NÁRODNÁ BANKA SLOVENSKA

EUROSYSTEM

Annexes to the Analysis of the Slovak Financial Sector

2011

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 horizon 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, we assume 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 were 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 was 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 was a multivariate BEKK-GARCH(1,1) that included the following equation for the estimation of covariance matrix Σ_t:

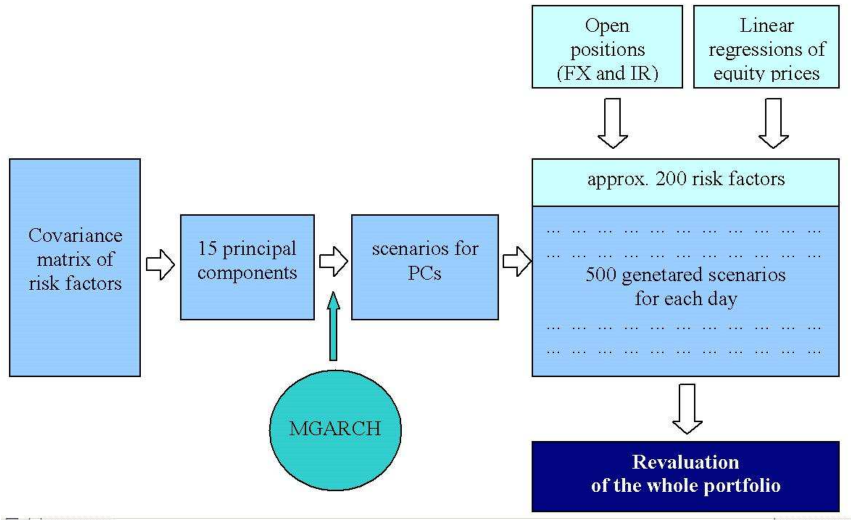
$$\Sigma_t = C^T C + A^T \Sigma_{t-1} A + B^T \varepsilon_t \varepsilon_t^T B \,,$$

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

Since approximately 200 market factors were used in the calculation, the dimension was reduced using the method of principal component analysis. The multivariate GARCH model was estimated only for the 15 main principal components, and the covariance matrix obtained was then transformed back to the original market factors. For investments in equities and mutual fund shares/units, the exposure to each market factor was 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 the worsening of the global economy and the effect of this worsening on loans to enterprises and loans to households. Since these two types of loan have different properties, and there are different data sources for the calculation of credit risk, two different approaches were 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 corporate loans are constructed for 18 corporate sectors for the period from 2000Q3, based on quarterly data on the number of non-performing loans and the number of total loans granted. 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 $ANTL_{t\text{-}3,t;i}$ is the average number of total loans granted in sector i during the quarters t-3 to t (the average number of loans granted in a one-year period ending with quarter t). Since the relatively short length of the time series made it ineffective to work with 18 sectors, the sectors were split into three categories based on their sensitivity to the economic cycle. This 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 below.

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

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

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

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

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

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 were 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 the NBS's structural macroeconomic model[2]) were used as estimates of the probabilities of default for each category for stress testing purposes. The estimated probabilities of default for each category of corporate loan were subsequently used to calculate by bootstrapping the loss stemming from non-performing corporate loans.

As part of this simulation a decision is taken in each period on whether the given loan defaults in that period or not. The probability of default of each loan entered in the stress test scenario is calculated in the way described above. If a loan defaults in the given period, it cannot default in the next period and the losses stemming from the default are materialised in the given period only. Using this procedure, the potential volume of non-performing loans is simulated 10,000 times for each scenario; the estimated volume of non-performing loans for each bank is the average volume of total

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

[2] For a description of the macroeconomic model, see: Reľovský, B., Široká, J.: A structural model of the Slovak economy, Biatec 7 / 2009, pp. 8 – 12.

non-performing loans for this bank across all simulations. The value and the type of the collateral is also taken into account when estimating potential losses. A decline in the value of the collateral is assumed for each scenario. Based on an expert assessment, the collateral is divided into two categories: collateral whose value is assumed to decline according to the scenario (e.g. collateral in the form of real estate or blank bills) and collateral whose value is assumed not to decline (e.g. third party guarantees).

The overall loss is obtained by multiplying the volume of non-performing loans, less the adjusted value of the collateral, by the coefficient LGD (loss given default). This coefficient value is set at 45%, meaning that, in the event of the bankruptcy, the bank would be able to cover up to (100-45)% of its claim on the unsecured part of the loan from bankruptcy proceedings.

Thus amount of loan loss provisions that each bank has to make during the stressed period due to the worsening of macroeconomic conditions is calculated at the end of each simulation.

Household credit risk

The volume of non-performing loans to households is estimated in two steps. First, the total volume of loans granted to the household sector is estimated; second, the volume of non-performing retail loans is calculated also using the volume of total loans granted.

Three types of household loans are estimated: housing loans, consumer loans and other loans. The overall volume 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 error correction (EC) equation is used to estimate each of the three categories, while a long-term relationship is assumed between the volume of loans and the macroeconomic variables. The estimated error correction equation for housing loans has the following form:

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

where HL_{AC} is the annual percentage change in housing loans, GDP_{AC} is the annual percentage change in seasonally adjusted nominal gross domestic product, UR_{AC} is the annual percentage change in the unemployment rate, HLR_{AC} is the annual rate of change in housing loan interest rates, SD is the effect of short-run dynamics and ε are residuals. The short-run effects include the effect of property price movements. Estimates of the coefficients are summarised in Table 2.
The estimated EC equation for consumer loans is as follows:

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

where CL_{AZ} is the annual percentage change in consumer loans and CLR_{AC} is the annual percentage change in consumer loan interest rates.
The estimated EC equation for other loans is as follows:

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

where OL_{AC} is the annual percentage change in other loans granted to the household sector and *HICP* is the annual percentage change in prices as measured by the harmonised index of consumer prices.

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

So as to cover the non-zero correlation of residuals between the different equations, these equations were simultaneously estimated using the method of seemingly unrelated regressions (SUR).

For the estimation of the volume of non-performing loans, similarly as for the volume of total loans granted, an EQ equation is used. The estimation is based on quarterly data from 2000Q1. Because a detailed breakdown of non-performing loans in each category has been available only since 2005, the aggregated volume of all non-performing household loans is estimated in the calculations. In this case the estimated EC equation has the form:

$$\Delta NPL_t = \alpha\left(NPL_{t-1} + \beta_0 + \beta_1 TRL_{t-1} + \beta_2 GDP_{t-1} + \beta_3 HICP_{t-1} + \beta_4 UR_{t-1}\right) + \sum_{i=1}^{1}\Gamma_i \Delta\left(NPL, THL, GDP, HICP, UR\right)_{t-i}^{T} + \varepsilon_t$$

where NPL is the volume of non-performing loans and TRL is the total volume of household loans granted. Other variables are the same as described above.

Table 2 Coefficient estimations for household credit risk models

	α	β_1	β_2	β_3	β_4	aR^2
Housing loans	-0.051	-1.321	0.039	-0.056	-	82.0%
Consumer loans	-0.123	-2.814	-0.623	0.978	-	79.2%
Other loans	-0.037	-7.514	0.042	-	-	92.6%
Non-performing loans	-0.312	-1.677	1.474	-0.113	-0.005	22.6%

As with corporate credit risk, so too in the case of household credit risk the volumes of each type of loan are estimated using an ex-ante fixed development of macroeconomic variables, which is calculated in accordance with the given scenario based on the structural macroeconomic model of NBS.

1.3 Calculation of interest rate risk

The following assumptions were 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 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 abovementioned 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 horizon 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 premium on the three most significant portfolios: the portfolio of loans and deposits, the portfolio of debt securities and the portfolio of interest rate derivatives.

Interbank interest rates

In 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 euro-area interbank rates with a maturity of up to one year was estimated using a VECM 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, ε_t is the random error, and a dummy variable is included to capture the effects of the ECB's non-standard operations conducted 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 constant 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 constant 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 measures 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*, was 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) were estimated using a Kalman filter (or the state space model) of the form:

signal equations:

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

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 1-year, 3-year or 10-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; and $GDP\_GAP_t^{EMU}$ 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 was based on the assumption that a change in the ECB key rate is reflected first in the interest rate curve and only subsequently in rates on loans to customers. The rate selected in the VECM was therefore one 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 due to the ECB's non-standard measures. The EC equation for lending rates was estimated in the form:

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

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

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

In the case of deposits, the cointegrating relationship includes the relevant interbank rate and a dummy variable (for the same reason that the cointegrating relationship for loans included a dummy variable). The EC equation for deposit rates was 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 in case of 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 firms 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 firms 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 case of 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 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 taken into consideration 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. When assessing the impact of an interest rate shock, the following procedure is used:

- 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.
- The volume of deposits is modelled as autoregressive processes with a trend and/or an intercept.
- The modelling of loans to the household sector is described in section 1.2.
- The volume of loans granted to the corporate sector was estimated on the basis of panel data representing seven selected subgroups of the corporate sector. A cointegrating relationship representing a long-run equilibrium relationship between the volume of loans granted, GDP, and lending rates was found using panel cointegration tests. The cointegrating relationship was estimated by the DOLS method, using one past and one future differential of the explanatory variables:

$$\log(LNC_{it}) = a_i + 1.63\log(GDP_{it}) - 0.08 r_{it} + \sum_{j=-1}^{1} c_j \Delta\log(GDP_{it+j}) + \sum_{j=-1}^{1} d_j \Delta\log(r_{it+j}) + \varepsilon_{it},$$

  where a_i are fixed effects typical for the i-th segment, LNC_{it} is the stock of loans to non-financial corporations, GDP_{it} is gross domestic product for the i-th segment at time t, and r is the interest rate on the loans granted (a more detailed description of the model is given in the Analysis of the Slovak Financial Sector for the First Half of 2011, Box 1).

  - The volume of interbank loans and deposits was set so that each bank in each quarter has an equal volume of assets and liabilities, assuming that these are short-term operations with interest charged or paid at the monthly EURIBOR rate.
  - With estimates for interest rates and for volumes 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 horizon.

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.

Interest rate derivatives

For the calculation of the impact of interest rate risk on interest rate derivatives, it is assumed that all such derivatives are fair valued. This assumption reflects the fact that, in a crisis situation, the bank can also sell interest rate derivatives held in the banking book.

For the valuation of swaps two approaches can be used: the first is based on the estimation of cash flows with fixed and variable interest rates and the subsequent calculation of the net present value of these cash flows; the second approach assumes that both parts of the swap (fixed and variable) can be viewed as coupon payments of the respective bonds (one with a variable rate and the other with a fixed rate). The fair value of the swap can then be calculated as the difference between the fair values of these two bonds. The exchange of principals at the maturity of the swap, assumed under this approach, does not ordinarily happen; nevertheless, it does not affect the calculated fair value of the swap since the principals would be identical. The second approach is closer to the way of reporting swaps in Statement Bd (HUC) 53-04 (since the nominal values of the swaps are reported in this statement), and therefore it is used to estimate the revaluation of swaps in the event of an interest rate shock. The fair values of these bonds are calculated analogously to those mentioned in the previous section (Debt securities).

In addition to the above assumptions, however, it is necessary to make several simplifications. This is because the only information we have about the reported swaps is the rate fixation period for the fixed and variable part of the swap, and even that is only in aggregate form. There is no information about the agreed value of the fixed rate or the periodicity of cash flows. Hence the calculations are based on the following assumptions:

- the fixed rate is set at 5% (although the level of the fixed rate has a relatively significant impact on the fair value of the swap, it is less relevant when estimating the impact of interest rate shock on the change in the fair value);
- the cash flows in the swap transaction at both the fixed and variable rates have an annual periodicity;
- the rate fixation period of the variable part of each swap is less than three months.

The last assumption is necessary for distinguishing which data in the Statement Bd (HUC) 53-04 refers to the variable part of the swap and which data refers to the fixed part. On this basis it is assumed that all data reported in time bands of up to three months refer to the variable parts of swaps and all data reported in time bands of over three months refer to the fixed parts. In each time band the difference between claims and liabilities is calculated and this difference is fair valued as mentioned above. Since this approach is consistent with that used to estimate the impact of the interest rate shock on the securities portfolio, any hedging of interest rate risk in the debt securities portfolio with interest rate derivatives is fully taken into consideration.

1.4 Assumptions for stress testing

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 volume of non-performing loans in the portfolio as at 31 December 2011 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). It is further assumed that the loss stemming from the unsecured part of a non-performing loan amounts to 45% of this value. Finally, the estimated losses are calibrated so that the total amount of corporate loans corresponds to the estimated value as at the end of 2012 and 2013.
- When estimating the loss on the household loan portfolio, the banking sector's total volume of non-performing loans is estimated. It is further assumed that the ratio of non-performing loans in any given bank to the total volume of NPLs in the sector remains constant over the two-year period under review and at the same level as at the end of 2011. Since the total volume of non-performing loans is estimated, it is assumed that the ratio of non-performing housing loans and other loans also remains constant and at the same level as at the end of 2011. This last assumption is necessary for determining the final loss on the estimated volume of non-performing loans: as 20% of volume of non-performing housing loans and 80% of the volume of other non-performing loans.
- For banks there are coupon income and interest income/expenses from the amortisation of securities in the held-to-maturity (HTM) portfolio stemming from the portfolio of securities. The revaluation of debt securities in other portfolios (held for trading / available for sale) is reflected in the banking sector's profitability or in the level of Tier 1 and Tier 2 capital. The debt securities portfolio used in the stress testing is the portfolio as at 31 December 2011; it is assumed that the portfolio does not change during the stressed 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. In the case of a revaluation of securities, it is assumed that the revaluation gains/losses will be reflected first in profitability and only subsequently in own funds.
- As regards Greek government bonds, it is assumed that their real value declined to 22.6% of their total nominal value at the beginning of 2012 and that their price is no longer fluctuating.
- For issued debt securities, the portfolio as at 31 December 2011 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 will remain constant during the stressed period and that the profit or loss will be affected only by changes in market factors.
- 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 will remain constant during 2012 and 2013 and at the same level as at 31 December 2011. It is further assumed

that the net profit will be 80% of the gross profit and that the method of calculating the bank tax will not change in 2012 and 2013 (i.e. it will remain at 0.4%, and there will be no change in the tax base either). Banks that end a year with a loss are assumed to reduce their equity by the total amount of the reported loss, while those that end a year with a profit are assumed to distribute this profit in accordance with the NBS recommendation (Table 2) and to use at least 50% of retained earnings to increase their equity.

- The estimation of the amount of risk weighted assets is based on data as at 31 December 2011. In the case of the retail and corporate sectors, it is assumed for each bank that the ratio of risk weighted assets to the total stock of retail and corporate loans will not change and therefore that the amount of risk weighted assets will change in line with developments in retail and corporate lending in the given bank. Other categories of risk weighted assets remain at a constant level, the same as at 31 December 2011.

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 loans received	V (NBS) 5 – 12
Funds from banks	Bil (NBS) 1 – 12
Issued securities	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 volume of the given item in the total volume 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 volume of the given item in the total volume 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 volume 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 volume 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 Revenues 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 statement 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 current volume of outstanding loans provided to a given counterparty, and, on the other hand, the ratio of cumulative expenses to the current volume 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:

- *Ratio of non-performing retail loans* = the gross outstanding amount of non-performing retail loans as a share of the gross outstanding amount of retail loans (Source: V (NBS) 33 – 12);
- *Ratio of provisions to the outstanding amount of non-performing loans* = the ratio of provisions to the gross outstanding amount 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 39(2)) and it does not concern branches of foreign banks (Source: BD (HMA) 8 – 12, part BazilejII_C).

- *Large intra-group exposures* – this indicator monitors as at the end of each month the number of breaches of limits laid down in the Banking Act (Article 39(1)), 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 outstanding amount 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);
- *Foreign exchange open 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);
- *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 foreign exchange open 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 adequacy 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 to own funds of a loss incurred by the capital adequacy ratio declining to 8%* = the ratio to own funds of the loss that would be caused by a decline in the capital adequacy 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.