NÁRODNÁ BANKA SLOVENSKA

EUROSYSTEM

Annexes to the Analysis of the Slovak Financial Sector

2016

Contents

1. Methodology of risk measurement and stress testing

1.1 Calculation of Value at Risk (VaR) for market risks

The VaR methodology is based on the estimation of the statistical distribution of possible gains or losses in the current portfolio. A quantile is then selected at a given confidence level (e.g. 99%), which represents the loss that the portfolio should not exceed within a given time period and with the given probability.

An assumption of the VaR calculation is that the distribution of market changes may be estimated using a normal distribution with a time-varying covariance matrix. For modelling changes in volatilities, it is assumed that the volatility, σ^2, of changes in market factor i at time t is affected by the volatility at time $t-1$ and by the value of the change, ε, in the market factor at time t, as follows:

$$r_t = c_1 + \varepsilon_t, \quad \varepsilon_t \sim N(0, \sigma_t^2)$$
$$\sigma_t^2 = \omega + \beta\sigma_{t-1}^2 + \alpha\varepsilon_t^2$$

This volatility calculation can be treated as a calculation with exponentially declining weights on historical changes in market factors. Correlations are modelled analogously. On the basis of this model the covariance matrix for a given day is calculated. This estimation method for the covariance matrix of market factor changes is relatively flexible in responding to changes in financial market volatility, which is the main advantage of this VaR approach. The VaR is then calculated using Monte Carlo simulations of 500 scenarios generated from a multivariate normal distribution with the estimated covariance matrix.

The model used to estimate parameters α_i and β_i is a multivariate BEKK-GARCH(1,1). It includes the following equation for the estimation of covariance matrix Σ_t:

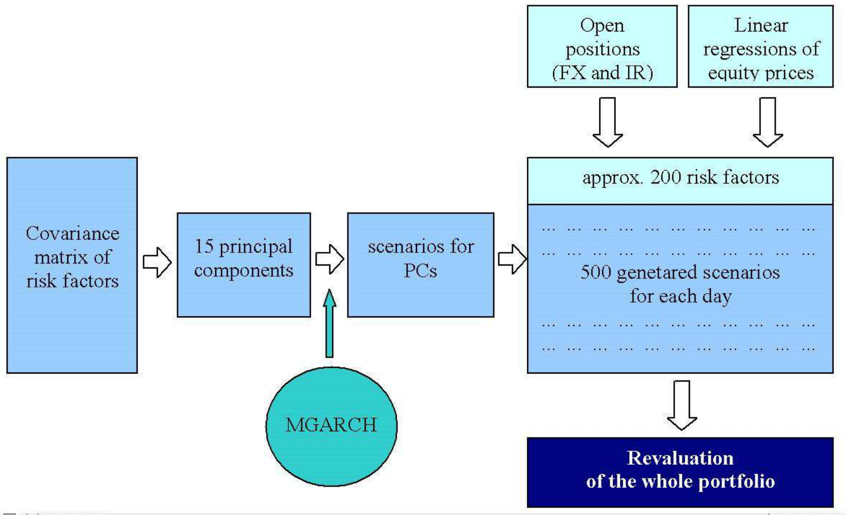
$$\Sigma_t = C^T C + A^T \Sigma_{t-1} A + B^T \varepsilon_t \varepsilon_t^T B,$$

where *A*, *B* and *C* are square matrices of parameters, with *C* being an upper triangular matrix.

Since approximately 200 market factors are used in the calculation, the dimension is reduced using the method of principal component analysis. The multivariate GARCH model is estimated only for the 15 main principal components, and the covariance matrix obtained is then transformed back to the original market factors. For investments in equities and investment fund shares/units, the exposure to each market factor is first estimated using linear regressions.

The following chart illustrates how the VaR for market risks is calculated:

Scheme 1 Calculation of VaR for market risks



- Source: NBS.

1.2 Calculation of credit risk

Regarding credit risk, the models focus on a worsening of the global economy and the effect of this worsening on NFCs loans and household loans. Since loans to these sectors have different properties and different data sources for the calculation of credit risk, two different approaches are used for the calculations.

Corporate credit risk

The estimation of corporate credit risk for the banking sector is based on data from the credit register. Time series of annual default rates of NFC loans are constructed for 18 business sectors for the period from 2000Q3, using quarterly data on the number of non-performing loans and the total number of loans provided. The annual default rate is calculated 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_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 provided in sector i during the quarters $t-3$ to t (the average number of loans provided in a one-year period ending with quarter t). Since the relatively short length of the time series makes it ineffective to work with 18 sectors, the sectors are split into three categories based on their sensitivity to the business cycle. This categorisation is based on economic theory and on a simple linear regression in the form

$$\Delta_{-4} ADR_{t,i} = \alpha_0 + \alpha_1 \Delta GDP\_g_{t-j} + dummy + \varepsilon_t ,$$

where $\Delta_{-4} ADR_{t,i} = ADR_{t,i} - ADR_{t-4,i}$ is the annual change in the default rate, $\Delta GDP\_g_{t-j} = GDP\_g_{t-j} - GDP\_g_{t-1-j}$ is the quarterly change in cumulative annual 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. The categorisation of sectors (as non-sensitive, sensitive, or very sensitive to the economic cycle) is summarised in Table 1.

Table 1 Categorisation of business sectors by sensitivity to the economic cycle

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

The aggregated data[1] on the annual default rate for each category are used for the modelling. The endogenous explanatory variables used to model the dependence of the annual default rate on macroeconomic factors are GDP growth (*GDP_g*), the inflation rate (*HICP*) and the interbank rate (*IBR* – the three-month BRIBOR or EURIBOR), and the exogenous explanatory variables are the NBS or ECB base 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 are entered in the model.

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

$$ADR_{i,t} = \frac{1}{1+e^{-y_{i,t}}}, \; i \in \{\text{non-sensitive sectors, sensitive sectors, very sensitive sectors}\}$$

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

$$\Delta_{-4} y_{t,i} = \beta_0 + \beta_{i,1}\Delta_{-4} y_{t-1,i} + \sum_{j=0}^{6} B_{i,t-j} X_{t-j} + dummy + u_{i,t},$$

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

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

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

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.

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

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

Estimates of the annual default rate of each category given fixed developments in the macroeconomic variables (their values being estimated on the basis of the given scenario, using NBS's structural macroeconomic model[2]) are 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 loans are subsequently used to calculate by bootstrapping the loss on 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 stock of non-performing loans is simulated 10,000 times for each scenario; the estimated stock of non-performing loans for each bank is the average stock of total non-performing loans for this bank across all simulations. The total loss on the stock of non-performing loans is

[1] The calculation method for the aggregated annual default rate is the same as for the calculation of the annual default rate for each business sector, i.e. the total number of newly defaulted loans is divided by the average number of loans provided in the given year.

[2] For a description of the macroeconomic model, see Reľovský, B. and Široká, J., "Štrukturálny model ekonomiky SR" (Structural model of the Slovak economy), Biatec, No 7, 2009, pp. 8-12.

calculated as the stock of non-performing loans less the assumed value of the collateral. 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).

Thus the 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.

Household credit risk

Quarterly time series of the non-performing loan (NPL) ratio for four types of loans – housing loans, consumer loans, current account overdrafts, and credit cards/other loans – are estimated using data from the beginning of 2006 and the Bayesian Model Averaging (BMA) method. The equations estimated using the least squares method has the form

$$\Delta NPL_{i,t} = \alpha + \rho_{i,1}\Delta NPL_{i,t-1} + \cdots + \rho_{i,p}\Delta NPL_{i,t-p} + \sum_{j=1}^{K} \left(\beta_{i,1}^{j} X_{i,t-1}^{j} + \cdots + \beta_{i,q}^{j} X_{i,t-q}^{j}\right) + \varepsilon_t$$

where index i is the loan type, ΔNPL is the quarterly change of the non-performing loan ratio and X contains a set of explanatory variables. The maximum number of lags is 4, with the optimal length of lags being chosen using the Bayesian information criterion. Equations are estimated individually for each of the loan categories. At any one time 2 to 4 four explanatory variables are included in the equations. The variables used are listed in Table 2. In the end, the estimated equations are weighted using the Bayesian information criterion.

Table 2 Explanatory variables used to estimate the NPL ratio time series

Real GDP	Year-on-year change in prices of flats
Real GDP growth	Average monthly wage (seasonally adjusted)
Nominal GDP	Rate of change in average monthly wage
Nominal GDP growth	Average real wage
Inflation (index)	Rate of change in average real wage
Year-on-year change in inflation	Interest rates on loans of a given type
Unemployment rate	1-month BRIBOR
Year-on-year change in unemployment	2-year Slovak government bonds
Property prices	Domestic credit-to-GDP$_{trend}$ gap
Year-on-year change in property prices	Average rate of change in the stock of loans over the last two years
Prices of flats	

For household credit risk, as with corporate credit risk, the stocks of each type of loans are estimated using an ex ante fixed time series of macroeconomic variables, which are calculated in accordance with the given scenario using NBS's structural macroeconomic model.

1.3 Calculation of interest rate risk

The following assumptions are used in modelling interest rate risk:

- Changes in the ECB key rate and changes in the credit spread approximated by a change in the 5-year iTraxx index are treated as the primary impulse of changes in interest rates. The model captures the lagged reaction of interbank interest rates and retail and corporate lending and deposit rates to changes in the above-mentioned variables and to the securities yield curve. This lagged reaction is modelled by estimating the short-run and long-run dynamics of interest rates using a vector error correction model (VECM).
- The aim of this approach is to approximate the actual impact on the profitability of the banking sector, especially on net interest income. In the case of loans and deposits the impact is modelled as a gradual change in profit generation vis-à-vis the baseline scenario over the selected time period through the modelling of interest income and interest costs.

The final estimate of the interest rate risk is therefore the sum of the expected loss (or profit) stemming from a shock in the form of a change in the ECB key rate or a change in the credit spread on the three most significant portfolios: loans and deposits, debt securities, and interest rate derivatives.

Interbank interest rates

Under this approach, it is first necessary to estimate the short-run and long-run dynamics of the gradual transmission of key interest rate movements to the interest rate curve (EURIBOR rates and zero coupon swap rates are estimated). The credit spread is approximated by the iTraxx Senior Financial index.

The movement of Europen interbank rates with a maturity of up to one year is estimated using an EC (error correction) model of the form

$$\Delta r_t = \alpha * CE + \delta_1 \Delta r_t^{ECB} + \delta_{2,1} \Delta r_{t-1}^{ECB\_up} + \delta_{2,2} \Delta r_{t-1}^{ECB\_down} + \sum_{i=1}^{n} \left(\gamma_i \Delta r_{t-1} + \varphi_i \Delta CDS_{t-i} \right) + \varepsilon_t ,$$

$$CE = \left(r_{t-1} + \beta_0 + \beta_1 E_{t-1}\left(r_t^{ECB}\right) + \beta_2 CDS_{t-1} + \beta_3 DUMMY \right)$$

where r_t is the modelled interest rate, r_t^{ECB} is the ECB key rate, CDS_t is the value of the iTraxx Senior Financial index, and ε_t is the random error. A dummy variable is included to capture the effects of non-standard operations conducted by the ECB in response to the financial crisis.

$E_{t-1}\left(r_t^{ECB}\right)$ is the expected level of the ECB key rate in the period *t-1* to *t*, assuming that $E_{t-1}\left(r_t^{ECB}\right) = r_t^{ECB} + u_t$, where u_t is white noise.

The expression CE represents the equilibrium relationship between the modelled interbank interest rate, the credit spread and the ECB key rate. The intercept β_1 represents the fraction of the expected change in the ECB key rate which is transmitted to the interbank rate in the long run. The intercept α represents the pace of the adjustment to the equilibrium state in the case of a deviation (i.e. if the interest rate is above the equilibrium level, a decline is expected). In order to capture any asymmetric response to an increase/decrease of the key rate, the time series of key rate movements is divided into two series: one capturing decreases in the key rate ($\Delta r_{t-1}^{ECB\_DOWN}$) and the other increases in the key rate ($\Delta r_{t-1}^{ECB\_UP}$). Coefficient β_3 is expected to have a positive sign, i.e. the ECB's non-standard operations are expected to cause a decline in interbank rates, particularly those with shorter maturities. The remaining terms are used to model the short-term dynamics. The number of lags, *n*, is optimally selected on the basis of statistical tests[3].

In the case of euro swap rates with a maturity of over one year, it is assumed that their level is affected by the ECB key rate $\left(r_t^{ECB}\right)$ and the credit risk premium $\left(RP_t\right)$, i.e. that they can be expressed in the form $r_t = \beta_1 r_t^{ECB} + RP_t$. It is further assumed that the credit risk premium is an unobservable variable which in the case of long-term rates is affected largely by expected developments in the euro area economy, meaning that its changes can to some extent be explained by expected developments in selected macroeconomic variables. Swap rates with maturities of one, three and ten years (the data for which have been available since February 1999) are estimated using a Kalman filter (or the state space model) of the form

signal equation:

$$\Delta r_t^i = \alpha^i\left(r_{t-1}^i - \beta_1^i r_{t-1}^{ECB} - RP_{t-1}^i\right) + \Delta r_{t-1}^i + \varepsilon_t^i$$

state equations:

$$RP_t^i = \delta_0^i + \delta_1^i RP_{t-1}^i + \delta_2^i \Delta HICP_{ti}^{EMU} + \delta_3^i GDP\_GAP_{ti}^{EMU} + u_t^i$$

$$\begin{pmatrix}\varepsilon_t \\ u_t\end{pmatrix} \sim N(0,\Sigma),\ \Sigma = \begin{bmatrix}\Sigma_\varepsilon & 0 \\ 0 & \Sigma_u\end{bmatrix},$$

where index *i* is the one-year, three-year or ten-year swap rate; index *ti* means, depending on the given maturity, *t* or *t+1*; $HICP_t^{EMU}$ is average euro area inflation measured by the HICP; $GDP\_GAP_t^{EMU}$ is the estimated average output gap of the euro area (expressed as the deviation of current annual GDP growth from potential annual growth estimated using an HP filter). The quarterly data on annual GDP growth are transformed into monthly data by means of cubic interpolation.

Retail interest rates

The modelling of deposit and lending rates is based on the assumption that a change in the ECB key rate is reflected first in the interbank interest rates and only subsequently in the retail rates. The rate selected in the VECM is therefore the EURIBOR rate (BRIBOR until the end of 2008) which, according to cointegration tests, is in long-run equilibrium with the respective deposit or lending rate.

In the case of loans, the cointegrating relationship includes a liquidity premium (*LP*) – which proved to be significant (after a sharp decline in short-term interbank rates), but only to a limited extent – and a dummy variable to capture the historically low levels of shorter-term interbank rates that result from the ECB's non-standard measures. The EC equation for lending rates is estimated in the form

$$\Delta r_t = \alpha\left(r_{t-1} + \beta_0 + \beta_1 r_{t-1}^K + \beta_2 LP_t + \beta_3 DUMMY\right) + \sum_{i=1}^{n}\left(\delta_i \Delta r_{t-i} + \gamma_i \Delta r_{t-i}^K + \varphi_i \Delta LP_{t-i}\right) + \varepsilon_t,$$

in the case that cointegration tests confirmed long-run equilibrium with some of the interbank rates (r^K).

[3] Based on several models, the value of *n* is chosen from 1 to 10 using the Schwarz information criterion, with testing for autocorrelation of the residuals in these models.

Interest rates on housing loans with a maturity of over five years are estimated using a panel regression with fixed effects. This estimation is based on individual data for the eight largest banks by share of the aggregate stock of this type of loan and on a common category for all other banks (not including home savings banks). The explanatory variables used are the lagged value of interest rates on housing loans with a maturity of over five years, each bank's share in the aggregate stock of housing loans of the given maturity (together with its lagged value), and the one-month EURIBOR/BRIBOR rate. Regression is estimated on the first differentials.

In the case of deposits, the cointegrating relationship includes the relevant interbank rate and a dummy variable to capture the historically low levels of shorter-term interbank rates that result from the ECB's non-standard measures. The EC equation for deposit rates is estimated in the form

$$\Delta r_t = \alpha\left(r_{t-1} + \beta_0 + \beta_1 r_{t-1}^K + \beta_2 DUMMY\right) + \sum_{i=1}^{n}\left(\delta_i \Delta r_{t-i} + \gamma_i \Delta r_{t-i}^K\right) + \varepsilon_t$$

The interpretation of the respective coefficients is the same as that applied to interbank rates:

- A general observation is that a change in the ECB key rate is transmitted by banks gradually, first into interbank rates and only subsequently into deposit and lending rates for NFCs and households. The changes are not transmitted in full, and the speed of adjustment to the long-run equilibrium is lower than for interbank rates.
- Looking at deposit and lending rates for NFCs in comparison with those for households, they are affected to a greater extent by changes in the ECB key rate and they adjust more quickly to the long-run equilibrium. This may be explained by the stronger competition in the corporate sector.

Table 3 Types of loans and deposits for which interest rates are estimated

Loans	**Deposits**
Non-financial corporations	
Current account overdrafts	Sight deposits
Real estate loans with a maturity of up to 1 year	Overnight deposits
Real estate loans with a maturity of between 1 and 5 years	Deposits with an agreed maturity of up to 7 days
Real estate loans with a maturity of over 5 years	Deposits with an agreed maturity of up to 1 year
Other loans with a maturity up to 1 year	Deposits with an agreed maturity of up to 2 years
Other loans with a maturity of between 1 and 5 years	Deposits with an agreed maturity of up to 5 years
Other loans with a maturity of over 5 years	Deposits with an agreed maturity of over 5 years
	Savings deposits
Households	
Credit cards	Sight deposits
Current account overdrafts	Overnight deposits
Housing loans with a maturity of up to 1 year	Deposits with an agreed maturity of up to 7 days
Housing loans with a maturity of between 1 and 5 years	Deposits with an agreed maturity of up to 1 year
Housing loans with a maturity of over 5 years	Deposits with an agreed maturity of up to 2 years
Consumer loans with a maturity up to 1 year	Deposits with an agreed maturity of up to 5 years
Consumer loans with a maturity of between 1 and 5 years	Deposits with an agreed maturity of over 5 years
Consumer loans with a maturity of over 5 years	Savings deposits
Other loans with a maturity of up to 1 year	
Other loans with a maturity of between 1 and 5 years	
Other loans with a maturity of over 5 years	

Loans and deposits

When estimating the impact of a shock on the reported profit/loss on the portfolio of loans and deposits, it is assumed that banks do not revalue these products to fair value (as they are held to maturity) and that the impact materialises only gradually in the accounting profit or loss through the longer-term impact on net interest income. The procedure used to assess the impact of an interest rate shock is as follows:

- The short-run and long-run dynamics of the transmission of ECB key rate movements to the interest rate curve (BRIBOR/EURIBOR rates and zero coupon swap rates) and subsequently to lending and deposit rates (classified by contractual maturity) are estimated using a VECM.
- Using this model, the movement of each type of interest rate is then estimated for the selected scenario of developments in the ECB key rate and the iTraxx index.
- The stocks of deposits are modelled as autoregressive processes with a trend and/or an intercept.
- Information about the estimated stocks of retail loans and NFC loans can be found below.
- The stocks of interbank loans and deposits are set so that each bank in each quarter has an equal stock of assets and liabilities, assuming these to be short-term operations charged or remunerated at the monthly EURIBOR rate.
- Using the estimated interest rates and stocks of deposits and loans, it is possible to calculate the impact of an interest rate shock on the change in interest income and interest expenses during the given time period.

Estimated stock of NFC loans

The stock of loans provided to the NFC sector is estimated using an EC model. This estimation is based on the stock of NFC loans provided by domestic banks since 2004Q4, excluding firms that have outstanding loans of more than €400 million in any one quarter. Thus the model is adjusted for the largest firms, whose decisions in the area of borrowing are most difficult to predict. For such firms, it is assumed that they do not default on their loans during the stress test period and that the nominal value of their loans remains constant. The estimated EC model has the form

$$\Delta ACL_t = \alpha(ACL_{t-1} + \beta_0 + \beta_1 GDP\_nom_{t-1} + \beta_2 EURIBOR3M_{t-1} + \beta_3 SPREAD10Y_{t-1}) + SD + \epsilon_t$$

where ACL represents the adjusted corporate loans, GDP_nom is nominal GDP, $EURIBOR3M$ is the three-month EURIBOR, and $SPREAD10Y$ is the spread between ten-year Slovak and German government bonds. The seasonally-adjusted nominal stock of loans and GDP are entered in the regression as logarithms.

Estimated stock of retail loans

Three types of household loans are estimated: housing loans, consumer loans and other loans. The overall stock is divided into these categories due to each category having a different sensitivity to individual macroeconomic variables. Quarterly data from 2004Q1 are used for the estimation. An EC equation is used to estimate each of the three categories, while a long-term relationship is assumed between the stock of loans and the macroeconomic variables. The estimated EC equation for housing loans has the form

$$\Delta HL_{AC,t} = \alpha\left(HL_{AC,t-1} + \beta_0 + \beta_1 GDP_{AC,t-1} + \beta_2 PP_{AC,t-1} + \beta_3 HICP_{t-1}\right) + SD + \varepsilon_t ,$$

where HL_{AC} is the annual percentage change in housing loans, GDP_{AC} is the annual percentage change in seasonally adjusted real GDP, PP_{AC} is the annual percentage change in property prices, $HICP$ is the rate of inflation, SD is the effect of short-run dynamics, and ε are residuals. The short-run effects include the effect of movements in housing loan interest rates.

The estimated EC equation for consumer loans is

$$\Delta CL_{AC,t} = \alpha\left(CL_{AC,t-1} + \beta_0 + \beta_1 CLIR_{AC,t-1} + \beta_2 UR_{AC,t-1} + \beta_3 HICP_{t-1}\right) + SD + \varepsilon_t ,$$

where CL_{AC} is the annual percentage change in consumer loans, $CLIR_{AC}$ is the annual percentage change in consumer loan interest rates, and UR_{AC} is the annual percentage change in the unemployment rate.

The estimated EC equation for other loans is

$$\Delta OL_{AC,t} = \alpha\left(OL_{t-1} + \beta_0 + \beta_1 UR_{AC,t-1} + \beta_2 GDP_{AC,t-1}\right) + SD + \varepsilon_t ,$$

where OL_{AC} is the annual percentage change in other loans provided to the household sector. The short-run effects included the effect of movements in interest rates on other loans.

In order to take account of methodological changes made during the period for which the equations are estimated, each equation includes a dummy variable.

Debt securities

The calculation of the impact of interest rate risk is based on detailed data about the securities held in banks' portfolios, including their classification into different types of portfolio (fair valued through profit and loss, available for sale, held to maturity). Securities are revalued on the basis of a discount curve estimated using EC models, similarly to how the deposit and lending rates are estimated. Since, however, the revaluation of debt securities available for sale and held to maturity does not affect the profit or loss reported while the securities are held, the only securities taken into consideration are those fair valued through profit and loss or through equity.

In the case of mortgage bonds, it is assumed that the amount of mortgage bonds issued during the stressed period does not change and that maturing bonds will be replaced with bonds of identical parameters. These bonds are not fair valued; the effect of their issuance on banks is confined to interest expenses in the form of coupon payments.

As regards floating coupon bonds, the coupon rate is always fixed at the beginning of the coupon period. When the coupon is paid, the value for the new period is fixed.

1.4 Stress test assumptions and parameters

Since stress testing concerns the estimation of potential future developments, it is necessary to introduce several simplifying assumptions in the estimation of different components of net profit and in the estimation of risk-weighted assets. The most important assumptions are as follows:

- Losses on the corporate loan portfolio are estimated using data obtained from the Register of Bank Loans and Guarantees. Firstly, the stock of non-performing loans in the portfolio as at 31 December 2016 is estimated using Monte Carlo simulations. This estimation takes into account the collateral used in each loan, and this collateral is divided into two categories: collateral whose value is assumed not to decline in any scenario (mostly third-party guarantees), and collateral whose value is assumed to decline by 0% in the baseline scenario, 15% in scenario 1 and 30% in scenario 2 (e.g. collateral in the form of real estate or blank bills). Finally, the estimated losses are calibrated so that the total amount of NFC loans corresponds to the estimated value as at the end of 2017 and 2018.
- In estimating the loss on the household loan portfolio, the banking sector's share of the stock of non-performing loans is estimated. Furthermore the stock of NPLs in each bank as a ratio to the total stock of NPLs in the banking sector is assumed to remain constant over the two-year stress test period and at the same level as at the end of 2016. The last assumption is necessary for determining the final loss on the estimated stock of non-performing loans: as 20% of the stock of non-performing housing loans and 80% of the stock of other non-performing loans.
- For banks, the debt securities portfolio is a source of coupon income and interest income/expenses from the amortisation of securities (including those in the held-to-maturity/HTM portfolio). The revaluation of debt securities in other portfolios (held-for-trading/HFT and available-for-sale/AFS) is reflected in the banking sector's profitability or in its level of own funds. The debt securities portfolio used in the stress testing is the portfolio as at 31 December 2016; it is assumed that the portfolio does not change during the stress test period, i.e. that maturing securities will be replaced with securities whose duration matches that of the overall securities portfolio of the given bank. The estimation of interest income does not take account of the amortisation of securities held in the HTM portfolio, but only the coupon income. As regards the revaluation of debt securities, it affects either the income statement or, directly, own funds depending on whether the securities are in the HFT portfolio or the AFS portfolio.
- For issued debt securities, the portfolio as at 31 December 2016 is taken as the basis. It is assumed that the portfolio in each bank does not change and that any maturing securities will be replaced with securities of identical parameters.
- In the case of equity and foreign exchange risk, it is assumed that the portfolios of each bank remains constant during the stress test period and that the profit or loss will be affected only by changes in market factors. Equity risk does not include shares held by banks as participating interests (eg. insurance companies or intragroup asset management).
- A more detailed description of the estimation method for net interest income from the portfolio of retail loans and deposits is given in section 1.3.
- As for other profit/loss items not estimated by the model, it is assumed that their value remains constant during each year of the stress test period and at the same level as at 31 December 2016, and that it is adjusted to take account of one-off effects. It is further assumed that the net profit will be 80% of the gross profit and that the bank tax will be set at the current level throughout the stress test period. It is assumed that banks ending the year with a loss reduced their equity by the total amount of the reported loss, while the profit-making banks retain earnings in a proportion based on the dividend policy applied in the previous three years.

- The estimation of the banks' total risk exposure is based on data as at 31 December 2016. In the baseline scenario, first the amount of risk exposures is adjusted for NFC and retail loans under the assumption of no change in the share of risk exposure amount in the amount of these two types of loans. Other categories of risk exposures remain constant at the level of 31 December 2016. Subsequently, on the basis of back-testing results, the total amount of risk exposure is adjusted (reduced) by 5% for 2017 and by 10% for 2018. As for the adverse scenarios, the amount of risk exposure is adjusted according to the results of a comparison of top-down and bottom-up stress tests. In scenario 1, the increase in the amount of risk exposure in 2017 and 2018 is assumed to be 6%, while in scenario 2 it is assumed to be 8%.
- The assumptions for specific macroeconomic variables and financial indices, as well as the outputs of the model estimates, are shown in Table 4.

Table 4 Stress testing parameters

			Baseline scenario		Scenario 1		Scenario 2	
			2017	2018	2017	2018	2017	2018
Baseline assumptions	Change in external demand		4%	4%	-19%	6%	-26%	-19%
	Change in EUR/USD exchange rate		-3%	0%	-3%	0%	-15%	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		0 b.p.	0 b.p.	0 b.p.	0 b.p.	0 b.p.	0 b.p.
	Change in the 3-month EURIBOR		9 b.p.	10 b.p.	-2 b.p.	0 b.p.	-2 b.p.	-1 b.p.
	Change in 1-year discount rate (EUR)		12 b.p.	11 b.p.	6 b.p.	0 b.p.	17 b.p.	1 b.p.
	Change in 2-year discount rate (EUR)		15 b.p.	10 b.p.	9 b.p.	0 b.p.	19 b.p.	1 b.p.
	Change in 5-year discount rate (EUR)		17 b.p.	7 b.p.	13 b.p.	-1 b.p.	19 b.p.	3 b.p.
	Change in the 5-year iTraxx Senior Financials index		0 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		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		3.09%	4.22%	-3.67%	-1.40%	-6.33%	-8.82%
	Average annual inflation		1.20%	1.91%	0.84%	0.23%	0.06%	-0.39%
	Unemployment		8.5%	7.9%	10.9%	11.8%	11.8%	15.3%
Credit risk variables estimated using macroeconomic variables	Annual probability of default	Non-sensitive sectors	1.70%	1.53%	1.80%	2.14%	1.83%	2.63%
		Less sensitive sectors	1.89%	1.56%	2.47%	3.52%	2.49%	4.05%
		Sensitive sectors	4.22%	4.01%	5.07%	8.28%	4.99%	9.67%
	Non-performing loan ratio for household housing loans		2.29%	2.29%	2.58%	3.03%	2.75%	3.67%
	Non-performing loan ratio for other household loans		9.63%	10.93%	10.58%	12.81%	11.23%	14.63%

2. Methodology of data gathering and indicator calculations

B 1 Banks and branches of foreign banks

B 1.1 Asset and liability structure of banks and branches of foreign banks

All assets are reported at gross value, i.e. not adjusted by provisions.

The category "Interbank market transactions in total" includes not only deposits with and loans to central banks and other banks, but also purchases of NBS bills, Treasury bills, and bills of exchange.

Data source:

Item	Source statement from STATUS
Retail loans	V (NBS) 33 – 12
Interbank market transactions	Bil (NBS) 1 – 12
Securities	V (NBS) 8 – 12, (NBS) Bil 1 – 12
Deposits and received loans	V (NBS) 5 – 12
Funds from banks	Bil (NBS) 1 – 12
Securities issued	Bil (NBS) 1 – 12
Risk-weighted assets	BD (PVZ) 20 – 12
Own funds	BD (HVZ) 19 – 12

Comments on the calculation of concentration indices:

CR3 index – the share of three banks with the largest stock of the given item in the total stock of the given item in the banking sector, including only those institutions in which the item has a positive value;

CR5 index – the share of five banks with the largest stock of the given item in the total stock of the given item in the banking sector, including only those institutions in which the item has a positive value;

Herfindahl index (*HHI*) – an index representing the sum of the squares of each bank's percentage share in the total stock of the given item, with the calculation including only those institutions in which the item has a positive value.

As regards interpretation of the *HHI* value, the concentration in a given item would, for example, be the same if there were 10,000 / *HHI* institutions in the sector each having the same stock of the given item. According to the definition of the US Department of Justice, a market is considered highly concentrated if the *HHI* value exceeds 1,800 and non-concentrated if it is less than 1,000.

B 1.2 Revenue and expenditures of banks and branches of foreign banks

Comments on selected items:

Net income from trading includes net income from transactions in securities (except for interest income), net income from forex transactions, and net income from transactions in derivatives.

Other net operating income includes net income from assigned claims, from transfers of tangible and intangible assets, from the share in profits generated on shares and deposits in equivalence, from transfers of shares and deposits, and from other operations, and other net operating income.

The source of data is the report Bil (NBS) 2 – 12.

B 1.3 Profitability indicators of banks and branches of foreign banks and their distribution in the banking sector

Calculation of the relevant indicators:

- *ROA* = return on assets – the ratio of cumulative net profit to average net assets (Source: Bil (NBS) 2 – 12, Bil (NBS) 1 – 12);
- *ROE* = return on equity – the ratio of cumulative net profit to average own funds; the calculation does not include branches (Source: Bil (NBS) 2 – 12, BD (HVZ) 19 – 12);
- *Cost-to-income ratio* = the ratio of cumulative operating costs to the cumulative total of net interest and non-interest income ratio (Source: Bil (NBS) 2 –12);
- *Relative significance of interest income* = the ratio of cumulative net interest income to the cumulative total of net interest and non-interest income (Source: Bil (NBS) 2 –12);
- *Net interest rate spread* = the difference between, on the one hand, the ratio of cumulative revenues (interest and non-interest) other than interest revenues from non-performing assets to the outstanding amount of loans provided to a given counterparty, and, on the other hand, the ratio of cumulative expenses to the outstanding amount of deposits held with that counterparty (Source: V (NBS) 13 – 04);
- *Net interest margin* = the ratio of net interest income less interest income from non-performing assets to the average value of net assets (Source: Bil (NBS) 2 – 12, Bil (NBS) 1 – 12);

The minimum, lower quartile, median, upper quartile, and maximum values indicate the distribution of the values of the given indicator in the banking sector. The lower quartile marks the lower 25% of the indicator values, meaning that one-quarter of all the banks (expressed by numbers) report a value for the indicator that is equal to or less than the lower quartile. The median is the middlemost value, meaning that half of all banks report a value that is equal to or greater than the median and half report a value that is equal to or less than the median. Finally, the upper quartile marks the upper 25% of the indicator values, meaning that three-quarters of all banks report a value that is equal to or less than the upper quartile. Since each bank's size is not a factor in this distribution, it is stated in brackets as a percentage share. For example, the number below the first quartile represents the share of the banks (measured by volume of assets) whose value for the given indicator lies in a closed interval between the minimum and lower quartile values. Similarly, the value below the median represents the share of banks whose value for the given ratio lies in an interval (closed from the right) between the lower quartile and median values.

B 1.4 Risk and capital adequacy indicators of banks and branches of foreign banks and their distribution in the banking sector

Calculation of the relevant indicators:

- *NPL ratio for retail loans* = the stock of non-performing retail loans as a share of the stock of retail loans (Source: V (NBS) 33 – 12);
- *Ratio of provisions to NPLs* = the ratio of loan loss provisions to the stock of non-performing loans (Source: BD (ZPZ) 1 – 04);
- *Large exposures (weighted) / own funds* = the ratio of weighted large exposures to own funds; the ratio must not exceed 800% according to the Banking Act (Act No 483/2001 Coll. Article 33e(2)) and it does not concern branches of foreign banks (Source: BD (HMA) 8 – 12, part BazilejII_C);
- *Large intragroup exposures* – this indicator monitors as at the end of each month the number of breaches of limits laid down in the Banking Act (Act No 483/2001 Coll. Article 33e(1)(b)), and it

does not concern branches of foreign banks (Source: BD (HMA) 8 – 12, part BazilejII_A and BazilejII_B);

- *Ratio of the claimable value of collateral to the stock of non-performing loans to customers* – this indicator does not include banks that pursuant to NBS Decree No 6/2009 have not classified claims due to having made provisions on a portfolio basis in accordance with International Accounting Standards (Source: BD (ZPZ) 1 – 04);
- *Open foreign exchange position in the balance sheet / own funds* = the ratio to own funds of the difference between assets and liabilities held in a foreign currency (Source: Bil (NBS) 1 – 12);
- *Open foreign exchange open position in the off-balance sheet / own funds* = the ratio to own funds of the difference between off-balance-sheet assets and liabilities (not including redistribution and registration accounts and claims/payables arising from entrusted assets) held in a foreign currency (Source: Bil (NBS) 1 – 12);
- *Overall open foreign exchange position / own funds* = the ratio to own funds of the sum of foreign exchange open positions in the balance sheet and off-balance sheet; a positive value for the foreign exchange position indicates a risk of a loss from any appreciation of the domestic currency (Source: Bil (NBS) 1 – 12);
- *Change in the economic value of the trading book/total balance sheet excluding/including interest rate derivatives / own funds (excluding branches)* = the ratio to own funds of a change in the economic value of the trading book/total balance sheet (excluding/including interest rate derivatives) in the event of an immediate parallel upward shift of all interest rates by 100 basis points. "Economic value" means the difference between the fair value of interest rate-sensitive assets recorded in the banking book and the fair value of interest rate-sensitive liabilities recorded in the banking book. Interest rate-sensitive assets and interest rate-sensitive liabilities are assets and liabilities whose fair value varies according to changes in market interest rates;
- *Overall open interest-rate position / own funds* = the ratio to own funds of the difference between assets plus liabilities and net positions calculated from underlying instruments and from transactions in fixed interest derivatives or derivatives with a residual maturity shorter than the given time period (1 month, 1 year, 5 years) (Source: BD (HUC) 53 – 04, BD (HVZ) 19 – 12);
- *Liquid asset ratio* = the ratio of liquid assets to volatile funds. Under Article 13 of NBS Decree No 18/2008 as amended, this ratio may not fall below 1;
- *Ratio of quick assets to highly volatile funds:* quick assets include cash, NBS bills and Treasury bills not held to maturity, and current account balances at central banks and other banks. Highly volatile funds include current accounts of central and other banks, current accounts and other sight deposits of customers, and all general government deposits (Source: Bil (NBS) 1 – 12);
- *Ratio of liquid assets (including collateral from reverse repo transactions) to volatile funds:* liquid assets other than quick assets include securities received from reverse repo transactions, Treasury bills held to maturity and all government bond holdings; their value is reduced, however, by securities pledged and collateral provided in repo transactions. Volatile funds include customers' term deposits (Source: Bil (NBS) 1 – 12, V (NBS) 8 –12);
- *Fixed and illiquid assets ratio* = the ratio of fixed and illiquid assets to selected liability items (it does not concern branches of foreign banks). Under Article 13 of NBS Decree No 18/2008 as amended, this ratio may not exceed 1 (Source: BD (LIK) 3 – 12);
- *Ratio of loans to deposits and securities issued* (Source: Bil (NBS) 1 – 12);
- *Overall liquidity position / assets* = assets and liabilities maturing within a given time period (up to seven days or up to three months) as a share of the balance sheet total. This calculation does not include balance-sheet items in which a security interest is established, nor off-balance sheet items with the exception of commitments to accept/provide credit and the values of underlyings in spot

and futures transactions (but only where the underlying is a financial asset that is exchanged for this underlying instrument) (Source: BD (LIK) 3 – 12);

- *Capital ratio* = the ratio of own funds to risk-weighted assets (it may not fall below a threshold of 8%) (Source: BD (PVZ) 20 – 12, BD (HVZ) 19 – 12);
- *Tier I capital as a share of own funds* = as a share of own funds, core capital less the respective part of items lowering the value of core and supplementary capital (Source: BD (HVZ) 19 – 12);
- *Ratio of own funds to the balance-sheet total* (Source: BD (HVZ) 19 – 12);
- *Ratio of to own funds of the loss incurred when the total capital ratio declines to 8%* = the ratio to own funds of the loss that would be caused by a decline in the total capital ratio to 8% (Source: BD (PVZ) 20 – 12, BD (HVZ) 19 – 12);

B 5 Investment firms

Abbreviations used:

IS-1 – reception of a customer's order to acquire, sell or otherwise dispose of an investment instrument and subsequent transmission of the customer's order for the purpose of its execution.

IS-2 – reception of a customer's order to acquire or sell an investment instrument and its execution for an account other than the account of the service provider.

IS-3 – reception of a customer's order to acquire or sell an investment instrument and its execution for own account.