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Macro Stress Testing Framework at the National Bank of Slovakia

Ján Klacso

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www.nbs.sk
Imricha Karvaša 1
813 25 Bratislava

research@nbs.sk

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Policy paper NBS

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Abstrakt

This paper describes the current macro stress testing framework at the National Bank of Slovakia. Stress testing is aimed at testing the resilience of the banking sector to negative developments on the financial markets and in the real economy. The paper describes satellite models and assumptions used in the framework. The results of back testing and the most actual results of stress testing are also presented.

JEL Classification: E44, E47, G21
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[2] Macroprudential policy department of the NBS, jan.klacso@nbs.sk

1. INTRODUCTION

Stress testing is a widely used tool among financial institutions, regulators, as well as central banks to test the resilience of a given portfolio, a given institution, or the entire sector to adverse developments on the financial markets and in the real economy. This paper aims to describe the macro stress testing framework of the Slovak banking sector at the National Bank of Slovakia (NBS). The term "macro" refers to the aim of testing the whole banking sector to adverse developments of the wider economy and on the financial markets (Geršl et. al, 2012 or Henry and Kok, 2013).

The role of stress testing as a forward looking tool in the analysis of the viability and riskiness of the banking sector is gathering more and more importance after the outburst of the financial crisis. Moreover, it seems to be a useful supporting tool also for decisions in the field of macroprudential policy. Therefore, it is crucial that the stress testing framework accurately addresses the main risks banking sectors are facing and it transmits in a proper way a potential negative macroeconomic development to the development in the portfolios of banks, thus enabling capture of potential future solvency position of the banks conditional on the stress scenarios. While the feedback loop between the financial and the real sector is also an important issue stress testing should be aware of, it is still hard to incorporate this issue into the framework (see Henry and Kok 2013, Burrows et. al 2012 or Jacobson et. al, 2005).

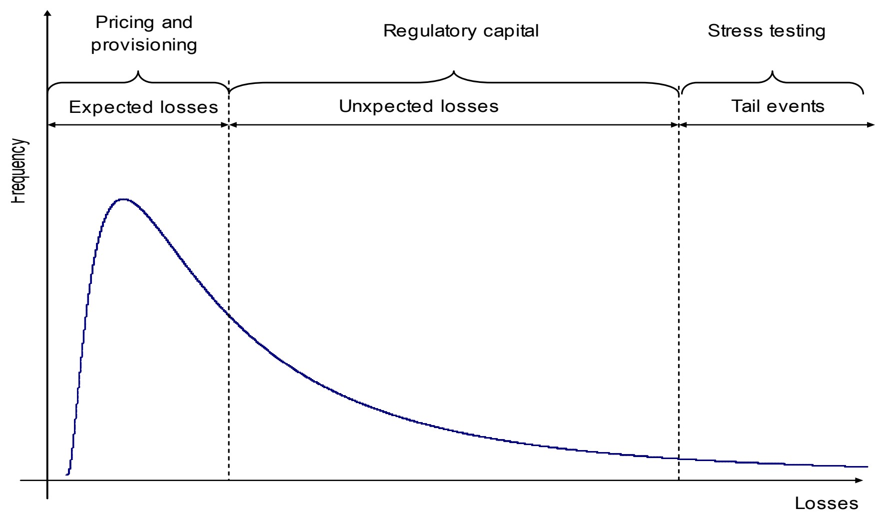
In the paper, we first give a brief overview of the basic concepts of stress testing in Section 2. Then, in Section 3 we describe the historical development and in Section 4 recent framework of the macro stress testing. We outline how scenarios are set, give a detailed description of the satellite models used in the framework and describe key simplifying assumptions that are necessary to fill in the gaps when conducting stress testing. We describe how the results are aggregated to obtain estimates of the net interest income and the solvency of the banks. Then, Section 5 presents the results of back testing, which is a useful tool in the assessment of the appropriateness of the models and assumptions used in the framework. Section 6 is dedicated to the most recent results of the macro stress test to give an overview of the risk profile of the Slovak banking sector. Finally, Section 7 concludes and outlines possible future improvements in the framework.

2. BASIC CONCEPTS OF STRESS TESTING

Stress tests are used to assess the resilience of a given portfolio, an institution or a sector to adverse scenarios that have low probability, but are still plausible. It is an important tool that can help to build a more complex risk assessment. In case of banks, while expected losses are covered by provisions and regulatory capital is needed to cover unexpected losses to a given extent, stress testing can help to discover the volume of additional capital that can prevent a failure of the institution in case of a tail event. This is also one of the purposes of the stress tests conducted by supervisors, as the results can be used to decide on the volume of additional capital that can be required within Pillar II of the Basel framework. Central banks usually use stress tests in the process of the assessment of financial stability. While generally used for analytical purposes by supervisors and regulators, after the outbreak of the financial crisis in 2007 this tool proved to be useful also for political purposes. The Supervisory Capital Assessment Program of the Fed in 2009[3] or the EBA stress testing exercise in 2011 with the consequent EBA Capital exercise in 2011/2012[4] was aimed at restoring market confidence by providing credible information about potential losses in the banking system.

As stress testing is an important part of the complex risk assessment of the banks and the banking sector as a whole, it could and should be also a part of the toolkit supporting macroprudential policy. Due to the fact that stress testing is a complex process with a lot of assumptions needed, it is however disputable if it is feasible as a forward-looking indicator or an early warning device (see, e.g., Borio et al, 2012). Also, due to its highly technical nature and due to the transparency needed in case of macroprudential policy, it would be hard to use it for calibration purposes in the built-up phase. On the other hand, the results of stress testing can serve as an interesting input to the decision during the release phase, for which there is still an on-going debate and different views about the potential interpretation. In cases where the release phase focuses on the loss-absorbing capacity of the sector in case a risk has materialized or is starting to materialize, the results of stress testing can give a first view on the minimum capital that has to be released in order for the banks to cover respective losses.

Figure 1 Expected, unexpected losses and the aim of stress testing



Source: NBS.

The aim of stress tests can vary to a great extent. In case of a given portfolio, the resilience to the changes of one or more risk factors can be questioned (so called sensitivity tests). In case of an institution, the tests can be used to assess the overall robustness. This requires that the stress scenarios include shocks stemming from different risk factors while the correlation between these factors and their mutual dependence has to be accounted for, too. Stress tests assessing the resilience of the whole or part of the financial sector, so called

[3] More details available at www.federalreserve.gov
[4] More details available at www.eba.europa.eu

macro stress tests, can take into account also the interconnectedness between financial entities as well as possible negative feedback loops between the financial system and the real economy. While in general central banks and supervisors are interested in the impact of the scenarios on the solvency of the institutions, the financial crisis revealed that liquidity is also an important issue. Therefore, stress tests aimed at or including also the testing of the liquidity position of the institutions are now being developed (see Geršl et. al, 2011 or Schmieder et. al, 2012).

In line with the goals gradually being more and more complex, the stress testing framework and the models also improved. While at the beginning models were based on simple scenarios linking historical macroeconomic development with financial variables (see, e.g., Blaschke et. al, 2001), they became much more complex integrating market risks such as interest rate risk, FX risk or equity risk, credit risk and, as a lesson from the recent financial crisis, also sovereign risk, as described also in Geršl et. al (2012). Currently, stress tests are not focusing solely on the losses from these risks, but try to incorporate them into the complex behavior of the financial institutions, which means estimation of the overall pre-provision income and risk weighted assets is also an important element of the tests. The financial crisis also showed that more attention has to be paid to the design of stress scenarios since in many cases proved to be not severe enough or didn't link the shocks from different risks in a proper way (see, e.g., Ong and Čihák, 2010). While a lot of work has been done in the field of stress testing, challenges remain mainly in the way how to incorporate funding shocks that can evolve relatively quickly compared to the impact of the scenarios on the solvency of institutions, which is a much more gradual process; or how to best address the possible feedback effects to the real economy.

3. THE HISTORY OF STRESS TESTING IN THE NBS

Stress testing is conducted semi-annually in the NBS since 2005 and the results are part of the Analysis of the Slovak Financial Sector published by the NBS. The first versions of stress tests consisted of sensitivity analysis of the banking sector to different risks: interest rate risk, FX risk, credit risk, liquidity risk and contagion risk. These were relatively simple scenarios, linking e.g. an increase in the default rate of the loan portfolio to the capital adequacy of the banks, or an increased outflow of interbank funds or client deposits to the liquidity position of the banks.

Macro stress testing, aimed at linking an expected worsening in the development of the real economy to the development of the quality of the loan portfolio, was conducted first in 2007. The testing was based on a macroeconomic VEC model. A detailed description of the model and the results is in Zeman and Jurča (2008).

Since 2009, the stress testing includes estimation of losses from corporate and household credit risk, FX risk, equity risk, sovereign risk and the estimation of net interest income. The estimation of the overall pre-provision income became also a part of the exercise. While up to 2009 the development of the domestic macroeconomic factors (GDP, inflation and unemployment) within the respective scenarios were determined by expert judgment, since 2009 the macroeconomic model of the NBS developed for medium term forecasts is used in setting the expected path of these variables. It means that the assumed path of the domestic GDP, inflation and unemployment in case of the baseline scenario coincides with that of the respective medium term forecast.

While up to 2011 the overall volume of the risk weighted assets was kept constant, since 2011 there are some simple assumptions linking the changes in the risk weighted assets to the expected changes of the overall loan portfolio. These simple assumptions aim to link the changes in the volume as well as in the riskiness of the loan portfolio to the risk weighted assets to give a more realistic picture about the possible development of the capital adequacy ratio.

Liquidity risk is not part of the macro stress testing aimed at the solvency position of the banking sector. On the other hand, since 2009 the NBS monitors the development of the liquid asset ratio that can be explained as the short term liquidity position of banks under stressed conditions. The basic principle of this ratio is to ensure that banks are able to cover a certain percentage of the liabilities to their customers with assets that are convertible into liquid funds within a period of up to 1 month. The method of the calculation is laid down in a decree.[5]

4. THE CURRENT FRAMEWORK OF MACRO STRESS TESTING IN THE NBS

Stress testing is focusing on the assessment of the robustness of the banking sector in terms of solvency to adverse macroeconomic development and adverse development on the financial markets. It means stress testing is focusing on how the capital adequacy ratios of the banks would be affected by the baseline and the stress scenarios.

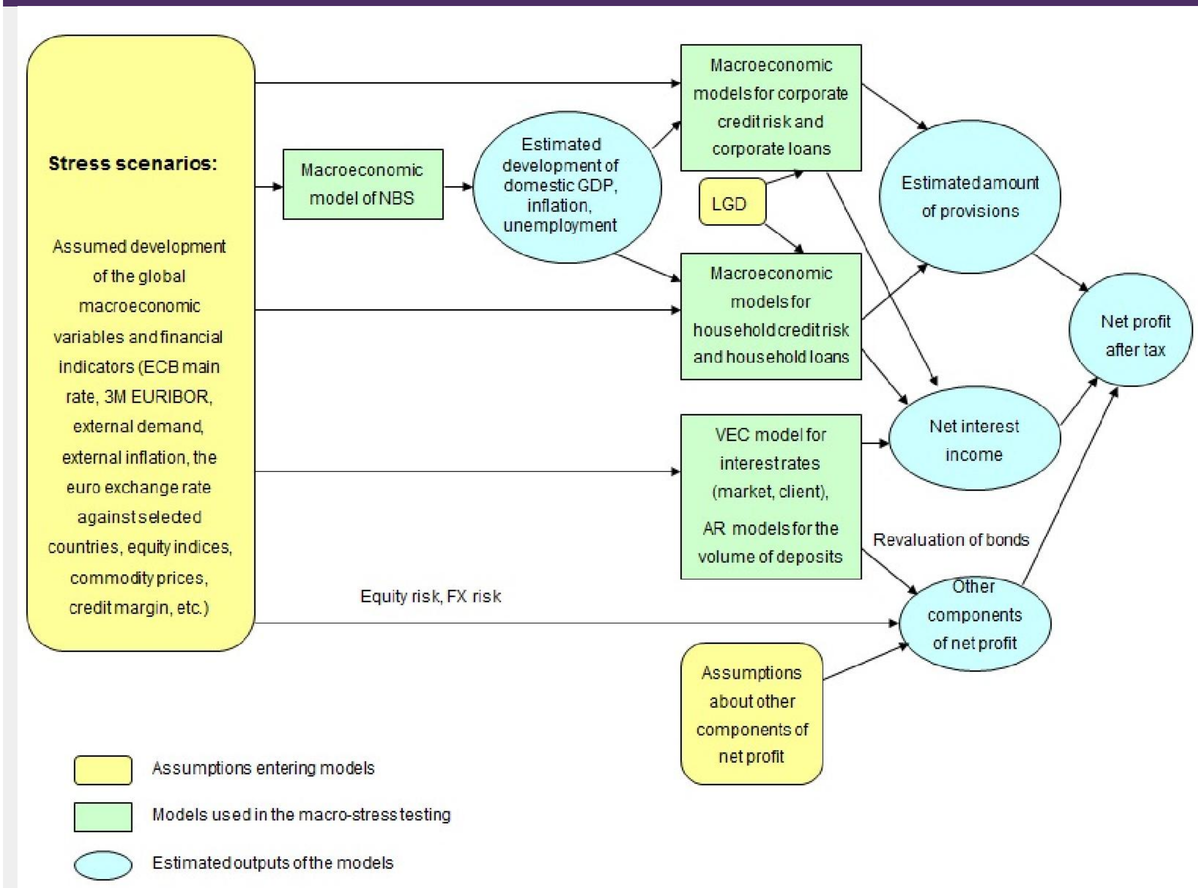
Three scenarios are considered for the stress testing exercise in general. The first is the baseline scenario that is based on the medium term forecast of the NBS and is used as a benchmark when assessing the impact of the two stress scenarios. The stress scenarios are designed to involve the risk factors that are deemed relevant for the banking sector as much as possible and to reflect the current macroeconomic situation and the possible future adverse development that stems from the actual situation. The horizon of the tests is set to be two years in case the stress testing is conducted based on end-year data and two and a half year in case of end-June data.

In the first round, the expected path of the global macroeconomic variables and financial indicators over the stress testing horizon is set by expert judgment. These variables are then used as an input to estimate the development of the domestic macroeconomic variables. The expected path of the global variables and the conditional estimates of the domestic macro variables are then used as an input for estimating the development of selected parts of the net profit of the sector by satellite models (net interest income, losses from corporate credit risk, household credit risk, FX risk, equity risk, sovereign risk). The remaining parts of the net profit, that are not modelled, are estimated using simplifying assumptions. The overall amount of capital of the banks is then affected by the net profit/loss after taxation and the

[5] Decree No. 18/2008 of Národná banka Slovenska of 28 October 2008

expected dividend policy of the respective banks. So far, there is no distinction made between the different types of capital banks report (Tier I, Tier II). However, as the total amount of own funds of the banking sector consists mainly of the highest quality capital (Tier I capital, which after the implementation of the Basel III framework will transform in case of Slovak banks to a great extent to Common Equity Tier I capital), the lack of this distinction does not seem to be a relevant issue. Finally, the volume of risk weighted assets (RWAs) is calculated for each bank using simple assumptions linking the volume of RWAs to the development of the loan portfolio of respective banks. The capital adequacy ratio is then a simple share of the own funds at the end of each year of the stress testing horizon and the volume of risk weighted assets. Currently the capital threshold for passing the exercise is 8%. With the implementation of the Basel III framework and the possible application of several capital buffers this threshold can change and may not be the same for every bank.

Figure 2 Scheme of the macro stress testing



Source: NBS.
LGD: Loss given default.

4.1. STRESS SCENARIOS

Stress testing uses three alternative scenarios: a baseline scenario that is based on the medium term forecast of the NBS and two stress scenarios. In the first round, the expected path of the global macroeconomic variables and financial indicators over the stress testing horizon is set by expert judgment. It means that there are no shocks imposed on these variables, but the whole path is set for the full stress testing horizon. The expected path has to fulfil three criteria (see, e.g., Rodrigo and Drehmann, 2009). First, the development of the respective variables has to be "economically reasonable", which means that the plausibility of the scenarios has to be assured. Second, the development of the variables has to reflect the actual view of the central bank about the possible risks that can affect the global macroeconomic development. Third, the stress scenarios have to reflect an economic downturn and a financial turmoil that is severe enough; it means that it deviates enough from the baseline scenario to assure a low probability of the scenarios. However, as the scenarios are set by expert judgment, it is hard to attach probability score to the manifestation of these scenarios.

The development of domestic macroeconomic variables (GDP, HICP inflation and the unemployment rate) is then estimated by the macroeconomic model of the NBS used for the medium term forecasts. This macroeconomic model is a structural model of a small and open economy (Slovakia in this case) consisting of several error-correction equations describing the development of the economy. The model assumes that in the long run the economy is in its "steady state" determined by the supply side while in the short run there can be and indeed are deviations from this steady state due to demand, supply and price shocks. As Slovakia is a member of the Euro area since 2009, the monetary policy is assumed to be exogenous (for more details see Reľovský and Široká, 2009). The development of the exogenous variables is calibrated in such a way that the estimated path of the GDP, the inflation and the unemployment within the stress scenarios deviates sufficiently from the baseline scenario in a way to pose severe stress on the domestic banking system. While in general there can be scenarios the calibration of which is not straightforward, so far it was always possible to achieve the desired stress scenarios using this macroeconomic model.

The global macroeconomic and financial variables and domestic macro variables then serve as an input to satellite models that link the development of the real economy and in the financial markets to the development in the banking sector.

4.2. ESTIMATION OF INTEREST RATES

In case of the interest rates, it is assumed that the changes of the ECB main rate (i.e. the interest rate for the main refinancing operations) are gradually transmitted, first into the changes of the interbank and discount rates and, second, into the lending and deposit rates of banks. It is assumed that the level of interbank rates also reflects counterparty credit risk and the level of discount rates (particularly with longer maturities above 12 months) reflects, at least partially, expected future macroeconomic development.

Interbank interest rates

EURIBOR interest rates are estimated using error-correction (EC) models, including a cointegrating relationship between the respective interbank rate, the main rate of the ECB and the iTraxx Senior Financial index that is used as a proxy for the level of the counterparty credit risk on the interbank market. This error correction approach is a widespread method in the literature when estimating the development of interest rates (De Bondt, 2002, Curcio and Gianfrancesco, 2010, Gambacorta and Iannotti, 2005). A dummy variable is also included into the cointegrating equation to reflect the possible effects of the non-standard measures of the ECB on the interbank rates. The dummy is set to be 1 from May 2009 until

September 2010 and then gradually deceases to 0 until December 2010 to reflect the effects of the 1Y long term refinancing operation (LTRO) of the ECB, than it is set to be 1 again from December 2011 onwards to reflect the effects of the 3Y LTRO of the ECB, and it is 0 elsewhere. Results of the unit root tests and cointegration tests are shown in Table 12 and Table 13 in the Appendix. The estimated equation has the form

$$\Delta r_t = \alpha . CE + \sum_{i=1}^{n}\left(\gamma_i \Delta r_{t-i} + \delta_i E_{t-i}\left(\Delta r_{t-i+1}^{ECB}\right) + \varphi_i \Delta CDS_{t-i}\right) + \epsilon_t, \quad (1)$$

$$CE = (r_{t-1} + \beta_0 + \beta_1 E_{t-1}(r_t^{ECB}) + \beta_2 CDS_{t-1} + \beta_3 dummy\_LTRO), \quad (2)$$

where r_t is the respective EURIBOR interbank rate, r_t^{ECB} is the main rate of the ECB, CDS_t is the iTraxx index, ε_t is white noise. $E_{t-1}(r_t^{ECB})$ is the expected value of the main rate of the ECB in time $t-1$ one period ahead. We assume that $E_{t-1}(r_t^{ECB}) = r_t^{ECB} + u_t$, where u_t is white noise. Lagged changes of the expected ECB main rate are included into the equation in a way that captures the possible asymmetric reaction of the market to the upward and downward changes of this rate. It means that the time series of the (lagged) changes of the ECB main rate are divided into two series, one consisting of the upward changes and zeroes elsewhere, the second consisting of the downward changes and zeroes elsewhere. For the estimation, we used monthly data from September 2004 to June 2013. Estimation results for equation 1 are summarized in Table 1.

The speed of adjustment (measured by the absolute value of α) in case of a deviation from the cointegrating relationship is higher in case of shorter maturities (especially in case of 1M and 2M EURIBOR) and is gradually decreasing. Based on the estimation of coefficient β_1, we cannot reject the full transmission of the changes of the ECB main rate to the changes of the interbank rates, as the estimated values are in all cases near -1. While counterparty credit risk in the interbank market has no significant effect on the rates of the shortest maturities, its impact is significant for the most of the rates and is growing with increasing maturities. Non-standard measures of the ECB have the highest impact in case of shorter maturities. While the impact has a decreasing importance with increasing maturities, it lowers the interbank rates through the whole yield curve.

Table 1 Estimation results for the interbank rates

	α	β_0	β_1	β_2	β_3	N	aR^2
O/N	-0.263 *(-3.661)*	0.273 *(0.086)*	-1.078 *(-37.430)*		0.434 *(5.490)*	1	69%
1W	-0.332 *(-6.921)*	0.052 *(0.967)*	-1.049 *(-60.455)*		0.639 *(11.697)*	1	78%
1M	-0.568 *(-7.790)*	0.130 *(1.982)*	-1.116 *(-49.384)*		0.509 *(8.281)*	1	70%
2M	-0.443 *(-7.692)*	0.138 *(1.543)*	-1.154 *(-42.103)*	-0.003 *(-0.088)*	0.433 *(6.030)*	1	74%
3M	-0.332 *(-6.435)*	0.099 *(0.806)*	-1.163 *(-31.190)*	-0.027 *(-0.535)*	0.376 *(3.836)*	1	73%
4M	-0.310 *(-6.313)*	0.047 *(0.369)*	-1.153 *(-29.662)*	-0.033 *(-0.620)*	0.340 *(3.320)*	1	73%
5M	-0.288 *(-5.992)*	-0.020 *(-0.142)*	-1.137 *(-26.862)*	-0.042 *(-0.731)*	0.323 *(2.900)*	1	73%
6M	-0.256 *(-5.638)*	-0.115 *(-0.741)*	-1.111 *(-23.478)*	-0.041 *(-0.641)*	0.299 *(2.394)*	1	72%
7M	-0.249 *(-5.537)*	-0.160 *(-0.993)*	-1.101 *(-22.458)*	-0.055 *(-0.828)*	0.312 *(2.409)*	1	72%
8M	-0.244 *(-5.460)*	-0.203 *(-1.225)*	-1.091 *(-21.534)*	-0.068 *(-0.991)*	0.322 *(2.407)*	1	71%
9M	-0.237 *(-5.401)*	-0.257 *(-1.490)*	-1.076 *(-20.457)*	-0.078 *(-1.091)*	0.330 *(2.373)*	1	70%
10M	-0.234 *(-5.361)*	-0.297 *(-1.685)*	-1.066 *(-19.827)*	-0.093 *(-1.266)*	0.345 *(2.423)*	1	70%
11M	-0.230 *(-5.301)*	-0.339 *(-1.869)*	-1.057 *(-19.118)*	-0.105 *(-1.388)*	0.354 *(2.420)*	1	69%
12M	-0.226 *(-5.262)*	-0.382 *(-2.051)*	-1.045 *(-18.408)*	-0.120 *(-1.544)*	0.367 *(2.443)*	1	69%

Source: NBS.
t-statistics in parenthesis..

Discount rates

While interbank rates are used to estimate coupon payments from fixed-income investments and we assume they impact loan and deposit rates, discount rates are used for the revaluation of the portfolio of securities. In the stress testing, we assume that discount rates used for the revaluation of the debt securities consists of a risk free discount rate and risk margin. While the risk margin is set by expert judgment based on the past development of government bond yields, zero coupon swap rates are used as risk free discount rates, as we assume they are less affected by the changes of the counterparty credit risk in the interbank market and they are available also with maturities of more than one year. For the estimation of swap rates, in line with the methodology used in case of the interbank rates, we use EC models. The model, however, differs in case of swap rates with maturities up to one year and more than one year. The former are estimated using similar EC model as in case of the interbank rates, i.e. we include cointegration between the respective swap rate, the main rate of the ECB and the iTraxx Senior Financial index. A dummy variable is also included. Results of the unit root tests and cointegration tests are shown in Table 14 and Table 15 in the Appendix. The estimated equation has the form

$$\Delta r_t = \alpha.CE + \sum_{i=1}^{n}\left(\gamma_i \Delta r_{t-i} + \delta_i E_{t-i}\left(\Delta r_{t-i+1}^{ECB}\right) + \varphi_i \Delta CDS_{t-i}\right) + \epsilon_t, \quad (3)$$

$$CE = (r_{t-1} + \beta_0 + \beta_1 E_{t-1}(r_t^{ECB}) + \beta_2 CDS_{t-1} + \beta_3 dummy\_LTRO), \quad (4)$$

where r_t is the respective swap rate, the other variables are the same as in case of the interbank rates. For the estimation, we used monthly data from June 2007 to June 2013. Estimation results for equation 3 are summarized in Table 2.

Table 2 Estimation results for the discount rates with maturities up to one year

	α	β_0	β_1	β_2	β_3	N	aR^2
1W	-0.304 *(-5.717)*	0.267 *(3.206)*	-1.142 *(-39.820)*		0.509 *(6.591)*	1	79%
1M	-0.350 *(-8.297)*	0.011 *(0.156)*	-1.070 *(-46.763)*		0.672 *(9.310)*	1	70%
2M	-0.387 *(-7.666)*	0.149 *(1.494)*	-1.199 *(-38.746)*	-0.005 *(-0.120)*	0.553 *(7.089)*	1	76%
3M	-0.331 *(-5.353)*	-0.041 *(-0.163)*	-1.190 *(-20.144)*	-0.009 *(-0.108)*	0.627 *(4.426)*	1	69%
6M	-0.242 *(-4.058)*	-0.357 *(-1.023)*	-1.102 *(-13.584)*	-0.051 *(-0.422)*	0.691 *(3.409)*	1	63%
9M	-0.238 *(-3.302)*	-0.636 *(-2.502)*	-1.028 *(-13.777)*		0.775 *(3.317)*	1	52%
12M	-0.194 *(-2.979)*	-0.200 *(-0.893)*	-1.091 *(-15.880)*	-0.081 *(-0.878)*	0.533 *(2.994)*	1	48%

Source: NBS.
t-statistics in parenthesis.

Results are similar to the case of the interbank rates. While the speed of adjustment is similar for both groups of interest rates and also the hypothesis of a full transmission cannot be rejected in this case, too, the impact of the ECB non-standard measures seems to be more pronounced in the case of the swap rates. Also, in line with expectations, the impact of the credit risk is lower in the case of the swap rates.

In case of discount rates with maturities of more than one year we assumed that these rates have the form:

$$r_t = \beta_1 r_t^{ECB} + RM_t, \tag{5}$$

where r_t^{ECB} is the main rate of the ECB, as before, and RM_t is a (risk) margin, which is an unobservable variable affected by, inter alia, the expected future development of the Euro area economy. Based on the economic theory, an expected future increase of economic growth or inflation can lead, through different channels of transmission, to an increase of the main rate of the central bank (the ECB in this case). This expected future increase of the main rate gradually transmits into an increase in the short term rates, while this expected future increase is at least partially captured in the current value of the long term rates. Based on the literature, it is mainly the development of the GDP and the inflation that affects the longer term rates; therefore we also assume that the margin is affected by these macro variables (Dewachter and Lyrio, 2006). As we assume that the margin is an unobservable variable, a Kalman filtering approach (state space model) is used when estimating the coefficients; it means we follow a similar approach as in Dewachter and Lyrio. Swap rates of 1-, 3- and 10-year maturities enter the model, as these rates have the longest available time series. The estimated model is of the form

signal equation: $$\Delta r_t^i = \alpha\left(r_{t-1}^i - \beta r_{t-1}^{ECB} - RM_{t-1}^i\right) + \varphi \Delta r_{t-1}^i + \mu_t^i \tag{6}$$

state equation: $$RM_t^i = \delta_0^i + \delta_1^i RM_{t-1}^i + \delta_2^i \Delta HICP_{ti}^{EA} + \delta_3^i GDP\_GAP_{ti}^{EA} + \vartheta_t^i, \tag{7}$$

$$\begin{pmatrix}\mu_t \\ \vartheta_t\end{pmatrix} \sim N(0,\Sigma), \Sigma = \begin{bmatrix}\Sigma_\mu & 0 \\ 0 & \Sigma_\vartheta\end{bmatrix}, \tag{8}$$

where i denotes swap rates of 1-, 3- and 10-years maturity, $HICP_{ti}^{EA}$ is the HICP inflation in the Euro area, while $ti = t$ for the 3 years maturity and $ti = t + 1$ for the 10 years maturity, $GDP\_GAP_{ti}^{EA}$ is the estimated output gap for the Euro area, while $ti = t + 1$ for the 10 years maturity and the gap is not included in the other equations. μ_t^i and ϑ_t^i are assumed to be white noises. The output gap is calculated as the difference between the annual real growth of the seasonally adjusted GDP and the potential annual real growth rate estimated using HP filter (with $\lambda = 14400$). For the estimation, we used monthly data from January 2000 to June 2013. Data on quarterly GDP growth were interpolated to monthly series using quadratic interpolation to match average. Estimation results for equations 6 and 7 are shown in Table **3**. As the swap rate of one year maturity is included just to increase the robustness of the results, the estimated coefficients for this maturity are not reported in the table.

Table 3 Estimation results for the discount rates with maturities above one year

	A	***β***	***δ₂***	***δ₃***
3y	-0.136***	0.737***	-0.042	
10y	-0.066***	0.587***	0.674*	0.013*
LLR statistics	400.5			

Source: NBS.
****, **, * shows significance at 1%, 5%, respectively 10% level.*

Estimated coefficients are mostly in line with expectations. The speed of adjustment is lower than in case of shorter maturities. Similarly, the transmission of the changes of the main rate of the ECB is not complete, as estimated values of the coefficient β are well below 1. While the effect of the inflation is the opposite to that expected in case of the 3 years maturity, it is near to zero and not significant; and both the estimated coefficient for the inflation and the output gap has the right sign in case of the 10 years maturity. It means that an expected increase of the inflation or the overheating of the economy will lead to higher long term interest rates. While swap rates of 3 years and 10 years maturity are estimated, other maturities are calculated using linear interpolation.

Loan and deposit rates

Estimated loan and deposit interest rates are used together with the estimated volume of loans and deposits for the calculation of net interest income from the portfolio of loans and deposits of customers. Therefore, we estimate retail and corporate interest rates on the stock of the loans and deposits. Time series for the (weighted) average loan and deposit rates on the stock of loans and deposits with different maturities[6] are available from bank reports. We assume that the development of these interest rates reflects mainly changes of the interbank interest rates. [7] Similarly to the previous cases, interest rates are estimated using EC models of the form:

$$\Delta r_t^c = \alpha(r_{t-1}^c + \beta_0 + \beta_1 r_{t-1} + \beta_2 dummy\_LTRO) + \sum_{i=1}^{n}(\delta_i \Delta r_{t-i}^c + \gamma_i \Delta r_{t-i}) + \epsilon_t, \qquad (9)$$

where r_t^c is the respective loan or deposit rate and other variables are the same as in previous cases. Time series of interbank interest rates consisted of BRIBOR interest rates until end-2008 and EURIBOR interest rates from 2009. As it is not straightforward, which maturity of the interbank rate should enter the equation, for each interest rate the respective interbank rate was chosen based on the aR^2 of the estimation and the Akaike and Schwarz information criterion. For the estimation of the loan interest rates, we used monthly data from January 2006 to June 2013. Results of the unit root tests and cointegration tests are shown in Table 16 and Table 17 in the Appendix. Estimation results for equation 9 are summarized in Table 4. For the estimation of deposit interest rates, we used monthly data from January 2005 to June 2013. Results of the unit root tests and cointegration tests are shown in Table 19 and Table 19 in the Appendix. Estimation results of equation 9 are summarized in Table 5.

As the table shows, there are just two categories of retail loan interest where estimation results are satisfactory. However, the share of the volume of loans of these two categories, house purchase loans with outstanding maturity above 5 years and other loans with outstanding maturity above 5 years, on the total volume of retail loans was nearly 80% as of end June 2013.

[6] Loans are differentiated by outstanding maturity while deposits by contractual maturity.
[7] Unlike many other countries, in Slovakia most of the retail loans are granted with interest rates that are not directly fixed to any benchmark interest rate. Therefore, when estimating these rates we have to use simplifying assumptions.

Table 4 Categories of retail and corporate loans and estimation of loan interest rates

			α	β_0	β_1	β_2	aR^2	Interbank rate maturity
Retail	Credit cards							
Retail	Overdrafts							
Retail	Consumer loans	Maturity up to 1 year						
Retail	Consumer loans	Maturity from 1 to 5 years						
Retail	Consumer loans	Maturity more than 5 years						
Retail	House purchase loans	Maturity up to 1 year						
Retail	House purchase loans	Maturity from 1 to 5 years						
Retail	House purchase loans	Maturity more than 5 years	-0.021 *(-3.982)*	-3.744 *(-10.346)*	-0.653 *(-6.560)*	-1.061 *(-2.919)*	51%	1M
Retail	Other loans	Maturity up to 1 year						
Retail	Other loans	Maturity from 1 to 5 years						
Retail	Other loans	Maturity more than 5 years	-0.040 *(-3.717)*	-3.841 *(-11.977)*	-0.688 *(-8.478)*	-0.909 *(-3.321)*	36%	9M
Corpo-rate	Overdrafts		-0.213 *(-3.349)*	-3.313	-0.588 *(-14.950)*		60%	1M
Corpo-rate	House purchase loans	Maturity up to 1 year	-0.169 *(-2.977)*	-3.543	-0.482 *(-3.363)*		24%	1M
Corpo-rate	House purchase loans	Maturity from 1 to 5 years	-0.109 *(-3.221)*	-3.460 *(-25.593)*	-0.640 *(-13.059)*		76%	1M
Corpo-rate	House purchase loans	Maturity more than 5 years	-0.057 *(-1.988)*	-3.118 *(-18.858)*	-0.653 *(-10.901)*		79%	1M
Corpo-rate	Other loans	Maturity up to 1 year	-0.131 *(-2.875)*	-2.938 *(-22.472)*	-0.586 *(-12.201)*		53%	1M
Corpo-rate	Other loans	Maturity from 1 to 5 years	-0.161 *(-3.470)*	-3.766 *(-46.919)*	-0.446 *(-15.105)*		62%	1M
Corpo-rate	Other loans	Maturity more than 5 years	-0.066 *(-2.077)*	-2.849 *(-14.157)*	-0.642 *(-8.674)*		67%	1M

Source: NBS.
t-statistics in parenthesis.
Estimation results are presented for loan rates where the existence of cointegrating relationship cannot be rejected or where it was possible to obtain statistically significant estimations.

Estimation results show that the adjustment in the case of loan interest rates is much lower than in the case of interbank rates or discount rates. The adjustment is higher for the corporate loan interest rates and is, in general, decreasing with increasing maturity. In contrast to the interbank rates the transmission is incomplete for these interest rates. The effect of non-standard operations of the ECB is significant only in case of retail loan interest rates, where the dummy variable compensates for the lower value of interbank rates. For the corporate loan rates, best estimates were achieved using interbank interest rates with 1 month maturity. This result probably reflects the fact that corporate loans have, in general, short fixation.

Table 5 Categories of retail and corporate deposits and estimation of deposit interest rates

		α	β_0	β_1	β_2	aR^2	Interbank rate maturity
Retail	Sight	-0.278 *(-6.053)*	-0.128	-0.095 *(-10.797)*	-0.088 *(-2.951)*	35.53%	12M
	Overnight						
	7 days	-0.305 *(-3.373)*	0.275 *(0.982)*	-0.614 *(-8.308)*	-0.799 *(-3.149)*	33.88%	12M
	1 year	-0.043 *(-2.660)*	-0.080 *(-0.226)*	-0.570 *(-5.917)*	-0.938 *(-3.076)*	70.08%	12M
	2 years	-0.068	-1.134	-0.533	-1.256	35.68%	12M
	5 years						
	More than 5 years						
	Savings	-0.076 *(-3.324)*	0.523	-0.579 *(-4.869)*	-1.171 *(-2.961)*	27.23%	12M
Corporate	Sight	-0.779 *(-5.951)*	0.025 *(0.786)*	-0.221 *(-20.911)*	-0.077 *(-2.049)*	52.34%	ON
	Overnight	-0.786 *(-6.101)*	-0.067 *(-0.699)*	-0.698 *(-17.951)*		56.50%	ON
	7 days	-0.818 *(-6.501)*	-0.096 *(-0.848)*	-0.747 *(-21.778)*	-0.154 *(-1.187)*	59.24%	1M
	1 year	-0.092 *(-1.887)*	-0.014	-0.902 *(-14.017)*	-0.722 *(-2.928)*	71.69%	1M
	2 years						
	5 years						
	More than 5 years						
	Savings						

Source: NBS.
t-statistics in parenthesis.
Estimation results are presented for deposit rates where the existence of cointegrating relationship cannot be rejected or where it was possible to obtain statistically significant estimations.

In case of deposit rates, similarly to the loan rates, the transmission is incomplete and the adjustment is higher in case of corporate deposit rates. The effects of the non-standard operations are significant nearly in all cases, when the dummy variable, like in case of loan rates, compensates for the lower value of interbank rates. In general, results show that the transmission of the monetary policy decisions and changes of the interbank rates is stronger in case of corporate loan and deposit rates.

As it is clear from this section describing the estimation of the interest rates, all the rates but discount rates reflect to some extent the development of the main rate of the ECB and the consequent development of EURIBOR interest rates or EUR zero coupon swap rates. It means that in case of deposit and lending rates, it is not possible to directly impose a country-specific shock. While in case of interest rates on corporate loans and deposits this shock is of lower importance due to the strong correlation with the EURIBOR interest rates, in case of retail loan and deposit rates this assumption can be subject to further revisions as the development of the Slovak government bond yields can have an effect even on the average interest rates on the outstanding stock of retail loans (mainly house purchase loans) and the increased competition among banks and credit and liquidity margin in stress periods can have an impact both on the deposit and loan rates.

4.3. ESTIMATION OF THE VOLUME OF LOANS

Retail loans

The overall outstanding amount of retail loans is estimated for the stress testing period. Due to the expected differences in the reaction of the development of different types of loans to the development of macroeconomic conditions, the volume of house purchase loans, consumer loans and other loans[8] is estimated separately. All loan categories are estimated using EC models, where the (endogenous and exogenous) explanatory variables were chosen based on economic theory and on the main findings of the related literature (see Calza et. al, 2001, Calza et. al, 2003, or Égert et. al, 2006). Best estimates were obtained using the following specification:

$$\Delta house\_loan\_g_t = \alpha(house\_loan\_g_{t-1} + \beta_0 + \beta_1 gdp\_real\_g_{t-1} + \beta_2 pro\_pri\_g_{t-1} + \beta_3 HICP_{t-1}) + SRD + \varepsilon_t, \quad (10)$$

$$\Delta cons\_loan\_g_t = \alpha(cons\_loan\_g_{t-1} + \beta_0 + \beta_1 ir\_cl\_g_{t-1} + \beta_2 unem\_g_{t-1} + \beta_3 HICP_{t-1}) + SRD + \varepsilon_t, \quad (11)$$

$$\Delta other\_loan\_g_t = \alpha(other\_loan\_g_{t-1} + \beta_0 + \beta_1 gdp\_real\_g_{t-1} + \beta_2 unem\_g_{t-1}) + SRD + \varepsilon_t, \quad (12)$$

where $house\_loan\_g_t$, $cons\_loan\_g_t$ and $other\_loan\_g_t$ is the annual percentage change of the outstanding amount of housing loans, consumer loans and other loans granted to retail, $gdp\_real\_g_t$ is the annual percentage change of the (quarterly) seasonally adjusted real GDP, $pro\_pri\_g_t$ is the y-o-y percentage change of the (nominal) property prices, $HICP_t$ is the HICP inflation, $ir\_cl\_g_t$ is the y-o-y percentage change of the (weighted) average interest rate on the outstanding amount of consumer loans, $unem\_g_t$ is the y-o-y percentage change of the unemployment rate, SRD refers to short run dynamics of the variables and ε_t are residuals. Short run dynamics include, besides the impact of the endogenous variables, also an impact of the (weighted) average interest rates on the outstanding amount of housing loans in case of the housing loans and the impact of the (weighed) average interest rates on the outstanding amount of other loans in case of other loans. Quarterly data from 2006 Q1 to 2013 Q2 were used for the estimation. Results of unit root tests and cointegration tests are shown in Table 20 and Table 21 in the Appendix.

[8] The category of other loans includes credit cards, overdrafts and other types of loans not included in the other categories.

Table 6 Estimation results for retail loans

House purchase loans		Consumer loans		Other loans	
Cointegrating Eq.:		**Cointegrating Eq.:**		**Cointegrating Eq.:**	
$house\_loan\_g_{t-1}$	1.000	$cons\_loan\_g_{t-1}$	1.000	$other\_loan\_g_{t-1}$	1.000
c	-0.214	C	-0.106	c	0.288
$gdp\_real\_g_{t-1}$	-0.585 *(-1.530)*	$ir\_cl\_g_{t-1}$	2.108 *(8.428)*	$gdp\_real\_g_{t-1}$	-10.599 *(-5.937)*
$pro\_pri\_g_{t-1}$	-0.366 *(-3.849)*	$unem\_g_{t-1}$	0.044 *(0.563)*	$unem\_g_{t-1}$	-2.031 *(-5.092)*
$HICP_{t-1}$	0.015 *(3.299)*	$HICP_{t-1}$	-0.021 *(-2.163)*		
Error Correction:		**Error Correction:**		**Error Correction:**	
Coint. Eq.	-0.237 *(-11.184)*	***Coint. Eq.***	-0.514 *(-8.785)*	***Coint. Eq.***	-0.050 *(-1.729)*
c	-0.009 *(-4.832)*	c	-0.020 *(-2.978)*	C	-0.029 *(-3.623)*
$\Delta house\_loan\_g_{t-1}$	0.038 *(0.446)*	$\Delta cons\_loan\_g_{t-1}$	-0.148 *(-1.232)*	$\Delta other\_loan\_g_{t-1}$	-1.104 *(-5.099)*
$\Delta gdp\_real\_g_{t-1}$	0.007 *(0.123)*	$\Delta ir\_cl\_g_{t-1}$	0.206 *(0.609)*	$\Delta unem\_g_{t-1}$	-0.089 *(-0.996)*
$\Delta pro\_pri\_g_{t-1}$	0.053 *(1.673)*	$\Delta unem\_g_{t-1}$	0.202 *(2.912)*	$\Delta gdp\_real\_g_{t-1}$	-0.086 *(-0.207)*
$\Delta HICP_{t-1}$	0.002 *(0.779)*	$\Delta HICP_{t-1}$	0.007 *(0.645)*	$\Delta ir\_ol\_g_{t-1}$	-0.530 *(-3.455)*
$\Delta ir\_hl\_g_{t-1}$	0.064 *(3.876)*				
aR²	87.52%		84.15%		48.26%

Source: NBS.
t-statistics in parenthesis.

Best estimates were obtained in case of house purchase loans and consumer loans. The estimates for other loans are of lower quality, which is a direct consequence of the structure of this category and the low share of the volume of these loans in the total volume of retail loans.

In case of house purchase loans (equation 10), the long-run relationship between the volume of loans, real GDP, property prices and inflation cannot be rejected. Estimated coefficients in the cointegrating equation for the real GDP and property prices are in line with the expectation, it means that a positive development of the domestic economy and increasing property prices are reflected in an accelerating growth of the volume of loans. The coefficient for the inflation is relatively low compared to the other coefficients; therefore it seems that inflation plays just a secondary role as a factor affecting the development of the volume of loans.

In case of consumer loans (equation 11), the endogenous variables entering the cointegrating relationship are the client interest rates, unemployment rate and the inflation. Based on the estimation results, decreasing interest rates and unemployment rate have both positive impact on the volume of consumer loans in the long run. An interesting result is that, however, in the short run increasing unemployment and interest rates are associated with accelerating growth of the volume of these loans. The error-correction is the strongest for this type of loans.

The cointegrating relationship with the real GDP and the unemployment rate cannot be rejected in case of other loans (equation 12). On the other hand, based on the low adjustment coefficient, it seems that short run dynamics play a more important role in the development of these loans than the deviation from long-term relationship. As mentioned before, the estimation results are the worst for this type of loans. On the other hand, in case of stress testing, more emphasis is on the other two categories of retail loans, due to the low importance of this category.

Corporate loans

The estimation of the volume of corporate loans is based on Repková (2011). Similarly as in case of retail loans, the total volume of the outstanding stock of loans granted to non-financial corporations is estimated. As a first step, the volume of loans of seven selected corporate segments is estimated based on a panel cointegrating relationship between these segments, GDP and interest rates on corporate loans. The cointegrating equation is estimated using DOLS method with one lag and one lead of the "exogenous variables":

$$log(LNC_{it}) = 5.498 + 1.269 log(GDP_{it}) - 0.099 r_t + \sum_{j=-1}^{1} c_j \Delta log(GDP_{it+j}) + \sum_{j=-1}^{1} d_j \Delta log(r_{t+j}) + \varepsilon_{it}, \quad (13)$$

where LNC_{it} is the stock of loans to non-financial corporations for the *i*-th segment at time *t*, GDP_{it} is the gross domestic product for the *i*-th segment at time *t*, r_t is the interest rate on the total loans granted to non-financial corporations at time *t*. The estimation is based on quarterly data from 2005Q1 to 2013Q3. The seven segments are agriculture, manufacturing, industrial (other), construction, trade, real estate activities and professional, scientific and technical activities, administrative and support service activities. In line with expectations, the volume of corporate loans is increasing with increasing GDP and decreasing with increasing interest rates.

In the second step, the estimated volume of the loans to non-financial corporations is calibrated to the total volume of loans to customers except retail (and interbank loans), so that the estimation for the seven selected segments is extrapolated to the whole portfolio of non-retail loans.

4.4. ESTIMATION OF LOSSES FROM CREDIT RISK

Both in case of household credit risk and corporate credit risk, models are focusing on linking the macroeconomic development to the development of the credit quality of the portfolio of loans. It means that losses are estimated conditional on the overall expected macroeconomic situation.

Household credit risk

Estimation of losses stemming from the portfolio of loans granted to households is based on the portfolio of non-performing loans reported by banks. As a detailed breakdown of non-performing loans in each category has been available only since 2005, the aggregated volume of all non-performing household loans is estimated using an error-correction equation of the from:

$$\Delta NPL\_g_t = \alpha(NPL\_g_{t-1} + \beta_0 + \beta_1 total\_loan\_g_{t-1} + \beta_2 unem\_g_{t-1}) + SRD + \epsilon_t, \quad (13)$$

where *NPL_g* is the annual percentage change in the amount of non-performing loans and *total_loan_g* is the annual percentage change in the total amount of household loans provided. The short-run effects include the effect of the annual rate of change in real GDP and in the HICP inflation rate. As it is the volume of non-performing loans entering the equation instead of the non-performing loans ratio, the total volume of household loans is also entering the equation to reflect the development of the "basis" for future non-performing loans. The estimation is based on quarterly data from 2004Q1 to 2013Q4. Results of unit root tests and cointegration tests are shown in Table 22 and Table 23 in the Appendix.

The cointegrating equation shows a positive dependence of the dynamics of non-performing loans on the dynamics of total loans and unemployment rate. The adjustment coefficient is relatively high, being nearly 50 %. In the short-run, increasing real GDP growth decreases the dynamics of the non-performing loans while increasing inflation increases this dynamics. Relatively low aR^2 and high absolute value of coefficients for the unemployment rate and the inflation shows however worse estimation outcome than in case of house-purchase loans and consumer loans. This result is probably caused by the fact that the total volume of non-performing loans is estimated, while non-performing house purchase loans and consumer loans can have a different reaction to the development of the real economy.

After estimating the total volume of non-performing loans, two assumptions are used to calculate losses from these loans. First, it is assumed that the share of non-performing house purchase loans and the share of other loans is constant and equal to the share on the respective date the stress testing is conducted at (it means equal to the share at the end of June or December of the respective year). Second, it is assumed that the overall loss stemming from non-performing house purchase loans is 20 % and from other loans is 80 % of the defaulted volume.

Table 7 Estimation results for non-performing loans

Non-performing loans	
Cointegrating Eq:	
NPL_g_{t-1}	1.000
C	15.686
$total\_loan\_g_{t-1}$	-1.715 *(-5.353)*
$unem\_g_{t-1}$	-11.198 *(-4.124)*
Error Correction:	
Coint. Eq.	-0.448 *(-3.411)*
C	-0.072 *(-0.025)*
ΔNPL_g_{t-1}	-0.362 *(-2.709)*
$\Delta gdp\_real\_g_{t-1}$	-0.714 *(-0.548)*
$\Delta HICP\_g_{t-1}$	11.521 *(3.530)*
$\Delta total\_loan\_g_{t-1}$	-2.104 *(-2.414)*
$\Delta unem\_g_{t-1}$	4.901 *(1.751)*
aR^2	40.25%

Source: NBS.
t-statistics in parenthesis.

Corporate credit risk

The estimation of losses stemming from the portfolio of corporate loans is based on the total volume of corporate loans reported by banks and on individual loan data from the credit register. While such a credit register with granular data about household loans on a debtor level is not available for stress testing purposes and therefore a more simple approach has to be used for calculating losses, total losses from the corporate loan portfolio can be calculated in this case as

$$Total\ losses = PD \times EAD \times LGD,$$

where PD is the probability of default, EAD is the exposure at default and LGD is loss given default.

A usual way of estimating corporate PDs is to use logit model, as in Boss et. al (2009), or probit model, as in Fidrmuc and Hainz (2010). Annual default rates that are estimated using the logit model are calculated based on data from the credit register. Quarterly data are available from 2000Q3 for 18 corporate sectors, and the annual default rate is calculated for each sector as

$$ADR_{t,i} = \frac{\sum_{j=t-3}^{t} NDL_{j,i}}{ANTL_{t-3,t;i}},$$

where $ADR_{t,i}$ is the annual default rate for sector i in quarter t, $NDL_{t,i}$ is the number of newly defaulted loans in sector i in quarter t, and $ANTL_{t-3,t;i}$ is the average number of total loans granted in sector i during quarters $t-3$ to t (the average number of loans granted in a one-year period ending with quarter t). Since the relatively short length of the time series made it ineffective to work with 18 sectors, the sectors were split into three categories based on their sensitivity to the economic cycle. This categorization is based on economic theory and on two simple linear regressions of the form

$$\Delta_{-4}ADR_{t,i} = \alpha_{i,0} + \alpha_{i,1}\Delta_{-4}ADR_{t,i-1} + \alpha_{i,2}GDP\_g_{t-j} + dummy + \varepsilon_t \quad (14)$$

$$\Delta_{-4}ADR_{t,i} = \alpha_{i,3} + \alpha_{i,4}\Delta_{-4}ADR_{t,i-1} + \alpha_{i,5}\Delta GDP\_g_{t-j} + dummy + \varepsilon_t \quad (15)$$

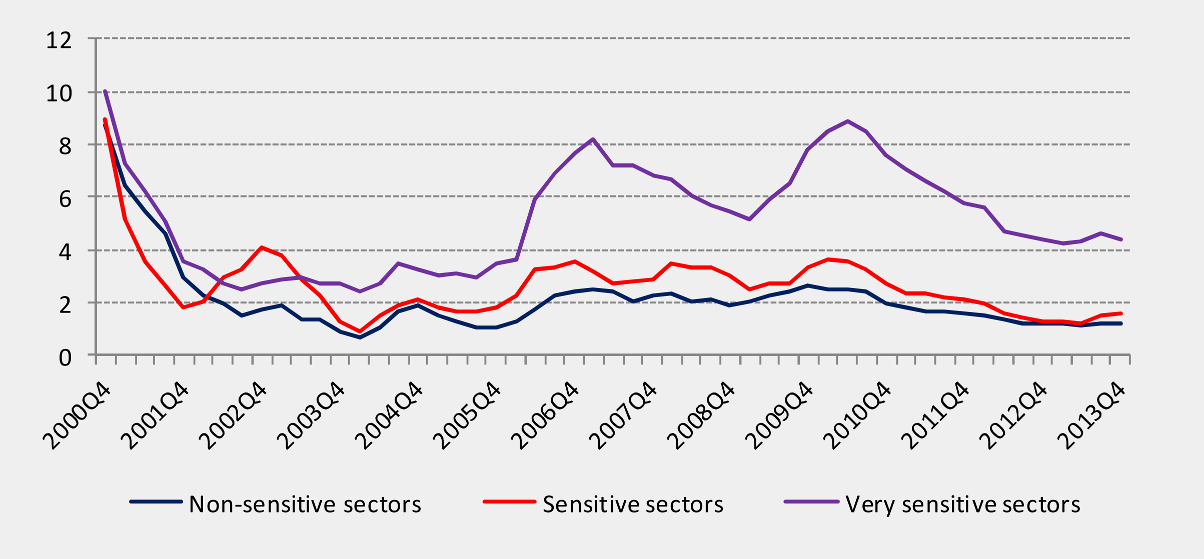
where $\Delta_{-4}ADR_{t,i} = ADR_{t,i} - ADR_{t-4,i}$ is the annual change in the default rate, GDP_g_{t-j} is the cumulative annual real (seasonally adjusted) GDP growth with a lag of j quarters, and a dummy variable is included to capture methodological changes in the reporting of non-performing loans during the period under review. Estimation results of the first equation are summarised in Table 24, estimation results of the second equation are summarized in Table 25 in the Appendix. The categorization of the sectors as non-sensitive, sensitive and very sensitive is as follows:

Table 8 Categorization of corporate sectors by sensitivity to the economic cycle

Non-sensitive sectors	Sensitive sectors	Very sensitive sectors
Forestry and logging	Chemical industry	Transport
Materials	Services	Electronics industry
Mining and quarrying	Telecommunications	Real estate activities
General government	Utilities	Trade
		Agriculture
		Food manufacturing
		Recreation
		Construction
		Machine industry
		Textile industry

Source: NBS.

Figure 3 Default rates for the aggregated categories of corporate sectors (in %)



Source: NBS.

It has to be noted, however, that the results of the categorization of the corporate sectors are affected not just by the sensitivity of the default rates in a given sector to the economic cycle but possibly also by data quality issues, as usually the less sensitive sectors have the less defaults and thus the time series are harder to use in a regression while some sectors appear to be more sensitive due to the fact that have a more volatile development of default rates.

A logit model was used for the dependency modelling; in other words, it was assumed that the annual default rate is a logistic function of the so called sector-specific index, which is dependent on the abovementioned macroeconomic variables. The model is described by the following equations:

$$ADR_{i,t} = \frac{1}{1+e^{-y_{i,t}}}, i \in \{\text{Non} - \text{sensitive sectors}, \text{Sensitive sectors}, \text{Very sensitive sectors}\},$$

where $y_{i,t}$ is the sector-specific index for category *i*,

$$\Delta_{-4}y_{i,t} = \beta_0 + \beta_1\Delta_{-4}y_{i,t-1} + \beta_2\Delta_{-4}y_{i,t-2} + \sum_{j=0}^{l} B_{i,t-j}X_{t-j} + dummy + u_{i,t},$$

$$X_t = \Gamma_0 + \Gamma_1 X_{t-1} + \Gamma_2 Z_{t-1} + v_t,$$

$$X_t = [\Delta GDP\_g_t, \Delta HICP_t, \Delta IBR_t]^T,$$

$$Z_t = [\Delta BR_t, \Delta EUR/USD_t, \Delta GDP\_g_{t,EXP}]^T.$$

It is further assumed that the residuals $u_{i,t}$ and v_t are normally distributed, non-autocorrelated random variables with non-zero correlation, i.e.

$$E_t = \binom{u_t}{v_t} \sim N(0, \Sigma),\ \Sigma = \begin{bmatrix} \Sigma_u & \Sigma_{u,v} \\ \Sigma_{v,u} & \Sigma_v \end{bmatrix}.$$

The endogenous explanatory variables used to model the dependence of the annual default rate on macroeconomic factors were GDP growth (*GDP_g*), the inflation rate (*HICP*) and the interbank rate (*IBR* – the three-month BRIBOR or EURIBOR), and the exogenous explanatory variables were the NBS or ECB main rate (*BR*), the exchange rate of the euro against the dollar (*EUR/USD*) and the average GDP growth of the country's main export partners, i.e. Germany, the Czech Republic, Italy, Austria, Poland, France and Hungary, weighted by relative share in exports (GDP_g_{EXP}). Quarterly changes in the explanatory variables were entered in the model.

Coefficients of the model were estimated using seemingly unrelated regressions (SUR).

Table 9 Estimation results for the sector-specific index for each category of corporate sectors

	Non-sensitive sectors	Sensitive sectors	Very sensitive sectors
c	-0.033	-0.054	-0.021
$\Delta_{-4}y_{i,t-1}$	0.720***	1.068***	0.722***
$\Delta_{-4}y_{i,t-2}$		-0.571***	
ΔIBR_{t-1}		0.034	
ΔIBR_{t-2}	0.111***		
ΔGDP_g_{t-3}	-0.034**	-0.023***	-0.023**
$\Delta HICP_{t-3}$		-0.103*	
ΔGDP_g_{t-4}			-0.020*
$\Delta HICP_{t-4}$	-0.073**		
ΔGDP_g_{t-5}	-0.047**		-0.020*
$\Delta EUR/USD_{t-5}$	0.013***		
aR²	78.33%	84.61%	85.90%

Source: NBS.
****, **, * shows significance at 1%, 5%, respectively 10% level.*

Best estimates are obtained for the very sensitive corporate sectors, then for the sensitive sectors and the results are the worse in case of non-sensitive sectors. Estimated coefficients are in general in line with expectations. Naturally, in all three cases a strong first order autoregression is present. In general, increasing interest rates and decreasing inflation and GDP increases default rates. A depreciating exchange rate of the EUR against USD has a significant impact in case of the non-sensitive sectors and it increases default rates. An interesting result is that in case of very sensitive sectors it is only the past development of the domestic GDP that enters the equation with significant coefficients.

Estimates of the annual default rate of each category given fixed developments in the macroeconomic variables were used as estimates of the probabilities of default for each category for stress testing purposes. The estimated probabilities of default for each category of corporate loan were subsequently used to calculate by bootstrapping the loss stemming from non-performing corporate loans. As part of this simulation a decision is taken in each period on whether the given loan defaults in that period or not. The probability of default of each loan entered in the stress test scenario is calculated in the way described above. If a loan defaults in the given period, it cannot default in the next period and the losses stemming from the default are materialised in the given period only. Using this procedure, the potential volume of non-performing loans is simulated 10 000 times for each scenario; the estimated volume of non-performing loans for each bank is the average volume of total non-performing loans for this bank across all simulations. The losses from the portfolio of corporate loans using the described Mont-Carlo simulations are calculated with a yearly frequency (in case the stress testing is conducted based on mid-year data the first period is half-year and the remaining periods are one year). As the PDs for the three categories of corporate loans are estimated using quarterly data, in each period the maximum value of the estimated PDs enter the simulation.

When calculating exposure at default, the value and the type of the collateral are also taken into account. A decline in the value of the collateral is assumed for each scenario. Based on an expert assessment, the collateral is divided into two categories: collateral whose value is assumed to decline according to the scenario (e.g. collateral in the form of real estate or blank bills) and collateral whose value is assumed not to decline (e.g. third party guarantees).

The overall loss is obtained by multiplying the volume of non-performing loans, less the adjusted value of the collateral, by the coefficient LGD (loss given default)[9]. This coefficient value is set at 45%, meaning that, in the event of the bankruptcy, the bank would be able to cover up to (100-45)% of its claim on the unsecured part of the loan from bankruptcy proceedings. Thus amount of loan loss provisions that each bank has to make during the stressed period due to the worsening of macroeconomic conditions is calculated at the end of each simulation.

Sections 4.2 - 4.4 described satellite models that are used to derive parameters necessary to calculate the impact of the respective scenarios on the capital adequacy ratios of the banks. While to a large extent the estimated parameters enter directly the calculations without any further adjustments, in some case it is plausible and also preferable to impose additional "stress" on them. The reason is that while the parameters are estimated using historical figures covering now a whole economic cycle in Slovakia, in stressed periods the elasticity of the parameters can be different from the average elasticity obtained by the estimations. So far it is only the estimated probability of default for the corporate sector where in case of the stress scenarios the estimated mean plus one standard deviation is used instead of using just the estimated mean parameters, but such adjustments need to be considered in every exercise, based possibly also on the results of back-testing (described in more details in Section 5).

[9] It means that in this case we take as a base the unsecured part of the exposure, therefore a more precise notation would be e.g. percentage loss on unsecured part of the loan (PLUP) instead of LGD.

4.5. ESTIMATION OF NET INTEREST INCOME

Net interest income is the main source of income for the Slovak banking sector; therefore it is a crucial part also of the stress testing. Net interest income is calculated as the sum of estimated interest income net of the sum of estimated interest expenses. Interest income is estimated from the portfolio of loans and the portfolio of debt securities, while interest expenses are estimated from the portfolio of deposits and debt securities issued.

The estimation of interest income from the portfolio of loans is quite straightforward, using the estimated volume of loans and client interest rates described in the previous sections. Interest income is calculated as a simple product of the estimated interest rates in a given loan category and the estimated volume of net loans in a given category in each quarter[10] and then summed (it means the estimated volume of loans is lowered by the estimated volume of defaulted loans during the stress testing period). However, there is a need for some simplifying assumptions in order to estimate net interest income. In case the estimated volume of loans does not match the categorization used for the interest rates (see Table 4), it is assumed that the share of loans in each category during the stress testing period is constant and equal to the share as of the end of the reference period (it means end June or end December). To obtain estimation at a bank level, it is also assumed that the share of each bank is also constant and equal to the share as of the end of the reference period.

In case of the securities portfolio, interest income is the sum of coupon payments and income/losses in form of premium/discount. In the stress testing, however, only coupon payments are estimated, while the impact of discount/premium is neglected. For the calculation of coupon payments, the estimated EURIBOR interest rates are used. As the majority of debt securities in the portfolio of Slovak banks is Slovak government bonds, that have fixed coupon payments or coupons linked to EURIBOR, this approach covers nearly the whole portfolio. In case the coupon payment is linked to a different benchmark interest rate, it is assumed that the development of this interest rate will be proportionate to the estimated development of the EURIBOR interest rates. It is also assumed that the volume of the portfolio of debt securities will be kept constant and that maturing securities will be replaced by securities with the same duration.

Interest expenses from the portfolio of deposits are estimated as the product of the estimated interest rates and the volume of deposits in a given category of deposits in each quarter (see Table 5). In case of corporate deposits, it is assumed that the volume of deposits is constant during the stress testing period and is equal in each category to the average volume in the last 12 month. The overall volume of retail deposits is modelled as a simple autoregressive process including an intercept and a trend. Then, like in the case of loans, it is assumed that the share of each category is constant and equal to the share as of the end of the reference period. It is also assumed that the share of each bank in each category is constant and equal to the share as of the end of the reference period.

In case of debt securities issued, interest expenses are expected in form of coupon payments. It is assumed that the portfolio is being kept constant during the stress testing period. Maturing securities are replaced with securities with the same attributes (maturity,

[10] As interest rates are estimated with monthly frequency, the quarterly average of the interest rate is used to calculate interest income/expenses.

coupon payments). In case there is a floating coupon rate, it is linked to the expected development of the EURIBOR interest rates (as majority of the debt securities issued are mortgage bonds with fixed coupon payments or floating coupon payments linked to EURIBOR interest rates, this assumption is sufficient for the stress testing purposes).

The remaining part of the net interest income estimated is net interest income from interbank operations. The total volume of interbank operations in each bank individually is adjusted in such a way that the total volume of net assets matches the total volume of liabilities in each quarter of the stress testing period. Net interest income is than calculated using the estimated development of the EURIBOR interest rate with one month maturity.

4.6. ESTIMATION OF OTHER PARTS OF PRE-TAX PROFIT

Other parts of pre-tax profit consist mainly of total operating costs, net non-interest income (net income from fees, revaluation of debt securities, equities and business share, trading and operating income) and net provisions and creation of reserves. While part of these items can be estimated, there is a relatively high portion of items where some simplifying assumptions have to be used.

Net income from the revaluation of the portfolio of securities is estimated using the assumption of constant portfolio of debt securities described in the previous section. For the revaluation of the portfolio of debt securities discount rates are used consisting of the risk-free discount rate (the estimation of which is described in Section 4.2) and of the risk margin. While the risk-free discount rate is estimated based on the expected development of the ECB main rate, the risk margin is set by expert judgment for each country separately based on the past development of the respective government bond yields, thus enabling also to cover sovereign risk in the stress testing. As the risk margin reflects the expected development of the government bond yields, discount rates for debt securities other than government bonds are not taken into consideration. However, as the share of debt securities other than government bonds in the overall securities portfolio of Slovak banks is negligible, this assumption is not constraining. While the risk margin is set for 5-year government bond yields, the slope of the credit spread curve (representing the difference between the risk margin for 1 and 5-year government bond yields) is also set to obtain the risk margin for all other maturities (see Table 11 for more details about the parameters used in the current stress testing presented in Section 6). To be in line with the accounting rules, securities in the Held-to-Maturity portfolios are not revaluated. It means these debt securities are not sensitive to the development of the market factors. The only exception is in case the assumption of partial or complete default of the counterparty is used, when losses are also stemming from this portfolio (for a more detailed example see Section 5).

Part of net non-interest income can be related to income/losses related to FX and equity risk. It is assumed that respective foreign exchange positions and the volume of equities in the portfolios of banks will be constant and equal to those as of the end of the reference period. It means that income/losses are impacted only by the expected development of the exchange rate of the EUR against foreign currencies and by the expected development of equity indices.

It is assumed that net provisions and reserves created are equal to the volume of losses stemming from the portfolio of client loans described in section 4.4. It means only losses are estimated, while the possible write-down of non-performing loans is neglected.

Other items are assumed to be in each year of the stress testing period equal to their yearly amount in the last reference year. In case stress testing is conducted based on end-June data, it is assumed that in every half-year the volume of other parts of the profit is equal to their amount at the end of June of the respective year. While there is some evidence that fee and commission income can be also linked to the macroeconomic development (ECB, 2013), such estimation is not yet available for the Slovak banking system.

4.7. ESTIMATION OF CAPITAL ADEQUACY RATIO

Capital adequacy ratio of each bank at the end of each year in the stress testing period is estimated[11]. Three parameters affecting the capital adequacy ratio are the adjusted capital adequacy ratio at the end of the reference period, estimated profit after tax at the end of each year and the volume of risk weighted assets at the end of each year in the stress testing period. In case the stress testing is conducted based on year-end data, total own funds in each bank are adjusted for the expected impact of the dividend policy. In case a respective bank ended the year with loss, this loss is already included in own funds, therefore no further adjustments are needed. In case the bank ended the year with profit, part of the profit is expected to be used to increase own funds and part of the profit is used to pay out dividends. The share is estimated using the figures from the last available year for each bank individually.

At the end of each year in the stress testing period the same process is done. If a bank ends the year with losses, these losses are fully deducted from own funds. If a bank ends the year with profit, part of the profit is used to increase own funds and part of the profit is used to pay out dividends.

The estimation of the amount of risk-weighted assets is based on data as at the end of the reference period. In case of the Baseline scenario, first the amount of RWAs is adjusted for corporate and retail loans, under the assumption of unchanged risk weights for the two types of loans (it means it is only the changes in the volume of loans that affects the development of risk weighted assets). Other categories of RWAs remain constant at the level as at the end of the reference period. Subsequently, the total amount of RWAs is adjusted (reduced) by 10% (Based on back-testing results, see section 5). For the stress scenarios, the amount of RWAs is being kept constant at the level as of the end of the reference period. While, on the one hand, this assumption does not reflect the decline in the overall volume of loans, on the other hand it captures the increasing riskiness of these loans during the stress period.

[11] As losses stemming from corporate loans are estimated using annual frequency, the estimation of profit and thus also the estimation of capital adequacy ratio can be obtained just with an annual frequency. It means that the parts of the pre-tax profit that are calculated with quarterly (like losses from household credit risk) or monthly (like net income from the revaluation of debt securities) frequencies are summed up to get their overall yearly impact.

5. Back-testing results[12]

Back-testing is an important part of stress testing procedure (see, e.g., Geršl, 2012), as it enables validation of the models and assumptions used in the test and to identify any deviations between the results estimated under the Baseline scenario and the actual figures.

Table 10 Assumptions for basic macroeconomic variables used in the back-testing

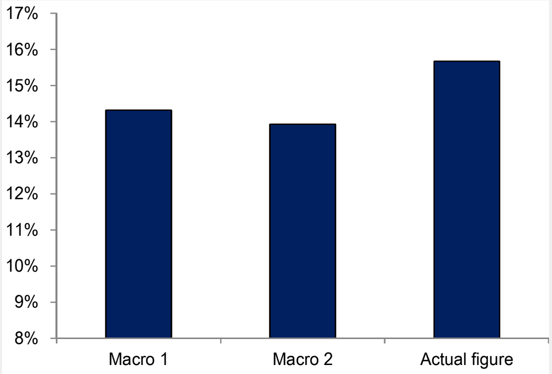
		Macro 2
Basic assumptions	External demand (year-on-year change)	4.9%
	USD/EUR (year-on-year change)	0%
	Exchange rates of CHF, JPY, GBP, DKK, CAD, HRK, LVL against EUR (year-on-year change)	0.0%
	Exchange rates of other currencies against EUR (year-on-year change)	0.0%
	Equity prices (year-on-year change)	0.0%
	ECB base rate (year-on-year change)	25 b.b.
	3M EURIBOR (year-on-year change)	-25 b.b.
	1Y EUR zero-coupon rate	-6 b.b.
	2Y EUR zero-coupon rate	44 b.b.
	5Y EUR zero-coupon rate	83 b.b.
	iTraxx Senior Financials index (year-on-year change)	0 b.b.
	Rise in 5Y credit spreads on debt issued by GR[1]	partial default
	Rise in 5Y credit spreads on debt issued by PT	0 b.b.
	Rise in 5Y credit spreads on debt issued by HU, ES, IT, IE	0 b.b.
	Rise in 5Y credit spreads on debt issued by BE, SK, SI	0 b.b.
	Rise in 5Y credit spreads on debt issued by PL, CZ	0 b.b.
	Rise in 5Y credit spreads on debt issued by FR, AT	0 b.b.
	Rise in credit spreads on debt issued by DE, FI, NL, GB, CH, US, JP	0 b.b.
	Increase in the slope of the credit spread curve[2]	0 b.b.
Macroeconomic variables estimated using a model	GDP growth (year-on-year change)	2.3%
	Inflation (HICP)	2.7%
	Unemployment	12.7%

Source: NBS.
1 It is assumed that the value of Greek government bonds decreases to 22.6 % of their nominal value as of the beginning of 2012 and remains at the same value for the whole stress testing horizon. As a partial default is assumed, the losses will be booked also on bonds in the Held-to-Maturity portfolio.
2 Increase in the slope of the credit spread curve refers to the difference between 1Y and 5Y credit spreads.

[12] Results presented here are also published in the Analysis of the Slovak Financial Sector 2013

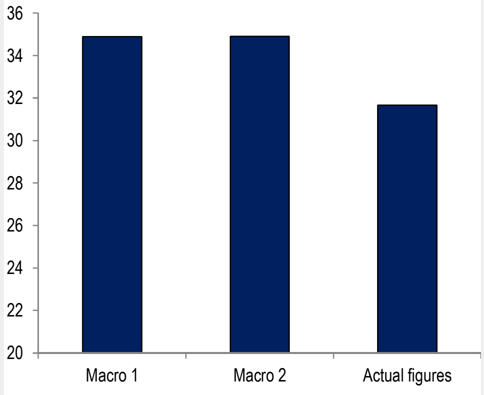
Back-testing was performed for 2012, meaning that data as at the end of 2011 were used. In the first scenario, named Macro 1, the input was the actual figures for particular basic macroeconomic and financial variables (GDP, inflation, unemployment, equity indices, interbank rates, the ECB main rate, etc.). The second scenario, Macro 2, used the assumptions applied in the Baseline scenario of the stress test conducted as at the end of 2011, the results of which are given presented in the Analysis of the Slovak Financial Sector for the Year 2011. The assumptions are summarized in Table 10. Therefore, under the Macro 2 scenario, the difference between the scenario and the actual developments is affected also by the assumption for input parameters, whereas under the Macro 1 scenario the differences are affected only by errors in the modelling and in the additional assumptions (e.g. the assumption of constant levels of fee income and trading income, etc.).

Figure 4 Estimation of the capital ratio



Source: NBS.
The chart shows the estimated capital ratio at end-2012 under the two scenarios and the actual figure at end-2012.

Figure 5 Estimation of risk-weighted assets



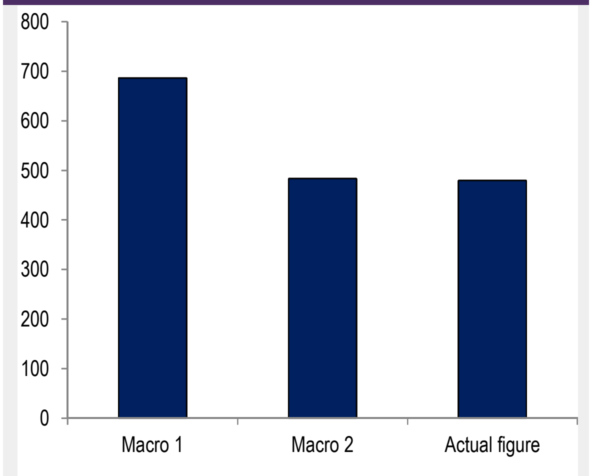
Source: NBS.
The chart shows the estimated amount of risk-weighted assets at end-2012 under the two scenarios and the actual figure at end-2012.
EUR billions.

The overall results concerning the estimation of the capital ratio as at end-2012 are satisfactory. The overall capital ratio of the banking sector as at the end of 2012 was 15.7%, while under the Macro 1 scenario it was estimated at 14.3% and under the Macro 2 scenario, at 13.9%. For each bank, under both scenarios, the difference between the estimated and actual capital ratio was within the range of +/-6%.

The capital ratio estimation reflects a moderate overestimation of the overall net profit for 2012 (particularly in the Macro 1 scenario) and a moderate overestimation of the amount of risk-weighted assets at end-2012. The amount of RWAs is lower than estimated owing mainly to developments in banks using the IRB approach. To compare the results with the actual figure and analyse the divergence will, however, require more in-depth study of each model and developments in the respective parameters.

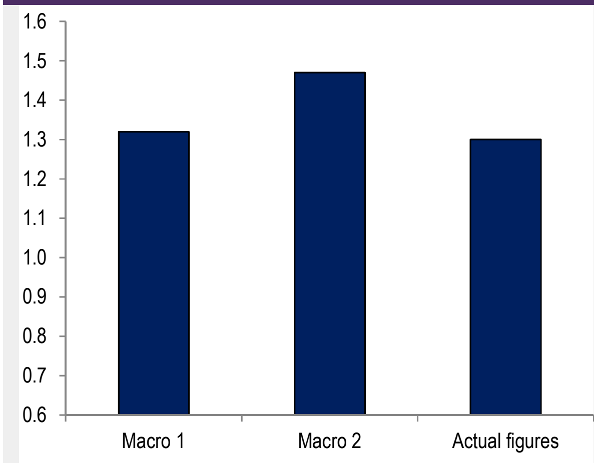
In case of the overall net profit, the main components estimated are net interest income on the portfolio of customers' loans and deposits, net interest income on the securities portfolio, and gains/losses on the revaluation of securities. Whereas the estimation of net interest income from customers' loans and deposits and estimation of gains from the revaluation of securities were higher than the actual figures, the estimation of net interest income from the securities portfolio was lower than the actual figure.

Figure 6 Estimation of net profit



Source: NBS.
The chart shows the estimated net profit at end-2012 under the two scenarios and the actual figure at end-2012.
EUR millions.

Figure 7 Estimation of net interest income from the retail portfolio



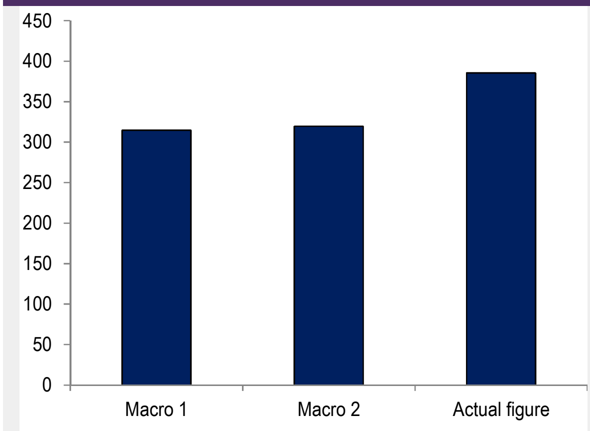
Source: NBS.
The chart shows the estimated net interest income from the portfolio of retail loans and deposits at end-2012 under the two scenarios and the actual figure at end-2012.
EUR billions.

The overvaluation of net interest income from customers' loans and deposits has two main causes. Since the stress testing entails estimating the average level of interest rates (on deposits and loans, as categorized in Table 4 and Table 5), net interest income is overvalued both for banks offering interest rates on selected loans which are substantially below the market average and for banks offering interest rates on selected deposit products which are significantly higher than the market average. However, this modelling 'error' is partially reduced in the stress testing, since the estimated interest rates are adjusted for those banks for which the estimated net interest income under the baseline scenario in the first year/half-year (according to whether the stress test is conducted at the end of the year or half-year period) differs markedly from the actual net interest income for the previous year/half-year period.

A second reason for the 'error' lies in the modelling of developments in the amount of corporate lending. This is because the assumed 'equilibrium' amount of corporate loans is estimated, but this equilibrium amount may not necessarily match the actual amount, which is affected also by short-term effects. Furthermore, it seems that a structural break may have occurred in the wake of the 2008 financial crisis and, consequently, that the amount of corporate loans estimated on the basis of historical data may not necessarily be the same as the current equilibrium amount. Hence, for stress testing purposes, the estimated amount of corporate loans is also adjusted.

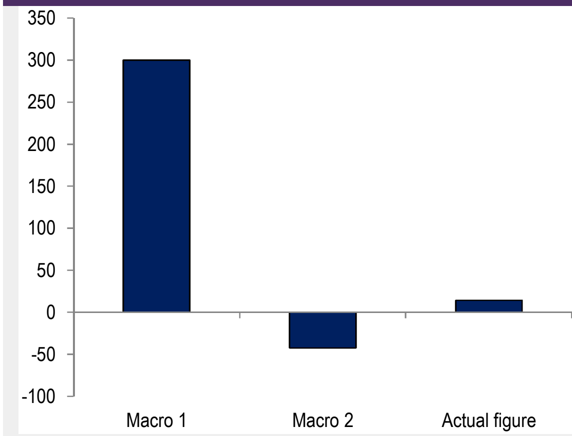
As for gains from the revaluation of securities, the estimated and actual figures diverged for two reasons in particular. First, the stress test used a simplifying assumption that the securities portfolio is revalued uniformly against the income statement, when in fact the revaluation of securities in the AFS portfolio has a direct effect on equity. That assumption has already been modified in the current version of the stress test. The second reason is the assumption that the composition of the securities portfolio remains unchanged, which in the event of significant changes in the portfolio (as happened in 2012) leads to greater deviations. This assumption is relatively difficult to modify, however, and therefore each stress test separately will probably require 'ad hoc' adjustment based on expert considerations.

Figure 8 Estimation of net interest income from the debt securities portfolio



Source: NBS.
The chart shows the estimated net interest income at end-2012 under the two scenarios and the actual figure at end-2012.
EUR millions.

Figure 9 Estimation of gains/losses on the revaluation of securities

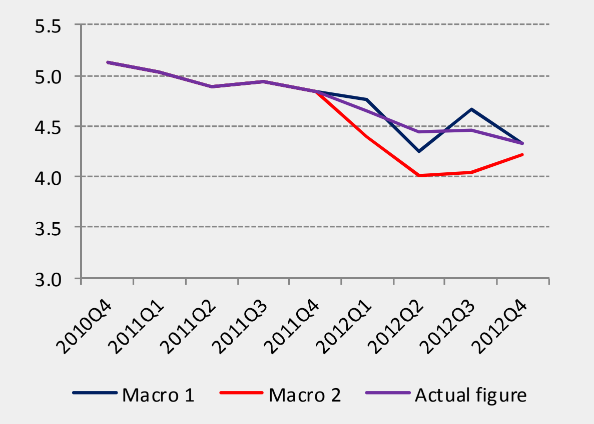


Source: NBS.
The chart shows the estimated overall gains/losses on the revaluation of securities at end-2012 under the two scenarios and the actual figure at end-2012.
EUR millions.

Net interest income from the securities portfolio is undervalued mainly because it does not include income/expenses arising from the sequential recording of discounts/premium.

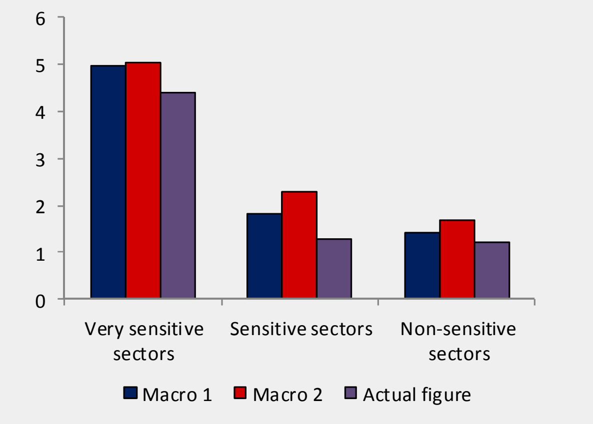
As the comparison of losses stemming from household and corporate credit risk between the results of stress testing and the actual figures is not straightforward, below we provide the comparison of the development of the non-performing loans (NPL) ratio for households and the comparison of the estimated corporate default rates on their actual figures. NPL ratios are to a large extent in line with actual figures in case of Macro 1 and mildly underestimated in case of Macro 2. This underestimation is caused by the fact that the forecast of macroeconomic factors used in this scenario were better than their actual figures. Corporate default rates are overestimated in both scenarios.

Figure 10 Estimation of the retail NPL ratio (in %)



Source: NBS.

Figure 11 Estimation of corporate default rates (in %)



Source: NBS.

Main findings of the back-testing may be summarised as follows:

- the setting of assumptions for risk-weighted assets requires further analysis, especially to achieve more accurate estimation of developments in IRB portfolios;
- the estimation of net interest income still requires regular checking of the results on a bank-by-bank basis and, if necessary, manual adjustment;
- the modelling of the amount of corporate loans requires in-depth analysis, especially with regard to the form of the estimation and to possible structural changes on the demand and/or supply side of this type of lending;
- the revaluation of securities following the back-testing has become more in line with the current regulatory regime.

The process of stress testing is evolving over time and there will be also some further revisions of the overall modeling framework. These revisions have to reflect the above findings to make the framework more in line with the possible real development and even more conservative. It is therefore crucial to repeat the back-testing on a regular basis to have an on-going check of the credibility of the results.

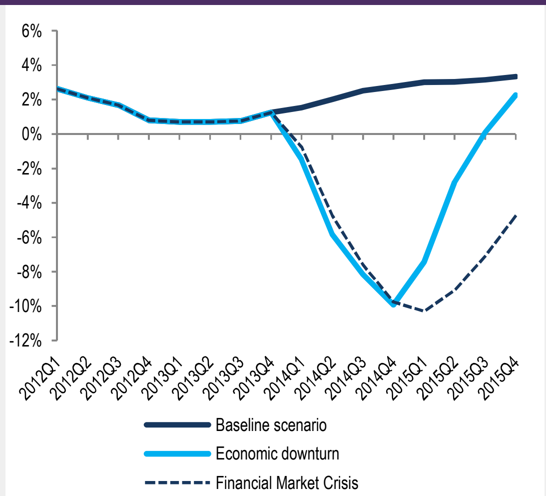
6. RESULTS OF MACRO STRESS TESTING AS AT END 2013

The stress scenarios

The stress testing based on end 2013 data involved a Baseline scenario and two stress scenarios. The Baseline scenario is based on the Medium-Term Forecast published by NBS as of the fourth quarter of 2013. It therefore assumes that over the stress test horizon, comprising 2014 and 2015, economic activity will gradually pick up amid increasing external demand and will be supported also by rising domestic demand and a loosening of fiscal policy. Inflation is expected to be relatively low, but to rise steadily in 2015 up to around 2%.

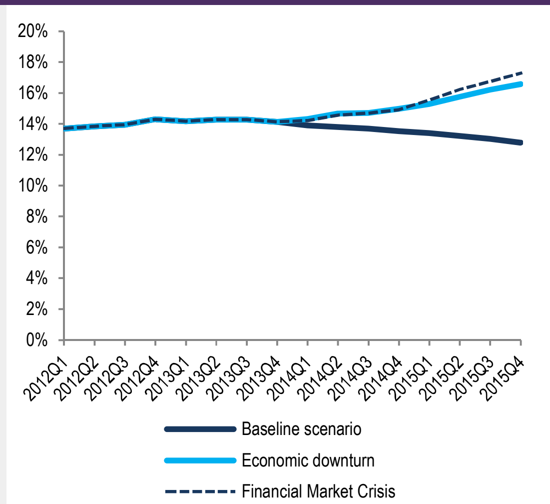
The stress scenario 'Economic Downturn' assumes that external demand declines because the impact of the unwinding of quantitative easing especially for developing countries is more negative than expected and because growth in global economy is weaker than projected. The result in Slovakia is that the economy contracts, inflation falls moderately, and unemployment rises. Uncertainty spreads to financial markets, resulting in sharp falls in equity indices and rising risk premium on interbank rates and government bonds yields.

Figure 12 GDP growth – Baseline and stress scenarios



Source: NBS.

Figure 13 Unemployment – Baseline and stress scenarios



Source: NBS.

In the stress scenario 'Financial Market Crisis', the assumptions of the Economic Downturn scenario are combined with headwinds from the euro area banking sector, triggered mainly by a further ebbing of confidence in banking groups. It is therefore assumed that financial market strains increase, the euro depreciates against the US dollar, and the effect of the shock on the real economy entails a longer lasting economic downturn, low inflation and moderately higher unemployment. Detailed parameters applied in the scenarios are described in Table 11.

Stress testing results[13]

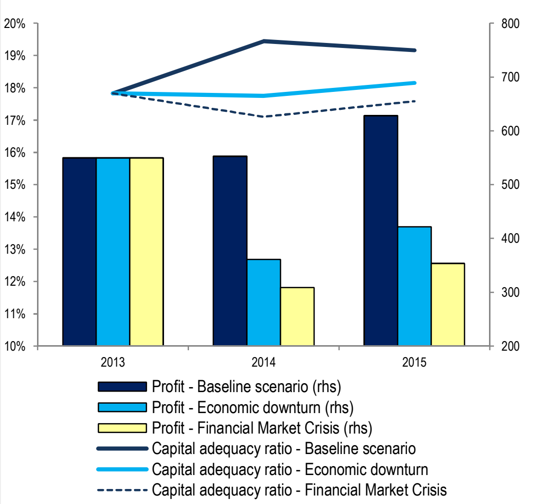
The banking sector as a whole appears to be relatively resilient to headwinds from financial markets and the real economy. That resilience is underpinned by banks' high levels of capital, as reported at the end of 2013, and their ability to generate interest income even in stress periods. The sector's capital adequacy ratio at the end of 2013 was 17.2%. Assuming

[13] Results presented here are published also in the Analysis of the Slovak Financial Sector 2013

that banks increased their equity capital by retaining a commensurate part of the profit for 2013, the capital adequacy ratio would rise to 17.8%.

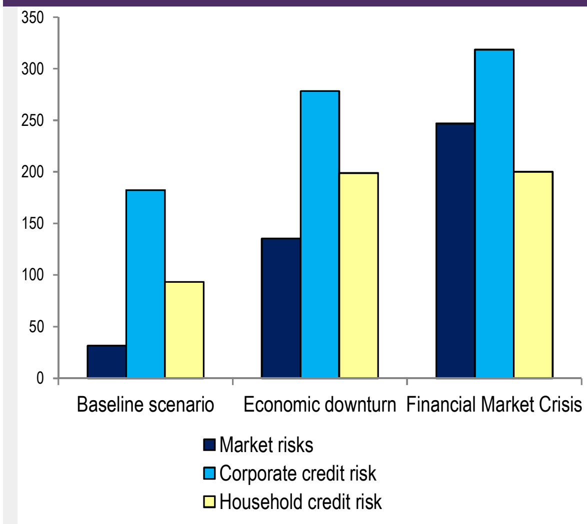
Under the Baseline scenario, the overall capital adequacy ratio (compared to the adjusted ratio) would increase to 19.2% as at the end of 2015. The Economic Downturn scenario envisages a slight increase in the overall capital adequacy ratio (compared to the adjusted ratio as at the end of 2013), due to a slightly higher amount of capital and the projected unchanged volume of risk weighted assets. The Financial Market Crisis scenario envisages a slight drop in the overall capital adequacy ratio, as the amount of own funds is lower at the end of 2015 while the amount of risk-weighted assets remains unchanged.

Figure 14 Capital adequacy ratio and profit of the banking sector



Source: NBS.
Data on right hand scale are in EUR mil.
Note: The capital adequacy ratio at the end of 2013 is adjusted to take account of the assumed impact of capital increase.

Figure 15 Losses arising from different types of risk under the Baseline and stress scenarios



Source: NBS.
Data in EUR mil.
Note: The chart shows the total loss for the stress period.

Under the Economic Downturn scenario, the amount of additional capital required to ensure that, as at the end of 2015, all banks meet the regulatory capital adequacy ratio of 8% is €3 million (or 0.1% of own funds as at 31 December 2013), while under the Financial Market Crisis scenario it is €7 million (or 0.2% of own funds). Under the Baseline Scenario, the capital adequacy ratio of all of the banks would not decline below the threshold of 8%. Assuming that the sector is required to maintain a full capital conservation buffer (2.5% of RWAs), the total amount of additional capital required as at the end of 2015 would be €26 million (0.5% of own funds as at 31 December 2013) under the Economic Downturn scenario and €30 million (0.6%) under the Financial Market Crisis scenario.

The number of banks reporting a loss at the end of the two-year stress period would be one under the Baseline scenario, six under the Economic Downturn scenario and seven under the

Financial Market Crisis scenario, but even in these cases the capital adequacy ratio remains high.

Under the stress scenarios, losses on the portfolio of loans to non-financial corporations would be higher than losses on other exposures. Under the Baseline and Economic Downturn scenarios, losses on household loans exceeded market risk losses, while under the Financial Market Crisis scenario market risk losses were higher, owing mainly to the increase in the risk premium on government bonds. In general, losses from market risk are lowered by the fact that a relatively high share of securities is held in the Held-to-Maturity portfolio that is not marked to market. On the other hand, losses from household credit risk are mitigated by the high share of house purchase loans that are in general viewed as more safe compared to, e.g., consumer loans.

7. CONCLUSIONS

The aim of this paper was to describe the current framework for stress testing the resilience of the Slovak banking sector. The framework is focusing on a proper estimation of the impact of the macroeconomic development on the main part of the sector's assets and liabilities as well as on the main risks the system is exposed to. It is also important to capture the impact on the development of the net interest income, as it is the most important source of income for the banks in general. The paper described the overall framework, the respective satellite models and the key assumptions used in the stress testing exercise.

Based on the results of the stress testing, it seems that the Slovak banking sector is currently relatively robust even in case of adverse macroeconomic development. Two key conditions of this robustness are the good current capital position of the banks and the ability to generate interest income even during stressed periods. The main risk for the banking sector is credit risk stemming from the portfolio of corporate loans, while market risks like FX and equity risk play just a marginal role for the sector in general. Losses from negative revaluation of the securities portfolio (i.e. interest rate risk and sovereign risk) are to a great extent mitigated by the fact that approximately two thirds of debt securities are in the Held-to-Maturity portfolio.

An important part of the stress testing framework is back testing of the models and assumptions used in the exercise. Results of back testing are fairly satisfactory, however, they point to the need of some further improvement, mainly in the field of the estimation of risk weighted assets and corporate loans. It is also crucial, as the results are calculated on a bank by bank basis, to check the results of the benchmark scenario and thus to challenge mainly the estimation of net interest income for each bank separately.

As stress testing is gaining more and more importance, and can be in the future a useful tool also for the macroprudential policy, it is important to further improve the ability of the framework to capture the impact and the reaction of the banks in case of negative macroeconomic development. It is crucial that changing regulatory environment and changing risk profile of the institutions is captured on time and that all the potential risks are addressed also within the stress scenarios. Moreover, future work should be dedicated also to the incorporation of liquidity risk into the framework, or to the so called financial real feedback loop.

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9. APPENDIX

Table 11 Stress testing parameters

			Baseline scenario		Economic Downturn scenario		Financial Market Crisis	
			2014	2015	2014	2015	2014	2015
Baseline assumptions	Change in external demand		4%	5%	-20%	-1%	-20%	-12%
	Change in USD/EUR exchange rate		0%	0%	0%	0%	-30%	0%
	Change in exchange rates of the CHF, JPY, GBP, DKK, CAD, HRK and LVL against the EUR		0%	0%	-10%	0%	-30%	0%
	Change in exchange rates of other currencies against the EUR		0%	0%	0%	0%	30%	0%
	Change in equity prices		0%	0%	-35%	0%	-50%	0%
	Change in the ECB key rate		25 b.p.	25 b.p.	0 b.p.	0 b.p.	0 b.p.	0 b.p.
	Change in the 3-month EURIBOR		13 b.p.	38 b.p.	-2 b.p.	1 b.p.	1 b.p.	2 b.p.
	Change in 1-year discount rate (EUR)		22 b.p.	38 b.p.	30 b.p.	0 b.p.	44 b.p.	-3 b.p.
	Change in 2-year discount rate (EUR)		47 b.p.	30 b.p.	43 b.p.	6 b.p.	53 b.p.	5 b.p.
	Change in 5-year discount rate (EUR)		49 b.p.	21 b.p.	37 b.p.	13 b.p.	42 b.p.	9 b.p.
	Change in the 5-year iTraxx Senior Financials index		-79 b.p.	0 b.p.	150 b.p.	0 b.p.	300 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of GR and PT		0 b.p.	0 b.p.	Return to value as at 30 September 2012	0 b.p.	1000 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of ES, IT, SI and IE		0 b.p.	0 b.p.		0 b.p.	500 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of SK, BE and HU		0 b.p.	0 b.p.		0 b.p.	300 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of CZ, PL and FR		0 b.p.	0 b.p.		0 b.p.	200 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of AT		0 b.p.	0 b.p.		0 b.p.	100 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of GB, CH, US, FI and NL		0 b.p.	0 b.p.		0 b.p.	50 b.p.	0 b.p.
	Increase in 5-year spreads on bonds of DE and JP		0 b.p.	0 b.p.		0 b.p.	0 b.p.	0 b.p.
	Increase in the slope of the credit spread curve[1]		0 b.p.	0 b.p.		0 b.p.	Increase to max. from 1 January 2012	0 b.p.
Simulated macroeconomic variables	Annual real GDP growth		2.21%	3.12%	-6.79%	-2.50%	-5.72%	-7.87%
	Average HICP inflation		1.25%	1.80%	1.28%	1.40%	1.35%	0.59%
	Unemployment		13.5%	12.8%	15.0%	16.6%	14.9%	17.3%
Credit risk variables estimated using macroeconomic variables	Annual probability of default	Non-sensitive sectors	1.27%	1.26%	1.73%	2.85%	1.84%	2.60%
		Sensitive sectors	1.50%	1.26%	1.83%	2.34%	1.94%	2.60%
		Very sensitive sectors	4.56%	4.09%	5.20%	7.96%	5.35%	8.44%
	Non-performing loan ratio for household loans			3.60%	4.79%	4.80%	4.91%	5.13%

Source: NBS.

1 Increase in the slope of the credit spread curve refers to the difference between 1Y and 5Y credit spreads.

Table 12 Results of unit root tests - EURIBOR

	ADF		Phillips-Perron	
	level	1st difference	level	1st difference
ECB1W	0.435	0.001	0.662	0.000
iTraxx	0.621	0.000	0.619	0.000
O/N	0.728	0.001	0.795	0.001
1W	0.686	0.000	0.703	0.000
1M	0.736	0.000	0.691	0.000
2M	0.562	0.000	0.688	0.000
3M	0.562	0.000	0.686	0.000
4M	0.450	0.000	0.689	0.000
5M	0.473	0.000	0.688	0.000
6M	0.444	0.000	0.685	0.000
7M	0.438	0.000	0.681	0.000
8M	0.438	0.000	0.676	0.000
9M	0.422	0.000	0.670	0.000
10M	0.424	0.000	0.664	0.000
11M	0.421	0.000	0.657	0.000
12M	0.414	0.000	0.649	0.000

Source: NBS.
Intercept was included in all cases.

Table 13 Results of Johansen's cointegration tests - EURIBOR

				No. Of cointegrating equations	
				Trace test	Max-eigenvalue test
O/N	ECB 1W	dummy		1	1
1W	ECB 1W	dummy		1	1
1M	ECB 1W	dummy		1	1
2M	ECB 1W	dummy	iTraxx	1	1
3M	ECB 1W	dummy	iTraxx	1	1
4M	ECB 1W	dummy	iTraxx	1	1
5M	ECB 1W	dummy	iTraxx	1	1
6M	ECB 1W	dummy	iTraxx	1	1
7M	ECB 1W	dummy	iTraxx	1	1
8M	ECB 1W	dummy	iTraxx	1	1
9M	ECB 1W	dummy	iTraxx	1	1
10M	ECB 1W	dummy	iTraxx	1	1
11M	ECB 1W	dummy	iTraxx	1	1
12M	ECB 1W	dummy	iTraxx	1	1

Source: NBS.
Table shows the number of cointegrating equations indicated by respective tests..
In all cases an intercept was included in the cointegrating equation.
One lag of the variables was included in the test.

Table 14 Results of unit root tests – discount rates

	ADF		Phillips-Perron	
	level	1st difference	level	1st difference
1W	0.693	0.000	0.660	0.000
1M	0.653	0.000	0.651	0.000
2M	0.388	0.000	0.667	0.000
3M	0.612	0.001	0.719	0.001
6M	0.478	0.024	0.721	0.000
9M	0.496	0.022	0.705	0.000
12M	0.600	0.000	0.723	0.000

Source: NBS.
Intercept was included in all cases.

Table 15 Results of Johansen's cointegration tests – Discount rates

				No. Of cointegrating equations	
				Trace test	Max-eigenvalue test
1W	ECB 1W	dummy		1	1
1M	ECB 1W	dummy		1	1
2M	ECB 1W	dummy	iTraxx	1	1
3M	ECB 1W	dummy	iTraxx	1	1
6M	ECB 1W	dummy	iTraxx	1	1
9M	ECB 1W	dummy		0	1
12M	ECB 1W	dummy	iTraxx	1	1

Source: NBS
Table shows the number of cointegrating equations indicated by respective tests.
In all cases an intercept was included in the cointegrating equation.
One lag of the variables was included in the test.

Table 16 Results of unit root tests – loan rates

			ADF		Phillips-Perron	
			level	1st difference	level	1st difference
Retail	House purchase loans	Maturity more than 5 years	0.987	0.013	0.987	0.000
	Other loans	Maturity more than 5 years	0.980	0.000	0.961	0.000
Corporate	Overdrafts		0.827	0.000	0.706	0.000
	House purchase loans	Maturity up to 1 year	0.165	0.000	0.127	0.000
		Maturity from 1 to 5 years	0.454	0.021	0.714	0.000
		Maturity more than 5 years	0.433	0.082	0.783	0.009
	Other loans	Maturity up to 1 year	0.786	0.000	0.739	0.000
		Maturity from 1 to 5 years	0.403	0.009	0.680	0.000
		Maturity more than 5 years	0.388	0.059	0.740	0.000

Source: NBS.
Intercept was included in all cases.

Table 17 Results of Johansen's cointegration tests – loan rates

					No. of cointegrating equations	
					Trace test	Max-eigenvalue test
Retail	House purchase loans	Maturity more than 5 years	Interbank rate 1M	dummy	1	1
	Other loans	Maturity more than 5 years	Interbank rate 9M	dummy	1	1
Corporate	Overdrafts		Interbank rate 1M		1	1
	House purchase loans	Maturity up to 1 year	Interbank rate 1M		1	1
		Maturity from 1 to 5 years	Interbank rate 1M		0	1
		Maturity more than 5 years	Interbank rate 1M		0	1
	Other loans	Maturity up to 1 year	Interbank rate 1M		1	1
		Maturity from 1 to 5 years	Interbank rate 1M		1	1
		Maturity more than 5 years	Interbank rate 1M		1	1

Source: NBS.
Table shows the number of cointegrating equations indicated by respective tests.
In all cases an intercept was included in the cointegrating equation.
One lag of the variables was included in the test.

Table 18 Results of unit root tests – deposit rates

		ADF		Phillips-Perron	
		level	1st difference	level	1st difference
Retail	sight	0.460	0.000	0.403	0.000
	7 days	0.235	0.026	0.243	0.000
	1 year	0.238	0.007	0.503	0.007
	2 years	0.095	0.000	0.454	0.000
	savings	0.631	0.000	0.432	0.000
Corporate	sight	0.807	0.000	0.318	0.000
	overnight	0.629	0.000	0.038	0.000
	7 days	0.813	0.000	0.410	0.000
	1 year	0.853	0.000	0.711	0.000

Source: NBS.
Intercept was included in all cases.

Table 19 Results of Johansen's cointegration tests – deposit rates

				No. of cointegrating equations	
				Trace test	Max-eigenvalue test
Retail	sight	Interbank rate 12M	dummy	1	1
	7 days	Interbank rate 12M	dummy	1	1
	1 year	Interbank rate 12M	dummy	1	1
	2 years	Interbank rate 12M	dummy	1	1
	savings	Interbank rate 12M	dummy	1	0
Corporate	sight	Interbank rate ON	dummy	1	1
	overnight	Interbank rate ON		1	1
	7 days	Interbank rate 1M	dummy	1	1
	1 year	Interbank rate 1M	dummy	1	1

Source: NBS.
Table shows the number of cointegrating equations indicated by respective tests.
In all cases an intercept was included in the cointegrating equation.
One lag of the variables was included in the test.

Table 20 Results of unit root tests – variables used in modelling the volume of retail loans

	ADF		Phillips-Perron	
	level	1st difference	level	1st difference
house_loan_g	0.113	0.009	0.085	0.008
cons_loan_g	0.197	0.000	0.156	0.000
other_loan_g	0.907	0.194	0.301	0.000
gdp_real_g	0.483	0.001	0.351	0.001
pro_pri_g	0.176	0.007	0.420	0.014
HICP	0.046	0.006	0.309	0.013
ir_cl_g	0.135	0.010	0.091	0.012
unem_g	0.043	0.001	0.326	0.066

Source: NBS.
Intercept was included in all cases.

Table 21 Results of Johansen's cointegration tests – variables used in modelling the volume of retail loans

				No. of cointegrating equations	
				Trace test	Max-eigenvalue test
house_loan_g	gdp_real_g	pro_pri_g	HICP	2	1
cons_loan_g	ir_cl_g	unem_g	HICP	2	1
other_loan_g	gdp_real_g	unem_g		1	1

Source: NBS.
Table shows the number of cointegrating equations indicated by respective tests.
In all cases an intercept was included in the cointegrating equation.
One lag of the variables was included in the test.

Table 22 Results of unit root tests – household credit risk

	ADF		Phillips-Perron	
	level	1st difference	level	1st difference
NPL_g	0.440	0.000	0.102	0.000
TL_g	0.105	0.004	0.693	0.004

Source: NBS.
Intercept was included in all cases.

Table 23 Results of Johansen's cointegration tests – household credit risk

			No. of cointegrating equations	
			Trace test	Max-eigenvalue test
NPL_g	TL_g	unem_g	1	1

Source: NBS.

Table 24 Estimation results 1 – corporate credit risk

Sector	α_1	α_2	l	aR^2
Transport	0.576	-0.131	1	78.4%
	(0.000)	*(0.004)*		
Forestry and logging	0.725	-0.133	1	58.6%
	(0.000)	*(0.024)*		
Electronics industry	0.460	-0.115	1	31.0%
	(0.001)	*(0.239)*		
Chemical industry	0.430	-0.276	1	63.4%
	(0.001)	*(0.027)*		
Materials	0.641	-0.152	2	58.3%
	(0.000)	*(0.006)*		
Real estate activities	0.620	-0.016	3	71.0%
	(0.000)	*(0.124)*		
Trade	0.643	-0.112	2	84.1%
	(0.000)	*(0.002)*		
Agriculture	0.678	-0.038	3	62.2%
	(0.000)	*(0.686)*		
Food manufacturing	0.568	-0.117	3	72.1%
	(0.000)	*(0.095)*		
Recreation	0.579	-0.149	3	81.0%
	(0.000)	*(0.006)*		
Services	0.534	-0.148	2	67.5%
	(0.000)	*(0.002)*		
Construction	0.605	-0.160	1	72.5%
	(0.000)	*(0.008)*		
Machine industry	0.487	-0.155	1	72.3%
	(0.000)	*(0.090)*		
Telecommunications	0.813	-0.099	1	70.2%
	(0.000)	*(0.346)*		
Mining and quarrying	-			
Textile industry	0.478	-0.142	3	56.9%
	(0.000)	*(0.025)*		
Utilities	-0.082	-0.157	1	97.9%
	(0.020)	*(0.011)*		
General government	0.599	-0.024	3	51.2%
	(0.000)	*(0.092)*		

Source: NBS.

t-statistics in parenthesis.

Table 25 Estimation results 2 – corporate credit risk

Sector	α_4	α_5	l	aR^2
Transport	0.568	-0.282	4	79.0%
	(0.000)	*(0.002)*		
Forestry and logging	0.670	-0.239	4	56.7%
	(0.000)	*(0.050)*		
Electronics industry	0.486	-0.484	3	42.0%
	(0.000)	*(0.011)*		
Chemical industry	0.725	-0.825	3	54.1%
	(0.000)	*(0.005)*		
Materials	0.613	-0.218	5	51.5%
	(0.000)	*(0.073)*		
Real estate activities	0.605	-0.030	4	70.8%
	(0.000)	*(0.143)*		
Trade	0.641	-0.254	4	85.4%
	(0.000)	*(0.000)*		
Agriculture	0.680	-0.278	3	65.1%
	(0.000)	*(0.114)*		
Food manufacturing	0.591	-0.129	3	56.6%
	(0.000)	*(0.447)*		
Recreation	0.593	-0.229	4	78.9%
	(0.000)	*(0.032)*		
Services	0.646	-0.216	2	61.1%
	(0.000)	*(0.037)*		
Construction	0.587	-0.358	4	74.0%
	(0.000)	*(0.003)*		
Machine industry	0.473	-0.624	4	76.4%
	(0.000)	*(0.020)*		
Telecommunications	0.805	-0.093	3	69.9%
	(0.000)	*(0.471)*		
Mining and quarrying	-			
Textile industry	0.481	-0.194	4	52.9%
	(0.000)	*(0.123)*		
Utilities	0.634	-0.918	3	34.3%
	(0.000)	*(0.187)*		
General government	0.520	-0.058	6	52.2%
	(0.000)	*(0.065)*		

Source: NBS.
t-statistics in parenthesis.