Stress testing the German banking system

Stress tests are a valuable aid in assessing the stability of the banking system. They permit a forward-looking analysis and a uniform approach to identifying potential risks to the banking system as a whole. Naturally enough, the assumptions made about risk scenarios mean that subjective elements enter into the stress tests. Continuous performance and development of stress tests are therefore needed. The IMF, too, regards stress tests as an important component of its Financial Sector Assessment Program. This is the background against which the Bundesbank and the Federal Financial Supervisory Agency, in cooperation with the IMF, conducted stress tests for the German financial system. The results have confirmed the resilience of the German financial system. Despite the scale of the assumed shocks and the fact that the financial intermediaries were already in a difficult position owing to the economic slowdown, the banks possessed sufficient capital to cushion the hypothetical losses. It is not only the capital and reserves base which is crucial for the long-term stability of the banks, however. The institutions also have to make further progress in their efforts to achieve a sustained improvement in their profitability and in limiting their credit and market risks.

Aim and object of the analyses

FSAP

In the first half of 2003, the IMF appraised the stability of the German financial system as part of the Financial Sector Assessment Program (FSAP). This included the performance of stress tests for the German credit institutions. The aim of these analyses was to detect potential weaknesses of the banking system when faced with extremely intense market changes or adverse macroeconomic developments. The IMF analyses focused on credit and market risks. Extensive macro stress tests were also conducted. The stress tests were designed and implemented in cooperation with the Federal Ministry of Finance, the Bundesbank and the Federal Financial Supervisory Agency. The reference date for the analyses was 31 January 2003.

Credit risk

Default risk and risk of deterioration in credit quality

For most banks, credit risk remains the most important single risk. In the narrower sense, credit risk denotes the risk that borrowers will not meet their contractual payment obligations or that they will fail to meet them punctually (default risk). In the broader sense, credit risk is understood as the risk of a general deterioration in the borrower's credit quality, without such a deterioration necessarily resulting in a default.

Quantitative Impact Study by the Basel Commitee

Under the current prudential rules (Basel I), banks have to hold capital amounting to at least 8% of their risk-weighted assets in order to cover their credit risks. A new version of the Basel Capital Accord is planned (Basel II), in which there will be a fundamental revision of the risk weights for the individual asset categories. In view of this, the stress tests conducted in cooperation with the IMF already used the risk-weighted assets in accordance with Basel II as a basis for measuring the credit risk. The tests were able to draw on the results of the Third Quantitative Impact Study (QIS 3) published by the Basel Commitee on Banking Supervision. Thanks to this study, a uniform database on the credit quality structure of the loan portfolios of a representative sample of German banks was available. This sample comprised the large internationally active banks (group 1) and a number of other *Landesbanken*, savings and cooperative banks (group 2).

Borrowers' probabilities of default

One parameter that is crucial in determining the risk weighting under Basel II is the probability of default by the individual borrower. The credit risk scenarios provided for a uniform, proportional 30% and 60% increase in the borrowers' probability of default (PD). A comparison with the default rates in the rating categories of Standard & Poor's reveals that such changes in the PDs roughly correspond to a one or two-step rating downgrade for the entire loan portfolio. Given the fact that there was already a high insolvency rate level on the reference date for the analysis, the second scenario, in particular, is therefore to be assessed as very conservative.

Heightened credit risk

The change ratios of the risk assets shown in the table on page 56 confirm the importance of the credit risk for banks. On average, the banks in group 1 – with a ratio of 15% in the second scenario – displayed a slightly higher increase in risks than did the banks in group 2

The design of stress tests

In contrast to forecasts, stress tests have to simulate extreme deviations from normal market developments. In that sense, they use "unrealistic" scenarios as a basis. On the other hand, the assumed scenarios for the risk factors have to be plausible to some extent in order to avoid incorrect conclusions.

In statistical methods of scenario selection, the common probability distribution of the relevant risk parameters (interest rates, equity prices, etc) are estimated from historical data. Then, scenarios representing the extreme events of the distribution (low-probability events) are selected. This method has the advantage that probability levels can be assigned to the scenarios. These are employed mainly in sensitivity analyses where only a single risk factor is "stressed".

Model-based analysis is another scenario option. This is applied especially if the impact of macroeconomic aggregates is to be studied (macro stress tests). This method is based on an econometric model, in which the interrelationships of the relevant risk factors can be shown.

The method ultimately used for selecting the stress test scenarios depends crucially on data availability. For example, in the area of market risk, where prices are quoted nearly continuously, statistical methods are often preferred. By contrast, in the area of credit risk, expert appraisals or model-based procedures tend to be used.

The banks' risk positions are normally calculated in the form of changes in the market value of assets. The calculations may be performed by the banks themselves using their own risk models ("bottom up") or centrally by the supervisory authorities ("top down"). Mixed approaches are also feasible, with some of the risk positions being calculated by the supervisors and others determined by the institutions. The "bottom up" approach is suited mainly to the field of market risk as many banks possess comparable market risk models. In the field of credit risk and in the case of macro stress tests, the heterogeneity of the models means that a "top down" approach tends to be called for.

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Results of the stress tests for credit risk *

Reference date: End-January 2003

Increase in PDs amounting to ...	Change in the risk-weighted assets under Basel II as a percentage of the liable capital		
	Mean value	Worst result	Best result
	Group 1 [1]		
... 30 %	8.22	9.96	6.46
... 60 %	15.31	17.47	12.12
	Group 2 [2]		
... 30 %	7.22	11.72	4.31
... 60 %	13.18	21.89	8.53

* Calculations for a selection of German banks based on the Third Quantitative Impact Study of the Basel Committee on Banking Supervision. — **1** Large internationally active banks. — **2** Other banks.

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with an average of 13%. In the most extreme case, a ratio of 22% was measured: owing to its adequate capital base, this bank, too, was able to comply with the regulatory capital ratio. The main reason for the relatively sharp increase in the risk-weighted assets in the above-mentioned scenarios is the large percentage of loans on German banks' balance sheets. Nevertheless, the IMF, too, is of the opinion that, since the institutions are well capitalised, credit risk does not pose a risk to the stability of the banking system. Taking as a basis, say, the average capital ratio of 11%, a maximum 22% increase in the risk-weighted assets leads to a lowering of the regulatory capital ratio to 9%, which is distinctly higher than the 8% ratio required by the regulations.

Market risk

A second important risk category – market risk – was included in the stress tests. The term "market risk" refers to the risk of a change in market value owing to changes in market prices. Market risk is usually broken down into the categories of interest rate risk, equity price risk, exchange rate and volatility risks. [1]

Banking and trading book positions

As in the analysis of the credit risk, the calculations were confined to a representative sample of internationally active banks and a selection of other banks. The sample for market risk is not identical with the sample for credit risk, however, as the latter was compiled for the requirements of another survey. For the purpose of conducting the stress tests, these banks were asked to calculate the changes in the market value of their positions in the banking and trading books based on predetermined scenarios. For the sake of simplicity, it was assumed that the losses which arose were reflected directly in changes in the value of the balance sheet assets. Possible adjustment measures by the banks as well as differing accounting rules for the banking and trading books were not taken into account. [2]

1 Volatility is a major parameter in price formulas of derivative instruments. Conversely, by resolving the price formulas, the implied volatility may be derived from the quoted prices of the derivatives. This represents, so to speak, the market view with regard to the future volatility of the securities underlying the derivative instrument.
2 In reality, banks constantly adjust to changes in market conditions. Nevertheless, under extreme market conditions, the scope for action may be severely restricted.

Scenarios for the yield curve

Changes in basis points

Position	Euro area			USA			Japan		
	short-term [1]	medium-term [2]	long-term [3]	short-term [1]	medium-term [2]	long-term [3]	short-term [1]	medium-term [2]	long-term [3]
Twist (+)	110	60	40	100	50	30	100	40	30
Parallel (+)	70	70	70	65	65	65	60	60	60
Peak (+)	0	30	0	0	25	0	0	20	0
Twist (–)	– 110	– 60	– 40	– 100	– 40	– 30	0	– 20	– 15
Parallel (–)	– 70	– 70	– 70	– 40	– 40	– 40	0	0	0
Peak (–)	0	– 30	0	0	– 25	0	0	– 10	0

1 Not more than three months. — **2** More than three months but not more than five years. — **3** More than five years.

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Fall in stock market prices

For the equity price risk, a sudden unexpected 30% slide in equity prices within a period of one month taking place simultaneously on all markets was assumed. The equity price risk was calculated for both the trading book and the banking book (at market values). Not least on account of the quite low general equity price level at the time, the further, sharp slump in equity prices was a relatively improbable scenario (albeit a meaningful one as a stress test).

Shifts in the yield curve

The entire term structure was used in the design of stress tests for the interest rate risk since particular problems are caused by assymetrical changes in interest rates. Three different types of shifts in the yield curve were assumed (see table above): twists in the curve at the short end, parallel shifts over all maturities and fluctuations in the middle range. In each case, the shifts were calibrated so that the scenario in question is to be expected only once in 25 years. The changes in the individual maturity segments amounted to up to 110 basis points.

Exchange rate changes

The exchange rate risk was calculated assuming a 15% appreciation or depreciation of the euro within one month. This scenario corresponds to the largest monthly change in the EUR/USD or DEM/USD exchange rate since the end of 1992.

Volatilty changes

Proportional increases of 35%, 30% and 25% respectively were assumed for interest rate volatilities, exchange rate volatilities and stock market volatilities. The rates of change were calculated using historical data.

Results of the stress tests for market risk

Scenario [1]	Change in market value as a percentage of the liable capital		
	Mean value	Worst result	Best result
	Group 1 [2]		
Decline in share prices	– 8.48	– 20.40	– 0.21
Interest rates: twist (+)	– 1.27	– 2.58	– 0.22
Interest rates: parallel (+)	– 0.86	– 1.80	0.17
Interest rates: peak (+)	– 0.46	– 1.14	– 0.05
Interest rates: twist (–)	1.16	0.29	1.89
Interest rates: parallel (–)	0.67	– 1.16	1.65
Interest rates: peak (–)	0.52	0.03	1.06
Euro appreciation	– 0.44	– 2.15	1.88
Euro depreciation	0.38	– 1.88	2.24
Volatility	0.05	– 0.22	0.29
	Group 2 [3]		
Decline in share prices	– 1.71	– 6.98	0.00
Interest rates: twist (+)	– 2.33	– 9.13	0.16
Interest rates: parallel (+)	– 2.86	– 11.75	0.81
Interest rates: peak (+)	– 0.95	– 3.53	0.10
Interest rates: twist (–)	2.20	– 1.14	9.35
Interest rates: parallel (–)	2.77	– 0.89	12.12
Interest rates: peak (–)	0.96	– 0.19	3.57
Euro appreciation	0.22	– 1.92	1.90
Euro depreciation	– 0.53	– 3.73	1.40
Volatility	0.03	– 0.35	0.56

Sources: Deutsche Bundesbank, institutions' calculations. — **1** The scenarios are defined as follows: 30% decline in equity prices; interest rate scenarios as in the table on page 57; +/-15% movement in the exchange rate; change in volatility for interest rates, exchange rates and shares of 35%, 30% and 25% respectively. — **2** Large internationally active banks. — **3** Other banks.

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Equity price risk

The equity price risk is the most important market risk for the large internationally active banks (see table above). The mean hypothetical loss amounted to just over 8%. In one case, it was, in fact, somewhat more than 20% of the equity capital. No bank undershot the 8% regulatory capital ratio, however.[3] The crucial factor in the large banks' higher-than-average equity price risk is their large portfolio of participating interests. In relation to the trading book on its own, the equity price risk is much lower.

Interest rate risk

The interest rate risk is crucial especially for small and medium-sized institutions. The maximum loss in the stress tests was 12% of the equity capital. One likely reason for the comparatively high interest rate risk is the fact that smaller institutions are unable to conclude interest rate hedging operations to the same extent as large institutions.

Exchange rate and volatility risks

As might be expected, the exchange rate risk and the volatility risk play a secondary role for both categories of institutions. Usually, the credit institutions are hedged almost entirely against the exchange rate risk, which fundamentally harbours a major risk potential. The banks' volatility risk is normally low as well.

Macro stress tests

Model-based scenarios

In all the stress tests considered so far, only a single risk factor was changed (univariate stress tests). This means implicitly making the very simplifying assumption of a null correlation between the risk factors. In reality, however, it tends to be the case that simultaneous changes in the risk factors are observed. Univariate stress tests should therefore be supplemented by multivariate stress tests, in which more than one risk factor at a time is changed. Simply combining the univariate scenarios is impractical, however, as they produce very unrealistic results in most cases. For that reason, historical risk factor situations that have actually occurred are often used. However, historical simulation severely restricts the choice of possible scenarios. One alternative, which was also adopted for the FSAP in Germany, is provided by a model-based selection of scenarios in a macro stress test.

3 Assuming, say, an average capital ratio of 11%, a loss of 20% results in a lowering of the capital ratio to just on 9%.

Macro-economic framework scenarios

For this purpose, the Bundesbank and the IMF studied three macroeconomic framework scenarios. The impacts of these scenarios on the relevant risk factors for the years 2003 and 2004 were determined using the Bundesbank's macroeconometric model. In doing so, it was assumed that the central bank leaves interest rates unchanged. An econometric regression equation for the banks' specific provisions created the link to the banks' credit risk. The market risk (which is not shown below owing to its minor importance) was calculated by the banks themselves. The three macro scenarios considered are listed below.

Iraq war

Scenario 1: at the start of 2003, when the stress tests were conducted, major geopolitical uncertainty prevailed on account of the looming war in Iraq. This then actually took place in March. The framework scenario envisaged a 45% hike in oil prices in the first half of the year and a 1% increase in US military spending. Furthermore, a global 10% fall in equity prices and a ½ percentage point rise in the saving ratio in all industrial countries were assumed. In the model calculations, this scenario led to real GDP diverging from the baseline scenario by 0.6 percentage point in the first year.

Negative demand shock

Scenario 2: in this scenario, a 0.3 percentage point increase in the saving ratio and an increase in capital costs of 100 basis points were assumed for Germany. In the model calculations, this led to a decline of 0.2 percentage point in real GDP in the first year compared with the baseline scenario.

Adjustment of global imbalances

Scenario 3: this assumed a gradual increase in the US saving ratio to 4%, a gradual decline in the US current account deficit and an 8% depreciation of the US dollar. This scenario led to a decline of 0.3 percentage point in real GDP growth in the first year compared with the baseline scenario.

Panel estimation

Using the econometric model, the impact on credit risk was calculated for the various scenarios. Using a panel approach, the banks' specific provisions were explained by individual balance sheet data and by macroeconomic variables.

$$\lambda_{it} = 0.37\lambda_{it-1} + 0.14\lambda_{it-2} - 0.3\Delta K_{it-1} - 6.5\Delta GDP_t + 10.7r_t + \varepsilon_{it}$$

where

- λ denotes the transformed specific provisions ratio, $\lambda = \ln\left(\frac{SPQ}{1-SPQ}\right)$,
- ΔK the credit expansion of the bank,
- ΔGDP the growth of real GDP
- r the short-term interest rates, and
- ε the residual.

GDP and interest rates as systemic risk factors

The above model equation resulted from estimations for the commercial banks, savings banks and cooperative banks. The underlying database consisted of the balance sheet data of all credit institutions (complete survey). As expected, the importance of current economic growth for loan losses is confirmed in the estimations. A 1 percentage point decline in

Results of the macro stress tests *

Figures as a percentage; reference date: end-January 2003

Year	Growth of allowance for loans	Specific provisions 1	Allowance for loan losses 1 (Mean value)	Specific provisions level: 1 5% quantile	Specific provisions level: 1 median	Specific provisions level: 1 95% quantile
	Baseline scenario					
2003	4.1	0.94	3.43	0.86	3.11	9.78
2004	– 6.3	0.85	3.22	0.69	2.91	10.02
	Iraq war					
2003	6.9	0.98	3.52	0.89	3.21	10.00
2004	– 4.4	0.88	3.37	0.72	3.03	10.39
	Negative demand shock					
2003	5.1	0.95	3.46	0.87	3.14	9.86
2004	– 4.4	0.87	3.31	0.71	2.98	10.21
	Adjustment of global imbalances					
2003	– 7.6	0.83	3.04	0.72	2.80	9.11
2004	– 20.0	0.71	2.48	0.48	2.14	8.30

* Panel estimation based on German banks' balance sheet data. — 1 Share of loans to non-banks.

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GDP growth thus leads to an increase in the provisions of roughly 7%. With regard to the apparently strong influence of the interest rates, it has to be borne in mind that large interest rate changes are comparatively rare. Moreover, economic developments and interest rates generally run in parallel, leading to opposite impacts on value adjustments. Among the considered balance sheet data, credit expansion is the main significant factor. The negative sign is probably due to the fact that there is a lower probability of default for new loans. A certain persistency of the provisions is also evident. This is revealed by the importance of lagged value adjustment ratios.

As an outcome, it may be noted that the macro scenarios produced no indication of a risk to the stability of the banking system (see table above). The allowance for loan losses for 2003 rose on average by a maximum of 7% and the level of provisions went up to a maximum of 3.5% of the credit volume, which is not unusual by historical standards. Owing to the assumed upward revision of economic growth in the second year of each stress scenario, there was a marked decline in the average provisions in 2004. Institutions already having high value adjustments were more strongly affected by the stress scenarios in 2003 and also benefited less from the economic recovery in the following year.

Macro-economic scenarios reveal no unusual risks

Overall judgement

IMF confirms the resilience of the banking system, ...

In its overall judgement, the IMF attested that the German banking system has a notable resilience. Because they are well capitalised, the banks were able to pass the stress tests satisfactorily. The most significant risks for the banks resulted mainly from a further deterioration in the credit quality of their borrowers. Furthermore, a further slump in equity prices is likely to harbour a certain risk potential especially for larger banks owing to their sizeable portfolios of participating interests.

Considering the macroeconomic setting at the reference date for the stress tests and the adjustment measures currently being taken by the banks, this generally good result is very significant.

... but improvement in profitability is crucial for long-term stability

Despite the satisfactory stress test results, there is a need for further adjustment in the German banking system. It is not only the capital and reserves base that is crucial for the long-term stability of the banks. Rather, the institutions have to improve, first and foremost, their profitability and limit their credit and market risks by intensive risk management. The relevant steps already taken by the banks therefore have to be pursued consistently in the future.