was high even for regional standards whereas in 2012 it was 17%. Montenegro still has a current account deficit but is trying to decrease this negative performance. Since surplus of over 6% in 2007, from the beginning of the crisis Montenegro started to experience deficits when in 2009 they reached 6% of GDP. This has been dealt with by fiscal consolidation. In this way the deficit is narrowed to a certain degree. The revenues are planned to be increased by increasing VAT from 17% to 19%. This increase is officially in use since June 30th.

Since the adoption of euro, CBM cannot influence money supply which is determined only by balance of payment flows and its capacity to act as lender of last resort is also limited. On the official website of CBM (Centralna banka Crne Gore, 2013) it is clearly stated that its main objective is to "foster and maintain financial system stability, including fostering and maintaining a sound banking system and safe and efficient payment systems." However, the Central bank also engages in liquidity management operations and issuance of the Treasury Bills on behalf of the Government.

2.3 Montenegrin banking system

Montenegro, in proportion with its country size, has a small banking sector which is mostly foreign-owned by EU parent banks (mainly from Hungary, Slovenia, Austria and France). These foreign-owned banks account for 90% of the total banking sector. The total number of banks has remained the same since 2007. There are 11 banks of which 9 are foreign-owned. Since the beginning of the crisis the degree of concentration of the banking sector has declined from 80% assets of the four largest banks to the 64.1% by the end of 2011. The majority of the loans are still traditional loans to the private sector. Loan to deposit ratio reached a peak in 2009 at more than 150% and declined in the review period of the paper to 107.6% at the end of 2011. The economic situation as well as credit growth went through boom and boost cycle whereas credit growth is currently contracting. It even reached 100% year on year growth in 2007 but this was obviously unsustainable. When the crisis started in 2008, CBM applied some credit controls, which reduced credit growth to 22%. However, these previous imbalances resulted in late-2008 liquidity crisis. This was surpassed with the help and capital injunctions from the parent banks. Since 2009 credit growth has been declining. Credit crunch began in 2010 and is still somewhat present. However, the recovery of the Montenegrin economy is currently in progress along with the

recovery of the banking system. What will be interesting to see from the panel VAR is how Loan Loss Provisions are specified baring in mind the differences between the banks included in the model. There are some (big foreign-owned) banks which had very high losses whereas there are some smaller banks which didn't experience losses at any point in time.

The NPLs have been increased in 2011 to a record of 25% whereas they are currently decreasing. This is maybe due to the fact that the banks have been writing-off the bad loans from their balance sheet. Even though the non-performing loans stabilized after the peak of the crisis, they started to increase again in the second half of the last year. During the beginning of 2013, there was an initiative by the World Bank and Central Bank of Montenegro to find a way to make the banking system of Montenegro healthier. These two institutions developed and proposed the so called "Podgorica model" (čg. *Podgoricki model*) which represents an appropriate way for banks to restructure the problematic loans and in that way improve their portfolio. The first phase of implementing the project is testing its performance by each bank on one of the companies which are problematic regarding the non-performing loans. The second phase includes formulating a specific law (lat. *lex specialis*) with which a specific way for restructuring loans in Montenegro would be established and appropriately incorporated in Montenegrin law. Despite of the need for this kind of solution, the first phase of the project is still in progress and it seems that the process is too slow.

Bank deposits decreased during the peak of the crisis due to loss of confidence but then in 2010 and 2011 (particularly household deposits) have stabilized and growing again. However, in order to reach the recovery of the pre-crisis level of deposits there has to pass more time. As far as the composition of the deposits is concerned, demand deposits account for 39% and time deposits for 61% of total deposits. Only 3.5% of deposits at the end of 2011 were denominated in other currencies than the euro (ECB, 2012, p. 64).

2.4 Financial stability challenges

The profitability of the banks and generally financial institutions remains low since they continue to produce losses. Before the crisis Montenegrin banks were relatively profitable. The losses in the 2011 could be due to the write-off of numerous non-performing loans. Moreover, real estate prices since the pre-crisis boom have been constantly decreasing. This decline can influence deterioration of the bank assets since property is typically used as collateral for housing loans.

On the other hand, one of the most severe risks remains to be liquidity risk. From the parent support this risk was somewhat reduced and mitigated, but the decline in deposits from 2008 makes this situation even more difficult. However, Central Bank of Montenegro could not intervene too much in order to help the liquidity to rise again and parent banks at the end of 2011 were not open to capital injunctions anymore. Still, the exposure of banks

to the market risk is low, due to low level of net open foreign exchange position relative to total bank capital.

In the most recent period, from 2011 and 2012 onwards, some of the large banks have been experiencing very high losses. Nevertheless, these losses were due to the three largest banks which lost 68.9 million EUR. Fortunately, the banks started to improve its management in order to cut losses and in the beginning of the 2013 it looks like they were successful regarding this goal. During the first quarter of 2013, 3 out of 11 banks were having losses, in total amount of 1.2 million EUR which is much better than the results of the previous year.

2.5 Stress tests performed by the ECB

As already mentioned, ECB performed a stress test for all candidate countries including Croatia which officially became an EU-member state on the 1st of July, 2013. These stress tests were performed during 2012 and the research paper was published in September 2012.

2.5.1 Financial stability assessment

This exercise performed by ECB was in a form of comparative analysis and is done in collaboration with many people from this field of research, some of them from these candidate countries and some from member countries. Data for this kind of stress test done on Montenegrin economy was provided by the Central bank of Montenegro. In this comparative analysis first the main challenges regarding financial stability of these countries were examined. It was established that during the review period (2010 and 2011) these countries were suffering from the consequences of the Euro area sovereign debt crisis. Rising of credits was one of the main challenges regarding financial stability in Montenegro, specifically the banking sector. In the case of Montenegro there were higher domestic imbalances, extremely high specifically in private sector credit growth. This was abnormally high in the late 2007. Consequently, excessive lending led to a credit crunch which started in the crisis period and continued during the review period (throughout 2010 and 2011). However, the overall credit level as a percentage of GDP remained relatively low in many candidate countries which can be seen as potential financial deepening in the financial sector (ECB, 2012, p. 9).

2.5.2 Capital Adequacy Ratio in Montenegro

Nonperforming loans which give information about the credit risk were relatively high in Montenegro since 2009 and in the 2nd quarter of 2011 they reached 25% of the total loans. The need for debt restructuring and cleaning-up banks balance sheet was obvious. According to the ECB (2012, p. 7) capital adequacy ratio of the candidate countries on average is higher than in the EU and in the euro area. Also, high capital adequacy ratio is a proof that these banks contain capital buffer against the losses. CARs were actually proven to be relatively high even after performed stress tests. The resilience of the banking system

is due to various factors: large capital buffers, low exposure to market risk and relatively low exposure to sovereign risk.

2.5.3 Macroeconometric model

The emphasis of the ECB's analysis provided to the candidate countries is at the financial system as a whole. Macro stress test exercise was performed by the central banks of the candidate countries. The test was performed in January 2012 and banks' balance sheets up to the end of 2011 were used when gathering the data. Typically such tests include a baseline scenario and an adverse scenario which are both based on the country-specific macroeconomic variables and their projections. Also, additional country-specific shocks are included in the model in order to make this exercise more realistic. The adverse scenario is formulated as common as possible in order to be able to compare the responses of these countries afterwards. The adverse scenario included real GDP growth which would turn negative, with the exception of Montenegro where GDP growth was (only) reduced significantly. The assumptions of the adverse scenario are similar to those imposed by ECB in its December 2011 Financial Stability Review. The adverse scenario was developed for each country separately and according to the macroeconomic and financial situation in that specific country. Consequently, the variables used in this stress test are the following: real GDP growth, net wage growth, unemployment rate, change in real estate prices, change in MOSTE stock exchange index, loan growth and interaction dummy variable between wages and unemployment. In the case of Montenegro, real GDP growth would slow down significantly to 0.8 and 0.6 % for 2012 and 2013 respectively, unemployment would increase for 0.7 and 0.1 pp, inflation would increase for 2.5% and gross wages would decrease for 5.4%. As far as the financial assumptions are concerned, house prices would decrease for 1.9 and 1.8% respectively, whereas stock market (MOSTE) index would decrease for 18.1%. These (country specific and macroeconomic) assumptions were then mapped into non-performing loans using models including NPL based either on the bank-by-bank data or on aggregated data.

2.5.4 Satellite model

The satellite model, the one which would link macroeconomic and financial situation in one country with banks and their balance sheet, is formulated by estimating NPL as the dependent variable. The results produced were somewhat satisfying since the capital adequacy ratios were high even after stress tests performed. In the adverse scenario NPLs in the case of Montenegro would rise from currently 15.5% to 21 and 22% in 2012 and 2013 respectively. Using ARIMA model the Central bank of Montenegro found the banks net income to fall to 29.8% in 2012 and 30% in 2013 (in terms of regulatory capital at the end of 2011). The average capital adequacy ratio would drop from currently 16.5% to 14.7% in 2012 and 14.2% in 2013. The conclusion of the ECB is that, with current regulatory capital well above the minimum, at the aggregate level the majority of the banks could absorb on average losses coming from an increase in credit risk (ECB, 2012, p. 18).

2.5.5 The supervisory framework in Montenegro

Institutional settings with regard to financial supervision are different from country to country and consequently provide specific characteristics of about its economy, political and cultural structures and historical features. In Montenegrin banks, securities firm and insurance companies are supervised by three different entities: Central Bank of Montenegro is responsible for the supervision of banks, Security Exchange Commission for the securities firm and Insurance Supervision Agency (hereinafter: ISA) for supervision of the insurance companies. Even though candidate countries have done a lot to strengthen regulation and supervision in different sectors of the financial system, some challenges still remain regarding the effectiveness and quality of the financial supervision. Further, despite already improvements already achieved, additional ones are needed regarding the administrative capacity of the Central bank and Insurance Supervision Agency (ECB, 2012, p. 38).

2.5.6 The macro-prudential framework

During the recent global financial crisis, developments regarding specific macro-prudential policies were also needed. These policies aim at identifying sources of systemic risks and developing effective ways to mitigate those risks. In January 2012 ECB published a set of recommendations regarding macro prudential policies of the national authorities, addressed to the EU member states. Candidate countries differ a lot from member countries in this area, because in many of these countries such a body with the explicit mandate regarding this topic doesn't exist. In Montenegro in 2010, Financial Stability Council was established by law with the task to monitor, identify, prevent and mitigate systemic risks (ECB, 2012, p. 40).

Regarding the implementation of the Basel II, Montenegro has already fully implemented Pillar 1 while all the other countries are in the course of implementing it or have already done it. Further, all the other countries included in this research plan to implement Basel III. However, the development of macro-prudential framework is still at early stage (ECB, 2012, p. 41).

2.5.7 Other stress testing practices

Those stress test performed by the Central Bank of Montenegro aren't publicly available. Beside already analyzed stress test performed by ECB, there were a few stress tests done by IMF team in 2006 and 2007 i.e. in the period before the crisis. In these stress tests it became clear that the credit and liquidity risks are becoming more severe and threatening due to the credit boom. The stress is introduced in these models by migrating borrowers from class A to class B (either by an increase in NPL in 50 % or by an increase in LLP in 30%). The impact of these stress tests is quite severe for one bank whose CAR falls below 8% in the first two tests. Other banks remain above regulatory minimum under the first test, but under more severe stress test two other banks fall below regulatory minimum.

However, default of the large borrower doesn't pull any of the banks below regulatory minimum (International Monetary Fund, 2008, p. 18).

2.5.8 Recommendations for the future

The general conclusion regarding the possible threats and a way to surpass them is to join forces and develop unified strategy of banks, supervisors and the legislative branch. Additionally, banks must be encouraged and motivated to strengthen their internal processes and controls. The authorities responsible for the supervision of banks must continuously evaluate the state of each bank's risk management and in line with these prepare some bank-specific responses. Further, liquidity regulation should be strict as well as the regulatory framework in the whole country.

3 EMPIRICAL ANALYSIS BASED ON AGGREGATED DATA

In the empirical part of the paper, two stress test models are estimated. The first one is presented in this chapter and it is based on aggregated data of the whole banking sector. The results are analyzed through the change in CAR. The second model, presented in the 4th chapter, is based on bank-specific data for 10 Montenegrin banks. In both chapters first the methodology in use will be explained followed by the estimation results.

Primary goal of this exercise is to see how resilient Montenegrin banking system is and how available is the application of the stress testing process in Montenegro. Aggregated data of the whole banking sector and its variables of interest are all available on the website of the Central bank of Montenegro. This chapter is organized in the following way. First, the construction of the macroeconomic model will be presented. This model is transformed into necessary adverse scenario through forecasting technique. The values of this forecast are then further used as the input for the satellite model where variable of interest (in this case, loan loss provision) is matched to these stressed macroeconomic conditions. The results of the stress tests are communicated in the form of the stressed LLP ratio but also in the form of stressed CAR.

Since in both models LLP was used as a measure of loan quality and as the dependent variable, some insights regarding loan loss provisioning practices are provided after which the methodology and the results will be explained.

3.1 The link between LLP and bank failure

Ng and Roychowdhury (2010, pp. 2-20) tried to detect the link between banks' loan loss reserve decisions in 2007 (i.e. in the period before the crisis) and the risk of the failure of banks during 2008-2009 economic crises. Their aim is to question the soundness of recent regulator proposals and their effectiveness. Specifically, the authors wanted to verify the fact that regulatory capital guideline can generate dysfunctional outcomes. They believe that this is so because under current guidelines banks are allowed to add their loan loss reserves to Tier 3 regulatory capital, up to a maximum of 1.25% of a bank's gross risk-

weighted assets. Given that regulatory capital adequacy is a key metric in judging a bank's solvency, banks can be motivated to account more loan loss reserves and seemingly provide a better quality of capital or higher regulatory capital. This illusion of better financial health can then lead to avoiding taking prudent actions like restricting risky lending, improving collection efficiency etc. Consequently, increases in loan loss reserves can be a sign of more severe cash flow losses in the future. Banks with similar practices are more likely to fail and this statement is known as the „troubled bank" hypothesis (Dechow, 1994). The other literature proves the opposite. Namely, banks can report large loan loss provisions and so increase their loan loss reserves exactly during the time when they are financially strong and can expect better performance in the future. This hypothesis is known as a „signal of strength" hypothesis.

However, Ng and Roychowdhury (2010, p. 1) suppose that there is much more complex relationship between loan loss reserves and banks' failure. After examining several components, the authors conclude that bank failure is positively associated with loan loss provisions while it is negatively correlated with loan charge-offs. They discover even more severe conclusions such as the one saying that loan loss reserve increases are not only associated with greater failure risk, but that they also contribute to more severe banks' failures.

3.2 Loan loss provisioning practices

Determining appropriate level of the reserves for loan losses depends on the appropriate balance between the protection of the safety and soundness of the bank on one side and emphasizing the transparency of financial statements on the other side. Highly important fact is that loan loss provisions have a significant effect on earnings and regulatory capital. There is a possibility that managers will use their discretionary right and try to smooth their income with loan loss provisions. In order to prevent this Financial Accounting Standards Board (hereinafter: FASP) has established guidelines saying that banks may increase their loan loss reserves only when it becomes highly probable that a loss is imminent and if the amount of a loss can be estimated. However, despite this potential misuse of loan loss reserves prudential considerations suggest that higher reserves enable the bank to absorb greater unexpected losses. Therefore, more forward-looking approach to loan loss provisions is desirable given the fact that in the times of high economic growth there is more risk-taking in lending and more potentially bad loans which will be revealed after the growth stops. These accounting guidelines could make loan loss reserves more pro-cyclical (or forward-looking) since demanding higher reserve is much more realistic when the economic situation is stable (Balla, Rose, & Romero, 2012, p. 2).

According to Angklomkliew, George and Packer (2009, p. 69) loan loss provisions have been backward looking and highly procyclical. In response to the latest crisis, there has become usual to perform more forward-looking practices which would provide banks entering the crisis characterized with credit deterioration to have higher level of reserves. In that way, they can be more prepared for the negative consequences of the economic downturn. This is evident when looking at the provision practices in Asia during the period

since the Asian financial crisis. Because there were great loans from the crisis, most jurisdictions adopted prudent policies with higher provisions during times of economic and credit growth. It is, however, important to know that the provisioning practice is only as good as the methodology used to estimate losses in a given portfolio. It the latter is not good, this can distort the bank's balance sheet and overestimate capital adequacy ratio.

Leaven and Majnoni (2002, p. 1) were interested to see what the most usual loan loss provisioning practices are and what role they can play in the overall minimum capital regulatory framework. They found out that in many cases banks delayed provisioning for bad loans until it was too late, i.e. when the crisis has already started. Additionally, they found out that different patterns of loan loss provisioning are present in different geographical areas. They also differ among the group of industrialized countries as well as among the emerging economies. Further, they find that larger and timelier provisions are associated with more economically developed economies.

3.3 Methodology and data

In the first part of the stress test macroeconomic model is estimated and forecasted in order to obtain the adverse macroeconomic scenario. Five variables that proved relevant and provide explanatory power for the state of the Montenegrin economy are included in the model. Afterwards, this macroeconomic scenario is linked to the loan performance variable. The only variable associated with loan performance that was available was LLP.

3.4 Adverse macroeconomic scenario

In order to construct a shock which will further be mapped to the banking sector, the scenario analysis was performed i.e. various macroeconomic variables exhibit negative forecasted levels and together form a stressed scenario. These five variables simultaneously perform a shock on the Montenegrin economy.

Generally, in stress tests the most commonly used macroeconomic variables are: GDP growth, unemployment and short term interest rate, but also export growth, domestic consumption, a stock index, and interest rate spread or a long term interest rate. In this stress test, as a proxy of the GDP growth i.e. the overall growth of the economy the only variable available was industrial production. Given that it is already heavily used in research analysis IP was chosen to enter the model. However, since Montenegro relies heavily on tourism, the assumption was that without inclusion of tourism in the macroeconomic scenario the overall economic growth would not be estimated as well as it should be. With the inclusion of variable related to tourism, two variables of great influence on the general economic activity are included in the model. These two variables account for major part of the percentage change in GDP. Unemployment, as a necessary variable of interest in constructing any type of macroeconomic analysis, is also included in this analysis. As far as the cost of lending is concerned, weighted average lending interest rate is used. Another variable included is Consumer Price Index (hereinafter: CPI). Since data on CPI are provided as the change relative to the value of the same month last year

this variable becomes a measure of inflation. The idea is that with these five variables all the important changes in the Montenegrin economy are taken into account.

3.5 Variables

The variables used throughout the whole model along with the detailed description of the data and the assumptions of correlation are the following:

- **Loan loss provisions** (in the analysis denoted as LLP): monthly data are used for all variables on the aggregate level of the whole banking sector. The variable is in the form of the ratio i.e. the percentage of total loans. The length of the series is 81 observations, from M9 2006 until M11 2012 and it is the same for all variables. It is used in the satellite model as the only endogenous variable.

- **Industrial production** (in the analysis denoted as IP): monthly data are used in the form of index change on the yearly basis. This variable along with the following one is used as a proxy for economic performance of Montenegro. The variable is assumed to be negatively correlated with loan loss provisions ratio meaning that the lower GDP the higher LLP ratio (the banks need to make more provisions in order to account for the increasing non-performing loans).

- **Tourism** (denoted as TOUR): measured with number of tourist nights spent in Montenegro. Negative correlation is assumed since tourism in the model is seen to be the proxy for the major part of the Montenegrin economic activity.

- **Unemployment rate** (denoted as UNR): The positive correlation is assumed indicating that more people out of work indicate more nonperforming loans and therefore more provisions for loan loss.
- **Consumer Price Index** (denoted as CPI): This variable is assumed to be positively correlated with loan loss provision since more costly items would imply that loans are more likely to become non-performing causing higher loan loss provisions.

- **Weighted average lending interest rate** (denoted as IR): Positive correlation is assumed since the higher the interest rate the higher cost of loans which leads to lower level of high quality loans. Then LLP ratio needs to be increased in order to account for the low quality loans now in use.

3.6 Macroeconomic model

In order to perform multivariate shock scenario or adverse macroeconomic scenario, vector autoregressive model (VAR) is used in the following form:

$$macro_t = A_1 macro_{t-1} + \cdots + A_p macro_{t-p} + CD_t + u_t, \qquad (1)$$

where $\mathrm{macro_t} = (\mathrm{IP, TOUR, UNR, CPI, IR})'$ is a vector of endogenous macroeconomic variables. $\mathrm{D_t}$ is the deterministic part of the equation which may be comprised of the constant, linear trend, seasonal dummies, and impulse dummies if necessary and u_t is unobservable zero mean white noise. A and C are parameter matrices. The model is estimated with vector autoregressive model up to the 11th month of 2012. When the model is properly estimated and the correlations between the macroeconomic variables are established, they are used in the forecast of the macro model. The coefficients surpassing the significance of the threshold of 2.00 are presented in the model. This forecast is done recursively as:

$$macro_{t+1|t} = A_1 macro_t + \cdots + A_p macro_{t+1-p} + CD_{t+1} \quad (2)$$

$$macro_{t+1|t} = A_1\left(a_1 macro_{t-1} + \cdots + a_p macro_{t-p} + cd_t + e_t\right) + \cdots + A_p macro_{t+1-p} + CD_{t+1} \quad (3)$$

$$macro_{t+2|t} = A_1 macro_{t+1|t} + \cdots + A_p macro_{t+2-p} + CD_{t+2} \quad (4)$$

These forecasts are done for 12 months ahead, which means that one year forecasted stressed values will enter the model with LLP ratio i.e. the satellite model. In order to satisfy the condition of the extreme but plausible events 95 % confidence interval is used but either lower or upper bound, depending on the type of the variable (as said, for GDP the lower bound is the stressed forecasted value while for the interest rate it is the upper bound).

Assuming that the disturbance factor u_t is normally distributed, confidence interval in the case of one variable, e.g. IP, for one period ahead forecast can be written as:

$$\left[IP_{t+1|t} - C_{1-\frac{\gamma}{2}}\sigma_{IP}, IP_{t+1|t} + C_{1-\frac{\gamma}{2}}\sigma_{IP}\right] \quad (5)$$

where $\mathrm{C}_{1-\frac{\gamma}{2}}$ is the $\left(1-\frac{\gamma}{2}\right)100$ percentage point of the standard normal distribution and σ_{IP} is the standard deviation of IP. Since the IP is assumed to be negatively correlated with LLP, values of the lower bound of 95% confidence interval are used in further analysis, specifically in the satellite model.

3.7 Satellite model

The output we got from the forecast of the macroeconomic model is an input for the model linking the LLP ratio (our variable of interest) with the economic situation in Montenegro. This is done with autoregressive distributed lag model (ARDL) where values of macroeconomic forecast enter the equation as exogenous variables and LLP ratio is the endogenous dependent autoregressive variable. The equation is the following:

$$LLP_t = A_1 LLP_{t-1} + \cdots + A_p LLP_{t-p} + B_0 macro_t + \cdots + B_q macro_q + CD_t + u_t, \quad (6)$$

where macro_t is the vector of exogenous macroeconomic variables, D_t is the deterministic part of the equation which may be comprised of a constant, linear trend, seasonal dummies and impulse dummies and u_t is the unobservable zero mean white noise process. As in the previous model, the significance threshold is set at 2.00. The already obtained values of the coefficients of adverse macroeconomic scenarios are added to the satellite model to forecast future LLP ratios under these scenarios.

3.8 Model adequacy

In this section, the necessary steps of the model checking procedure are described.

Firstly, all time series were checked for stationarity. The process is considered to be non-stationary if it contains a unit root. In simple terminology, the moments of the process are time-dependent which means they are changing with time in a characteristic way. If we consider a simple first order autoregressive process:

$$y_t = \rho_1 y_{t-1} + \varepsilon_t, \tag{7}$$

with characteristic polynomial defined as $\alpha(L) = 1 - \rho L = 0$. The process contains a unit root when $\rho = 1$, so that the unit root of the polynomial $z = 1 / \rho = 1$. When this is the case we can rewrite the process by iterative substitution, starting from $y_o = 0$, so that:

$$y_t = y_o + \sum_{j=1}^{t} \varepsilon_j. \tag{8}$$

In that case the variance of the process takes form of $E(y_t^2) = \sum_{j=1}^{t} \sigma^2 = t\sigma^2$, which means that variance depends on t and is diverging to infinity with t. In order to check for the potential unit roots present in the data the Augmented Dickey-Fuller and KPSS tests were applied.

The Augmented Dickey Fuller test is applied to the following form of the model:

$$\Delta y_t = intercept + \beta t + \phi y_{t-1} + \sum_{j=1}^{p-1} \alpha_j^* \Delta y_{t-1} + u_t \,, \tag{9}$$

Where $\phi = -\alpha(1)$ and $\alpha_j^* = -(\alpha_{j+1} + \cdots + \alpha_p)$. Restrictions on the deterministic part of the equation can be imposed, which corresponds to modeling a random walk (intercept and β equal to 0) or random walk with a drift ($\beta = 0$).

The Dickey Fuller statistics tests the null hypothesis of the presence of the unit root. When values of the DF statistics are smaller than critical values, the null hypothesis of the presence of unit root is rejected. KPSS test the null hypothesis of stationarity so when the statistics is higher than the critical value the null hypothesis of stationarity is not rejected and thus the data are stationary. There was no specific necessary transformation of the time series since the unit root presence was rejected, in most of the cases, with both tests. The variables where stationarity was confirmed are marked with the $+$ in Table 2 while the one case where the null in ADF wasn't rejected is marked with $-$.

Table 2. Augmented Dickey-Fuller and KPSS tests

Variable / type of test	ADF	KPSS
Tourism_d1	+	+
Industrial production	+	+
Unemployment	+	+
CPI	+	+
Interest rate	+	+
LLP	−	+

Stationarity of the variables is confirmed with both tests for all the variables except for LLP.

Futher, from the table can be seen that the only variable that is transformed is Tourism which measures the number of nights spent by tourists in Montenegro on a monthly basis. Since this variable showed one negative forecasted value which logically doesn't makes sense, it is transformed with first difference. This way, what we observe is the monthly change in the number of nights tourists have spent in Montenegro.

3.8.1 The lag order of the VAR

The determination of the lag order of the VAR was determined through information criteria computation. The information criteria computation is based on testing the goodness of fit and is comprised of the two terms; minimizing residual variance-covariance term and penalty term:

$$C(m) = logdet(\sum m) + C_t\varphi(m), \tag{10}$$

where $\sum \mathrm{m} = \mathrm{T}^{-1} \sum_{\mathrm{t}=1}^{\mathrm{T}} \hat{\mathrm{u}}_\mathrm{t}\, \hat{\mathrm{u}}_\mathrm{t}'$ is the term estimating residual variance-covariance for the model of order m, φ(m) is function that penalizes the large VAR orders and $\mathrm{C_t}$ is the sequence that identifies a specific criterion (since there are three criteria: the Akaike criterion, Hannan and Quinn and Schwarz criterion). When the sum of the two terms is at the minimum, the lag order is determined. The rule for choosing the lag number was to pick the lag that most tests were pointing to. When there were different results, the possibilities of different lags were tried starting with the smallest lag. When a certain lag showed least deficiency of the residuals along with the significance of the coefficients that lag was considered a proper choice. In the case of the satellite model, first the exogenous lags were determined to the point of the last significant lag and then tests for endogenous lags were applied (Lütkepohl & Krätzig, 2004, p. 34). Described method was used in order to determine the appropriate lag order and the majority of the information criteria such as Akaike, Hannan-Quinn and Schwarz suggested that 6 is the appropriate one.

3.8.2 The residual analysis

As far as the residual analysis of the model is concerned, the model was checked for autocorrelation and non-normality. In the case of autocorrelation the Breusch-Godfrey LM test was applied. The test verifies whether residuals follow the autoregressive process of the following form:

$$u_t = \rho_1 u_{t-1} + \rho_2 u_{t-2} + \cdots + \rho_p u_{t-p} + e_t, \tag{11}$$

meaning that the past errors influence the size of the errors in the current period. The null hypothesis tested is, therefore, $H_0: \rho_1 \dots \rho_p = 0$, against the alternative stating that at least one of the parameters is statistically different from zero. The Breusch-Godfrey test statistics is constructed with estimates of the residuals of the above autoregressive process and are obtained from the following auxiliary VAR model:

$$\widehat{u_t} = \alpha_1 y_{t-1} + \cdots + \alpha_p y_{t-p} + \rho_1 \hat{u}_{t-1} + \cdots + \rho_p \hat{u}_{t-p} + e_t \tag{12}$$

The Breusch-Godfrey LM statistics then takes the following form:

$$LM = T\left(K - tr\left(\widetilde{\sum}_R^{-1}\widetilde{\sum}_e\right)\right) \sim X^2, \tag{13}$$

where $\widetilde{\sum}_e = 1/T \sum_{t=1}^{T} \hat{e}_t \hat{e}_t'$ is the residual covariance matrix estimator obtained from the full auxiliary model, whereas $\widetilde{\sum}_R = {}^{1}/_{T} \sum_{t=1}^{T} \hat{e}_t^R \hat{e}_t^{R\prime}$ is the residual covariance matrix estimator obtained from a restricted auxiliary model, where $\rho_1 \dots \rho_p = 0$. The statistics is proven to follow the asymptotic distribution. Autocorrelation problem was treated where needed by increasing endogenous lags (Lütkepohl, 2004, pp. 27-28).

The process was also tested for potential deviation from normality assumptions. In other words, third moment was examined for potential asymmetries in distribution (skewness) as well as the fourth moment for potential fat tails of distribution (excessive kurtosis). Normality condition is not a necessary one for the estimation of the model, but it indicates room for improvement. The intuition behind normality tests is to decompose residual vectors into independent components and then check the compatibility of the third and fourth moments with those of normal distribution. The first step is to compute the residual covariance matrix:

$$\widetilde{\sum}_u = T^{-1} \sum_{t=1}^{T} \hat{u}_t \hat{u}_t' , \tag{14}$$

from which the standardized residuals can be computed as $\hat{u}_t^S = \left(\hat{u}_{1t}^S \dots \hat{u}_{Kt}^S\right)' = \widetilde{\sum}_u^{-\frac{1}{2}} \hat{u}_t$, where $\widetilde{\sum}_u^{-\frac{1}{2}} = \sigma$. By using standardized residuals, the third moment (skewness) can be defined as:

$$b_1 = (b_{11}, \dots, b_{1K})' \text{ with } b_{1K} = T^{-1} \sum_{t=1}^{T} (\hat{u}_{kt}^s)^3, \tag{15}$$

and fourth moment (kurtosis) as equation (15):

$$b_2 = (b_{21}, \dots, b_{2K})' \text{ with } b_{2K} = T^{-1}\sum_{t=1}^{T}(\hat{u}_{kt}^{s})^4. \quad (16)$$

From this, the Jarque-Bera test for normality can be defined as:

$$JB = \frac{T}{6}\left(S^2 + \frac{1}{4}K^2\right), \quad (17)$$

where S^2 is the test statistics for skewness defined as $\mathrm{S}^2 = \mathrm{b}_1'\mathrm{b}_1$ and K^2 is a test statistics for the excessive kurtosis defined as $\mathrm{K}^2 = (\mathrm{b}_2 - 3_{\mathrm{K}})'(\mathrm{b}_2 - 3_{\mathrm{K}})$. Vector $3_{\mathrm{K}} = (3, \dots, 3)'$whose dimensions are (K × 1) is a correction term that makes normal distribution kurtosis 0. This means that normal distribution samples have value of skewness equal to 0 and value of the excessive kurtosis equal to 0 (value of kurtosis equal to 3). Larger JB statistics implies larger deviations from the normal distribution. In cases where non-normalities were detected, impulse dummies were applied in order to encompass excessive extreme deviations (values of standard residuals larger than three standard deviations). Extreme deviations and thus dummy value of 1 was determined based on the residual plots. The rule was not to allow for more than 1 % of such observations (Lütkepohl, 2004, p. 29).

In the table below one of the specification tests for autocorrelation and non-normality of the residuals are presented.

Table 3. Tests for model specification

Test	P-value
LM test for autocorrelation with 5 lags	0.9639
Jacque Bera test for non-normality	
U1	0.0605
U2	0.6005
U3	0.1396
U4	0.0744
U5	0.4952

3.9 The estimation results

The VAR macroeconomic model was estimated with 6 lags. Since the data are on a monthly basis, this lag order is the expected one. The variables included are: tourism_d1 (first difference of tourism), industrial production, unemployment, CPI and interest rate. Since the model exhibited non-normality additional impulse dummy were introduced, for the data of third month of 2010 where the residuals exhibited more than 3 standard deviation differences. Another deterministic part of the equation is broken_trend included on order to account for the decreasing trend of interest rate. After including this

deterministic part, the forecasts of this variable become more realistic i.e. aren't biased toward smaller values. Along with the trend and intercept, seasonal dummies are also included in the model because of the variable Tourism which is extremely seasonal.

3.9.1 The macroeconomic forecast

When the model is estimated and checked for auto-correlation or non-normality, the forecast is done on 95% confidence interval. Extreme but plausible forecast values are presented in the table below where for each variables either upper or lower value of the CI is accordingly chosen.

Table 4. Adverse macroeconomic scenario

Time	Industrial production	Tourism_d1	Unemployment	CPI	Interest rate
2012 M12	-18.801	-747.5	0.156	7.093	9.7342
2013 M1	-24.739	-42261.8	0.159	8.060	9.6225
2013 M2	-28.453	-51489.6	0.160	9.773	9.7241
2013 M3	-22.226	-9769.5	0.161	9.127	9.8497
2013 M4	-25.471	-20600.5	0.157	9.266	9.9242
2013 M5	-48.182	-1833.7	0.152	9.862	9.8253
2013 M6	-43.562	2979.9	0.146	10.426	9.8568
2013 M7	-24.259	148895.1	0.140	10.772	9.9674
2013 M8	-30.468	37554.2	0.140	10.702	9.9648
2013 M9	-32.902	-285499.1	0.142	10.678	9.944
2013 M10	-29.979	-185144.1	0.147	11.156	9.9355
2013 M11	-23.408	-61615.3	0.149	11.117	9.9566

As it can be seen, the model predicts a decline in IP of 48% which is to be expected since the fluctuation of the IP index is large over the sample period. However, this is the lower bound of CI. Regarding tourism, the largest change in the number of tourist nights spent in Montenegro is in the 7^{th} month of 2013 when the season is at its peak. Unemployment, which has been experiencing a declining trend since 2006 doesn't increase as much since the highest rate is in March of 2013 and is 16.05%, only 1% change. CPI increases up to the 11.12% change, which is higher than in the values experienced so far.

Interest rate, since it doesn't experience too much fluctuations recently, increases only for 0,5 percentage points and this negatively affects potential loans. Seasonality is present in the forecasted fluctuations of the variables, especially in tourism and industrial production where there are many factors influencing this kind of economic performance. Those factors are numerous and usual, for example extremely bad weather conditions in winter or extremely good (or bad) tourist season during the summer. Moreover, these factors can then influence other ones (CPI, interest rate and unemployment) which then exhibit seasonality themselves.

3.9.2 Satellite model

Satellite model is estimated in the next step. It has LLP as the only one endogenous variable. The intercept, seasonal dummies and trend were all included in the model. This model is estimated with 5 exogenous lags and 10 endogenous lags which was the suggestion of all three information criteria: Akaike, Hannan-Quinn and Schwartz.

Broken trend and impulse dummies were again included to account for the same deviation. However, the model doesn't exhibit autocorrelation and non-normality. Non-normality was tested also by plotting the standardized residuals. Some of the specification tests used in estimation of the model are presented in the table below.

Table 5. Specification tests of the model

Test	**P-value**
LM test for autocorrelation with 2 lags	0.8608
Jacque-Bera test for non-normality of the residuals	
U1	0.9347

When the model is correctly specified, the estimation of the model can be done. The significant coefficients of this model are presented in the table below.

LLP is expected to be negatively correlated with tourism and industrial production and, despite the small values of the coefficients in the first three lags, it is indeed negatively correlated. However, unemployment exhibits both positive and negative coefficients, all significant at 1% significance level. As far as the CPI is concerned, there are more lags in which there is positive correlation then negative and the assumption was that with the increase in CPI there will be an increase in LLP ratio also. Interest rate is supposed to be positively correlated and indeed in the last two lags it is positively correlated which may imply that there has to pass some time in order for borrowers to start backing up from loans. Additionally, banks are able to identify the negative selection happening only with a lag.

Table 6. The restricted satellite model with LLP as the endogenous and macroeconomic variables as the exogenous variables

Lag	LLP	Industrial production	Tourism	Unemployment	CPI	Interest rate
T		-0.0001***			-0.002***	0.013**
t-1	0.916***					-0.015***
t-2	-0.234***	0.002***	-0.0001***	-0.438***	0.001***	-0.045***
t-3			-0.0002***	0.605***		-0.012**
t-4	0.209***			-0.622***	-0.001***	0.012***
t-5				0.326***	0.002***	
t-6						
t-7						
t-8						
t-9						
t-10	0.317***					

Note: * indicates 10% significance level, ** 5% significance level and *** 1% significance level.

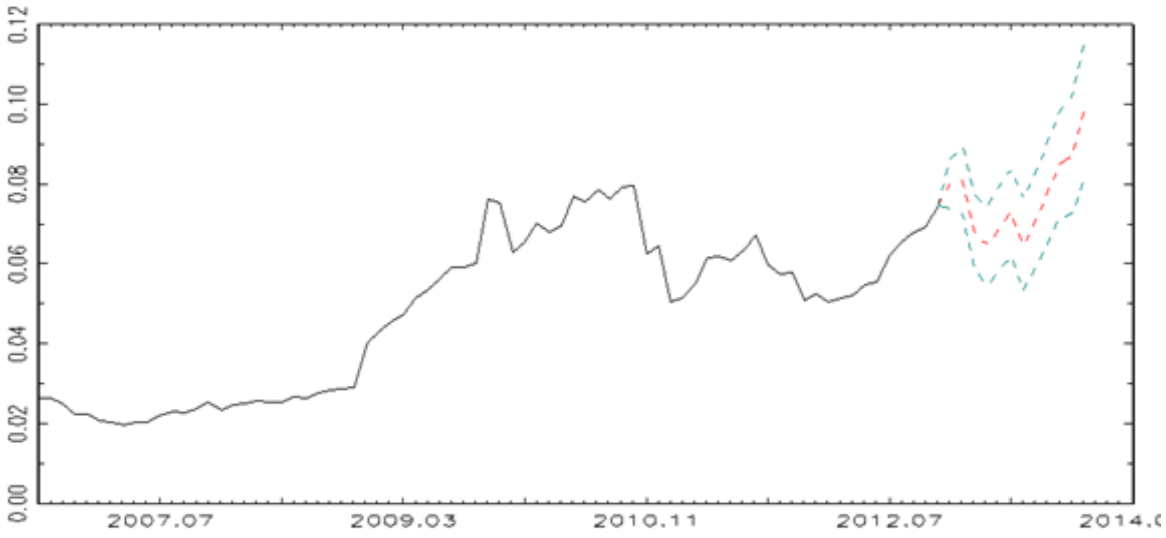
These correlations were then used to perform a forecast of LLP ratio under stressed values of macroeconomic conditions presented in Table 4. However, these values of LLP were forecasted for 1 year ahead since LLP depends up to five lags on macroeconomic variables. This way, LLP variable is affected by macroeconomic stress with at least a half year window. The forecasted values of LLP with lower and higher bound of CI are presented in the table below as well as in the Figure 3.

This is 95% CI and we can see that the change in LLP ratio in the 11th month of 2012 (the actual level before the forecast) and the last forecasted value in 11th month of 2013 is around 2.3%. Since the actual level of LLP ratio was 7.45 % the forecasted has increased to 9.84% which is a significant change since the fluctuations in LLP are not usually as large. It is the assumption of the model that negative i.e. adverse macroeconomic scenario implemented in this VAR model resulted in the worse loan quality. The measure of loan quality is, in this case, LLP ratio. Banks are supposed to put aside more provisions for loan losses when the economy is performing negatively.

Table 7. LLP forecast with 95% upper and lower confidence interval

Time	Forecast	Lower bound	Higher bound	+/-
2012 M12	0.0802	0.074	0.0864	0.0062
2013 M1	0.081	0.0725	0.0894	0.0084
2013 M2	0.0677	0.0584	0.0771	0.0094
2013 M3	0.0643	0.0545	0.0741	0.0098
2013 M4	0.0687	0.0583	0.0792	0.0105
2013 M5	0.0729	0.062	0.0839	0.0109
2013 M6	0.0646	0.0532	0.076	0.0114
2013 M7	0.0708	0.0589	0.0827	0.0119
2013 M8	0.0777	0.0652	0.0903	0.0126
2013 M9	0.085	0.0716	0.0984	0.0134
2013 M10	0.0869	0.072	0.1018	0.0149
2013 M11	0.0984	0.0814	0.1153	0.0169

Figure 3. LLP forecast with upper and lower bound of 95% confidence interval



As it can be seen, these forecasts predict an increase in the LLP ratio of almost 3 percentage points which is a lot since the average of the LLP ratio throughout the sample period was around 4.5% and the highest value reached was in 2009 when they peaked at 10%. Therefore, the forecasted value of almost 10% is quite high for Montenegrin banking system and it represents significant level of stress which is necessary exactly what is needed for this kind of exercise.

3.9.3 Capitalization

One of the usual ways of checking how stressed is a particular variable of interest is to calculate capital adequacy ratio.

Table 8. CAR during the 2011 and 2012

Time	Risk-weighted assets	Total capital	CAR (in percentages)
31.03.2011.	2131709	302605	14.20
30.06.2011.	2120724	305101	14.39
30.09.2011.	2038323	290938	14.27
31.12.2011.	2028697	305229	15.05
31.03.2012.	1990431	303540	15.25
30.06.2012.	2058936	291567	14.16
30.09.2012.	2017925	270086	13.38
31.12.2012.	1972771	288686	14.63

Source: *Centralna banka Crne Gore – monetarna statistika*, 2013.

After taking notice of the level of CAR before the stress (which was around 14%), the computation of the capital adequacy ratio for Montenegrin banking sector, already affected by macroeconomic shock, can be performed. However, in order to check for the amount of the stress the next necessary step is to calculate the capital loss.

The calculation of the new and stressed CAR can be seen in the Table 9 where the first step is to check the level of total loans of the banking sector in the last month of the actual data in time series. When this is done the calculation of the capital loss is performed in the following way. The difference in the LLP ratio before and after the stress is, by assumption, transformed into capital loss through loan losses. The capital and risk weighted assets are also, because of the data constraints, kept the same as in the actual data, the one of November 2012. This way the difference in the level of LLP is transformed into loss of capital and the capital (which remains the same) is decreased by this amount. After calculation of the new level of capital the stressed CAR can be calculated. All the calculated data in these steps are presented in the Table 9.

Table 9. The computation of the stressed CAR

Total loans	**2,341,978.00**
Difference in LLP ratio before and after stress (in percentages)	2.40
Loss of capital	56,207.47
Total capital	288,686.00
Risk weighted assets	1,972,771.00
Total capital after the stress	232,478.53
CAR after the stress (in percentages)	**11.78**

As it can be seen the CAR has decreased for more than 2 percentages. However, the countries in the region of Montenegro are known to have high capital adequacy ratio so it is not odd that even after the stress CAR is above the regulatory minimum which is 10% in the case of Montenegro.

The conclusion is that the overall banking system is resilient to the negative economic performance according to its capital adequacy ratio. However, it is important to point out that other explanatory variables can be taken into account like: house price, stock exchange index etc. Further, other types of stress tests such as testing the trade book or liquidity stress test can provide a broader overview of the banking and financial system. However, because of the data constraints stress test was performed only on credit risk and the explanations are all addressed only to this type of risk.

4 EMPIRICAL ANALYSIS BASED ON BANK-SPECIFIC DATA

Unlike the previous stress test which was performed on the aggregated data i.e. on the banking sector as a whole, in this exercise the bank-specific data us used. The model is estimated through panel VAR while the response of LLP to the shocks in other variables is analyzed through impulse response functions. The main goal is to provide more insight into the determinants of LLP in Montenegrin banking system. Hopefully, the banking system would benefit from different kind of information provided by testing several hypotheses. The model aims at answering the following question: How to explain the banking sector on a basis of the information about certain variables from micro level bank-specific data? In order to control for the macroeconomic situation or generally the economy the idea is to include macroeconomic variable such as industrial production which will be the same for all the banks and would only change in time. Since the overview of the banking system has been already explained, small introduction regarding practices in Montenegrin banking system will be provided. Then, the methodology that is going to be used will be explained after which I will describe the data and the variables

used. At the end, the results of the estimated model along with the impulse response functions will be presented and analyzed.

4.1 Hypotheses of the model

In the analysis done by the Bank of Greece (Louzis, Vouldis, & Metaxas, 2010, p. 35) dynamic panel data methods are used in order to examine the determinants of non-performing loans. It is assumed that the period of economic growth or expansion of the economy was characterized by low number of non-performing loans while during the recession and economic downturn there are more low-quality loans and consequently more NPL. In this paper several bank-specific variables were used according to a proper assumption assigned to each one of them. These are summarized in the table below.

Table 10. Definition of bank-specific variables

Variable	Definition	Hypothesis tested
Return on Assets*	$ROA_{it} = \frac{Profits_{it}}{Total\ assets_{it}}$	„Bad management II“ (-)
Return on Equity*	$ROE_{it} = \frac{Profits_{it}}{Total\ equity_{it}}$	„Bad management II“ (-)
Solvency ratio	$SOLR_{it} = \frac{Owned\ capial_{it}}{Total\ assets_{it}}$	“Moral hazard” (-)
Loans to Deposit ratio*	$LtD_{it} = \frac{Loans_{it}}{Deposits_{it}}$	“Moral hazard” (+)
Inefficiency	$INEF_{it} = \frac{Operating\ Expenses_{it}}{Operating\ income_{it}}$	“Bad management” (+) “Skimping” (-)
Credit growth	$GLOANS_{it}{}^{h} = \frac{Loans_{it}{}^{t} - Loans_{it-1}^{h}}{Loans_{it-1}^{h}}$	“Procyclical credit policy” (+)
Market power	$MPOW_{it}{}^{h} = \frac{Loans_{it}^{h}}{\sum_{i=1}^{9} Loans_{it}^{h}}$	“Size” (-)
Size	$SIZE_{it} = \frac{Total\ assets_{it}}{\sum_{i=1}^{9} Total\ assets_{it}}$	“Size” (-)

Note: * indicates variables used in the exercise performed by the author i.e. in Montenegrin panel VAR.

Source: D. Louzis, A. Vouldis, & V. Metaxas, *Macroeconomic and bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios*, 2010, p. 31.

All variables regarding the hypothesis presented in the table were included in the model but the results were not satisfying i.e. some proved to not provide enough explanatory power while some were not able to improve the model. This empirical analysis for Montenegro is based on the assumption that there is correlation between the NPLs and LLPs which was already proved in many researches. The proper term considering LLP over NPL is coverage ratio. The aim is, therefore, to prove that Montenegrin banking system can be explained with macroeconomic and certain bank-specific variables. As already said, some of the variables (those in the table marked with *) are used in the estimation of panel VAR for Montenegrin banking system. The same method of computation along with the hypotheses described in Table 10 is used in PVAR model. The model, therefore, consists of the following variables: LLP, ROA ROE, LtD, IP.

The "bad management" hypothesis implies that low cost efficiency is positively associated with increases in future non-performing loans. Since the future loan losses are supposed to be backed up with provisions of loans the both of the bank-specific variables are used with the same assumption of the coefficient sign. "Moral hazard" hypothesis implies that low capitalization of banks leads to an increase in non-performing loans. Banks' managers can also increase the riskiness of their portfolio by increasing loan to deposit ratio (more loans not backed up with deposits) and this leads to more non-performing loans. Similar logic holds for LLP ratio regarding this hypothesis. "Skimping" hypothesis is related to the fact that banks which devote less effort to ensure higher loan quality are more likely to seem more cost-efficient but there will be increased number of NPLs in the long run. Finally, the "size" hypothesis suggests that the size of the banks is negatively correlated with non-performing loans (Louzis et al. 2010, p. 13).

4.2 PANEL VAR

Dataset used in the model contains strongly balanced panel data on quarterly basis. The time series is in a range from the 1st quarter of 2007 until the 3rd quarter of 2012. The last quarter of 2012 was not included since the data were only partly available. 10 out 11 Montenegrin banks are included in the model.

The appropriate model for estimation when using micro-level data and bank specific variables is panel data Vector Autoregressive model or panel VAR (hereinafter: PVAR). PVAR is estimated by using the package provided by Inessa Love. This package was first used and presented in Love & Zicchino (2002). This approach allows us to benefit from both the advantages of VAR approach and panel data techniques. For example, VAR can address endogeneity in the model by allowing endogenous interaction between the variables. The usual form of this model is the following:

$$Y_{it} = a_0 + \sum_{l=1}^{m} Y_{it-1} + f_i + e_t \qquad (18)$$

where a_0 is a constant term, Y_{it} is a vector of bank-specific variables for bank i at time t, and e_t is the disturbance factor (Holtz-Eakin, Newey, & Rosen, 1988, p. 1373). Still, some bank-specific heterogeneity is likely to affect this process. In order to allow for this heterogeneity, fixed effects (f_i) are included in the model. Those unobserved effects can be

a propensity of an individual bank towards particular relation to one of the variables. In order to eliminate fixed effects, mean difference approach is usually used. It has been proved that this way produces biased estimates when lagged dependent variables are included in the model. Therefore, in this panel VAR another transformation has been used, namely Helmert transformation of the parameters as Love and Zicchino (2002, p. 10) suggest in their paper regarding panel VAR. Variables are transformed with forward mean differencing which in Hayakawa (2009, p. 7) was suggested to perform better with GMM estimator than the first difference transformation. This kind of transformation preserves homoscedasticity and does not cause serial correlation.

The variables are transformed in the following way:

$$y_{it}^{*} = y_{it} + w\left[\frac{y_{it+1}+\cdots+y_{it+m}}{t+m-1}\right] \tag{19}$$

When these individual unobserved effects have been removed, the model takes the following form:

$$y_{it} = \sum_{l=1}^{m} Y_{it-1} + \sum_{l=1}^{m} IP_{t-l} + e_t \tag{20}$$

Where $\mathrm{Y_{it}} = [\mathrm{LLP_{it}}, \mathrm{ROA_{it}}, \mathrm{ROE_{it}}, \mathrm{LtD_{it}}, \mathrm{IP_t}]'$ is the vector of bank-specific variables. The ordering of variables here is very important since the further analysis is based on impulse response functions. The methodology regarding impulse response functions as well as the ordering of the variables will be described later. Variable than contains information about IP remains constant throughout cross-sectional units and only changes with time.

4.3 GMM estimator

The model and its parameters are estimated with Generalized Method of Moments (hereinafter: GMM). This method is recently becoming more used due to its flexibility and consistency. It has been specifically in use in finance. It is extremely useful in cases when the distribution of the data is unknown. It is capable of overcoming the omitted variable bias, the problem which causes one or more explanatory variables to be correlated with the error term because some important factors have been left out. This is particularly important in the case of models with lagged dependent variables and panel data models where fixed cross sectional specific effects cannot be ignored. OLS is, therefore, biased and tends to overestimate or underestimate one of the other factors included in the model (Alastair, 2010, p. 2).

GMM combines the information in the population moment condition with economic data used in the model. Statistical moments are in a way a population average raised to the power. So, the r^{th} statistical moment can be written as $\mathrm{Y_r} = \mathrm{E}[\mathrm{V_t^r}]$ or expected value of V raised to the power of r. The first statistical moment ($\mathrm{r} = 1$) is just the mean of the population, the second is the variance of the distribution, the third is the skewness and the fourth is the kurtosis of the distribution. All of these moments contain information on aspects of a given distribution. A general representation of the population moment condition can be written as the expected value of a function of observed economic data

(V_t) and unknown parameter vector (Θ_0) being equal to zero for all t (Hansen, 2007, pp. 1-2)

$$E[f(V_t, \Theta_0)] = 0 \tag{21}$$

This representation indicates the population quantity, but for the purpose of the estimation of GMM we need a sample moment condition, which would replace the population average with a sample average:

$$T^{-1} \sum_{t=1}^{T} f(V_t, \Theta_0) = 0, \tag{22}$$

It can be assumed, for this specific example, that economic data is normally distributed with unknown mean Θ_0 (what is to be estimated) and a known variance which is equal to 1. The parameter vector $\Theta_0$can be worked out from the population moment condition:

$$E[V_t] - \Theta_0 = 0 \tag{23}$$

By replacing this population moment with the sample moment the equation can be transformed into a proper form able to produce estimates of the parameter vector:

$$T^{-1} \sum_{t=1}^{T} V_t - \hat{\Theta}_T = 0. \tag{24}$$

Solving this equation the Method of Moments is produced:

$$\hat{\Theta}_T = T^{-1} \sum_{t=1}^{T} V_t. \tag{25}$$

Even though this estimate has its advantages among which is a simple intuition behind its computation, it also has some deficiencies. First, the estimator was derived based on the extracted information from the first moment. Nevertheless, the other moments also contain relevant information regarding unknown parameter vector. For example, the second moment would, with the assumption that the variance is equal to 1, would have the following form:

$$E(V_t^2) - \Theta_0^2 - 1 = 0 \tag{26}$$

The estimation is now based on the information about the second moment also. Now there are two equations with one unknown that should be solved when in general there is no solution to these two equations:

$$\sum_{t=1}^{T} V_t - \hat{\Theta}_T = 0 \qquad T^{-1} \sum_{t=1}^{T} {V_t}^2 - {\hat{\Theta}_T}^2 - 1 = 0 \tag{27}$$

To allow for estimates to be based also on information about other population condition what has to be done is generalization of Method of Moments, namely GMM estimator.

The GMM estimator of Θ_0 is defined to be a value of Θ that minimizes the function $Q_t(\Theta)$ where $Q_t(\Theta)$ is a quadratic form of the sample moment condition with weighting matrix W_t:

$$\hat{\Theta}_T = argmin_{\Theta \in \Theta} Q_t(\Theta) \tag{28}$$

$$Q_t(\Theta) = T^{-1} \sum_{t=1}^{T} f(V_t, \Theta_0)' \, W_t T^{-1} \sum_{t=1}^{T} f\,(V_t, \Theta_0) \tag{29}$$

In other words, the GMM estimates the value that minimizes the distance from $\mathrm{Q_t}(\Theta)$ to zero. The $\mathrm{Q_t}(\Theta)$ can be also referred to as the measure of closeness to zero, whereas the weighing matrix simply assignes the weight to the particular coordinate in the distance. This example considers the case where information out of first two moments is to be extracted. The two-dimensional vector can be described with first moment information on top and second moment bellow (Alastair, 2010, p. 6):

$$f(V_t, \Theta_o) = \begin{bmatrix} E[V_t - \Theta_o] \\ E[V_t^2] - \Theta_o^2 - 1 \end{bmatrix} = \begin{bmatrix} g_a \\ g_b \end{bmatrix} \tag{30}$$

If the weighting matrix is a simple identity matrix $\mathrm{Wt} = \mathrm{I}$, then the coordinates are equally important. Alternatively, the weighting matrix used in the example attaches the greater importance to the first coordinate in the distance

$$Q_T(\Theta) = f(V_t, \Theta_o)' W_t f(V_t, \Theta_o) = [g_a \quad g_b] \begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} g_a \\ g_b \end{bmatrix} = 2g_a^2 + g_b^2 \tag{31}$$

The optimal choice of weighting the matrix is to minimize the population variance of the sample moment (S), meaning that $\mathrm{W} = \mathrm{S}^{-1}$. This, however, imposes difficulties in implementing the GMM, since for the calculation of S the estimates of the parameter vector Θ_0 are needed. Therefore, GMM is implemented in a two-step or a multi-step iterative process, where in the first step the identity matrix is used in order to produce preliminary parameter estimates which are then used in the following steps (Alastair, 2010, p. 4-6).

Some characteristics of the GMM method can be derived from the explanations above. Let the dimensions of f(.) be qx1 ad dimensions of Θ be px1. If $\mathrm{q} = \mathrm{p}$, then simple method of moments applies and the structure is independent from W. But, if q is greater than p, then the GMM estimator is the value of Θ closest to solving sample moment condition and $\mathrm{W} = \mathrm{S}^{-1}$.

4.4 Impulse response functions

One of the advantages of the VAR approach as a way of performing stress test is that impulse response analysis can be carried out. It is used in the model in order to observe the reaction of LLP as the variable of interest on the external or other policy shocks in the model. In panel VAR impulse responses are an answer of each variable to a one standard deviation shock in one of them. When variables are scaled in a different way, it is useful to consider changes of one standard deviations rather than unit shock. Equivalently, the response of other variables to the shock in LLP can also be examined as some kind of feedback effects. Being aware of the fact that variables that come earlier in the system affect other variables contemporaneously while those that come later affect the variables only with a lag, the appropriate order of the variables in PVAR is chosen accordingly (Love & Zicchino, 2002, p. 8)

Since the variance-covariance matrix is unlikely to be diagonal, the residuals have to be orthogonalised. This is done by applying Cholesky decomposition of the variance-covariance matrix which has made the ordering of the variables look like this: $[\mathrm{LLP_{it}}, \mathrm{ROA_{it}}, \mathrm{ROE_{it}}, \mathrm{LtD_{it}}, , \mathrm{IP_t}]'$. The assumption was that all variables are affected by change in LLP contemporaneously and with a lag, while the other variables affect LLP only with a lag. LLP, since it is part of the bank's balance sheet, affects the ROA and ROE immediately. LtD is affected also immediately since the size of net loans is lower for the loan loss provisions. IP will be decreased as a consequence of the deterioration in the banking system while economic cycle affects the bank's balance sheet only with a lag. According to these facts, one can conclude that the impulse responses are sensitive to the specific order of the variables and this may be considered a disadvantage of this kind of analysis. Given this fact, by changing the order of the variables, a different structure of the model is considered. Nevertheless, when changing the order of the variables in this model similar results are obtained which may suggests that the analysis is not sensitive to the specific identification scheme (Hoggarth, Sorensen, & Zicchino, 2005, p. 10).

4.5 Estimated model

The 5 lag panel VAR was estimated with explained vector Y_{it} and with IP variable as the one to control for the macroeconomic environment. The panel VAR is estimated with GMM method and the variables are transformed with Helmert transformation before the estimation was done. Six equations were formulated but the only one that will be presented is the one where LLP is the dependent variable since the goal is to see the response of LLP to the shock in other variables. In some cases the response of the other variable to the shock in LLP will also be analyzed in order to be aware of the possible implications of the feedback effects.

As it can be seen from the table the coefficients of the 4 (out of 5) variables are significant. As it was assumed, LLP depends on its endogenous lags and these coefficients are significant in 3 lags. Coefficients related to ROA don't show significance in this model, even though they have a negative sign in the first and last lag. LtD ratio, as a variable implying possible moral hazard in the management of the banks, is positively negatively correlated. The highest order significance is in the 4^{th} and 5^{th} lag where there is first positive correlation and then negative sign. ROE, as a variable assumed to be negatively correlated with LLP, in three out of 5 lags experienced negative correlation.

The coefficients of the equation where the LLP is the dependent variable (and standard errors of coefficients) are presented in the Table 11.

However, only in the third lag the coefficient was negative and significant at 10% level. IP is also expected to be negatively correlated since the increase in IP may imply less problematic loans. It is indeed negatively correlated in the third lag where the coefficient is significant at 10% significance level.

Table 11. Estimated PVAR (LLP as the dependent variable)

Time	LLP	ROA	LtD	ROE	IP
t-1	1.049*** (0.293)	-0.002 (0.001)	-0.008** (0.004)	0.017* (0.010)	0.001 (0.013)
t-2	-0.26* (0.142)	0.001 (0.002)	0.009** (0.004)	-0.010 (0.015)	0.027 (0.019)
t-3	-0.117 (0.136)	0.002 (0.001)	-0.003 (0.005)	-0.021* (0.013)	-0.022* (0.013)
t-4	0.256** (0.119)	0.0004 (0.002)	0.014*** (0.004)	0.007 (0.010)	-0.001 (0.015)
t-5	-0.069 (0.080)	-0.00004 (0.002)	-0.012*** (0.004)	-0.002 (0.014)	-0.011 (0.014)

Note. * - significant at 10% ** - significant at 5% *** - significant at 1% level; in brackets – standard errors of coefficients.

In order to see which variables provide the most explanatory power to LLP for 10 periods ahead, variance decomposition will be presented. As it can be seen in Table 12, LLP is mostly explained by its own lagged dependent values while ROE also accounts for major explained part, namely 22.28%. Industrial production as well as LtD ratio provides around 1.5 % of explanatory information. ROA provides the least relevant information according to variance decomposition but also according to the significance level of the coefficients. However, when we look at the percentages which tell us how much these variables are explained by LLP, we can see that ROA is explained by LLP with 14.43% which can indicate interesting analysis of a feedback effect of the shock in LLP. ROE is explained by LLP with only 5.67%.

Table 12. Variance decomposition (percent of variation in the row variable explained by column variable)

Variable	S	LLP in %	ROA in %	LtD in %	ROE in %	IP in %
LLP	10	74.17	0.44	1.69	22.28	1.42
ROA	10	14.43	45.41	1.82	34.68	3.66
LtD	10	5.98	5.65	84.98	1.58	1.80
ROE	10	5.67	11.96	3.58	77.19	1.59
IP	10	1.58	0.80	3.95	27.37	66.30

LtD ratio is explained with 5.98% by LLP which is more than the percent of explanation provided by LtD to LLP. Nevertheless, IP still doesn't provide too much explanatory power to the LLP.

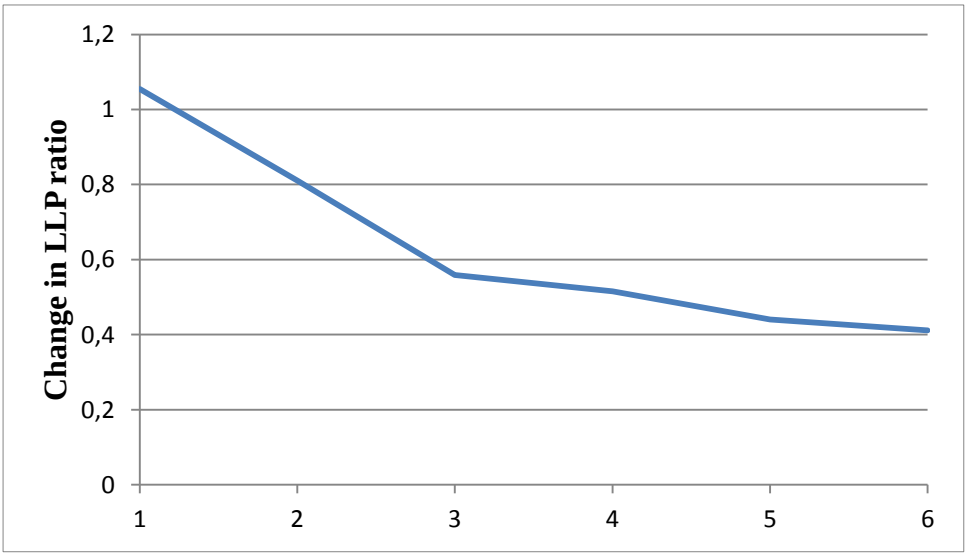
4.6 The results

The impulse response functions were estimated for all variables while for those which were provided significant explanatory power by shock in LLP also feedback effects were analyzed. First, the size of the shock in LLP is presented in order to see how it depends on its own lagged values and to be aware of the size of shock which will be used in feedback effect analysis.

When the shock is done to the LLP, it increases for over than 1% which represents a large fluctuation in LLP during only 6 quarters. However, after the initial shock this ratio starts to decrease and up to the 6th quarter it is decreased to 0.4% above the level it had before the shock was introduced.

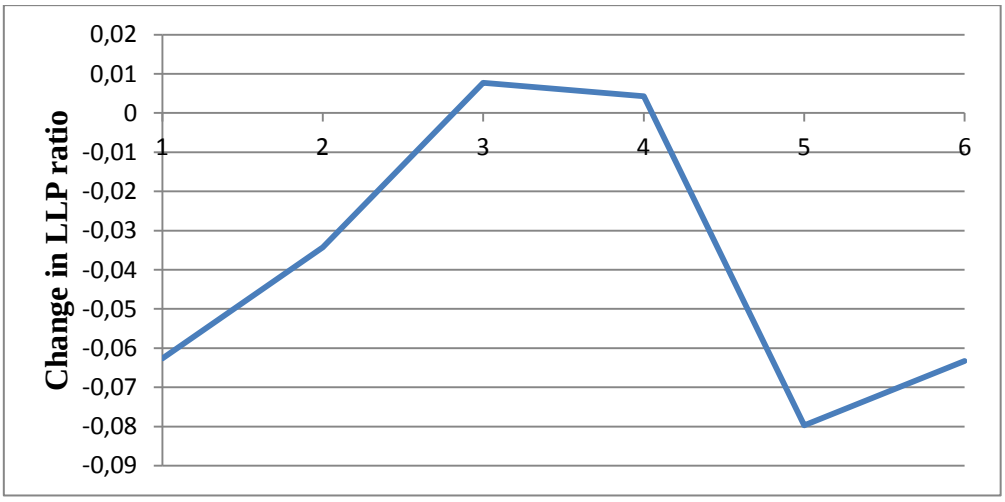
Further in the analysis, the responses of LLP to the shocks in other variables will be presented as well as some of the feedback effects.

Figure 4. Response of LLP to LLP shock



When the negative shock on one standard deviation in ROA is induced, the response of LLP is very small and can be seen in Figure 5. At the very first moment the LLP is decreased for 0.06 p.p. while it starts to increase up to the third quarter. After that, it starts to decrease again and it does so up to the 5th quarter when it will reach 0.08 p.p. decrease compared to the level before the shock.

Figure 5. Response of LLP to a negative ROA shock

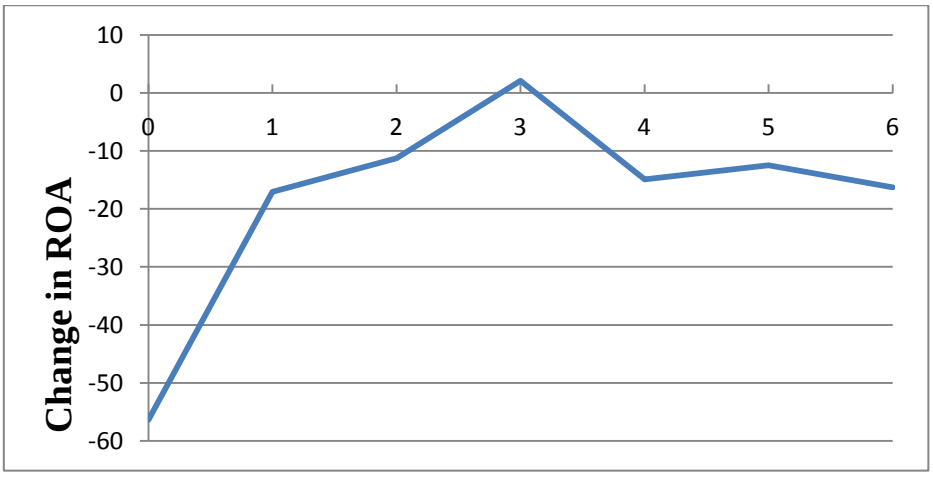


After this quarter it starts to increase again with returning gradually to the initial level. The small deviations in LLP ratio due to shock in ROA is possibly due to the small explanatory power ROA has on LLP. Also, this variable doesn't provide as much useful information since the coefficients weren't also significant up to these 6 quarters.

As it can be seen the response of ROA is consistent with the bad management hypothesis, since when the ROA decreases LLP is increased. However, having in mind the fact that the fluctuations in LLP are not as much sizeable as in NPLs this size of response may not be so strange. Possibility is also the fact that Montenegrin banks have too different management practices so that no relevant conclusion can be made regarding the response of the management to the decrease in ROA.

As said, it would be interesting to have a look at the feedback effect, i.e. at the response of ROA to the shock in LLP. The shock is, in this case, positive indicating the increase in LLP ratio and the goal is to see how this affects ROA, if it does at all.

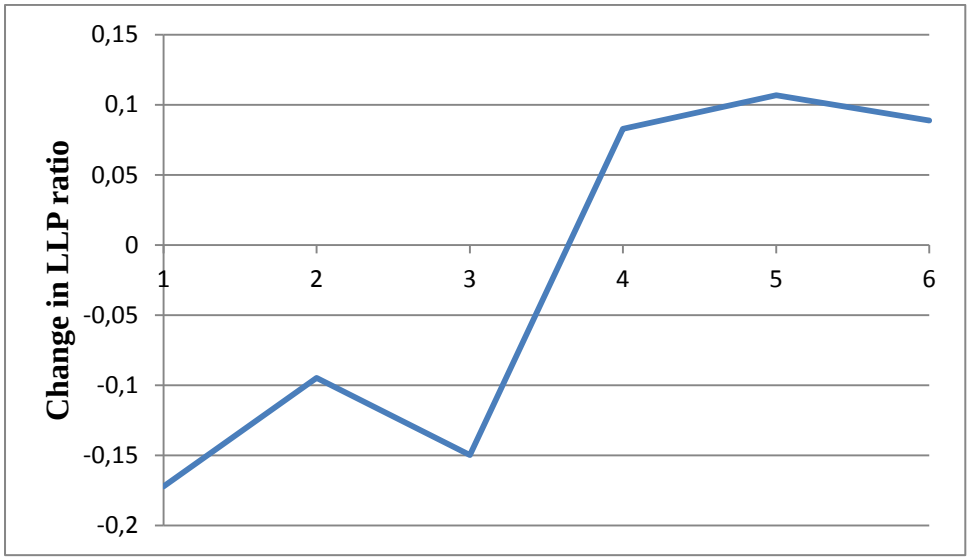
Figure 6. Feedback effect on ROA



What we find out is that ROA is affected in the very first moment when the shock is applied which is consistent with the ordering provided by Cholesky decomposition. Namely, LLP ratio is supposed to influence other variables contemporaneously and with a lag while other variables are supposed to influence LLP only with a lag. Return on asset has immediately decreased for over 50% and in the next 3 quarters it is increasing toward the initial level. After reaching the initial level, it starts to decrease again and up to the 6th quarter it has decreased for around 15%. However, the explanatory power that ROA provides to LLP and viceverca is not so sizeable.

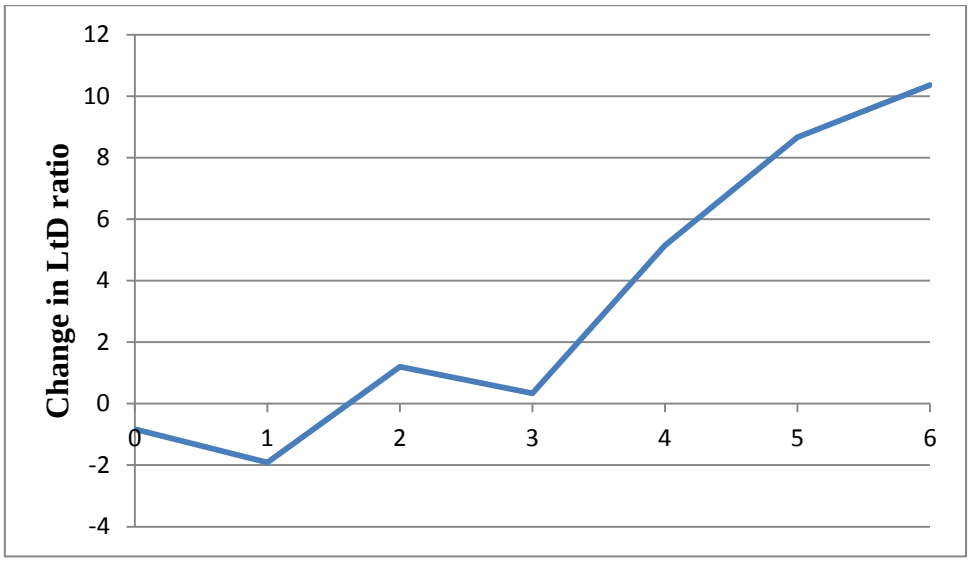
On the next figure, there is a response of LLP to a positive shock in LtD ratio. In the first quarter the LLP ratio is decreased while it starts to increase along third and four quarter reaching a level of 0.1 % above the initial level. When the banks give out more loans which are not backed up with deposits the LLP decrease. This delayed effect can be due to the fact that other variables are supposed to affect LLP only with a lag. So, after initial delay, the LLP starts to increase.

Figure 7. Response of LLP to a positive LtD shock



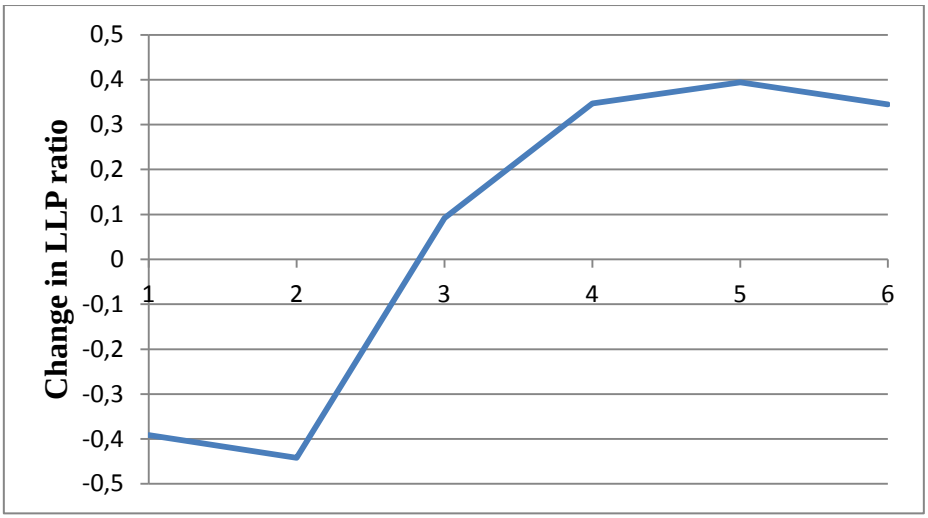
Feedback effect may also be interesting to explore in this case also as it can be seen in the Figure 8. The initial increase in LLP ratio increases the LtD ratio up to the 10% above the level it had before the shock happened. This proves the hypothesis that LLP is connected with the NPL in a way that similar response is happening regarding the bad management hypothesis. Since the increase in LLP ratio implies the worse state of the economy, LtD ratio has still increased for 10% and the obvious conclusion can be that this is the underlying problem of the Montenegrin banking system.

Figure 8. Feedback effect of LLP to LtD ratio



The next impulse response that will be analyzed is the response of LLP to a negative shock in ROE. Since the ROE was mostly negatively correlated with LLP, the response that is seen in the graph is expected. After initial decrease which can be due to delayed effect of the shock, the ROE increases for total of 0.8 p.p. i.e. almost 1% or 0.4% above the level it had before the shock was introduced.

Figure 9. Response of LLP to a negative ROE shock

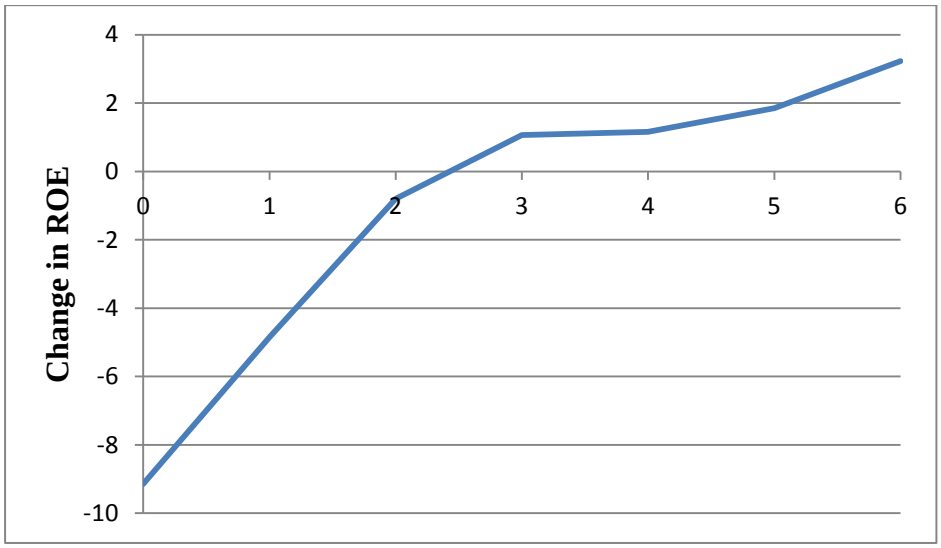


An increase in LLP of almost 1% in a half year's time is large and it implies that the bad management hypothesis tested was confirmed with this variable. When the return on equity is decreased, loan loss provisions increase in order to account for the bad loan decisions made by the management.

The response of the ROE to the shock in LLP is also analyzed since the variance-decomposition implied that LLP accounted for a significant part of the explanatory power in ROE. In Figure 10 can be seen immediate response of ROE in a decrease of around 9%.

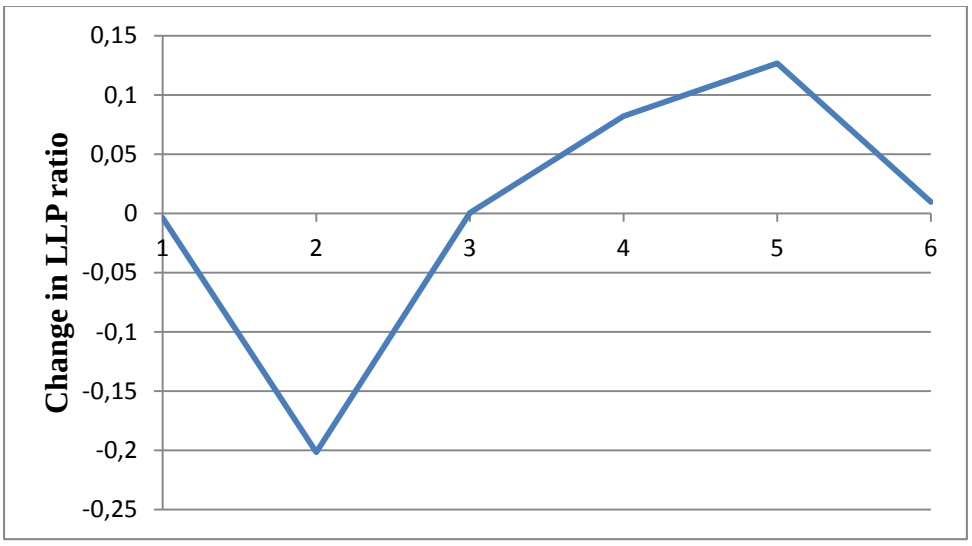
Then ROE starts to increase in the same time as the LLP starts to decrease. This is also consistent with bad management hypothesis where in the case of the increase in LLP ratio the ROE is decreases significantly.

Figure 10. Feedback effect of ROE to LLP shock



Last but not the least, the response of LLP to a negative shock in IP will be analyzed. After an initial decrease which can be due to some other effects the delayed shock starts to affect LLP ratio during the second quarter. The increase in LLP is, in total amount, equal to 0.3 %. After 5th quarter the effect is to decrease i.e. gradually return to the initial level. However, the negative effect of the decrease of industrial production is present in LLP ratio after the third quarter.

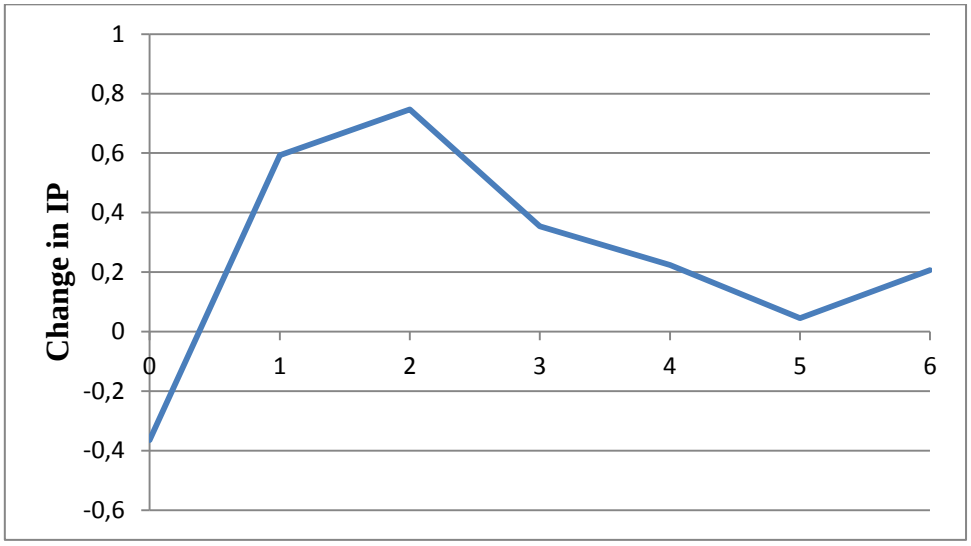
Figure 11. Response of LLP to a negative IP shock



This kind of response is to be expected since industrial production is an economic variable which needs time to be transmitted to the banking system. However, the variance-decomposition didn't show too much of the explanatory power provided neither from LLP

to IP, neither the opposite. The feedback effect is, still, interesting to be analyzed since it can be considered as a kind of response of the economy to the shock in banking sector. After the positive shock in LLP, the IP has decreased initially for 0.4%.

Figure 12. Feedback effect of IP to LLP shock



This initial decrease is consistent with the assumption of the contemporaneous effect of LLP to other variables. After initial decrease IP starts to increase up to the 2nd quarter with getting back at the 5th quarter to the initial level it had before the shock. The total change in IP is equal to 1.2%.

CONCLUSION

The main goal of the thesis is twofold: one to test the resilience of the whole banking system and the other was to establish the bank-specific determinants of the loan loss provisions. Within a first stress test, the banking system of Montenegro proved to be resilient to the stress performed by a scenario of decreasing industrial production and tourism (overnights) and increasing lending interest rate, unemployment and CPI. The capital adequacy ratio proved to be above the regulatory minimum even after the stress was introduced to the model. However, it is important to keep in mind that this was the credit risk stress test and neither one of other risks was included in the analysis. The main reason for this was data limitation.

The other stress test was done by estimating panel VAR and analyzing impulse responses. This was done with bank-specific data and the problem of data constraints was encountered again. For example, the only variable available with regard to loan quality on each bank separately was loan loss provisions. In the analysis, this variable is used in the form of the ratio of total loans and it represents the loan quality. Two main hypotheses were tested: „the bad management" hypothesis and "moral hazard" hypothesis as well as the influence of the economic situation to the loan quality and banking management

practices. The bad management hypothesis was tested through two variables: return on assets and return on equity. This hypothesis was confirmed with the second variable indicating that the smaller return on equity stimulates higher loan loss provision ratio. This implies the fact that the bad management in banks is tried to be covered by approving more risky loans, and consequently increasing LLP ratio. In this way, the bad position of the bank regarding return on equity is trying to be improved by higher credit activity. Because of the motive for this credit activity, the loans are not prudently revised and more nonperforming loans are present consequently increasing loan loss provisions. The response of LLP to the shock in loan to deposit ratio confirmed moral hazard hypothesis. By the increase in loan to deposit ratio the LLP ratio has also increased indicating that the loans that are not backed up with deposits are also the riskiest ones since they indicate the increase in LLP. The main finding is the fact that loan loss provisioning practices are not forward-looking but precisely the opposite. When the situation regarding the profit or the credit activity is bad, there are attempts to improve it by increasing the level of loans even though this increase implies more risky loans in the bank's portfolio.

Finally, the banking system should be more forward-looking in a way to increase the loan loss provisions while the economy is in good shape, so that when there is an economic downturn the banks are somewhat secure with the provision they left aside for loan losses. The Central bank of Montenegro should, as the supervisor authority, motivate banks to practice good and sensible decisions regarding their portfolio management. The data regarding the stress tests should be more available for researches. Consequently, more stress testing exercises could be done and the better implications for the banking system could be made. In addition, if the data were more available and better organized, more different risk types could be assessed and consequently broader conclusion regarding the resilience of the financial sector could be established.

Stress tests have, undoubtedly, become regularly used as a macro-prudential analysis and crisis management tool. These practices have improved over the years and have now become a crucial component of the methodology used by banking supervisors and central banks for assessing financial stability. Hopefully, more practitioners will start performing this exercise on the Montenegrin banking system. Consequently, more information regarding deficiencies of the financial system will be available and this kind of information can then be used as an input to the new and more reliable stress tests. Possible threats regarding the financial system could be determined more accurately and there would be higher probability that the financial stability is preserved. Nevertheless, it is extremely important to bear in mind that the stress tests, as useful and informative as they can be, are of the greatest value when followed by concrete and appropriate actions, first by the central authority and then by each bank separately.

REFERENCE LIST

1. Alastair, R. (2009, March). Generalized Method of Moments. Retrieved March 2, 2013, from http://personalpages.manchester.ac.uk/staff/Alastair.Hall/HbkRM_GMM_111202.pdf
2. Angklomkliew, S., George, J., & Packer, F. (2009). Issues and developments in loan loss provisioning: the case of Asia. Retrieved February 20, 2013, from http://www.bis.org/publ/qtrpdf/r_qt0912h.pdf?noframes=1
3. Balla, E., Rose, M., & Romero, J. (2012, March). Loan Loss Reserve Accounting and Bank Behaviour. Retrieved April 3, 2013, from http://www.richmondfed.org/publications/research/economic_brief/2012/pdf/eb_12-03.pdf
4. Baltagi, B. H. (2006). *Panel Data Econometrics, Theoretical Contributions and Empirical Applications*. Amsterdam: ELSEVIER.
5. Bank of Japan. (2007, September). Financial System Report, Financial Analysis and Research. Retrieved March 8, 2013, from http://www.boj.or.jp/en/research/brp/fsr/fsr07b.htm/
6. Basel Committee on Banking Supervision. (2005). *Basel II: International Convergence of Capital Measurement and Capital Standards: A Revised Framework.* Basel: Bank for International Settlements.
7. Basel Committee on Banking Supervision. (2006). *International Convergence of Capital Measurement and Capital Standards*. Basel: Bank for International Settlements.
8. Blascke, W., Jones, M. T., Majnoni, G., & Peria, S. M. (2001). Stress Testing of Financial Systems: An Overview of Issues, Methodologies, and FSAP Experiences. Retrieved March 16, 2013, from http://www.imf.org/external/pubs/ft/wp/2001/wp0188.pdf
9. Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*, 2-20.
10. Borio, C., Drehmann, M., & Tsatsaronis, K. (2012, January). Stress testing macro stress testing: does it live up to the expectations?. *Monetary and Economic Department, BIS Working papers No. 369.* Retrieved March 13, 2013, from http://www.treasury.gov/initiatives/wsr/ofr/Documents/OFRBorioDrehmannTsatsaronis.pdf
11. *Centralna banka Crne Gore* [Central bank of Montenegro]. Retrieved May 7, 2013, from http://www.cbcg.me
12. *Centralna banka Crne Gore – monetarna statistika* [Central bank of Montenegro – monetary statistics]. Retrieved March 8, 2013, from http://www.cb-mn.org/index.php?mn1=statistika&mn2=monetarna_statistika
13. Chopra, G. (n.d.). Stress testing Financial Systems: A Macro Perspective. Retrieved May 16, 2013, from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1529434

14. Coletti, D., Lalonde R., Misina M., Muir D., St-Amant P., & Tessier, D. (2008). Bank of Canada Participation in the 2007 FSAP Macro Stress-Testing Exercise. *Bank of Canada Financial System Review*, pp. 51–59.
15. Čihák, M. (2004). Stress Testing: A Review of Key Concepts, *Czech National Bank Research Policy Note No. 2/2004*. Retrieved May 7, 2013, from http://www.cnb.cz/en/pdf/IRPN_2_2004.pdf.
16. Čihák, M. (2007). Introduction to Applied Stress Testing. Retrieved April 25, 2013, from http://www.imf.org/external/pubs/ft/wp/2007/wp0759.pdf
17. Dechow, P. (1994). Accounting earnings and cash flows as measures of firm performance. Retrieved March 10, 2013, from http://econ.au.dk/fileadmin/Economics_Business/Education/Summer_University_2012/6308_Advanced_Financial_Accounting/Advanced_Financial_Accounting/2/Dechow_1994.pdf
18. Drehmann, M. (2008). Stress Tests: Objectives, Challenges and Modelling Choices. *Economic Review*. Retrieved March 1, 2013, from http://www.riksbank.se/Upload/Dokument_riksbank/Kat_publicerat/Artiklar_PV/2008/drehmann2008_2_eng_ny.pdf
19. Drehmann, M. (2009). Macroeconomic stress-testing banks: a survey of methodologies. In M. Quagliariello (Eds.), *Stress-testing the Banking System: Methodologies and Applications* (pp. 37-67). New York: Cambridge University Press.
20. Eklund, T., Larsen K., & Bernhardsen, E. (2001). Model for analysing credit risk in the enterprise sector. *Economic Bulletin 72*(3), pp. 99—106.
21. Engelmann, B., & Rauhmeier, R. (Eds.) (2006). The Basel II Risk Parameters, Estimation, Validation and Stress testing. Retrieved Fabruary 16, 2013, from http://d.yimg.com/kq/groups/12093474/1121755262/name/The+Basel+II+Risk+Parameters.pdf
22. Espinoza, R., & Prasad, A. (2010, October). Nonperforming Loans in the GCC Banking System and their Macroeconomic Effects. Retrieved May 26, 2013, from http://www.imf.org/external/pubs/ft/wp/2010/wp10224.pdf
23. European Banking Authority. (2011a). *2011 EU-wide stress test aggregate report*. Retrieved May 2, 2013, from http://hofinet.org/documents/doc.aspx?id=613
24. European Banking Authority. (2011b). *2011 EU-wide Stress Test: Methodological Note – Additional Guidance.* London: European Banking Authority
25. European Banking Authority. (2012). *2013 ANNUAL REPORT.* Luxembourg: Publications Office of the European Union
26. European Central Bank. (2006). *Financial Stability Review*. Frankfurt: European Central Bank.
27. European Central Bank. (2008). "Financial stability challenges in EU candidate countries: Managing the transition to deeper and more market-oriented financial systems". *Occasional Paper Series* (No. 95, 2008). Frankfurt: European Central Bank

28. European Central Bank. (2012). *Occasional Paper Series* (No. 136, 2012). European Central Bank. Retrieved on February 13, 2013, from http://www.ecb.europa.eu/pub/pdf/scpops/ecbocp136.pdf
29. Foglia, A. (2009). *Stress Testing Credit Risk: A Survey of Authorities' Approaches, Banking and Financial Supervision*. Rome: Bank of Italy.
30. Greene, W. (2012). *Econometric Analysis*. Cambridge: Pearson Education.
31. Hoggarth, G., Sorensen, S., & Zicchino, L. (2005). Stress tests of UK banks using a VAR approach. Retrieved February 2, 2013, from http://www.bankofengland.co.uk/publications/Documents/workingpapers/wp282.pdf
32. Hayakawa, K. (2009, August). First Difference or Forward Orthogonal Deviation - Which Transformation Should be Used in Dynamic Panel Data Models?: A Simulation Study. *Economics Bulletin, 29*(3), 2008-2017.
33. Holtz-Eakin, D., Newey, W., & Rosen, H. S. (1988, November). Estimating Vector Autoregressions with Panel Data. *Econometrica, 56*(6), 1371-1395.
34. International Monetary Fund. (2010). *Montenegro: 2010 Article IV Consultation – Staff Report; Public Information Notice on the Executive Board Discussion; and Statement by the Executive Director for Montenegro*. Washington D.C.: IMF.
35. Krätzig, M., & Lütkepohl, H. (2004). *Applied Time Series Econometrics*. Cambridge: Cambridge University Press.
36. Laeven, L., & Majnoni, G. (2002). Loan Loss Provisioning and Economic Slowdowns: Too Much, Too Late?. Retrieved February 3, 2013, from http://www.bostonfed.org/bankinfo/conevent/slowdown/laeven_majnoni.pdf
37. Lehmann, H., & Manz, M. (2006, April). The exposure of Swiss Banks to Macroeconomic Shocks – an Empirical Investigation. Retrieved February 20, 2013, from http://www.snb.ch/n/mmr/reference/working_paper_2006_04/source
38. Louzis D., Vouldis A., & Metaxas, V. (2011). Macroeconomic and bank-specific determinants of non-performing loans in Greece: A comparative study of mortgage, business and consumer loan portfolios. Retrieved March 14, 2013, from http://www.journals.elsevier.com/journal-of-banking-and-finance
39. Love, I., & Zicchino, L. (2002, October 31). Financial Development and Dynamic Investment Behavior. Retrieved April 22, 2013, from http://wwwwds.worldbank.org/servlet/WDSContentServer/WDSP/IB/2002/11/11/000094946_02102904035126/Rendered/PDF/multi0page.pdf
40. Lütkepohl, H., & Krätzig, M. (2004). *Applied Time Series Econometrics*., Cambridge: Cambridge University Press.
41. Lütkepohl, H., & Krätzig, M. (2006). Initial Analysis in JMulTi. Retrieved March 16, 2013, from http://www.jmulti.de/download/help/initanal.pdf
42. Lütkepohl, H., Krätzig, M., & Boreiko, D. (2006). VAR Analysis in JMulTi. Retrieved March 15, 2013, from http://www.jmulti.de/download/help/var.pdf
43. Marcucci, M., & Quagliarello, M. (2006). Credit Risk and Business Cycle over Different Regimes. Retrieved April 10, 2013, from http://www.cide.info/conf/papers/m20.pdf

44. Ng, J., & Roychowdhury, S. (2010, July 16). Loan Loss Reserves, Regulatory Capital, and Bank Failures: Evidence from the 2008-2009 Economic Crisis. Retrieved April 16, 2013, from http://www.lse.ac.uk/accounting/news/MAFG/RoychowdhuryMAFGpaper2011.pdf
45. Oesterreichische Nationalbank. (2006, March). Risk Assessment and Stress Testing for Austrian Banking System. Retrieved April 23, 2013, from http://www.gwu.edu/~gefri/PDF/SrmModelBook.pdf
46. Pesaran, H. M., Schuermann, T., Treutler, B. J., & Weiner, S. M. (2005). Macroeconomic Dynamics and Credit Risk: A Global Perspective. Retrieved April 20, 2013, from http://fic.wharton.upenn.edu/fic/papers/03/0313.pdf
47. Quagliariello, M. (2009). Macroeconomic stress-testing: definitions and main components. In M. Quagliariello (Eds.), *Stress-testing the Banking System: Methodologies and Applications*. (pp. 18-35). New York: Cambridge University Press.
48. Schinasi, G. (2004, October). Defining financial stability. Retrieved March 10, 2013 from http://cdi.mecon.gov.ar/biblio/docelec/fmi/wp/wp04187.pdf
49. Stock, J., & Watson, M. (2012) *Introduction to Econometrics*. Boston: Pearson Education.
50. Trapanese, M. (2009). A framework for assessing financial stability. In M. Quagliariello (Eds.), *Stress-testing the Banking System* (pp. 7-17). New York: Cambridge University Press.
51. Vukelić, T. (2011, May 20). Stress Testing of the Banking Sector in Emerging Markets: A Case of the selected Balkan Countries. Retrieved February 10, 2013, ies.fsv.cuni.cz/default/file/download/id/17084
52. Wooldridge, J. M. (2002). *Econometric Analysis of Cross Section and Panel data*. Cambridge: The MIT Press.
53. World Bank. (2011). *Montenegro – Programmatic Financial Sector Development Policy Loan Program.* Washington D. C.: World Bank.

APPENDIXES

TABLE OF APPENDIXES

Appendix 1: Summary

Realna ekonomija in finančni sektor sta močno povezana. Na eni strani igra finančna stabilnost kot nujen pogoj za uspešno delovanje bančnega sistema ključno vlogo pri zagotavljanju učinkovite razporeditve finančnih sredstev in spodbujanju gospodarske rasti. Podobno pa makroekonomsko okolje vpliva na stabilnost bančnega sektorja. Večji del magistrske naloge je namenjen obravnavi vpliva makroekonomskih sprememb na bančni sektor, v zadnjem delu naloge pa bo testiran tudi obraten vpliv, in sicer predvsem s pomočjo funkcij impulznih odzivov.

Še vedno se čutijo posledice gospodarske krize, kar se v Evropi kaže predvsem v globoki dolžniški krizi. Kljub temu da so posledice krize v Črni gori prišle na plan nekoliko kasneje, je kriza močno oslabila črnogorsko gospodarstvo. Posledično so bile potrebne korenite spremembe celotnega gospodarstva. Tako je Centralna banka Črne gore omejila najvišje kreditne obrestne mere, vlada pa zvišala davek na dodano vrednost z namenom povečanja lastnih dohodkov. Vendar je kreditnemu razmahu v letu 2008 sledil kreditni krč v luči krize, zato je bil bančni sistem v slabem stanju. Večina bank je prejela kapitalske injekcije s strani njihovih materinskih bank, kar je bilo ključnega pomena za tako majhno gospodarstvo, kot je črnogorsko. V nasprotnem primeru bi prišlo do velikih težav pri premagovanju krize.

Pri obravnavanju finančnih dogodkov, ki so sicer malo verjetni, a zelo uničujoči, je izrednega pomena zavedanje, da do takšnih dogodkov lahko pride v vsakem trenutku. Vendar je večina teh ekstremnih finančnih dogodkov obvladljivih. Da bi se okrepilo zavedanje o možnih negativnih finančnih šokih, so Evropska centralna banka (v nadaljevanju ECB) in druge institucije določile nabor kontrolnih okvirjev in metod, ki bi jih morale vse države članice Evropske unije (tudi kandidatke za pristop k EU) redno izvajati. Ena od teh metod so t. i. stres testi, ki jih morajo banke izvajati individualno, ECB pa jih je že večkrat izvajala v bankah na območju celotne Evropske unije. Centralne banke bi morale redno izvajati stres teste, saj razpolagajo z večino potrebnih podatkov. Stres teste v Črni gori izvaja centralna banka vsako četrtletje že več kot tri leta.

Obstaja veliko različnih pristopov k izvedbi stresnega testiranja, v magistrski nalogi pa bosta analizirana dva. Prvi pristop vključuje stres test, ki se izvaja na podlagi agregiranih podatkov, to pomeni v bančnem sistemu kot celoti. V obeh pristopih je spremenljivka, ki nas zanima, razmerje rezervacij. Glavni cilj magistrske naloge je najti odgovor na naslednji vprašanji: Katere makroekonomske spremenljivke najmočneje vplivajo na spremenljivko rezervacije in kako se bo ta spremenljivka odzvala v situaciji, ko bodo vse makroekonomske spremenljivke istočasno pod vplivom ekstremnega scenarija? Odpornost bančnega sistema na takšen scenarij se bo testirala s stopnjo kapitalske ustreznosti. Da bi izvedeli več o metodah bank pri obvladovanju ekstremnih finančnih dogodkov, so bili pri analizi uporabljeni tudi mikroekonomski podatki o bankah. Namen je ugotoviti, katere spremenljivke lahko pojasnijo razmerje rezervacij za vsako banko posebej ter kako je lahko ta informacija koristna za morebitno izboljšanje bančnega sektorja. Korelacije med

danimi spremenljivkami naj bi pojasnile nekatere bančne izgube in njihove metode pri izvajanju kreditnih aktivnostih. S pomočjo stresne analize bodo oblikovani predlogi za banke in Evropsko centralno banko, pa tudi za vplivanje ECB na metodologijo v bančnem sektorju.

Pregled metodologije

V makroekonomskem scenariju stresnega testiranja je vplive šokov na makroekonomske in finančne spremenljivke moč oceniti s pomočjo različnih modelov, navadno pa so za stresno analizo uporabljeni trije pristopi: 1) strukturni modeli, 2) vektorsko avtoregresijski modeli in 3) čisti statistični modeli.

Mnogi raziskovalci uporabljajo obstoječe strukturne modele (ki jih razvijajo in uporabljajo centralne banke za predvidevanja in analizo) za prikaz ravni ključnih makroekonomskih indikatorjev. Uporaba strukturnih modelov je primerna, ker dopušča endogeni odziv na začetni šok. Če takšni modeli niso na razpolago oziroma če so na razpolago, a ne morejo oblikovati doslednih in relevantnih šokov, je na voljo druga možnost − vektorsko avtoregresijski modeli (VAR). Pri tovrstnih modelih začetni šok vpliva na skupek makroekonomskih spremenljivk. Primerni so zato, ker omogočajo večjo fleksibilnost in relativno preprosto oblikujejo medsebojno dosledne šoke. Poleg tega se rezultati teh modelov relativno lahko razumejo in interpretirajo. Slabost modelov VAR v primerjavi s strukturnimi modeli pa je, da ne vključujejo ekonomskih struktur, prisotnih v strukturnih modelih. Po podatkih Foglie (2009, pp. 34–42) in na podlagi raziskave, ki jo je izvedla, modele VAR uporabljajo centralna banka Velike Britanije, Japonske, Španije in Nizozemske ter Evropska centralna banka. Nekatere od teh bank uporabljajo globalni vektorski avto-regresijski model (GVAR). Tretja vrsta modelov za izvajanje stres testov temelji na čistih statističnih pristopih za oblikovanje scenarijev. Statistične modele uporablja avstrijska centralna banka v svojem modelu nadzora sistemskih tveganj (ang. *Systemic Risk Monitor*; v nadaljevanju SRM), ki ga je razvila za zagotavljanje sistemske finančne stabilnosti in analizo stres testov. SRM vključuje tri različne vrste tveganja: kreditno in tržno tveganje ter tveganje okužbe.

Ker je v obeh tipih empirične analize (analiza na podlagi agregiranih podatkov celotnega bančnega sektorja z uporabo modela VAR in analiza na podlagi bankam specifičnih podatkov z uporabo panelnega modela VAR) ključni cilj oceniti in prepoznati glavne težave v zvezi s kreditnim tveganjem bančnega sektorja v Črni gori, bo raziskan tipičen način ocenjevanja te vrste tveganja.

Tako pristop k analizi z modeli VAR kot pristop s strukturnimi modeli potrebujeta metodo za spreminjanje makroekonomskih spremenljivk v indikatorje, ki bodo kasneje uporabljeni za ocenjevanje vpliva spremenljivk na bilančno stanje bank. Makroekonomski modeli navadno ne vključujejo spremenljivk, povezanih s kreditnim tveganjem, zato je treba vključiti drugi model, t. i. satelitski model. V satelitskem modelu se šoki v makroekonomskih spremenljivkah odražajo kot šoki v bilančnem stanju bank. Tovrstni

regresijski modeli ponujajo nekaj načinov za vključevanje spremenljivk, ki zadevajo kakovost kreditov. Splošna predpostavka teh modelov je, da na kakovost posojil vpliva splošen ekonomski cikel. Blaschke, Jones, Majnoni & Peria (2001, str. 25) uporabljajo denimo razmerje med slabimi posojili in bilančno vsoto kot odvisno spremenljivko, na katero negativno vplivajo nominalna obrestna mera, stopnja inflacije, sprememba v stopnji BDP-ja in poslovne spremembe. Z regresijskimi koeficienti se ocenjuje občutljivost posojil na vplive naštetih makroekonomskih indikatorjev (Foglia, 2009, str. 18).

Prvi korak pri analizi kreditnega tveganja je ocenjevanje spremenljivk, tako makroekonomskih kot finančnih, ki vplivajo na samo tveganje. Praviloma je obrestna mera ključnega pomena in potemtakem glavna spremenljivka, saj predstavlja direktni strošek posojila. Slabost satelitskega modela, ki obravnava makroekonomske spremenljivke kot eksogene, je, da ne more analizirati povratnega učinka – vpliv poslabšanega bilančnega stanja bank na makroekonomske spremenljivke oziroma makroekonomsko okolje. Analiza povratnih učinkov pa je neizogibna iz kar nekaj razlogov. Navadno se izvaja v okviru modelov VAR, pri čemer so makroekonomske spremenljivke in spremenljivke, ki se nanašajo na kreditno tveganje, endogene ter vplivajo ena na drugo. Marcucci in Quagliarello (2006, str. 22) sta analizirala stopnjo neplačil posojil kot odvisno spremenljivko, v makroekonomski scenarij pa sta vključila rast BDP-ja, dolgoročne obrestne mere, razpon v razmerju med krediti in depoziti ter gibanje borznega indeksa. Za boljše razumevanje spremenljivk sta avtorja analizirala tudi funkcije impulznih odzivov kot povratne učinke. Glavni cilj je bil preveriti, ali je uspešnost bank povezana s splošno makroekonomsko klimo, in prepoznati trenutek odziva bank na gospodarske spremembe. Pomembna lastnost satelitskega modela, ki ga loči od makroekonomskih modelov, je dejstvo, da se lahko analizira na podlagi podatkov za posamezne banke, včasih celo za posamezne posojilojemalce. Čihák (2007, str. 29) je razdelil satelitske modele v dve veliki skupini. Ena skupina temelji na podatkih o kakovosti posojil (denimo podatki o slabih posojilih, rezervacijah in stopnjah neplačil v preteklosti), druga skupina pa na podatkih na mikroekonomskih ravni, ki se nanašajo na kakovost posojilojemalcev oziroma na tveganje nezmožnosti vrnitve kreditov posojilojemalcev – to so lahko posamezna gospodinjstva ali korporacije (Foglia, 2009, str.18).

Empirična analiza na podlagi agregiranih podatkov

V prvem koraku stres testa je bil ocenjen makroekonomski model, v katerem so bili napovedani stresni dogodki z namenom oblikovanja makroekonomskega stresnega scenarija. V model je bilo vključenih pet relevantnih spremenljivk, ki zagotavljajo prikaz in pojasnitev gospodarskega stanja v Črni gori. V drugem koraku se makroekonomski stresni scenarij poveže s spremenljivko, ki se nanaša na kakovost posojil. Edina tovrstna razpoložljiva spremenljivka so bile rezervacije.

Z namenom oblikovanja šoka, ki kasneje vpliva na bančni sektor, je bila izvedena analiza stresnega scenarija. Pri tem različne makroekonomske spremenljivke predstavljajo ravni s

stresno napovedjo in skupaj oblikujejo stresni scenarij. Teh pet spremenljivk istočasno izvaja šoke za gospodarstvo Črne gore.

V splošnem so najpogosteje uporabljene makroekonomske spremenljivke v stres testih naslednje: rast BDP-ja, nezaposlenost in kratkoročna obrestna mera, prav tako rast izvoza, domača poraba, borzni indeks ter obrestni razpon ali dolgoročna obrestna mera. V tem stres testu kot predstavnik rasti BDP-ja, torej splošne gospodarske rasti, nastopa industrijska proizvodnja kot edina razpoložljiva spremenljivka. V model je bila torej vključena spremenljivka industrijska proizvodnja, ki se zelo pogosto uporablja v analizah. Ker pa gospodarstvo Črne gore močno temelji na turizmu, je bilo predpostavljeno, da splošne gospodarske rasti države ne bo moč primerno oceniti brez vključitve spremenljivke, ki zadeva turizem, v makroekonomski model. Tako sta bili v model vključeni dve spremenljivki, ki se nanašata na turistični sektor in imata velik vpliv na splošno gospodarsko aktivnost Črne gore, saj sta odgovorni za večji del sprememb vrednosti BDP-ja. Stopnja nezaposlenosti kot nepogrešljiva spremenljivka pri oblikovanju katere koli makroekonomske analize je tako prisotna tudi v tej analizi. Kar zadeva stroške posojil se za spremenljivko uporabi povprečna ponderirana posojilna obrestna mera. Naslednja spremenljivka je indeks cen življenjskih potrebščin, ki postane mera inflacije, saj so podatki o aktualnim indeksom dejansko sprememba le-tega od vrednosti indeksa v istem mesecu preteklega leta. Ideja modela je, da so z danimi spremenljivkami zajete vse pomembne gospodarske spremembe v Črne gori.

Spremenljivke, uporabljene v modelu skupaj z natančnim opisom podatkov in predpostavkami korelacij med spremenljivkami, so torej naslednje:

- **Rezervacije:** Mesečni podatki se uporabljajo za vse spremenljivke na ravni celotnega bančnega sektorja. Spremenljivka se pojavi v obliki razmerja, tj. odstotka vseh posojil. Dolžina časovnih vrst je 81 opazovanj od septembra 2006 do novembra 2012 in je enak za vse spremenljivke. Spremenljivka se uporablja v satelitskem modelu kot edina endogena spremenljivka.

- **Industrijska proizvodnja:** Mesečni podatki se uporabljajo v obliki vsakoletne spremembe indeksa. Ta spremenljivka je skupaj z naslednjo (turizem) pokazatelj gospodarske uspešnosti Črne gore. Predpostavlja se, da spremenljivka negativno korelira z razmerjem rezervacij – nižji kot je BDP, višje je razmerje rezervacij (banke morajo zagotoviti več odhodkov za rezervacije, da bi poravnale slaba posojila).

- **Turizem:** Meri se s številom nočitev tujih turistov v Črni gori. Predpostavlja se, da spremenljivka negativno korelira z ostalimi, saj je predstavlja večji del gospodarske aktivnosti v Črni gori.

- **Stopnja nezaposlenosti:** Predpostavlja se, da spremenljivka pozitivno korelira z nekaterimi spremenljivkami – več brezposelnih ljudi prinaša več slabih posojil in posledično več potrebnih odhodkov za rezervacije.

- **Indeks cen življenjskih potrebščin:** Predpostavlja se, da spremenljivka pozitivno korelira z odhodki za rezervacije – dražje življenjske potrebščine povečujejo verjetnost, da se bodo posojila spremenila v slaba posojila, kar pa hkrati povzroča več odhodkov za rezervacije.

- **Povprečna ponderirana posojilna obrestna mera:** Predpostavlja se, da spremenljivka pozitivno korelira – višja kot je obrestna mera, višji so stroški posojila, kar pa zmanjšuje število kakovostnih posojil. Posledično se morajo povečati odhodki za rezervacije z namenom reševanja posojil, ki so izgubila na kakovosti.

Makroekonomski model VAR je bil ocenjen s šestimi odlogi. Ker gre za podatke na mesečni ravni, je vrstni red odlogov pričakovan. Vključene spremenljivke so: turizem_d1 (prva sprememba spremenljivke turizem), industrijska proizvodnja, stopnja nezaposlenosti, indeks cen življenjskih potrebščin in obrestna mera. Ker je model prikazal nenavadnosti, je bila vključena dodatna odzivna umetna spremenljivka, in sicer za testiranje podatkov tretjega meseca v letu 2010. V tej spremenljivki so bile vidne spremembe za več kot 3 standardne odklone. Naslednja determinanta enačbe, ki je vključena z namenom ohranjanja trenda padanja obrestnih mer, je prekinitev trenda. Z vključitvijo te determinante postanejo napovedi za spremenljivko realnejše, kar pomeni, da ne težijo k manjšim vrednostim. Poleg spremenljivke, ki upošteva trend in presek (ang. *intercept*) so zaradi sezonske spremenljivke turizem v model vključene tudi umetne sezonske spremenljivke.

Model predvideva zmanjšanje industrijske proizvodnje za 48 % zaradi močnega nihanja indeksa industrijske proizvodnje v vzorčnem časovnem intervalu. Pri spremenljivki turizem se v letu 2013 največja sprememba v številu nočitev tujih turistov v Črni gori dogaja v mesecu juliju, torej v vrhuncu turistične sezone. Stopnja nezaposlenosti, ki se zmanjšuje od leta 2006, se ne poveča znatno, in sicer zgolj za 1 %, najvišja stopnja 16,05 % pa je bila zabeležena marca 2013. Indeks cen življenjskih potrebščin se poveča do 11,12 %, kar je najvišje do zdaj.

Obrestna mera, ki v zadnjem času ne doživlja pretiranih nihanj, se poveča za zgolj 0,5 odstotne točke, kar negativno vpliva na potencialna posojila. Pri napovedanih nihanjih spremenljivk igra vlogo odvisnost od sezone, predvsem pri spremenljivkah turizem in industrijska proizvodnja. Na ti dve spremenljivki vpliva ogromno dejavnikov, ki so običajni, denimo izredno slabi vremenski pogoji pozimi ali zelo dobra (ali slaba) turistična sezona poleti. Poleg tega lahko ti dejavniki vplivajo tudi na druge spremenljivke (indeks cen življenjskih potrebščin, obrestna mera, stopnja nezaposlenosti), ki potem same kažejo odvisnost od sezone.

V naslednjem koraku se oceni satelitski model, v katerem so rezervacije edina endogena spremenljivka. V model so bili vključeni tudi presek (ang. *intercept*), sezonska umetna spremenljivka in trend. Model se oceni s petimi odlogi eksogenih spremenljivk in desetimi odlogi endogenih spremenljivk, kar je bil predlog vseh treh informacijskih kriterijev: Akaike, Hannan – Quinn in Schwarz.

Po napovedih sodeč naj bi se razmerje rezervacij povečalo za skoraj 3 odstotne točke, kar je veliko, saj je povprečno razmerje v vzorčnem časovnem intervalu znašalo približno 4,5 %, najvišjo vrednost 10 % pa so dosegli v letu 2009. Potemtakem je napovedana vrednost 10 % precej visoka za bančni sistem Črne gore in predstavlja ustrezno stopnjo stresa, ki je potrebna za tovrstno testiranje.

Predpostavlja se, da rezervacije negativno korelirajo s turizmom in industrijsko proizvodnjo. Kljub majhnim vrednostim koeficientov v prvih treh odlogih je korelacija dejansko negativna. Na drugi strani pa stopnja nezaposlenosti predstavlja tako pozitivne kot negativne koeficiente. Pri indeksu cen življenjskih potrebščin je več odlogov s pozitivno korelacijo. Predpostavlja se, da bo s povečanjem indeksa prišlo tudi do povečanja rezervacij. Obrestna mera naj bi pozitivno korelirala, kar se v zadnjih dveh odlogih tudi uresniči. To lahko implicira, da imajo posojilojemalci šele po nekem časovnem obdobju korist od posojil. Poleg tega so banke zmožne prepoznati negativne dogodke samo z odlogom.

Korelacije so bile uporabljene za napovedovanje razmerja rezervacij v stresnih makroekonomskih okoliščinah. Stresne vrednosti rezervacij so bile napovedan za eno leto vnaprej, saj makroekonomske spremenljivke vplivajo na spremenljivko rezervacije v maksimalno petih odlogih. Potemtakem makroekonomski stres vpliva na spremenljivko rezervacije v vsaj polletnem obdobju.

Eden od običajnih načinov preverjanja, pod kakšnim stresom je posamezna spremenljivka, je izračun kapitalske ustreznosti. Pred stres testom se zabeleži stopnja kapitalske ustreznosti (ki je znašala približno 14 %), ko pa doživi makroekonomski šok, se lahko izvede izračun nove kapitalske ustreznosti za bančni sektor Črne gore. Za nadaljnje preverjanje obsega šoka je nepogrešljiv naslednji korak − izračun kapitalskih izgub.

Izračun nove kapitalske ustreznosti v stresnem scenariju se izvede na sledeči način. V prvem koraku se preveri stopnja vseh posojil bančnega sektorja v zadnjem mesecu aktualnih podatkov v časovnih vrstah. Nato se izvede izračun zneska pričakovanih kapitalskih izgub na naslednji način. Razlika v razmerju rezervacij pred in po stresnem dogodku naj bi se z izgubami pri posojilu spremenila v kapitalsko izgubo. V aktualnih podatkih iz novembra 2012 ostaneta kapital in tveganju prilagojena aktiva zaradi omejitev nespremenjena. Na ta način je razlika v stopnji rezervacij spremenjena v izgubo kapitala, kapital (ki ostane nespremenjen) pa se zmanjša za to razliko. Po izračunu novega obsega kapitala se lahko izračuna kapitalska ustreznost v stresnem scenariju. Ugotovljeno je, da se je povečala za več kot 2 %. Vendar je znano, da je stopnja kapitalske ustreznosti na

območju Črne gore visoka, zato ne preseneča, da je celo po stresnem dogodku nad minimumom, ki znaša v primeru Črne gore 10 %.

V splošnem je bančni sistem glede na kapitalsko ustreznost odporen na negativne gospodarske dogodke. Vendar je treba vzeti v ozir druge pojasnjevalne spremenljivke, kot je denimo borzni indeks ipd. Poleg tega lahko drugi stres testi, kot sta denimo stres test trgovalne knjige ali likvidnostnega šoka, omogočijo širši pregled bančnega in finančnega sistema. Zaradi omejenih podatkov je bil izveden samo stres test kreditnega tveganja, zato se tudi pojasnila nanašajo zgolj na to vrsto tveganja.

Empirična analiza na podlagi bankam specifičnih podatkov

Za razliko od predhodno analiziranega stres testa, ki je bil izveden na podlagi agregiranih podatkov, tj. v bančnem sektorju kot celoti, temelji ta analiza na specifičnih podatkih posameznih bank. Korelacije med spremenljivkami so ocenjene s pomočjo panelnega modela VAR, odziv spremenljivke rezervacije na šoke v drugih spremenljivkah pa je analiziran s funkcijami impulznih odzivov. Glavni cilj je dobiti boljši vpogled v determinante spremenljivke rezervacije v bančnem sistemu Črne gore v upanju, da mu bodo različne informacije, pridobljene s testiranjem nekaj hipotez, prinesle korist. Z analizo želimo najti odgovor na naslednje vprašanje: Kako pojasniti bančni sektor na podlagi informacij o določenih spremenljivkah, ki jih dobimo iz specifičnih mikroekonomskih podatkov posameznih bank? Ideja je, da se za testiranje makroekonomske situacije ali splošnega gospodarskega stanja v model vključi primerjalna makroekonomska spremenljivka, kot je denimo industrijska proizvodnja. Ta spremenljivka bo enaka za vse banke, spreminjala pa se bo le občasno. Bančni sistem je že bil pojasnjen, zato bo sledil le kratek uvod v zvezi z metodami v bančnem sistemu Črne gore. Nato bom pojasnila metodologijo, ki bo uporabljena v analizi, ter zatem še opisala uporabljene podatke in spremenljivke.

V analizi, ki jo je izvedla Banka Grčije (Louzis, Vouldis & Metaxas, 2010, str. 35), so za testiranje determinant slabih posojil uporabljene metode za obdelovanje dinamičnih panelnih podatkov. Predpostavlja se, da je za obdobje gospodarske rasti ali konjunkture značilna nizka mera slabih posojil, medtem ko se v obdobju recesije in upadanja gospodarske rasti poveča število manj kakovostnih posojil in posledično slabih posojil. V magistrski nalogi so bile uporabljene različne bankam specifične spremenljivke glede na ustrezno predpostavko, ki jim je dodeljena.

Empirična analiza za Črno goro temelji na predpostavki, da obstaja korelacija med slabimi posojili in odhodki za rezervacije, kar so že dokazale mnoge raziskave. Ustrezen termin za označevanje korelacije med omenjenima spremenljivkama je stopnja kritja slabih posojil z rezervacijami. Cilj je dokazati, da je bančni sistem Črne gore moč pojasniti z makroekonomskimi in nekaterimi bankam specifičnimi spremenljivkami. Model potemtakem vključuje naslednje spremenljivke: rezervacije, donosnost na sredstva,

donosnost na lastniški kapital, razmerje kreditov glede na depozite, industrijska proizvodnja.

Hipoteza slabega upravljanja predpostavlja, da je slaba stroškovna učinkovitost pozitivno povezana s povečanjem slabih posojil v prihodnosti. Izgube posojil naj bi se potem pokrile z rezervacijami, zato sta obe bankam specifični spremenljivki prav tako vključeni s predpostavko o pozitivni korelaciji. Hipoteza moralnega hazarda bank predpostavlja, da nizka kapitalizacija bank vodi v povečanje slabih posojil. Dodatno povečanje slabih posojil pa lahko povzročijo bančniki, ki lahko s povečanjem razmerja kreditov glede na depozite (tj. povečanje kreditov, ki niso kriti z depoziti) še bolj povečajo tveganje. Pri tej hipotezi se podobna logika nanaša tudi na razmerje rezervacij. Hipoteza prociklične kreditne politike se nanaša na dejstvo, da se banke, ki ne posvečajo preveč pozornosti zagotavljanju kakovostnih posojil, sicer zdijo bolj stroškovno učinkovite, vendar na daljši rok to pomeni povečanje števila slabih posojil. Hipoteza o velikosti pa predpostavlja, da velikost banke negativno korelira s slabimi posojili (Louzis et al. 2010, str. 13).

Niz podatkov v modelu zajema panelne podatke na četrtletni ravni. Časovne vrste segajo od prvega četrtletja v letu 2007 do tretjega četrtletja v letu 2012. Zadnje četrtletje leta 2012 ni vključeno, ker ni bilo na voljo zadosti podatkov o le-tem. V model je vključenih 10 od 11-ih bank v Črni gori. Ustrezen model za ocenjevanje mikroekonomskih podatkov in bankam specifičnih spremenljivk je panelni model VAR. Ocenjen je s posebnim pristopom, ki ga je uvedla Inessa Love ter prvič uporabila in predstavila z Leo Zicchino v raziskavi leta 2002. Ta pristop nam prinaša koristi tako s prednostmi modela VAR, kot tudi s tehnikami za ocenjevanje panelnih podatkov.

Ena od prednosti modelov VAR pri izvajanju stres testov je, da omogoča tudi analizo impulznih odzivov. Uporablja se za opazovanje odziva spremenljivke rezervacije na zunanje ali druge stresne dogodke. V panelnem modelu VAR so impulzni odzivi reakcije posamezne spremenljivke na šok v eni od njih. Če so spremenljivke v modelu razporejene na drugačen način, je priporočeno opazovati spremembe, ki jih povzroči en standardni odklon in ne celoten šok. Podobno se lahko odziv drugih spremenljivk na šok v spremenljivki rezervacije testira kot neka vrsta povratnih učinkov. Ustrezen vrstni red spremenljivk v panelnem modelu VAR se izbere na podlagi dejstva, da spremenljivke, ki se prej vključijo v model, na druge spremenljivke vplivajo istočasno, medtem ko spremenljivke, ki se vključijo kasneje, vplivajo na druge spremenljivke z odlogom (Love & Zicchino, 2002, str. 8).

Ker matrika varianc in kovarianc verjetno ne bo diagonalna, je treba elemente matrike (spremenljivke) razporediti pravokotno. To naredimo s Cholesky razčlenitvijo (ang. *Cholesky decomposition*), ki razporedi spremenljivke takole: $[\mathrm{LLP_{it}}, \mathrm{ROA_{it}}, \mathrm{ROE_{it}}, \mathrm{LtD_{it}}, , \mathrm{IP_t}]'$. Kratica LLP označuje rezervacije (ang. *loan loss provisions*), ROA donosnost na sredstva (ang. *return on* assets), ROE donosnost na lastniški kapital (ang. *return on equity*), LtD razmerje kreditov glede na depozite (ang. *loan to deposit*) in IP industrijsko proizvodnjo (ang. *industrial production*). Predpostavka je

bila, da sprememba v spremenljivki rezervacije vpliva na ostale spremenljivke tako istočasno kot z odlogom, medtem ko druge spremenljivke vplivajo na rezervacije zgolj z odlogom.

Spremenljivka rezervacije kot del bilance bank takoj vpliva na spremenljivki donosnost na sredstva in donosnost na lastniški kapital. Spremembo čuti takoj tudi razmerje kreditov glede na depozite, ker je za rezervacije nižja višina neto posojila. Industrijska proizvodnja se zniža kot posledica deterioracije v bančnem sistemu, ekonomski cikel pa vpliva na bilančno stanje banke zgolj z odlogom. Glede na našteta dejstva lahko sklepamo, da so impulzni odzivi občutljivi na specifičen vrstni red spremenljivk, kar se lahko pri tovrstni analizi obravnava kot slabost. Zato je pri spreminjanju vrstnega reda spremenljivk priporočljivo oblikovati drugačno strukturo modela. Vendar so bili pridobljeni podatki v našem modelu podobni tudi po zamenjavi vrstnega reda spremenljivk. Iz tega lahko domnevamo, da na analizo ne vpliva specifična identifikacijska shema (Hoggarth, Sorenson & Zicchino, 2005, str. 10).

Panelni model VAR s petimi odlogi je bil ocenjen s pojasnjenim vektorjem Y_{it} in spremenljivko industrijska proizvodnja, ki je vključena za testiranje makroekonomskega okolja. Pred ocenjevanjem modela so bile spremenljivke transformirane s Helmertovo transformacijo, nato pa je sledila ocena modela s splošno metodo momentov (GMM). Formuliranih je bilo šest enačb, vendar bo predstavljena samo ena, in sicer tista, v kateri je spremenljivka rezervacije odvisna spremenljivka. Cilj je namreč opazovati odziv spremenljivke rezervacije na šok v drugih spremenljivkah. Da bi se zavedali možnih posledic povratnih učinkov, bo v nekaterih primerih analiziran tudi odziv drugih spremenljivk na šok v spremenljivki rezervacije.

Pomembni so koeficienti štirih spremenljivk (od skupno petih). Kot sem domnevala, je spremenljivka rezervacije odvisna od odlogov endogenih spremenljivk, ti koeficienti pa so pomembni v treh odlogih. Koeficient, ki se nanaša na donosnost na sredstva, se je v tem modelu izkazal za nepomembnega, čeprav je v prvem in drugem odlogu negativen. Spremenljivka razmerje kreditov glede na depozite, ki opredeljuje morebiten moralni hazard pri upravljanju bank, korelira pozitivno in negativno. Največjo pomembnost kaže v četrtem in petem odlogu, kjer sprva korelira pozitivno, nato pa negativno. Spremenljivka donosnost na lastniški kapital, ki naj bi negativno korelirala z rezervacijami, je v treh odlogih od petih pokazala negativno korelacijo.

Zaključek

Cilj magistrske naloge je dvojen: na eni strani testirati odpornost celotnega bančnega sistema in na drugi strani oblikovati bankam specifične determinante rezervacij. V prvem stres testu je bančni sistem Črne gore dokazal, da je odporen na stresni scenarij, ki zajema nižanje industrijske proizvodnje in turizma (turističnih nočitev) ter povišanje posojilne obrestne mere, indeksa cen življenjskih potrebščin in povečanje nezaposlenosti. Stopnja kapitalske ustreznosti je ostala nad regulatornim minimumom tudi po vključitvi stresnih

dogodkov v model. Kljub temu ne smemo pozabiti, da je bil izveden zgolj stres test kreditnega tveganja, kar pomeni, da v analizo niso bile vključene nobene druge vrste tveganja. Glavni razlog za to je omejena dostopnost podatkov.

Drugi stres test je bil izveden z oceno panelnega modela VAR in analizo impulznih odzivov. Pri tem so bili uporabljeni podatki, specifični za posamezne banke, znova pa smo naleteli na težavo omejenosti podatkov. Edina razpoložljiva spremenljivka denimo, ki se nanaša na kakovost posojil posameznih bank, so bile rezervacije. V analizi je bila ta spremenljivka uporabljena v obliki razmerja vseh posojil. Testirani sta bili dve glavni hipotezi – hipoteza slabega upravljanja in hipoteza moralnega hazarda, prav tako vpliv gospodarske situacije na kakovost posojil in metode upravljanja bank. Hipoteza slabega upravljanja je bila testirana z dvema spremenljivkama: donosnost na sredstva in donosnost na lastniški kapital. Potrjena je bila z dodatno spremenljivko, ki je pokazala, da manjša donosnost na lastniški kapital stimulira povečanje rezervacij. To kaže na dejstvo, da se slabo upravljanje v bankah poskuša skriti z odobravanjem bolj tveganih posojil, s tem pa se posledično povečajo rezervacije. Na ta način banke slabo stanje glede donosnosti na lastniški kapital poskušajo izboljšati z večjo kreditno aktivnostjo. Zaradi takšnega motiva za večjo kreditno aktivnost so posojila premalo natančno pregledana, kar posledično povečuje število slabih posojil in s tem rezervacij. Odziv spremenljivke rezervacije na šok v razmerju kreditov glede na depozite je potrdil hipotezo moralnega hazarda. Povečanje razmerja kreditov glede na depozite je povečalo razmerje rezervacij, kar kaže, da so posojila, ki jih ne krijejo depoziti, najbolj tvegana, saj povzročajo porast rezervacij. Glavna ugotovitev je, da metode rezervacij niso dovolj napredne. V primeru slabe situacije glede dobičkov ali kreditne aktivnosti banke težijo k izboljšanju s povečanim odobravanjem posojil, kljub temu da to vodi k bolj tveganim posojilom v bančnem portfelju.

Bančni sistem bi moral biti naprednejši v smislu, da poveča rezervacije v obdobju dobrega gospodarskega stanja. Na ta način bi bile banke s shranjenimi sredstvi varne v primeru upada gospodarske rasti. Centralna banka Črne gore bi morala kot nadzorni organ spodbujati ostale banke k sprejemanju dobrih in pametnih odločitev glede upravljanja bančnega portfelja. Podatki za uporabo pri izvajanju stres testov bi morali biti bolj dostopni raziskovalcem. Tako bi se lahko izvajalo več stresnih testiranj, kar bi omogočilo izboljšave v bančnem sistemu. Poleg tega bi lahko z večjo dostopnostjo do podatkov in boljšo organiziranostjo le-teh ocenili več različnih vrst tveganja, s tem pa bi lahko razširili spekter odpornosti finančnega sektorja.

Nedvomno se stres testi redno uporabljajo kot makroprudenčna analiza in orodje za obvladovanje krize. Z leti so se testi izboljšali in postali ključna komponenta v metodologiji, ki jo bančni nadzorniki in centralne banke uporabljajo za ocenjevanje finančne stabilnosti. Želja je, da bi več raziskovalcev začelo izvajati stres teste za bančni sistem Črne gore. Posledično bi bilo na voljo več informacij o pomanjkljivostih finančnega sistema, ki se lahko kasneje uporabijo v novih in zanesljivejših stres testih. Tako bi se lahko natančneje določile morebitne grožnje finančnemu sistemu, s tem pa bi se lažje

vzdrževala finančna stabilnost. Vendar je zelo pomembno, da se zavedamo, da imajo stres testi največjo vrednost šele, ko jim sledijo konkretni in ustrezni ukrepi za izboljšanje, sprva s strani centralnega organa, nato pa še s strani vsake posamezne banke.

Appendix 2: Dedication

This thesis is dedicated to my grandmother Ružica for her endless support and encouragement.