Annexes to the Analysis of the Slovak Financial Sector

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NÁRODNÁ BANKA SLOVENSKA
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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, , 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. Based on 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 the parameters is a multivariate BEKK-GARCH(1,1). It includes the following equation for the estimation of covariance matrix Σt:

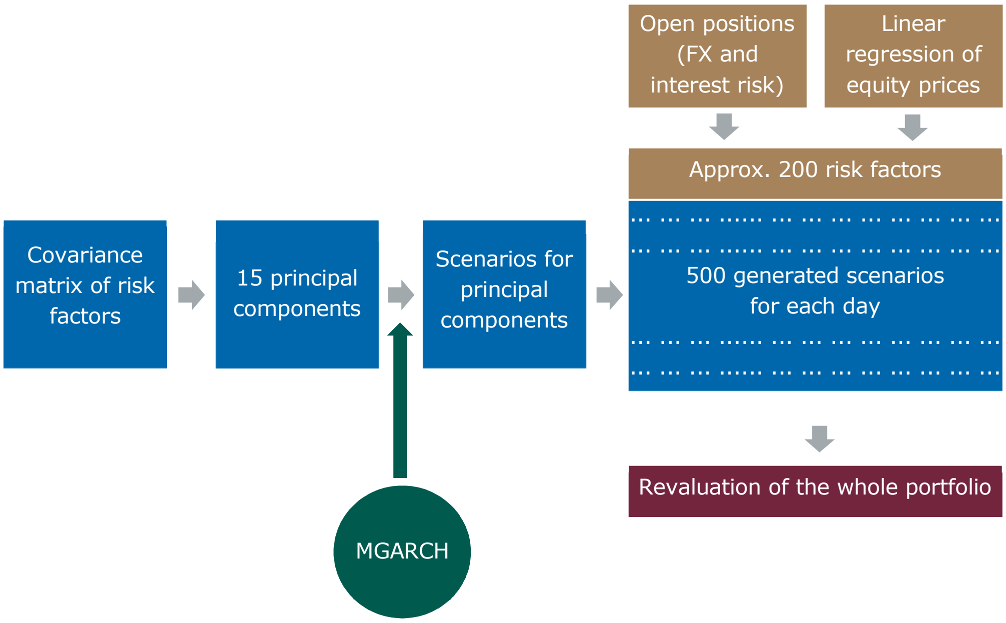
$$\Sigma_t = C^T C + A^T \Sigma_{t-1} A + B^T \varepsilon_t \varepsilon_t^T B,$$

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 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 figure illustrates how the VaR for market risks is calculated:

Figure 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 loans to NFCs and loans to households. 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.

1.2.1 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 Q3 2000, 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 $ANTL_{t\text{-}3,t;i}$ is the average number of total loans provided in sector i during the quarters $t\text{-}3$ 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 business cycle) is summarized in **Error! Reference source not found.**.

TABLE 1 CATEGORISATION OF BUSINESS SECTORS BY SENSITIVITY TO THE BUSINESS 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

Source: NBS.

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

[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.

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

[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.

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 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 stress test period due to the worsening of macroeconomic conditions is calculated at the end of each simulation.

1.2.2 Household credit risk

Quarterly time series of the non-performing loan (NPL) ratio for four types of loan – 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 **Error! Reference source not found.**. 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	

Source: NBS.

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 impetus for 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 expenses.

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.

1.3.1 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 European one-year interbank rates 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 shorter-term rates. 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

[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.

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.

1.3.2 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 lending rates for NFCs, we estimate interest rates on the stock of NFC loans. Given that NFC loans are provided with relatively short interest rate fixation periods and that majority of the loan interest rates are linked to interbank rates, the transmission can be measured quite accurately also for interest rates on the stock of loans. In the case of lending rates for the retail sector, we estimate interest rates on newly granted loans and then calculate the interest rates on the stock of loans using an assumption that the loan repayment rate in the given loan category corresponds to the historical average. The EC equation for lending rates is estimated in the form

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

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

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.

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	Overnight deposits
Other loans	Deposits with an agreed maturity of up to 7 days
	Deposits with an agreed maturity of up to 1 year
	Deposits with an agreed maturity of up to 2 years
	Deposits with an agreed maturity of up to 5 years
	Deposits with an agreed maturity of over 5 years
	Savings deposits
Households	
Housing loans	Sight deposits
Consumer loans	Overnight deposits
Other loans	Deposits with an agreed maturity of up to 7 days
	Deposits with an agreed maturity of up to 1 year
	Deposits with an agreed maturity of up to 2 years
	Deposits with an agreed maturity of up to 5 years
	Deposits with an agreed maturity of over 5 years
	Savings deposits

Source: NBS.

1.3.3 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 (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; these are assumed 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.

1.3.4 Estimated stock of NFC loans

The stock of loans to NFCs is estimated using an EC model. This estimation is based on the stock of NFC loans provided by domestic banks since Q4 2004, 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

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

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.

1.3.5 Estimated stock of retail loans

The total amount of retail loans is estimated, and the natural logarithm of the year-on-year absolute change in the volume, is included in the model. The model uses quarterly data from the first quarter of 2005. The change in amount is estimated using an EC model in the form

$$\Delta ZOU_t = \alpha\left(ZOU_{t-1} + \beta_0 + \sum_{i=1}^{n} \beta_i X_{i,t}\right) + KD + \varepsilon_t,$$

where ZOU_t is the logarithm of the year-on-year absolute change in the loans. The model incorporates as explanatory variables a pair or trio of selected macroeconomic variables. From the total possible number of equations, nine are selected on the basis of the cointegration properties of the selected variables, the interpretability of the estimated coefficients, and the predictive power of the models. Macroeconomic variables included in individual equations of the nine models are drawn from the following: GDP (real and nominal), inflation (year-on-year and index), residential property prices (all dwellings / flats only), the three-month EURIBOR, and the yields on five-year and ten-year Slovak and German government bonds and the spreads between them. The average amount of loans estimated using these nine models is included in the stress test. The amounts of housing loans, consumer loans and other loans were then determined on the basis of the assumed share of these loans in the total amount of loans during the three years under review.

1.3.6 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 stress test 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. First, the stock of non-performing loans in the portfolio as at 31 December 2019 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 scenario 0, 15% in scenario 1 and 30% in scenario 2 (e.g. collateral in the form of real estate or blank bills). After that, the estimated losses are calibrated so that the total amount of NFC loans corresponds to the estimated value as at the end of the years 2020, 2021 and 2022.
- 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 2019. 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.

- Given that the new accounting standard IFRS 9 has been in force since 1 January 2018, it is assumed that banks will be increasing their provisioning for loans that are not impaired but show an increase in credit risk, i.e. Stage 2 loans. Scenario 0 assumes that the share of such loans remains constant and equal to the average sectoral share in 2019 for both household loan portfolio and NFC loan portfolio. The adverse scenarios assume that this share increases to one and a half times in Scenario 1 and to two times in Scenario 2.
- For banks, the debt securities portfolio is a source of coupon income and interest income/expenses from the amortisation of securities (including those held to maturity, i.e. in the LAR portfolio). The revaluation of debt securities in other portfolios (held-for-trading/HFT and available-for-sale/FVOCI) 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 2019; 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 LAR 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 FVOCI portfolio.
- For issued debt securities, the portfolio as at 31 December 2019 is taken as the basis. It is assumed that the portfolio in each bank that has already re-registered their issued mortgage bonds as covered bonds does not change and that any maturing securities will be replaced with securities of identical parameters. In the case of banks that have not re-registered their issued bonds, it is assumed that their maturing mortgage bonds will be gradually replaced with funding from the interbank market.
- In the case of equity risk and foreign exchange risk, it is assumed that the portfolios of each bank remain 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 (e.g. 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.
- It is assumed that banks subject to the resolution regime will gradually have to comply with the minimum requirements for own funds and eligible liabilities (MREL) as defined under decisions currently in force. It is assumed that the required yields on the instruments that banks issue to meet the MREL will reflect yields on issues recently issued by their parent groups. In scenario 0, the yield during the three-year stress test period is assumed to be 1.18%; in scenario 1, 2.18%; and in scenario 2, 3.18%. Since it is not clear which part of a given bank's liabilities will be replaced by these new instruments, it is assumed that for a proportion of liabilities corresponding to the share of MREL-eligible liabilities in the bank's total liabilities in the given year, their

cost will be increased from the average cost for the given bank to the assumed yield on MREL-eligible instruments.

- 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 2019, 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 levy 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 2019. To begin with, in scenario 0, the amount of risk exposures is adjusted for NFC and retail loans under the assumption of constant risk weights for these two types of loans. Other categories of risk exposures remain constant at the level of 31 December 2019. Subsequently, on the basis of back-testing results, the total amount of risk exposure is adjusted (reduced) by 5% for 2020 and by 10% for 2021 and 2022. 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 years 2020, 2021 and 2022 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 TEST PARAMETERS

			Scenario 0			Scenario 1			Scenario 2		
			2020	2021	2022	2020	2021	2022	2020	2021	2022
Baseline assumptions	Change in external demand			2.90%	3.00%	-18.20%	-7.60%	3.00%	-26.20%	-18.10%	-10.00%
	Change in EUR/USD exchange rate			0.00%	0.00%	-0.10%	0.00%	0.00%	-15.00%	0.00%	0.00%
	Change in exchange rates of the CHF, JPY, GBP, DKK, CAD, HRK and LVL against the EUR			0.00%	0.00%	-10.00%	0.00%	0.00%	-30.00%	0.00%	0.00%
	Change in exchange rates of other currencies against the EUR			0.00%	0.00%	0.00%	0.00%	0.00%	30.00%	0.00%	0.00%
	Change in equity prices			0.00%	0.00%	-35.00%	0.00%	0.00%	-50.00%	0.00%	0.00%
	Change in the ECB key rate			0 bp	0 bp	0 bp	0 bp	0 bp	0 bp	0 bp	0 bp
	Change in the 3-month EURIBOR			6 bp	11 bp	-2 bp	0 bp	-1 bp	-2 bp	0 bp	0 bp
	Change in 1-year discount rate (EUR)			7 bp	11 bp	9 bp	0 bp	1 bp	17 bp	-1 bp	1 bp
	Change in 2-year discount rate (EUR)			7 bp	8 bp	12 bp	8 bp	4 bp	19 bp	15 bp	5 bp
	Change in 5-year discount rate (EUR)			19 bp	8 bp	22 bp	22 bp	13 bp	29 bp	38 bp	18 bp
	Change in the 5-year iTraxx Senior Financials index			0 bp	0 bp	203 bp	0 bp	0 bp	353 bp	0 bp	0 bp
	Increase in 5-year spreads and in the slope of the credit spread curve			0 b.p.	0 b.p.	Increase to the midpoint between the current value and the value as at 30.9.2012	0 b.p.	0 b.p.	Return to value as at 30.9.2012	0 b.p.	0 b.p.
Model-simulated macroeconomic variables	Annual real GDP growth			2.48%	2.55%	0.10%	-1.69%	1.49%	-1.14%	-3.81%	-0.70%
	Average annual inflation			2.09%	1.70%	2.34%	2.35%	1.58%	1.68%	1.81%	1.62%
	Unemployment			6.40%	6.50%	6.70%	8.10%	9.30%	7.00%	9.00%	11.10%
Credit risk variables estimated using macroeconomic variables	Annual probability of default	Non-sensitive sectors	3.79%	3.77%	3.79%	4.38%	4.53%	4.84%	4.57%	4.98%	5,16%
		Less sensitive sectors	3.22%	3.17%	3.22%	4.97%	5.41%	5.56%	5.01%	5.80%	5,87%
		Sensitive sectors	5.40%	5.13%	4.95%	6.07%	7.19%	7.27%	6.87%	9.62%	10,34%
	Non-performing loan ratio for household loans			2.80%	2.70%	2.61%	3.25%	3.59%	3.77%	4.21%	5.06%

Source: NBS.