STRESS TESTING OF THE SLOVAK BANKING SECTOR

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The stress testing applied by the regulator is aimed at quantifying the ability of individual banks to cope with certain exceptional market or macroeconomic conditions, and at testing the banking sector as a system. The methods used are based on principles employed by other central banks of European Union Member States and by the International Monetary Fund. The stress testing results form part of the systemic analyses of the banking sector and they are discussed on a regular basis by the NBS Bank Board. At the same time, however, these results only give a rough idea and cannot be taken as an accurate evaluation of possible consequences nor as a predictorion of development.

Foreign exchange risk

A bank is exposed to foreign exchange risk when it has a mismatch between the volume of assets and liabilities in a certain foreign currency. Where a bank has a surplus of assets over liabilities in a foreign currency (the so-called "long foreign exchange position"), it is exposed to the risk of a loss should the koruna appreciate against this currency. Therefore the starting point for assessing foreign exchange risk is the size of open positions in individual currencies on the overall balance sheet and off-balance sheet (excluding receivables / liabilities arising from vested assets). Stress testing of the foreign exchange risk is therefore based on quantifying the size of this loss, calculated as the product of the expected change in the exchange rate,and the open position value, and the subsequent change in the capital adequacy indicator after the loss has been deducted from own funds.[1]

As for designing stress scenarios for the stress testing of foreign exchange risk, the following two approaches are taken:

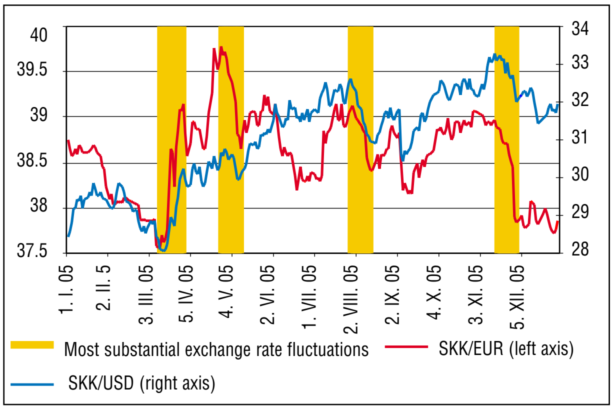
– the approach based on the assumption that the "worst" exchange rate fluctuations in the stipulated period will recur;

– the approach based on the simulated exchange rate fluctuations, where the simulation is based on an expert estimate of one exchange rate and of mutual correlations between exchange rates estimated from historical data.

Scenarios 1 to 3: Historically worst exchange rate fluctuations

This approach to stress scenario design is based exclusively on the historical development of exchange rates (from 1 January 2004 to 31 December 2005) where the period under review is 10 working days. The selected 10-day period takes into account the assumption that sudden and substantial exchange rate fluctuations will not be

Chart 1 EUR/SKK exchange rate in 2005



Source: NBS

responded to by the immediate closure of foreign exchange positions. When calculating the loss on a given day, it is assumed that "worst" relative exchange rate fluctuations will recur over the next 10-day period.

The first option is to select the same 10-day period for the whole banking sector, so that in the event on an exchange fluctuation the same as that in this period, the whole banking sector would suffer the largest loss. In this case, the banking sector as a whole would make the largest loss upon the recurrence of the exchange rate development between 11 March 2005 and 29 March 2005 (scenario 1) or between 14 April 2005 and 28 April 2005 (scenario 2). In both periods there was substantial depreciation of the Slovak currency against the euro (by 3.7% and 2.8%, respectively) and against the US dollar (by 7.1% and 3.0%, respectively). The effects of both scenarios on the distribution of banks' capital adequacy isare shown in Chart 1.

The second option is to select the 10-day monitored period on a bank-by-bank basis (scenario 3). A The 10-day period was selected for each bank on the grounds that during this period there occurred exchange rate fluctuations that would cause the bank the largest loss. Although the results of this stress scenario cannot be

[1] Branches of foreign banks are excluded from the calculation.

aggregated for the whole banking sector, such an approach may serve to supplement the VaR calculation. The VaR gives the assumed loss which, on the basis of historical exchange rates development, should not be exceeded with 99% probability, whereas the said stress scenario indicates the potential loss upon a recurrence of the historical development that would be least favourable at the present time.

Scenarios 4 and 5: Simulated exchange rate fluctuations taking into account correlations

The inherent drawback of stress scenarios that are rooted exclusively in the comparison of historical exchange rates development is their limited capacity to predict future development. This limitation is even more pronounced when it comes to predicting extreme events, since these occur too rarely in historical data. It is therefore necessary to design stress scenarios on the basis of simulations, or assumptions about exchange rates development. There remains, however, the question of how a fluctuation in one exchange rate appears in the estimated fluctuations of other rates. It is necessary to consider the mutual correlations between the exchange rates, though in periods of substantial exchange rate changes ("hectic periods") these may be correlations other than those estimated on the basis of historical developmentdata.

The estimate of the correlation in hectic periods is derived from the historical development data of logarithms of the relative exchange rate fluctuations[2] in period between 2002 and 2005, on the basis of the following model:

$$\ln\left(\frac{eur_t}{eur_{t-1}}\right) \sim \omega\, N\left(\mu_{eur}, \sigma_{eur}\right) + \left(1-\omega\right) N\left(\tilde{\mu}_{eur}, \tilde{\sigma}_{eur}\right),$$

where eur_t is the exchange rate EUR/SKK. It is assumed that the logarithms of changes in the EUR exchange rate arise with a probability of ω from the quiet period (simulated by a normal distribution) and with a probability of 1- ω from the hectic period (simulated by another normal distribution with a greater standard deviation). It is expected that the quiet period will have a probability of between 70% and 95%, while the hectic period is represented to a lesser extent and is indicated by sudden fluctuations in exchange rate values and by stepped growth in volatility. The model parameters (including ω probability ω of the quiet period) were estimated from historical time series data on exchange rates for the period 2002 – 2005, using the maximum credibility likelihood method.

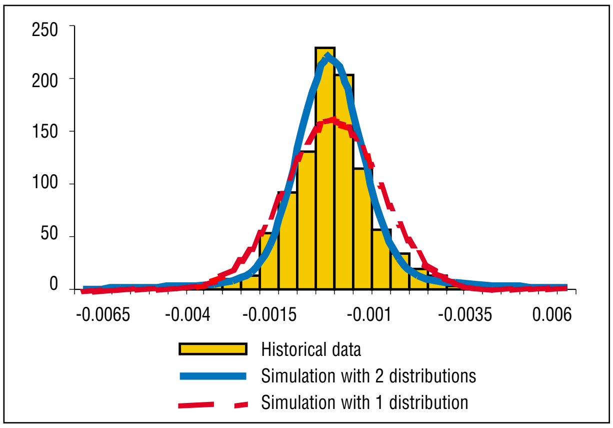
As Chart 2 shows, the model based on differentiating the quiet and hectic periods – notably highlighting the different volatilities – better represents the historical data than does the model based on a single normal distribution. Moreover, the aforementioned model records the fact that extreme values occur more frequently than in the normal distribution.[3]

It should be noted that the data distribution partition into the hectic and quiet periods is not based on some a priori definition of hectic periods (e.g. according to the size of the relative fluctuation, and so on). It is in fact the case that for each piece of data on the logarithm of changes, we know howit is possible to assign the probability that it was from the hectic period. Naturally, the greater the relative exchange rate fluctuation, the greater the probability that the data was from the hectic period – though the nature of the model means this cannot be stated unequivocally. However, by estimating this probability for all data, we calculate for a second exchange rate (e.g. USD) the qualified conditional medians means and variances in the quiet and hectic periods, as well as the qualified conditional correlations between these exchange rates in both the quiet and hectic periods.[4] The calculations are based on standard relations formulas used in the calculation of mediansmeans, variances and correlations. The only difference is that each item of data is weighted by the probability that it is derived from the hectic period (or from the quiet period if the values are

Table 1 Estimated parameter values for the EUR/SKK exchange rate

	Probability	Mean	Standard deviation
Quiet period	85 %	-0.00012	0.085 %
Hectic period	15 %	0.00033	0.27 %

Chart 2 Comparison of the model based on a single normal distribution and a the model based on a combination of two normal distributions



Source: NBS, own calculations.
Note: The horizontal axis shows the logarithmic values for fluctuations in the SKK/EUR exchange rate; the vertical axis shows the number of data items in the intervals given on the horizontal axis.

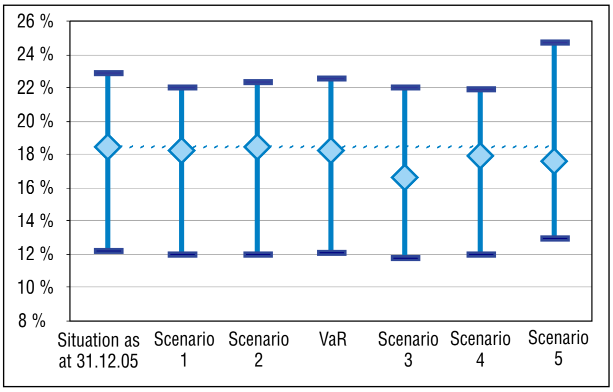
[2] The transformation of the original data is aimed mainly at their stationarization.
[3] The model has a drawback, however, in that it does not take into account autocorrelation during the time series.
[4] Further details about the calculations may be found in the following article by Kim. J. and Finger Ch. C. – A Stress Test to Incorporate Correlation Breakdown, Journal of Risk (2000).

Table 2 Estimated parameter values for individual currencies

			USD	CZK	HUF	PLN	JPY	CHF	GBP
Quiet period	Mean	μ	-0.00022	-0.00007	-0.00009	-0.00012	-0.00017	-0.00014	-0.00017
	Standard deviation	σ	0.29 %	0.15 %	0.19 %	0.24 %	0.26 %	0.12 %	0.27 %
	Correlation	ρ	31.4 %	26.7 %	21.9 %	8.4 %	21.9 %	69.1 %	39.5 %
Hectic priod	Mean	$\tilde{\mu}$	0.00033	0.00028	0.00007	0.00008	0.00008	0.00028	0.00024
	Standard deviation	$\tilde{\sigma}$	0.40 %	0.22 %	0.30 %	0.29 %	0.35 %	0.28 %	0.27 %
	Correlation	$\tilde{\rho}$	69.2 %	66.4 %	45.4 %	31.5 %	45.4 %	93.6 %	79.3 %
Appreciation of EUR/SKK rate by 5%*			+ 5.3 %	+ 2.8 %	+ 2.5 %	+ 1.7 %	+ 2.9 %	+ 4.9 %	+ 4.0 %
Depreciation of EUR/SKK rate by 5%*			-5.0 %	-2.6 %	-2.6 %	-1.7 %	-3.0 %	-4.8 %	-3.9 %

*Expected relative fluctuation upon a 5% appreciation/depreciation in the EUR/SKK on the assumption of a hectic period for the EUR.

Chart 3 Comparison of the effects that foreign exchange risk scenarios have on the distribution of capital adequacy in the sector.



Source: NBS, own calculations.
Note: The chart shows the lower quartile, median, and upper quartile of the distribution of estimated capital adequacy values in the sector after applying the individual scenarios.

being calculated for the quiet period). This means suggests that greater relative exchange rate fluctuations are included in the calculation with a greater weight than are small fluctuations, which provides for a more accurate calculation of the exchange rate correlation we are interested in. The estimated parameter values are given in Table 2. Assuming a linear correlation between the fluctuations of individual exchange rates, the equation shown below may be used to calculate the expected fluctuation in the USD/SKK exchange rate (and by analogy the other exchange rates) when the EUR/SKK exchange rate appreciates by 5% (scenario 5), or when it depreciates by 5% (scenario 6), while taking into account the correlation between the currencies on the assumption of a hectic period:

$$\frac{\ln(usd_{t+10}/usd_t)-10\,\tilde{\mu}_{usd}}{\sqrt{10}\,\tilde{\sigma}_{usd}}=\tilde{\rho}_{usd,eur}\frac{\ln(eur_{t+10}/eur_t)-10\,\tilde{\mu}_{eur}}{\sqrt{10}\,\tilde{\sigma}_{eur}}+$$

$$+\sqrt{1-\tilde{\rho}^2}\,\varepsilon_t \qquad \varepsilon_t \sim N(0,\sqrt{10})$$

The results of particular stress scenarios indicated that extreme exchange rate fluctuations should not pose a significant threat to the stability of the banking sector. Most banks have sufficient capital to cover any substantial exchange rate changes.

Interest rate risk

The stress testing for interest rate risk was aimed solely at interest rates in SKK and EUR, due to the fact that assets and liabilities include a high share of interest-sensitive items in these currencies.[5] The interest rate risk stress test is specifically limited by assumptions of a shift in the curves and the fact that it does not take account of the effect on the margin.

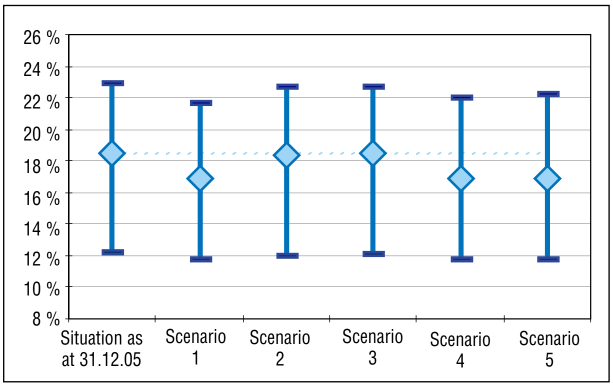
When specifying stress scenarios for interest rate risk, we took as a basis the historical fluctuations in interest rates (monthly changes of ten-year, two-year and one-month points on the yield curve since the beginning of 2003). The historical changes were treated so that, on the one hand, they included assumptions for the possible development changes of interest rates and, on the other hand, they formed stress scenarios. The actual effects of the stress scenarios were calculated as the remainder of the net present values of interest sensitive positions prior to the application of the stress scenarios and of the net present values calculated with the stress values of the interest rates. The difference between the net present values was deducted from or added to the bank's capital. Although this procedure can test the effect of a rise or fall in interest rates, the banking sector as at 31 December 2005 would be adversely affected mainly by the increase in interest rates shown in Chart 4.

Scenarios 1 and 2: Parallel fluctuation shift in SKK and EUR yield curves

For the first scenario, with the SKK yield curve, the parallel rise in interest rates is assumed to be 150 basis points, and for the second scenario, with the EUR yield curve, it is assumed to be 130 basis points.

[5] The interest-sensitive positions were taken from banks' quarterly statements on interest-rate sensitivity.

Chart 4 Comparison of the effects that interest rate risk scenarios have on the distribution of capital adequacy in the sector



Source: NBS, own calculations
Note: The chart shows the lower quartile, median, and upper quartile of the distribution of estimated capital adequacy values in the sector after applying the individual scenarios.
Key to scenarios: 1 – parallel rise in SKK yield curve by 150 b.p.; 2 – parallel rise in EUR yield curve by 130 b.p.; 3 – interest rate rise during in the shortest time interval bucket by 150 b.p.; 4 – interest rate rise in the longest time interval bucket by 150 b.p.; 5 – steepening of the curve.

Scenarios 3 and 4: Fluctuations Shifts at the ends of the SKK yield curve

The third scenario represents a rise in interest rates by 150 basis points during in the shortest time interval bucket of up to one month. Conversely, the fourth scenario records the same interest rate increase during in the longest time intervalbucket of more than 15 years.

Scenario 5: Steepness fluctuation change in the SKK yield curve

The last scenario for SKK interest rates considers a change in the yield curve steepness, in other words, the fall in interest rates within one year bucket and the rise in interest rates during longer time intervalsbucket. It was assumed for this scenario that the one-year interest rate did not change.

As with foreign exchange risk, the banking sector is not significantly vulnerable to any extreme fluctuations in interest rates.

In 2005, the banking sector was mainly sensitive to scenarios 1, 4 and 5, in other words, to the raising of interest rates during in longer time intervalsbucket. This relates to the standard structure of banking assets and liabilities where banks' assets have a longer duration than do their liabilities. The largest average decline in capital adequacy (by 100 basis points) occurred with scenario 1 (parallel rise in interest rates by 150 b.p.).

We have also applied a supplementary stress scenario given as standard in the interest rate risk stress test framework: a parallel growth in interest rates of 200 b.p. Under this scenario, capital adequacy in the banking sector fell by an average of 140 b.p.

Credit risk

With credit risk representing the most significant risk in banks' business, stress testing is largely focused on the quality of the loan portfolio. Impairment of the portfolio quality (where lower-quality loans account for an increasing share of all loans) means the bank has to spend more on the creation of provisionsprovisioning or the write-off of receivables. This loss impairs reduces the value of own funds, hence also the bank's capital adequacy. Two scenarios will be used for this stress test.

Scenario 1: Credit crunch

The first scenario simulates a substantial deterioration in the financial position of banks' clients. For this reason, it is assumed that banks will in the following period significantly reduce the provision granting of new loans. In this scenario, there is therefore no change in the value of risk-weighted assets. It is assumed that the increase in non-performing loans (NPLs)[6] will be caused exclusively by the transition of standard and special mention loans into substandard loans as the result of the deteriorating financial position of enterprises and households.

Thus we calculate the maximum percentage month-on-month growth in the value of NPLs (Δ) during 2005, and we assume that this growth, adjusted by multiplier M, occurs in the following period. The value of NPL_s for the following

$$NPL_{t+1} = NPL_t \cdot (\Delta \cdot M + 1)$$

period, NPL_{t+1}, is then calculated as follows:

It is assumed that this entire increase in NPLs is reflected in the loss by which the bank's own funds are reduced.

Scenario 2: Provision Granting of loans with a high rate of failure

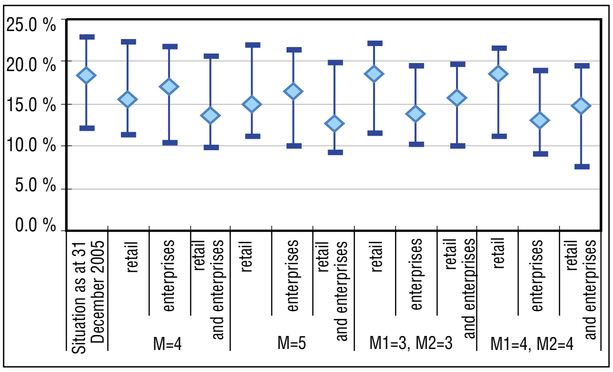
The second scenario is derived from the increasing competitive pressure related to the relatively high pace of loan growth. It therefore simulates the situation where banks, in striving to increase their market share, provide more loans overall and also increase the share of loans provided to less solvent clients. There will in future be defaulting on loan repayments leading to the higher share of NPLs in the portfolio of newly-provided loans.

Our first step is therefore to find the maximum share of NPLs in overall loans for 2005. The share of NPLs in the given year will form the basis for estimating the future share of NPLs in new loans. Their relationship is expressed by the coefficient M1, which is used to simulate the increase in this share.

The second step is to assume a continuing increase in lending. Its average month-on-month change is stressed

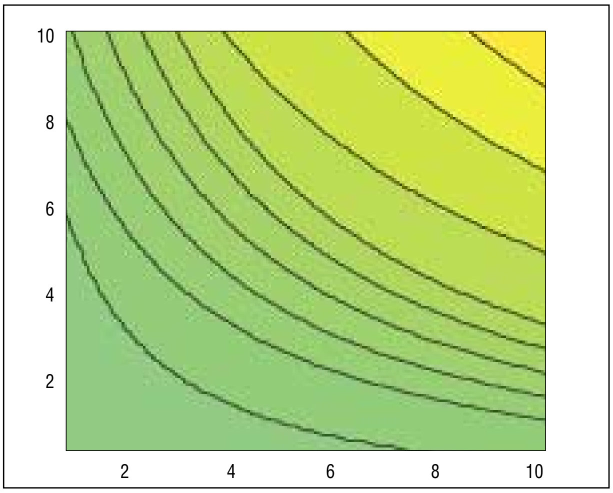
[6] For a loan to be classified as NPL, one of the criteria is more than 90 days past due payment.

Chart 5 Comparison of the effects that credit risk scenarios have on the distribution of capital adequacy in the sector



Source: NBS, own calculations.
Note: The chart shows the lower quartile, median, and upper quartile of the distribution of estimated capital adequacy values in the sector after applying the individual scenarios.

Chart 6 Effect of scenario 2 on the capital adequacy median for M1 and M2 parameter values



Source: NBS, own calculations.
Note: M1 values are shown on the horizontal axis and M2 values on the vertical axis. Marked in colour on the chart are the areas that progressively representing the median capital adequacy of banks (excluding branches of foreign banks), from the range 18-19% (green, bottom left) to the range 7-8% (yellow, upper right). Each shade represents a change of one percentage point in the median capital adequacy.

in the scenario by the coefficient M2. In addition, Tthis is also the coefficient by which risk weighted assets are increased. The volume of NPL_{t+1} is then calculated as follows:

The calculation takes into consideration that the stress scenarios do not count on a decline in NPL_s

When calculating capital adequacy after the application of this stress scenario, it will be assumed (similar to how it was in scenario 1) that the value by which the NPLs increase will be expressed as a loss (Loss Given Default = 100%), one that lowers the bank's own funds. It is also assumed that new loans have a risk weight of 100%, which will be reflected in the volume growth of risk weighted assets.[7]

The effects of individual scenarios were observed in regard to the most important portfolios: retail and corporate. As regards the first scenario, the results show that volume growth of non-performing receivables does not have a significant effect on banks. Most banks would continue to record a capital adequacy of more than 10%. In the second scenario there is impairment of banks' median capital adequacy, and there is a decline in the capital adequacy of certain banks where the product of the M1 and M2 multipliers is greater than 8. That an increase in the M2 multiplier causes a slight impairment is natural, given that this multiplier not only increases the volume of NPLs but also raises the volume of risk weighted assets.

$$NPL_{t+1} = \mathrm{Max}\left\{\left(M_1 \cdot \max_i \frac{NPL_t}{loans_i}\right) \cdot \left(M_2 \cdot \frac{1}{11} \sum_{j=feb\,05}^{dec\,05} loans_j - loans_{j-1}\right), 0\right\} + NPL_t .$$

Liquidity risk

The liquidity risk stress test is tied to special limitations. A typical problem is the ambiguity of the link between liquidity risk and capital adequacy. Even if a bank makes a loss due to a liquidity problem (for example, amid rapid selling of securities), it is not a simple matter to simulate such a situation. Scenarios do not consider existing credit lines to other banks or the parent bank, nor core deposits.

For this reason, the stress test was not applied to capital adequacy but to three selected liquidity indicators (the indicator of instant liquidity, the indicator of liquidity for up to 7 days, and the indicator of liquidity for up to 3 months) and the size of the shock was assessed in regard to the average month-on-month fluctuations in these indicators. Each indicator is calculated as the share of liquid assets and on volatile funds in the respective categories:

- For the first indicator, liquid assets include vault cash items, the bank's current accounts with other banks and all treasury bills and government bonds which are not subject to a lien, including those that the bank acquired in reverse repo transactions; volatile funds include current accounts maintained by theof other banks and all liabilities towards clients.
- For the second and third indicators, liquid assets include the liquid assets under the first indicator as well as all receivables against clients and banks with a residual maturity of up to 7 days or up to 3 months; volatile funds under these indicators are the total liabilities towards banks and

[7] As far as stress scenarios are concerned, it is immaterial whether we increase the value of the M1 or M2 multiplier. But it does make sense to draw a distinction between them when quantifying the effects of individual scenarios on risk weighted assets, where only the M2 multiplier is inputted

clients with a residual maturity of up to 7 days or up to 3 months. which fall due within 7 days or within 3 months.

It should be noted that the approach towards the maturity of assets and liabilities is not inconsistent. For deposits, current maturity is used and the estimate for core deposits is not considered. For government securities and treasury bills, an assumption of absolute liquidity is made regardless of their current or estimated maturity.

Three basic scenarios were selected for the liquidity risk stress test. The first two are standard, in variations used by central banks in the EU. The third attempts to reflect the situation in the Slovak banking sector.

Scenario 1: Depreciation of government bonds by 10%

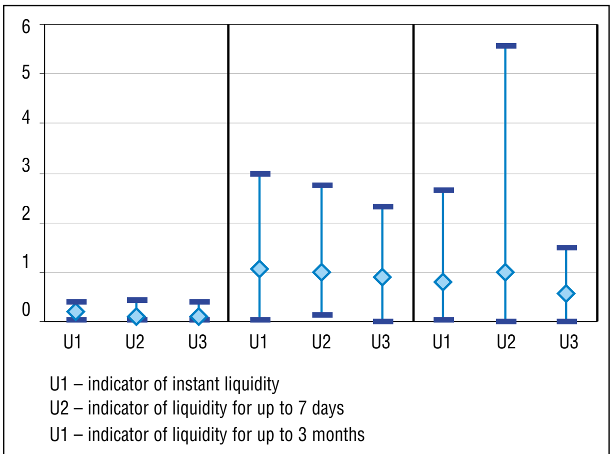
This is a straightforward simulation where the value of government bonds and treasury bills in the bank's portfolio (excluding securities that the bank acquired as collateral in repo transactions) is reduced by 10% for all three indicators. One reason for the depreciation of government bonds could be an increase in interest rates.

Scenario 2: Decline in client deposits by 20%

The volume of liquid assets is reduced by an unexpected withdrawal of some of the client deposits. As regards liabilities, it is assumed that client funds decline equally in all time intervals. Volatile funds are therefore reduced by 20% of all liabilities towards clients (for the first indicator), or by 20% of the liabilities towards clients with a residual maturity of up to 7 days (for the second indicator) or up to 3 months (for the third indicator).

Scenario 3: Outflow of short-term capital from the bank sector for external reasons

Chart 7 Comparison of the effects of individual liquidity risk scenarios



Source: NBS, own calculations.
Note: The chart shows the lower quartile, median, and upper quartile of the distribution of the share of liquidity indicator changes after applying the individual scenarios to the average month-on-month changes in 2005.

This simulates the situation where investors decide to reduce substantially their positions in Slovak banks regardless of the domestic conditions. In a simplified form, the volume of deposits of non-resident banks declines by 90%. Such a situation could arise, for example, when investors simply decide to invest their short-term funds in other, more profitable markets.

Under this scenario, liquid assets are reduced by 90% of the value of deposits of non-resident banks. For liabilities, it is assumed that funds with the shortest residual maturity are the first to leave; therefore the said value (90% of foreign banks' deposits) is also deducted from volatile funds, although by an amount not exceeding the amount in banks' current accounts (for the first indicator), or the amount of banks' deposits with a maturity of up to 7 days (for the second indicator) or up to 3 months (third indicator).

Since the actual value of the indicators may only be used to a limited extent to assess liquidity, the stress test results are focused on the percentage changes, as opposite to not absolute, changes in the indicators. The Each scenario's significance was determined by comparing two values. The first was the percentage change in the indicator's value as a result of applying the scenario in regard to the value as at 31 December 2005. The second was the average month-on-month percentage change in the value of the same indicator in 2005. Where the change in an indicator under the given scenario is similar to the usual month-on-month change, it is thereby not considered significant.

The first scenario – the depreciation of government bonds – did not have a significant effect on banks. Despite the fact that government bonds are held by banks also for reason of their liquidity, a slight fall in their value does not jeopardize banks' liquidity.

In general, it may be said that the scenario for a withdrawal of 20% of client deposits had the biggest effect on large and medium-sized banks, in other words mainly retail banks. The scenario for a withdrawal of 90% of deposits of foreign banks had the biggest effect on some medium-sized banks, but also on banks bound to their own financial groups that are more heavily engaged in short-term capital trading.

Stress testing limitations

Stress testing is similar to other models in that it simplifies the real market situation. Even if we strive to design and quantify stress scenarios in a way that approximates as far as possible the market reality, the complexity of the reality compels us to work with certain assumptions and simplifications.

The measuring of individual risks is largely limited by the input data – the existing existence of options and other non-linear instruments in banks' portfolios, changes in reporting methodology, and a lack of information on real cash flows. Losses are calculated on the assumption that they will be apparent immediately after the scenario has been applied, which may not be the case with instruments not revalued at fair value. Since we do not have data on the extent of loss given default at our disposal, we assume that it is equal to 100%. Nor is there an assessment of the indirect risk to which banks are exposed through their clients, for example, the indirect risk that is the foreign exchange or interest rate risk of banks' clients.

The specification of stress test scenarios is itself subject to certain limitations. The scenarios are somewhat static, not taking account of portfolio adjustments in the stress situation. They are designed largely on the basis of historical development data or with simulated fluctuations, but there is no link to external factors or interconnection between individual risks. As regards foreign exchange risk and interest rate risk the largest historical fluctuations are seen as the margins of fluctuation distribution.