NATIONAL BANK OF SLOVAKIA

Juraj Zeman, Pavol Jurča

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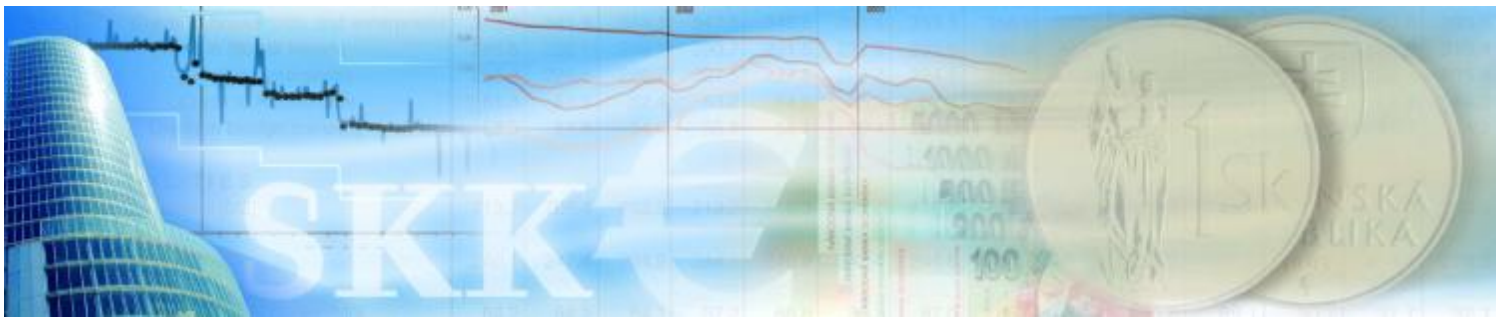

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Macro Stress Testing of the Slovak Banking Sector*

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Abstract

In this paper we estimate the impact of a simulated slowdown in the Slovak economy on the Slovak banking sector. Using a vector error correction model, the impact of the slowdown on interest rates and exchange rates is assessed. This allows us to estimate the aggregated impact of the credit risk, interest rate risk and exchange rate risk. The significance of indirect impact of interest rate risk and foreign exchange risk via possible worsening of financial situation of debtors has also been considered. The results suggest that even significant slowdown of the GDP growth would not substantially threaten the Slovak banking sector provided that the response of the monetary policy would be adequate. Given the current portfolio of the Slovak banking sector, this monetary policy would have positive impact on Slovak banking sector also by direct increase of real value of this portfolio, mainly through the interest rate channel. The shocks in GDP growth that would be left without relevant response in other factors might represent more noticeable threat.

Keywords: Macro stress testing, Credit risk, Slovakia
JEL classification: C32, G18, G21

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1 Introduction

Recent credit boom in Central and Eastern Europe results in an increasing exposure of banking sector to the private sector. Slovakia is not an exception. Mainly loans to households have been growing quite rapidly in the recent years. Consequently, banks are more vulnerable to the adverse impact of various macroeconomic shocks. It is crucial to take into account various channels of these shocks with respect to their linkages. For example, a decrease in the GDP growth could worsen the financial situation of households and corporations and in turn increase the credit losses in the bank portfolios. In addition, the interest rates may decrease as a result of expansionary monetary policy of the central bank, which could have further impact on the profit or loss of the banking industry.

The aim of this paper is to present a small macroeconomic model that allows us to estimate the impact of real economic shocks on bank portfolios through changes in credit risk and market risk factors. We will stress not only the risk factors alone, but also the historical relationship between these factors.

This paper consists of nine sections and an appendix. The second section reviews the relevant literature, including a brief summary of macro stress tests that have been done in Slovakia so far. The next two sections deal with the recent development on the credit market in Slovakia and with the comparision to the EU market and characterize the quality of the credit porfolio. In addition, some details on the turbulent development in late 90s are presented. The econometric techniques and models which have been used are described in section 5. In the sixth section, we describe in detail various scenarios that are used in the macro stress testing based on the examination of the historical data and on the econometric models. Section 7 describes the methodology which is used to calculate the impact of the scenarios. The estimates of the post-shock values of the capital adequacy ratio are presented. These results are interepreted in section 8. Finally, section 9 concludes the paper. More details on the econometric models and some statistical tests are given in the appendix.

2 Literature overview

Several studies have dealt with the modeling of credit risk using macroeconomic explanatory variables. The most common indicator of credit risk is the ratio of non-performing (defaulted)[1] loans to total loans (NPL ratio). Many authors tried to find a robust relationship between this ratio and some other macroeconomic variables (see Kalirai and Scheicher (2001) and Boss (2002) for Austria, Virollainen (2004) for Finland, Babouček and Jančar (2005) for Czech Republic, among others).

Although this paper uses an approach similar to the papers cited above, it can be useful to review some other types of models that have been used to assess the credit risk behind the rapid household credit growth and their implications for Slovakia. It is possible to calibrate a panel error correction model (based on a panel of similar countries) to estimate the equilibrium level of credit to GDP. This approach was used e.g. by Kiss et al. (2006) and Égert et al. (2006). Kiss et al. (2006) estimated that the equilibrium level increases by 1 % if real GDP per capita in PPP terms increases by 0,7 % or real interest rate or inflation decreases

[1] We treat “non-performing loans” and “defaulted loans” as synonyms in this paper.

by 0,1 p.p. This result confirms that an adverse shock in the variables mentioned above can decrease the equilibrium level of the loans-to-GDP ratio and hence increase the credit risk of households. The key variables identified by Égert et al. (2006) are in principle similar. In addition, they found other significant variables such as share of government loans to GDP and spread between interest rates on loans and deposits as a proxy for liberalization and competition in the banking sector. Moreover, Kiss et al. (2006) concluded that the share of household loans to GDP does not exceed the equilibrium level in Slovakia. This result is confirmed by Égert et al. (2006). However, they indicated that this equilibrium level has been temporarily exceeded in Slovakia during 1997 – 1998.

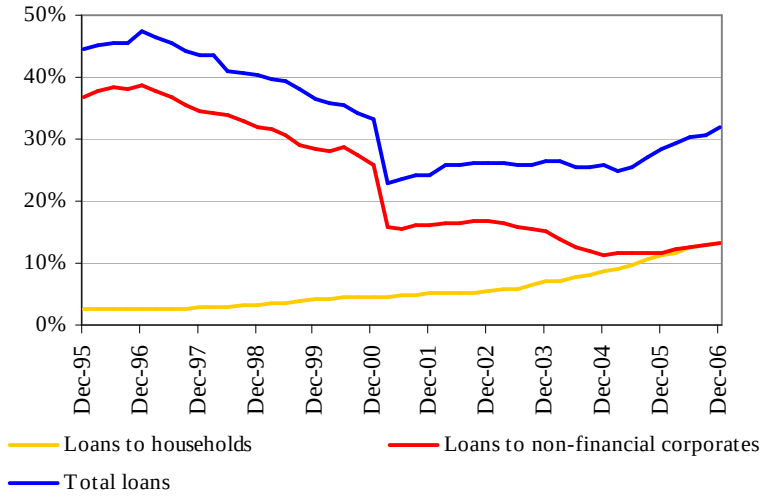
However, a compact econometric model for the linkages between various macroeconomic variables and quality of credit portfolio that would facilitate estimation of the impact of downturn in Slovak economy possibly including the interest rate and foreign exchange rate channels is still missing. Although several models dealing with this issue have been developed, they are focused more on partial problems. One of these models is a model of default rates in portfolio of loans to small and medium enterprises (SME) by Fidrmuc et al. (2006). Using probit model and panel probit model they found that liquidity and profitability factors and the legal form (due to the level of liability of their owners) are important factors for SME default rates. Indebtness seems to be less robust. Regarding household credit risk, the impact of an increase of unemployment rate has been studied (NBS (2007)). Using Monte Carlo simulations on a panel of 5000 households, it has been found that the increase in unemployment rate by 2 p.p. results in the increase of NPL ratio of household loans by 0.8 p.p. This result was confirmed also on aggregated level by using a simple vector error correction model. Moreover, Lintner and Rychtárik (2007) studied the impact of rapid fall in real estate prices trough creating additional provisions for impaired and defaulted loans collateralized by real estate. They concluded that even a 50% decrease of real estate prices would not cause decrease in capital adequacy ratio by more than 2 p.p. in most banks.

The National Bank of Slovakia (NBS) has also internally developed an industry-specific model where the explanatory variables for the NPL ratio has been modelled using various financial ratios based on microeconomic data and GDP. Using the panel regression, this model identifies three most significant financial ratios – financial leverage (assets to equity), inventory turnovers, liquidity ratio (inventory to short term liabilities) and real annual GDP growth rate. Increase in value of all three financial ratios contributes to increase of the NPL ratio. However, this model has not been published.

3 Development of credit market

Between 2000 and 2005 the volume of total loans granted by banks rose significantly, with average annual increase of 16%. This growth was even more significant in 2005 and 2006. Not only the volume of total loans rised, but also the share of loans to GDP increased. However, trends in loans to non-financial corporates and in loans to household were different. Whereas the share of loans to non-financial corporates to GDP decreased until 2004 and increased only slightly after that, the share of loans to households to GDP has been increasing since 1998, when the mortgage business started up, and accelerating in the last two years.

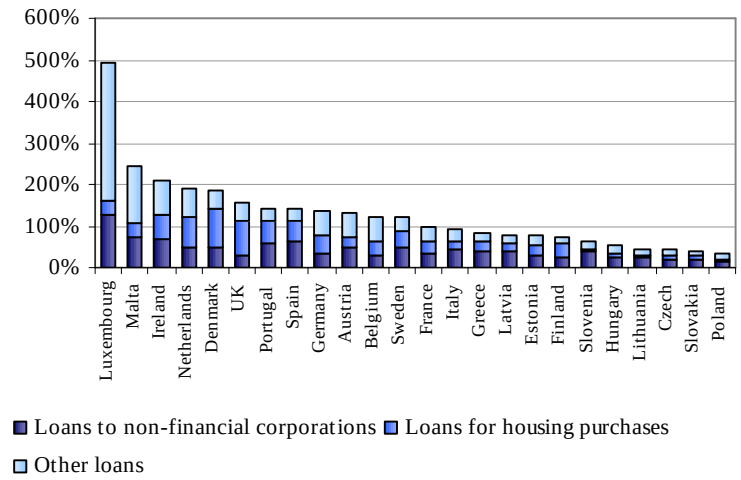
Figure 1 Loans as a share of GDP



Source: NBS.

Despite the significant growth, the share of total loans to GDP in Slovakia was one of the lowest in the European Union at the end of 2006. In addition to this, other sources of debt (e.g. bond issue for corporates or leasing for households) are not significant. Hence, this low level of indebtedness of Slovak economy was a natural reason for the growth in the last years.

Figure 2 Loans as a share of GDP



Source: ECB, data as at December 2005.

As Figure 1 indicates, three periods of the development of the loan activity during the past 10 years can be identified. First, in 1997 – 2000 the volume of loans to corporations stagnated and the share to GDP gradually declined. In addition, the quality of the portfolio worsened (see Figure 3). This was a result of rapid growth of corporate loans before 1997. This period was also identified by Égert et al. (2006) as a period when the sound level of growth was exceeded.

In the next period (2001 – 2003), the banking sector was restructured and significant portion of the defaulted loans was removed from banks and was substituted by government bonds in some banks in the first quarter of 2001. In 2002, the consolidation of the Slovak

banking sector was finished. The Slovak banks have been prevailingly owned by foreign banking groups since 2002. Regarding the situation in the loan market, the share of total loans to GDP stagnated; the growth of volume of total loans was similar as the growth of nominal GDP (about 10 % yearly). After period of increased default rates, banks were more cautious when granting corporate loans. In the household loan market, the share of these loans to GDP increased gradually after starting up the mortgage business (nine banks had mortgage license at the end of 2002).

In the recent years (since 2004), the share of corporate loans as well as household loans to GDP has increased. There are several factors behind this growth. One of the most influential one was the decrease of interest rates until 2005. In addition, there were changes in some conditions attributable to shifting of both demand and supply.[2] On the demand side, one of the most significant factors is the above-mentioned low level of initial indebtedness of Slovak economy resulting in the catch-up effect. The situation on the household loan market, where the growth is most significant, is influenced also by increasing real estate prices (although this increase was slightly dampened after the EU entry in May 2004) and by improvement of financial situation of households. On the other hand, in corporate sector the increased demand is mainly due to the need of financing long-term investment and operating capital. In addition, the increase in demand has been followed also by the increase in supply from bank which eased their lending standard. The lending conditions were more liberalized mainly after the restructuring and consolidating of banking sector. Households and small and medium enterprises gained easier access to loans, mainly due to the increasing competition in the banking sector and positive macroeconomic situation. This development was similar to development in other new members states.

4 Credit risk of loan portfolio

To describe the past and current status of the quality of the loan portfolio in Slovak banking sector with more detail, we briefly analyze some indicators related to the credit risk.

For the corporate sector, two indicators shall be discussed in more detail: the share of total defaulted corporate loans to total corporate loans (NPL ratio) and the default rate. Both of them are shown on Figure 3. The NPL ratio is the most frequently used indicator of credit risk. However, it has several shortcomings that have to be taken into account when interpreting the results. Firstly, there were several methodological changes in the definition of defaulted loans. Secondly, as the main quantitative condition for the defaulted loans is that these loans are at least 90 days past due, this indicator is backward looking; a loan qualifies as defaulted only 90 days after the debtor is not able to repay the loan. Thirdly, the changes in this indicator have to be interpreted together with the changes in the volume of total loans. In the period of rapid credit growth, declining NPL ratio does not have to imply decreasing credit risk. Finally, it should be taken into account whether the decrease of NPL was due to improvement of the credit quality or due to selling of the loans. However, this seems to be quite tricky given the data that are available. On the other hand, the last shortcoming can be overcome by using default rate instead. The default rate can be calculated as the number of corporate loans that defaulted during one-year horizon to the total number of non-defaulted corporate loans. The source for these calculations is the Register of Bank Loans and

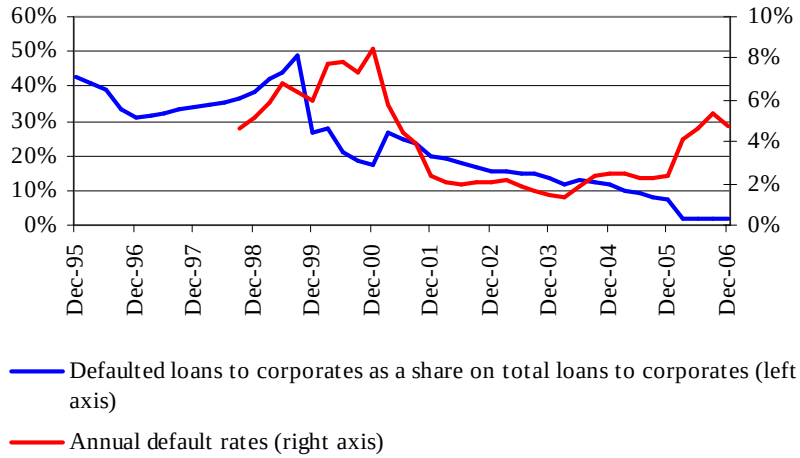
[2] The details on changes in demand and supply are taken from the Questionnaire on loan market development, that has been sent on semiannual basis to most banks and branches of foreign banks since 2005.

Guarantees. However, the quality of this indicator is subject to the limited quality of the information contained in this register for years 1997 – 2002. In addition, methodological changes in the definition of defaulted loans had even higher impact on this indicator. The most significant methodological change occurred at January 1, 2006. Before that, the category of defaulted loans included substandard, doubtful and loss loans. These loans were characterized as follows:[3]

- they were past due more than 90 days (more than 60 days in 2003 and 2004),
- the debtor was or was supposed to be unable to repay the loan,
- the debtor was under liquidation or composition proceedings,
- the loan is not recognized by the debtor.

Until the end of 2005, two methodological changes occurred but they were rather minor: The minimum number of days past-due was changed and some qualitative criteria were added or refined. However, the principles of classifying loans as defaulted have changed since January 1, 2006. The reason was the adoption of IAS / IFRS. The above-mentioned classification was abolished. Loans which were past due more than 90 days or for which the present value of the future cash flows (regardless collateral) was below 50% of the outstanding amount of the loan are now considered to be defaulted. This change in the definition of the defaulted loans caused that their volume decreased. In addition, the increase in defaulted rate, which could be seen in 2006, could be attributed mainly to these methodological changes. As a result of this change, many loans that were previously reported as defaulted were classified as standard and vice versa, causing a sharp increase in the default rate.

Figure 3 Indicators of credit quality of corporate loan portfolio

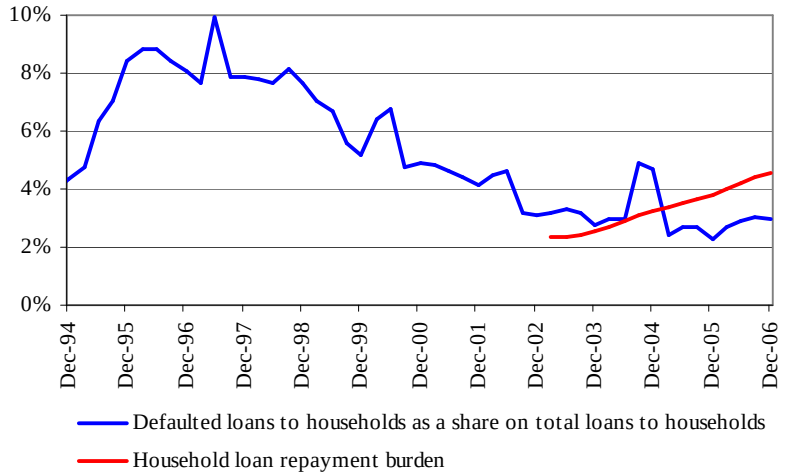


Source: NBS.

For household loan portfolio, two indicators are commonly used for accessing the credit risk in this sector: the ratio of defaulted loans and the household repayment burden. Until 2002, the ratio of defaulted loans was decreasing. The reason was that the pace of household loans growth was greater than the pace of growth of defaulted loans. This ratio has been roughly stable since 2003, despite the significant growth of household loans during this period.

[3] For detailed list of all characteristics and their changes, see Decrees of the NBS No. 3/1995, 7/2002 and 13/2004.

Figure 4 Indicators of credit quality of household loan portfolio



Source: NBS.

The loan market and the quality of the loan portfolio itself were largely influenced by the development of other macroeconomic variables. As we have mentioned earlier, the quality of the credit portfolio worsened significantly until the restructuring of the banking sector in 1999 and 2000. During this period, the credit market and the debtors' ability to repay loans was affected by very high values of interest rates. One of the reasons was that until September 1998 the main objective of the monetary policy was to maintain the stability of the Slovak currency in the fixed (although widening) band with respect to the basket of USD and DEM. After massive outflow of foreign exchange reserve of the NBS, the fixed exchange rate regime was replaced by managed floating in October 1998, resulting in substantial depreciation of the Slovak currency. In 2000 and 2001, the exchange rate SKK/EUR was stabilized and it has gradually appreciated since then. The stabilization of the Slovak currency and positive macroeconomic outlook enabled the NBS to change the main objective of the monetary policy from currency stability to price stability. The qualitative control of liquidity in the banking sector via key interest rate of the NBS has started. This policy resulted in decrease of BRIBOR which have stayed below the level of 10% since 2000. Moreover, the growth of the real GDP began to accelerate in 2000. Together with the stabilization of the currency and the interest rates, the reforms of the banking sector started in 1999. The capital of the largest state-owned banks was increased and large part of defaulted loans in their portfolios was replaced by government bonds in the second half of 1999 and in the first half of 2000. After this restructuring took place, banks were privatized. This transformation process also contributed to decrease in the interest rates on the loan market. The reason is that the part of the funds which was blocked by defaulted assets diminished and the funding of loans was cheaper.

5 Models for macro stress tests

In this section we try to find the link between the quality of the aggregate bank portfolio and macroeconomic environment. We estimate how the quality indicator – the ratio of non-performing loans to total loans, is affected by certain macroeconomic variables.

In the first part of this section we identify significant factors and in the second part we estimate relationship between non-performing loans ratio and those identified variables using

two different techniques. Then we run some scenario analysis and compare outcomes. The starting point of our analysis is IMF methodology of assessing credit risk of aggregate bank portfolio (Blaschke et al., 2001). Non-performing loans ratio is regressed against various macroeconomics variables such as real GDP growth rate, inflation rate, nominal interest rate and terms of trade changes. The coefficients of these regressions provide an estimate of the sensitivity of bank borrowers to the relevant macroeconomic risk factors.

5.1 Identifying significant risk factors and bivariate regressions

In order to identify significant risk factors we run, similarly to Kalirai and Scheicher (2002), univariate ordinary least square (OLS) regressions of non-performing loans ratio on the comprehensive data set of macroeconomic variables. Our sample consists of quarterly data from 1995 to 2006. OLS regression requires using stationary series. The Augmented Dickey-Fuller test indicates that all series are non-stationary, hence the original series are transformed. In the case of interest rate we use original data in levels, in case of inflation we use annual differences and in all other cases annual percentage changes are used.

Macroeconomic variables are divided into the following four categories: cyclical indicators, price stability indicators, financial market indicators and external sector indicators. The list of variables is given in Table 1.

Table 1 List of variables

Group	Variables
Cyclical indicators	Real GDP, industrial production, output gap
Price stability indicators	Inflation, growth of M1 monetary aggregate
Financial market indicators	Nominal and real 3-month BRIBOR (Bratislava Interbank Offered Rate), SAX (Slovak stock index)
External indicators	Export, oil price, exchange rate SKK/EUR

Cyclical indicators.
In this category there are indicators that characterize overall economic activity. It is expected that quality of aggregate portfolio depends on economic activity. If economy is in recession, activity deteriorates which causes falling income, business failures and payment difficulties and this leads to worsening of quality portfolio. Hence GDP growth, output gap and industrial production are expected to be negatively correlated with NPL ratio.

Price stability indicators.
Price stability is usually measured by consumer price indicator. Higher inflation lowers the real value of outstanding loans and eases borrowers situation. Higher inflation also reduces the value of real interest rate and encourages economic activity. That is why inflation is expected to be negatively correlated with the growth of non-performing loans. Monetary aggregate is generally expected to be closely related to inflation and is also included as an indicator.

Financial market indicators.
Interest rate represents the direct cost for borrowers. As the cost of borrowing increases more firms and households become unable to repay their loans and the volume of non-performing loans increases. Higher interest rate thus worsens portfolio quality. Stock market indices are positively related to economic activity and their growth usually indicates booms in economic cycles. Portfolio quality gets better.

External indicators.
Export is an important part of gross domestic product for a small open economy. Growing export positively affects export-oriented sector of the economy and indirectly the whole economy. Repayment conditions for most firms improve. Oil price on the other hand represents direct cost for most firms and its rise generally worsens ability to repay loans. Impact of exchange rate on the firms' repayment conditions is ambiguous as depreciation of domestic currency favors exporters and harms importers.

Bivariate regressions are estimated using a single macroeconomic risk factor. The regression equation is of the form:

$$\Delta npl_t = a * \Delta npl_{t-1} + b * \Delta x_{t-k},$$

where Δ denotes annual percentage change and k denotes the most significant lag of the independent variable. Results of these regressions are listed in Table 2.

Table 2 Bivariate regresion results

	Variable x_i	Expected sign	Regression ΔNPL_t on ΔNPL_{t-1} and $\Delta x_{i,t-k}$		
			Coefficient β	t-statistics	R^2
Cyclical factors	real GDP	-	-0.005	-2.271	0.829
	industrial production	-	-0.001	-0.652	0.404
	output gap	-	0.221	0.292	0.593
Price stability	inflation	-	-0.005	-4.046	0.720
	M1	-	0.000	-0.524	0.587
Financial markets	3MBRIBOR nominal	+	0.003	2.727	0.787
	3MBRIBOR real	+	0.006	3.831	0.710
	SAX	-	0.000	-0.789	0.590
External factors	Export	-	0.003	2.889	0.564
	Oil price	+	-0.001	-2.711	0.652
	exchange rate SKK/EUR	-/+	-0.004	-4.339	0.669

Source: NBS, own calculations.

We see that in each category there is at least one risk factor that is significant at the level 5% and has expected sign. This factor is highlighted. Among cyclical variables real GDP enters significantly with lag zero, inflation and nominal interest rates enters with lag 5, while SKK/EUR nominal exchange rate enters regression equation significantly with lag 3. Note that some dummy variables were used in the equations where necessary. For more details on equations which will be used further to estimate scenarios, see Table 12 to Table 14 in the Appendix.

5.2 Multivariate regression model

The results of the univariate regressions give us a list of relevant variables including the growth rate of real GDP, the CPI inflation, the short-term nominal and real interest rates and the nominal SKK/EUR exchange rate. These are possible candidates for a multivariate model. We now proceed by choosing a combination of variables that produce a model in which all parameters are significant, have expected signs and residuals behave decently. We are left with the model, which is reported in Table 3.

Table 3 Estimated coefficients of the multivariate regression model

Dependent variable: change in the ratio of non-performing loans to total loans		
	coefficient	*t*-statistic
Change in NPL with lag 1	0.677	5.42
Real GDP growth	-0.008	-3.44
Change in BRIBOR with lag 1	0.0015	1.85
Change in exchange rate with lag 3	-0.010	-2.83

Source: NBS, own calculations.
Note: In addition, a constant and two variables were included in the equation. For more details, see Table 15 in the Appendix.

Results suggest that the change of non-performing loans ratio is strongly autocorrelated (increase in non-performing loans ratio now results in further increase in next period); a negative function of GDP growth (higher GDP growth results in decline in NPL ratio); a positive function of change in nominal interest rate with the lag of one quarter (an increase in interest rate is associated with higher financing cost for debtors); a negative function of change of nominal SKK/EUR exchange rate with the lag of three quarters (SKK depreciation make domestic products more competitive and improves financial situation of exporters).

All coefficients of multivariate regression are significant at the 5% level (see *t*-statistics), except change in BRIBOR which is significant at the10% level. Adjusted R^2 equals 0.84. Both Ljung-Box test and Breusch-Godfrey test for autocorrelation in residuals cannot reject the null hypothesis of no serial correlation in the residuals (see Table 16 in the Appendix). The regression results are obtained using the Newey-West variance estimator, to control for possible autocorrelation or heteroskedasticity in the presence of lagged dependent variables among the regressors. Very similar coefficients together with their *t*-statistics are obtained by White estimator.

5.3 Cointegration techniques

Graphical inspections as well as formal tests suggest that all time series involved in the analysis are non-stationary, more precisely they are integrated of order one. Hence we may try to test for the existence of a long-run equilibrium. We performed the Johansen cointegration test on the group of following variables: NPL ratio, real GDP, BRIBOR and SKK/EUR exchange rate. Trace test and rank test both indicate the existence of one cointegration equation. The estimated coefficients of the long-run relationship are listed in Table 4.

Table 4 The long-run relationship in the vector error correction model

Dependent variable*: ratio of non-performing loans to total loans		
	coefficient	t-statistic
Log(real GDP)	-0.602	6.09
BRIBOR	0.0086	-5.13
Log(SKK/EUR exchange rate)	-0.517	3.30

Source: NBS, own calculations.
Note: For more details, see Appendix and Table 17 for short-rate dynamics.
* This form of the presentation of the long-rn relationship was chosen to enable the comparison with the previous model. However, regarding the cointegrating relationship in a vector-error correction model, the variables are not split to dependent and independent.

All the coefficients are significant and have expected signs. The growth of GDP and depreciation decrease the non-performing loans ratio in the long run. In addition, the growth of nominal interest rate increases this ratio.

6 Constructing scenarios

In this section, we construct several macroeconomic scenarios, which can be used to perform macroeconomic stress testing of the banking sector. Three types of macroeconomic scenarios are considered:

1. Stand-alone changes in individual macroeconomic risk factors (3-month BRIBOR, exchange rate SKK/EUR and growth of real GDP) and their impact on non-performing loans ratio. Only changes in one risk factor are considered in each scenario, the relationships between the risk factors are neglected.
2. Simultaneous changes in all macroeconomic risk factors and their impact on non-performing loans ratio. The aim of this type of scenarios is to model hypothetical changes in the risk factors that have all negative impact on the banking sector rather than to consider the mutual correlations between the risk factors.
3. Change in one individual macroeconomic risk factor (e.g. the annual growth of the real GDP) and its impact on non-performing loans ratio and other risk factors. Unlike the second type of scenarios, this approach takes into account the historical relationship between the risk factors.

It is clear that the stand-alone changes in individual risk factors will hardly occur in isolation. In addition, the results have to be interpreted with caution, as the model used to assess the impact on the non-performing loans ratio does not include long-run relationship. However, by considering these shocks we are able to assess whether and to what extend the conjecture about the indirect interest rate and exchange rate risk are important for the Slovak banking sector.

Table 5 Annual and quarterly extreme changes of macroeconomic variables

Macroeconomic variable	Most extreme quarterly changes		Most extreme annual changes	
	1997 - 2006	2002 – 2006	1997 - 2006	2002 - 2006
Nominal 3-month BRIBOR	- 31% (00q1), i.e. - 4.3 p.p.	- 28% (05q1), i.e. – 1.1 p.p.	91% (97q4), i.e. 12.8 p.p.	69% (06q3), i.e. 2.0 p.p.
Exchange rate SKK/EUR	9.2% (98q4)	- 5.1% (02q4)	20.0% (99q2)	- 6.5% (06q4)
Real GDP - positive change	*	*	9.8% (06q3)	9.8% (06q3)
Real GDP - negative change	*	*	- 1.2% (99q3)	3.6% (02q1)

Source: NBS, Statistical office of the Slovak Republic.
Note: Note that the data represent relative changes (in % of initial value), for BRIBOR also respective absolute changes (in p.p.) are given.
Data in parentheses represent the year and quarter when the most extreme change occurred.
* Data on most extreme quarterly changes of GDP are not considered due to the seasonality of GDP.

The construction of each scenario includes two steps: First, the magnitude of the change in the risk factor(s) is chosen based on its historical development and historical extreme relative changes in 1997 – 2006 and in 2002 – 2006 (see Table 5). The reason for calculating relative changes instead of absolute is that in our understanding the increase of interest rates e.g. by 3 p.p. is more extreme in case that the initial level was 2% than in case that it was 10%. For BRIBOR and SKK/EUR exchange rate, the most extreme changes were

based on the most extreme negative or positive changes. The idea behind this consideration is, that if e.g. a large negative change occured in the past, than the large positive change could be also possible. However, the situation is different regaring the GDP, where only negative changes are considered.

The reason of considering the extreme events in the longer and shorter period separately is that in the late 90s the economy underwent through a turbulent period of its development. Some variables recorded very extreme changes, which could be regarded too high even in the context of stress testing. Two versions – moderate version and severe version – of each scenario are constructed. The results are summarized in Table 6.

Table 6 Description of shocks

Type of shock	Scenario number	Type	Version	Description
Interest rate shock (stand-alone)	Scenario 1A	1	Moderate	20% increase of BRIBOR in 3 subsequent quarters (i.e. increase by 1 p.p.)
	Scenario 1B	1	Severe	40% increase of BRIBOR in 3 subsequent quarters (i.e. increase by 2 p.p.)
Exchange rate shock (stand-alone)	Scenario 2A	1	Moderate	3% appreciation of SKK against EUR in 4 subsequent quarters
	Scenario 2B	1	Severe	6% appreciation of SKK against EUR in 4 subsequent quarters
Slowdown of economy growth (stand-alone)	Scenario 3A	1	Moderate	Real GDP change 3% in 2007*
	Scenario 3B	1	Severe	Real GDP change -3% in 2007*
Immediate macroeconomic shock (relationship of macrovariables not modelled)	Scenario 4A	2	Moderate	Decrease of real GDP by 6%**, increase of BRIBOR by 20% (i.e. 1 p.p.) and appreciation of SKK against EUR by 3% in first quarter 2007 (in comparison to fourth quarter 2006)
	Scenario 4B	2	Severe	Decrease of real GDP by 12%, increase of BRIBOR by 40% (i.e. 2 p.p.) and appreciation of SKK against EUR by 6% in first quarter 2007 (in comparison to fourth quarter 2006)
Immediate macroeconomic shock (relationship of macrovariables modelled)	Scenario 5A	3	Moderate	Decrease of real GDP by 6%
	Scenario 5B	3	Severe	Decrease of real GDP by 12%

Source: NBS, own calculations.
Notes: * The annual change of the real GDP is supposed to gradually decrease to 3% (-3%, respectively) at the end of 2007 and gradually increase back to the pre-shock level in 2008.
** This is only decrease in one quarter. Given the growth of GDP in 2006, the estimated annual real GDP change in the first quarter of 2007 would be higher than – 6% or –12%, respectively.
Types of the stress scenarios:
(1) Stand-alone shock
(2) Shock in several factors, neglecting their relationship
(3) Shock in several factors, taking into account their relationship

The reasoning behind the constructing of the scenarios is as follows: The decrease or the increase of the respective factors has been chosen according to what the econometric models predict to be more harmful for the quality of the credit portfolio of the banking sector. Regarding the interest rate shock, the size of most extreme quarterly change was roughly one third of the size of the most extreme annual change in the last decade. Therefore, the interest rate shock is supposed to last for three subsequent quarters. Afterwards we assume no changes and BRIBOR is assumed to stay at the post-shock level. Note that the extent of the interest rate shock was derived using the most extreme relative shock. However, the simulated shock is lower than the most extreme change in absolute terms (i.e. in percentage points), as the

present level of interest rates is significantly below the level of the interest rates when the most extreme changes occurred. On the other hand, the simulated exchange rate shocks are even more severe compared to the most extreme changes in the last decade. The 3% and 6% quarterly appreciation in four subsequent quarters results in annual change of 12.5% and 25%, respectively. However, this is partly offset by the fact that the exchange rate shocks are assumed to be uniformly distributed in several quarters as opposed to shocks concentrated in one or two quarters. The exchange rates are supposed to stay at the post-shock level afterwards. Finally, the shock in the real GDP is based on the most extreme annual change during the last 5 and 10 years, respectively, but is even more severe. Notice that the moderate version of the shock still assumes some GDP growth. However, this growth is still significantly lower comparing to the pre-shock figures (9%). The growth of the GDP is supposed to return to the pre-shock values after one year.

In the second step, the impact on non-performing loans ratio and on other risk factors (if relevant) is assessed following the estimation results for the models introduced in the previous section. In the first type of scenarios, the impact can be estimated using both single-factor models and the multivariate regression model. Regarding the second type, the vector error correction model can be used. However, there are some methodological differences when estimating the impact of the shocks using the vector error correction model compared to the first two models. In the single factor and multivariate models, the value of variables that are not changed or the value of changed variables after the shock is supposed to stay at their initial values as at fourth quarter 2006. In contrast, the values of these variables in the vector error correction model are assumed to be on their equilibrium level. In this framework, the impulse-response analysis is employed. Note that we estimate the impact of the shock on non-performing loans ratio as the difference between the value of this ratio in a given time horizon (e.g. fourth quarter 2007) with shock and without shock, instead of comparing the after-shock value of this ratio in the given time horizon to its initial level.

Table 7 Impact of scenarios 1 – 4

Scenario	Impact on NPL ratio 1 year horizon			Impact on NPL ratio 2 years horizon		
	Single factor equation model	Multivariate regression model	Vector error correction model	Single factor equation model	Multivariate regression model	Vector error correction model
1A	0.0 p.p.	0.8 p.p.	–	1.9 p.p.	1.5 p.p.	–
1B	0.0 p.p.	1.9 p.p.	–	4.5 p.p.	3.6 p.p.	–
2A	0.8 p.p.	1.1 p.p.	–	7.6 p.p.	9.7 p.p.	–
2B	1.5 p.p.	2.3 p.p.	–	14.7 p.p.	18.6 p.p.	–
3A	4.5 p.p.	9.8 p.p.	–	5.3 p.p.	15.3 p.p.	–
3B	8.7 p.p.	18.9 p.p.	–	10.2 p.p.	29.3 p.p.	–
4A	–	–	1.8 p.p.	–	–	4.35 p.p.
4B	–	–	3.6 p.p.	–	–	8.70 p.p.

Source: NBS, own calculations.
Note: The impact of the shocks on non-performing loans ratio was estimated using the abovementioned econometric models and represent the difference between the value of this ratio in a given time horizon with shock and without shock.

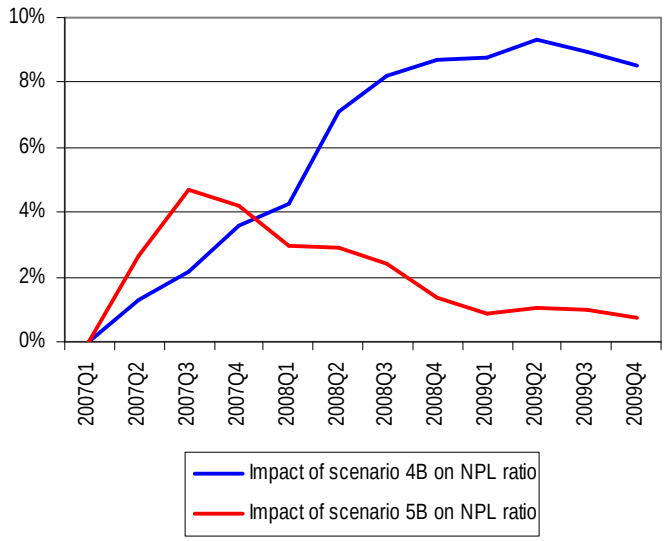
Table 8 Impact of scenario 5

Scenario	Impact in 1 year horizon			Impact in 2 years horizon		
	Exchange rate SKK/EUR	3-month BRIBOR	NPL ratio	Exchange rate SKK/EUR	3-month BRIBOR	NPL ratio
5A	Depreciation by 1.5 %	Decrease by 0.7 p.p.	Increase by 2.1 p.p.	Depreciation by 1.1 %	Decrease by 1.2 p.p.	Increase by 0.6 p.p.
5B	Depreciation by 3.1 %	Decrease by 1.4 p.p.	Increase by 4.2 p.p.	Depreciation by 2.2 %	Decrease by 2.3 p.p.	Increase by 1.4 p.p.

Source: NBS, own calculations.

It is reasonable to assume that the impact of the scenarios of the third type reflecting the relationship between the macroeconomic variables would have smaller impact on the NPL ratio compared to the scenarios of the second type. This conjecture can be theoretically justified by the fact that the historical relationship expresses the corrective development of other variables in case of shock in one variable. Particularly, it is reasonable to assume that in the period of the economic slowdown, an expansionary monetary policy might take place. Consequently, interest rates would decrease which in turn decreases the debt burden for the loans with float interest rate and improves the credit quality of the credit portfolio. This is in contrast with the second type of scenario, where we can stress test the validity of the long-run relationship and assume for example economy slowdown together with growth of nominal interest rates. Indeed, the error correction model can be used to empirically verify this conjecture. In the scenario 4B, the estimated impact of the macroeconomic shock on the NPL ratio is increasing in the first two years after the shock. On the other hand, the impact of the shock in scenario 5B is gradually decreasing after the rise following immediately after the shock, which could be the effect of the decrease in the interest rates.

Figure 5 Impact of scenarios 4B and 5B on the NPL ratio



Source: NBS, own calculations.

The abovementioned result is true subject to the requirement that the reaction of the monetary policy will be appropriate. In the model, this has been taken into account as both interest rate and SKK/EUR exchange rate are endogenous variables. Indeed, the Granger causality test (see Table 19 in Appendix) indicates, that the interest rate was influenced by other macroeconomic variables in the past. Nevertheless, this may not be the case after the

euro adoption, when the monetary policy will be controlled by the ECB. Therefore, it makes sense to reestimate the impact of scenarios 5A and 5B using a shortened, two-equation version of the vector error correction model where BRIBOR and SKK/EUR exchange rate are considered to be exogenous. Using this model and assuming no change in the current level of the BRIBOR and the SKK/EUR exchange rate, we obtain that the estimated impact of scenario 5A is an increase in NPL ratio by 1.7 p.p. in one-year horizon and 2.0 p.p. in two-year horizon, respectively. In case of scenarios 5B, the NPL ratio would increase by 3.4 p.p. in one-year horizon and by 4.1 p.p. in two-year horizon. Comparing these figures to the estimations given in Table 8, we can conclude that the impact is slightly less significant in the case of no reaction of the monetary policy. As the difference is relatively small, we will not treat this modified version of scenarios 5A and 5B separately from their original version. However, it should be noted that the absence of the corrective action of the monetary policy is visible in the two-year horizon, where the impact is more pronounced if this reaction is missing.

7 Results of the stress testing

In this section, we estimate the impact of the scenarios presented in the previous section on the banking sector. To be more specific, the results are presented as the impact on the capital adequacy ratio in order to estimate the number and market share of banks, in which the after-shock solvency deteriorate below the regulatory threshold 8%. In individual scenarios, we assume that the level of risk-weighted assets is constant and the level of capital decreases by the loss resulting from these scenarios. Note that the assumption neglects possible changes in the banking portfolio and exposures to various risks during the considered time horizon. Even given the constant portfolio, the volume of risk-weighted assets could change due to changes in risk factors when using advanced risk models. The second assumption overlooks the fact that the loss would diminish the profit created in the given year which is not, however, included in the capital.

Let us briefly describe the methodology employed to assess the impact of change in NPL ratio, exchange rate SKK/EUR and 3-month BRIBOR. We also present its major shortcomings that we have to bear in mind when interpreting the results of the stress tests. This methodology follows the approaches previously used by the NBS that were summarized by Jurča and Rychtárik (2006).

Regarding the change in NPL ratio, the loss is caused by the provisions that have to be created for the newly defaulted loans. The estimation of the volume of the provision is based on the prudent assumption that the whole volume of the defaulted loans has to be covered by the provision, irrespective of the volume of collateral (LGD = 100%). As we try to estimate the effect of shocks on individual banks, the change in total non-performing loans has to be allocated to individual banks, too. This is based on the assumption that the volume of new non-performing loans is calculated by using the volume of loans in individual banks and the change of the non-performing loans in the given scenario, regardless of the NPL ratio in the individual banks.

The simulated change in the exchange rate SKK/EUR can be directly translated to the profit or loss given the open on-balance and off-balance sheet position in EUR in the individual banks. When calculating the off-balance sheet position, we take only position from nominal value of derivatives. We do not consider collaterals and loan commitments in EUR, as these instruments are not repriced when the exchange rate moves. However, as the only exchange rate included in the model is the exchange rate SKK/EUR, a question arises what is the relationship between the changes in this exchange rate and in changes of other exchange rates. The estimation of this relationship depends on the ratio of variances of these two

exchange rates and their mutual correlation. As the changes of the exchange rate SKK/EUR could be considered as quite high in individual scenarios, we use the concept of modeling the relative changes of exchange rates using a mixture of normal distribution based on Finger and Kim (2000). This concept allows us to estimate these parameters conditionally assuming that the given change of the exchange rate SKK/EUR was from so-called hectic period (i.e. from the normal distribution with higher variance). As this concept was already used by the NBS in the past, we will not reestimate the model here. We only present the "conversion factors" that enable us to quickly assess the change in other exchange rate given the change of the exchange rate SKK/EUR, simply by multiplying this change by the relevant factor. The estimation of these factors is based on NBS (2007).

Table 9 Conversion factors used to estimate the change of exchange rates given the change in the exchange rate SKK/EUR

Currency	CHF	CZK	DKK	GBP	HUF	JPY	PLN	SEK	USD	OTHER
Conversion factor	1.07	0.53	1.00	0.93	0.27	1.00	0.13	0.93	1.07	1.00

Source: NBS.

As it has been already mentioned, it is a very plausible feature of the model that it provides a possibility to assess the effect of slowdown of economy on both direct and indirect effect[4] of interest rate risk. However, two main restrictions have to be taken into account. First, we only estimate the impact of net economic value of the bank. In this approach, all interest sensitive assets and liabilities are revalued to their real value, regardless the fact whether or not they are revalued in the accounting. For example, if the interest rates change, the change in real value of tools such as loans, deposits and securities held to maturity typically does not influence the profit & loss in the accounting. These changes materialize only gradually through the changes in net interest income. In contrast, in our approach all the future changes of net interest income effect immediately the economic value of the bank. Second, in scenarios we have only estimated the change of 3-month BRIBOR, but we are left without estimation of changes in long-term interest rates, which seem to be more influential to profit and loss of the banking sector. Hence it is crucial to estimate the impact of changes in short-term interest rates on changes in long-term interest rates. The background for this estimation can be the analysis by Čársky and Trajlinková (2007) and NBS (2007), where the transmission of changes in basic interest rate of the NBS to other interest rates is modeled using cointegration techniques. The results from these studies basically confirm that the transmission process is slower in interest rate for longer period and the extent is lower for loans and deposits to household in comparison to enterprises where the competition is higher. As we consider only immediate changes we assume that the long-term interest rates (i.e. interest rates with fixation more than 5 years) increase by 50% of the increase of short-term interest rate. The increase of other interest rates is estimated using linear approximation.

The impacts of the various stress tests on capital adequacy ratio of Slovak banks are presented in Table 10.

[4] The direct effect reffers to the changes in the economic value of the banking portfolio due to the changes in interest rates. However, changes in interest rates influence the ability of debtors to repay loans and the development of macroeconomic developement which also contribute to the quality of credit portfolio. These effects are considered to be indirect effect of interest rate risk.

Table 10 Impact of stress tests on capital adequacy ratio of banks in one-year horizon

Scenarios	Description (estimated changes in 1 year horizon)			Capital adequacy ratio		
	Change in 3-month BRIBOR	Change in exchange rate SKK/EUR	Change in NPL ratio	First quartile	Median	Third quartile
Baseline*				12%	19%	21%
1A	Increase by 3.5 p.p.		Increase by 0.5 p.p.	9%	15%	18%
1B	Increase by 7 p.p.		Increase by 1.5 p.p.	4%	12%	14%
2A		Appreciation by 12.5 %	Increase by 1.0 p.p.	11%	17%	20%
2B		Appreciation by 26 %	Increase by 2.0 p.p.	10%	16%	19%
3A			Increase by 7 p.p.	5%	12%	15%
3B			Increase by 14 p.p.	0%	3%	8%
4A	Increase by 1 p.p.	Appreciation by 3 %	Increase by 2 p.p.	9%	16%	19%
4B	Increase by 2 p.p.	Appreciation by 6 %	Increase by 3.5 p.p.	7%	13%	16%
5A	Decrease by 0.7 p.p.	Depreciation by 1.5 %	Increase by 2 p.p.	10%	17%	20%
5B	Decrease by 1.4 p.p.	Depreciation by 3 %	Increase by 4 p.p.	9%	15%	19%

Source: NBS, own calculations.
Notes: The changes in the NPL ratio are based on the estimated changes given in Tables 7 and 8.
The impact on the capital adequacy ratio includes estimated possible losses due to changes in all three factors.
* Value of the capital adequacy ratio as at December 31, 2006.

8 Interpretation of the results and discussion

Bearing in mind the limitations of the presented approach, the results should be interpreted very cautiously. The models have been estimated using the data from period with several structural changes in the economy, including the crisis in the banking sector. The credit quality of the portfolio has been modeled using the NPL ratio, which has several disadvantages as described in Section 4. Estimation of the impact of chosen scenarios on capital adequacy ratio has been also based on several simplifications. Notwithstanding these constraints, the results could shed light on identification which scenarios could have major impact on the banking sector.

The results suggest that stand-alone growth in interest rates would have negative impact on banks. This growth influences banks in two channels: The direct channel is represented by the decrease on economic value of banks. The reason is that they have unhedged interest rate positions, mainly in the banking book. To be more specific, the volume of assets with long-term interest rate fixation (mainly government bonds) substantially exceeds the volume of liabilities with long-term interest rate fixation. If the interest rate increases, the price of these assets decreases. The indirect channel seems to be less important. This channel reflects the fact that in case of rise in interest rate, the installments of loans with floating rate or loans with short-term fixation of interest rate and hence the debt burden increases, contributing to the worsening of the financial situation of debtors. The indirect channel is responsible for approximately 25% of the fall of median capital adequacy ratio after the interest rate shock.

Regarding the stand-alone foreign exchange shock, the situation is different. The direct channel reflecting the immediate impact on the revaluation of the banks' portfolio is of negligible importance. Even the impact of extreme exchange rate changes is low. The reason is that the positions in foreign currency are basically closed in all currencies. Although many

banks have significant long open positions in the balance sheet, they are hedged by derivatives reported in off-balance sheet. A relatively low level of foreign currency-denominated loans means that also the indirect, second-round foreign exchange risk is limited, which contrasts the situation in many other CEE countries where unhedged foreign currency lending represents an important source of concern. In addition, in Slovakia as a small open economy, the indirect effect of extreme appreciation of domestic currency could significantly worsen the financial situation of exporters, which could have a strong effect on the quality of credit portfolio.

Note that although the indirect effect of the foreign exchange shock is higher compared to the indirect effect of the interest rate shock (the estimated decrease of the NPL ratio is more substantial for the exchange rate shock), the total impact on the capital adequacy ratio is higher for the interest rate shock. This is caused by the direct effect of the interest rate shock due to the relatively significant open interest rate position mainly in the banking book of the banks, whereas the foreign exchange rate position is almost closed.

Finally, we have stress-tested the growth of Slovak economy, which was quite strong in 2006. In Scenario 3, we assumed the slowdown in the year 2007. Without considering other risk factors, its effect is significant and some banks might suffer from substantial credit losses. Scenarios 4 and 5 take into account also change in interest rates and exchange rates, hence the results can be considered to be more realistic. Scenario 5 is based on the long-run historical relationship and short-term dynamics between the risk factors. On the other hand, Scenario 4 studies not only the slowdown of Slovak economy, but also shock in interest rates and exchange rate which is purely hypothetical, assuming breakdown of the historical relationship. In one-year horizon, the effect of both scenarios on the quality of the credit portfolio is similar. However, this is not true in longer horizon as the expansionary monetary policy considered in Scenario 5 improves the financial situation of debtors by decreasing of loan installments and supporting of investment and unemployment growth. In one-year horizon, the difference between estimated impacts of Scenario 4 and Scenario 5 on banking sector is caused mainly by interest rate risk. As we have mentioned earlier, the direct effect of interest rate risk is that increasing of interest rates has negative impact on banks. Therefore the impact of Scenario 5 is less negative. We should bear in mind, however, that these losses or profit of interest rate change, however, will only materialize in the profit and loss account only gradually in longer time horizon.

9 Conclusion

The aim of this paper was to describe the relationship between macroeconomic variables and the quality of loan portfolio in the Slovak banking sector. Real GDP, exchange rate SKK/EUR and 3-month BRIBOR were identified as the most important variables. We have presented different types of models that allow us to stress test the capital adequacy of banking sector using three different types of scenarios. Moreover, the set of variables that seems to be most important to explain the movement in the quality of credit portfolio, allows us to link the credit and market risk in the macroeconomic stress testing.

The results suggest that a temporary, although significant slowdown of the GDP growth would not substantially threaten the Slovak banking sector provided that the response of the monetary policy would be adequate. This monetary policy would have positive effect on the quality of the credit portfolio by mitigating the recession. In addition, the decrease in interest rates diminishes the debt burden of debtors with loans with short-term fixation interest rate. Finally, given the current portfolio of the Slovak banking sector, this monetary policy would have positive impact on Slovak banking sector also by direct increase of real value of

this portfolio, mainly through the interest rate channel. Nevertheless, the shocks in GDP growth that would be left without relevant response in other factors might represent more noticeable threat. Moreover, the significance of indirect impact via possible worsening of financial situation of debtors has been shown regarding the exposure of the Slovak banking sector towards interest rate risk and foreign currency risk. Whereas the impact of the interest rates would be realized via the direct channels in greater extend, the indirect channel is more important regarding the exchange rate shock. It is a consequence of the high openness of the Slovak economy.

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Appendix

Unit root tests

Table 11 Augmented Dickey-Fuller unit root test

Exogenous variables	None	Constant	Constant and linear trend
NPL	0.35	0.88	0.08
BRIBOR_3M	0.42	0.80	0.39
GDP_real	0.57	0.41	0.61
Ln(*GDP_real*)	0.91	1.00	0.94
SKK_EUR	0.69	0.32	0.85
Ln(*SKK_EUR*)	0.73	0.29	0.84

Source: NBS, own calculations.
Notes: Null hypothesis: No unit root.
The data in the table represent p-values of the ADF test statistics.
The number of lags of the difference term was selected automatically based on Schwartz information criterion, with maximum lags 10.
The p-value of the ADF statistics for differentiated variables is less than 0.03.

Bivariate regression models

Table 12 Bivariate regression model for 3-month BRIBOR

Dependent variable: ΔNPL_t			
	Coefficient	*t*-Statistic	*p*-value
Constant	-0.006	-0.987	0.331
ΔNPL_{t-1}	0.751	4.369	0.000
ΔNPL_{t-2}	-0.241	-3.804	0.001
$\Delta BRIBOR\_3M_{t-5}$	0.003	2.727	0.010
Dummy_1999Q4_single	-0.130	-4.750	0.000
Dummy_2000Q3_single	-0.120	-3.624	0.001

Source: NBS, own calculations.
Notes: *Dummy*_1999*Q*4*_single* has value 1 in 4th quarter of 1999, 0 elsewhere
*Dummy*_2000*Q*3*_single* has value 1 in 3rd quarter of 2000, 0 elsewhere
Estimation method: Least squares with Newey-West HAC covariance matrix
Sample (adjusted): 1997, 4th quarter – 2006, 4th quarter (37 observations)
Adjusted R^2: 0.79

Table 13 Bivariate regression model for exchange rate SKK / EUR

Dependent variable: ΔNPL_t			
	Coefficient	*t*-Statistic	*p*-value
ΔNPL_{t-1}	0.828	10.550	0.000
ΔSKK_EUR_{t-3}	-0.004	-4.339	0.000

Source: NBS, own calculations.
Notes: Estimation method: Least squares with Newey-West HAC covariance matrix
Sample (adjusted): 1995, 2nd quarter – 2006, 4th quarter (47 observations)
Adjusted R^2: 0.66

Table 14 Bivariate regression model for real GDP

Dependent variable: ΔNPL_t			
	Coefficient	*t*-Statistic	*p*-value
ΔNPL_{t-1}	0.385	2.954	0.006
ΔGDP_real_t	-0.005	-2.233	0.032
*Dummy*_1999*Q*4_*single*	-0.178	-5.628	0.000
*Dummy*_2000*Q*1	-0.129	-3.468	0.001
*Dummy*_2000*Q*3	0.140	3.773	0.001
*Dummy*_2000*Q*3_*single*	-0.177	-5.453	0.000
AR(1) term	0.492	2.633	0.012

Source: NBS, own calculations.
Notes: *Dummy*_1999*Q*4_*single* has value 1 in 4th quarter of 1999, 0 elsewhere
*Dummy*_2000*Q*1 has values 1 since 1st quarter of 2000, 0 elsewhere
*Dummy*_2000*Q*3 has values 1 since 3rd quarter of 2000, 0 elsewhere
*Dummy*_2000*Q*3_*single* has value 1 in 3rd quarter of 2000, 0 elsewhere
Estimation method: Least squares with Newey-West HAC covariance matrix
Sample (adjusted): 1996, 2nd quarter – 2006, 4th quarter (43 observations)
Adjusted R^2: 0.80

Multivariate regression model

Table 15 Multivariate regression model - details

Dependent variable: ΔNPL_t			
	Coefficient	*t*-Statistic	p-value
Constant	0.0306	2.7840	0.0087
ΔNPL_{t-1}	0.6779	5.4188	0.0000
ΔGDP_real_t	-0.0082	-3.4394	0.0016
$\Delta BRIBOR\_3M_{t-1}$	0.0015	1.8527	0.0726
ΔSKK_EUR_{t-3}	-0.0104	-2.8256	0.0078
Dummy_2000Q3_single	-0.1218	-4.1453	0.0002
Dummy_1999Q4_single	-0.1239	-4.4721	0.0001

Source: NBS, own calculations.
Notes: *Dummy*_2000*Q*3_*single* has value 1 in 3rd quarter of 2000, 0 elsewhere
*Dummy*_1999*Q*4_*single* has value 1 in 4th quarter of 1999, 0 elsewhere
Estimation method: Least squares with White-consistent covariance matrix
Sample (adjusted): 1996, 4th quarter – 2006, 4th quarter (41 observations)
Adjusted R^2: 0.84

Table 16 Testing of autocorrelation in residuals

Order of autocorrelation (*k*)	1	2	3	4	5	6
Ljung-Box Q-statistics	0.01	0.63	0.98	1.13	1.66	1.66
p-values	0.92	0.73	0.81	0.89	0.89	0.95
Breusch-Godfrey statistics	0.02	0.87	1.96	2.98	4.53	4.85
p-values	0.90	0.65	0.58	0.56	0.48	0.56

Source: NBS, own calculations.
Notes: Null hypothesis: No autocorrelation up to order *k*.
All p-values are greater than 0.05, hence the null hypothesis cannot be rejected on confidence level 5%.
The p-values are adjusted for the lag of the dependent variable included in the regression equation.

Vector error correction model

Cointegrating equation (*t*-statistics in []):

$$NPL_{t-1} = 9.50 - 0.602\ \mathrm{Ln}(GDP\_real_{t-1}) + 0.009\ BRIBOR\_3M_{t-1} - 0.517\ \mathrm{Ln}(SKK\_EUR)_{t-1}$$
$$[6.090] \qquad [-5.132] \qquad [3.303]$$

Table 17 Short-term dynamics of the vector error correction model

	ΔNPL_t	$\Delta \mathrm{Ln}(GDP\_real)_t$	$\Delta BRIBOR\_3M_t$	$\Delta \mathrm{Ln}(SKK\_EUR)_t$
Residuals from cointegrating equation	-0.514 [-6.562]	-0.008 [-0.059]	2.207 [0.363]	-0.157 [-1.823]
ΔNPL_{t-1}	-0.219 [-1.930]	0.378 [1.895]	15.284 [1.733]	0.106 [0.848]
ΔNPL_{t-2}	0.056 [0.480]	-0.101 [-0.490]	-9.022 [-0.990]	-0.017 [-0.132]
$\Delta \mathrm{Ln}(GDP\_real)_{t-1}$	0.090 [1.089]	-0.230 [-1.591]	15.597 [2.439]	0.026 [0.291]
$\Delta \mathrm{Ln}(GDP\_real)_{t-2}$	-0.146 [-1.936]	-0.607 [-4.587]	0.310 [0.053]	-0.085 [-1.021]
$\Delta BRIBOR\_3M_{t-1}$	0.001 [0.484]	-0.001 [-0.135]	0.351 [2.050]	-0.001 [-0.374]
$\Delta BRIBOR\_3M_{t-2}$	-0.006 [-2.923]	0.001 [0.27]	0.021 [0.124]	-0.005 [-2.035]
$\Delta \mathrm{Ln}(SKK\_EUR)_{t-1}$	0.673 [4.042]	-0.330 [-1.129]	-33.810 [-2.616]	0.185 [1.012]
$\Delta \mathrm{Ln}(SKK\_EUR)_{t-2}$	0.703 [3.116]	-0.307 [-0.773]	-1.231 [-0.07]	0.272 [1.097]
Constant	-0.008 [-1.898]	0.023 [3.181]	-0.278 [-0.883]	-0.001 [-0.212]
Adjusted R^2	0.59	0.44	0.25	0.03
F-statistic	7.68	4.60	2.58	1.14
Akaike criterion	-4.59	-3.46	4.12	-4.40
Schwarz criterion	-4.18	-3.05	4.53	-3.99

Source: NBS, own calculations.
Notes: *t*-statistics in [ ].
Sample (adjusted): 1996, 2nd quarter – 2006, 4th quarter (43 observations)

Table 18 Cointegration tests for the vector error correction model

Number of cointegrating equations (null hypothesis)	Eigenvalue	Trace statistics	Maximum eigenvalue statistics
None	0.63	66.93	42.57
		[0.00]	[0.00]
At most 1	0.34	24.35	17.59
		[0.19]	[0.15]
At most 2	0.14	6.77	6.52
		[0.60]	[0.55]
At most 3	0.01	0.25	0.25
		[0.62]	[0.62]

Source: NBS, own calculations.
Notes: p-values in [ ].
Both trace and maximum eigenvalue test indicate 1 cointegrating equation.

Table 19 Granger causality test for the vector error correction model

Variable	Δ *NPL*	Δ Ln(*GDP_real*)	Δ *BRIBOR_3M*	Δ Ln(*SKK_EUR*)
Chi-square stat.	35.47	6.47	19.10	7.98
p-value	0.00	0.37	0.00	0.24
Conclusion	endogenous	exogenous	endogenous	exogenous

Source: NBS, own calculations.
Notes: Null hypothesis: The given variable is exogenous.
The null hypothesis is rejected if p-value is less than 0.05.