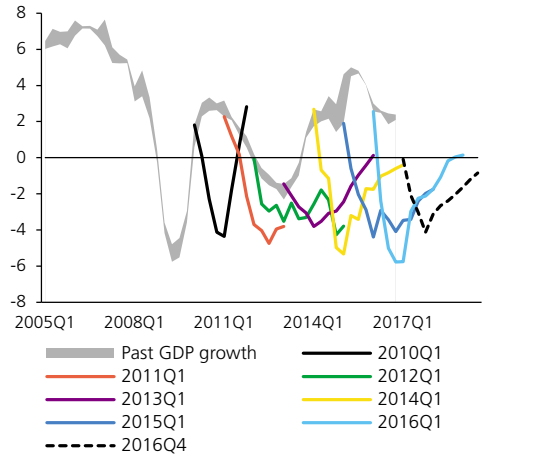
CHART IV.1 BOX

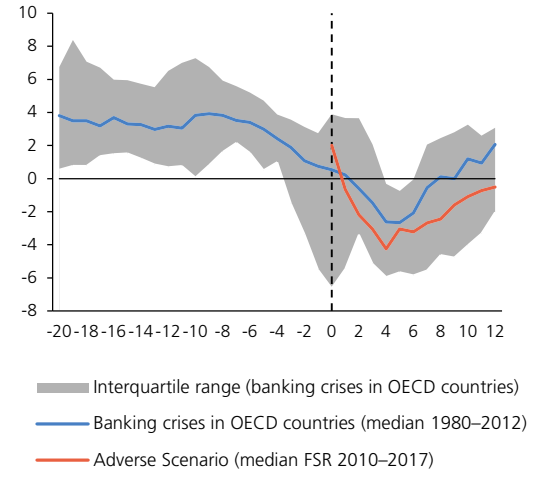
Adverse scenarios in Financial Stability Reports 2010–2017
(change in real GDP; year-on-year in %)



Source: CNB
Note: The 2010 and 2011 tests had a two-year horizon. Since 2012 the tests have had a three-year horizon. The grey area indicates the range of data revisions.

CHART IV.2 BOX

GDP growth during banking crises
(%)



Source: CNB
Note: The vertical line separates the pre-crisis period and shows the start of the simulation of the *Adverse Scenario*. The figures on the horizontal axis represent the quarters before (-) and after (+) the onset of the crisis or since the start of the simulation. The data for OECD countries are taken from Drehman, M. and Juselius, K. (2013): *Evaluating early warning indicators of banking crises: Satisfying policy requirements*, BIS Working Papers 421.

4 STRESS TESTS

4.1 SOLVENCY STRESS TESTS OF BANKS AND PENSION MANAGEMENT COMPANIES

The stress tests demonstrate that the banking sector is highly resilient to the chosen adverse scenarios. Banks have a large enough capital buffer to absorb adverse shocks and maintain their overall capital ratio sufficiently above the regulatory threshold of 8% even under a very adverse scenario. The pension management company sector has long been sensitive to interest rate volatility. A decline in prices of Czech government bonds could adversely affect its solvency.

The stress tests are based on the *Adverse Scenario*, which has been extended to include other sensitivity analyses

The resilience of banks and pension management companies was tested in macro stress tests using a *Baseline Scenario* for the most probable future developments and a hypothetical *Adverse Scenario* (see Box 2 for the approach to setting it). The latter assumes a strong and long-lasting decline in economic activity in the Czech Republic accompanied by a fall of the economy into deflation (see section 2.1). The development represented by the *Adverse Scenario* is extended to include other sensitivity analyses that amplify its impacts and thus enable the sectors' resilience to relevant risks to be assessed.

BOX 2: WHEN SETTING UP ADVERSE SCENARIOS, THE CNB TAKES INTO ACCOUNT HISTORICAL EXPERIENCE AND THE BUSINESS CYCLE

The stress test scenarios are designed using the CNB's official prediction model supplemented with an estimate of the evolution of some additional variables not directly generated by the model (satellite models). An *Adverse Scenario* is constructed on the basis of the identification of risks to the Czech economy in the near future. This scenario should be severe but plausible.[1]

The CNB does not set the strength of the shocks at unrealistically high levels. It uses historical experience, especially the GDP data for 2008–2009 (see Chart IV.1 Box) and developments during banking crises in other OECD countries (see Chart IV.2 Box). The CNB does not intend to set the severity of the scenario mechanically according to the distribution quantile of the historical values of the variables used. Such an approach would

1 Breuer, T., Jandacka, M., Rheinberger, K., and Summer, M. (2009): *How to Find Plausible, Severe and Useful Stress Scenarios*, International Journal of Central Banking 5(3), pp. 205–224.

ignore the CNB's forward-looking approach, the nature of the individual risks and the fact that it is difficult to estimate the quantiles of the distribution with sufficient accuracy. When setting the severity of adverse scenarios, the CNB respects the need for a countercyclical approach. It takes into account the extent of the risks identified (such as the estimated degree of property price overvaluation) and the current cyclical position of the economy. The CNB uses more severe scenarios at times of economic growth than in periods of recession.[2] The estimated phase of the financial cycle is reflected in the degree of stress in the same way. This approach results in a stress scenario in which GDP growth falls towards the lows historically observed in the Czech Republic and other relevant economies (see Charts IV.1 Box and IV.2 Box).

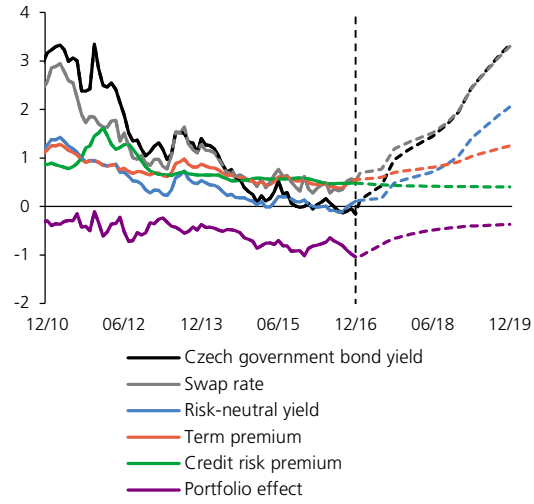
The need to take the cycle into account is due to the fact that when the economy has been showing favourable developments for a time, optimistic expectations grow and banks and their clients consequently start to be willing to take on greater risks. This can be reflected in excessive loan growth, overvaluation of some assets and the creation of macroeconomic imbalances. Some firms and households may increase their debt to a level that is inconsistent with their incomes and their ability to create buffers for worse times. Against this background, risks to financial stability may, after a while, build up unobserved in the system.

The stress test methodology was refined by extending the model simulating Czech yields

The yields entering the stress tests are now based on an extended methodological framework presented in a thematic article[3] in this Report. The new method[4] decomposes the Czech government bond yield curve and the koruna interest rate swap rate curve into its components. These reflect various factors determining the shape of the yield curve: (i) expectations about future macroeconomic developments, (ii) the related uncertainty, (iii) the risk of sovereign default and (iv) investors' portfolio allocation decisions. The components corresponding to these factors are called the risk-neutral yield, the term premium, the credit risk

CHART IV.1

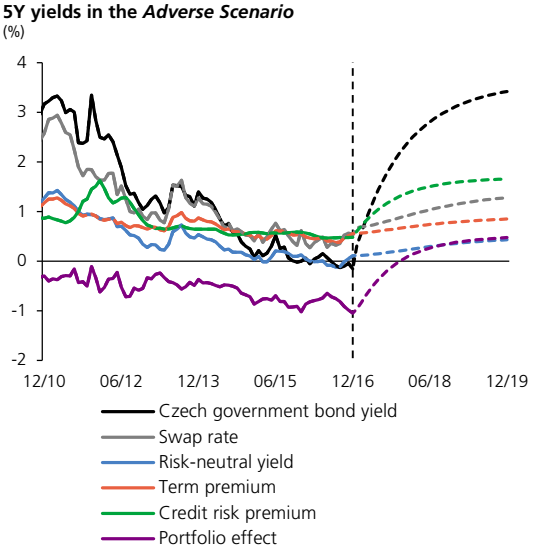
5Y yields in the *Baseline Scenario*



Source CNB
Note: The vertical line separates the historical (solid line) and simulated (dashed line) values.

CHART IV.2

5Y yields in the *Adverse Scenario*



Source: CNB
Note: The vertical line separates the historical (solid line) and simulated (dashed line) values.

2 A countercyclical aspect is used, for example, by the Federal Reserve, whose unemployment scenario assumes an increase of 4 pp, but at least to 10% (see Edge, R. and Lehnert, A. (2016): *Recent Experience with Supervisory Stress Testing in the United States*, Stress Testing and Macroprudential Regulation: A Transatlantic Assessment, CEPR Press). The ECB uses a similar procedure where a stricter baseline scenario results in a more moderate adverse scenario.

3 See the thematic article Decomposition of the Czech Government Bond Yield Curve in this Report.

4 The affine model and a comparison of Czech government bond yields, interest rate swap rates and credit default swap rates are used to decompose the yield curve. The Nelson-Siegel function and a dynamic factor model are used to simulate the evolution of the components. For details see the thematic article Decomposition of the Czech Government Bond Yield Curve in this Report.

TABLE IV.1

Key variables in the individual scenarios
(averages for given years)

	Actual value	*Baseline Scenario*			*Adverse Scenario*		
	2016	2017	2018	2019	2017	2018	2019
Macroeconomic variables							
GDP (y-o-y %)	2.4	2.8	2.8	3.5	-2.3	-2.5	-1.1
Inflation (%)	0.7	2.4	2.2	2.0	1.0	-2.4	-0.2
Unemployment (%)	4.1	3.7	3.6	3.4	4.8	6.9	9.0
Nominal wage growth (%)	4.3	5.3	5.1	4.9	-2.1	-7.2	-0.6
Effective GDP growth in euro area (%)	2.1	1.6	1.9	1.9	0.0	-1.2	-0.7
Credit growth (%)							
Total	6.3	7.1	7.4	8.3	2.2	-2.6	-3.4
Non-financial corp.	6.8	6.9	8.3	9.6	0.1	-6.4	-6.1
Households	7.3	7.9	7.8	8.2	3.9	-0.1	-1.9
Default rate (PD, %)							
Non-financial corp.	1.8	1.8	1.9	1.9	4.7	5.6	5.5
Loans for house purchase	1.7	1.6	1.7	1.8	3.7	4.2	4.6
Consumer credit	4.9	5.5	6.0	6.5	9.8	11.1	11.5
Loss given default (LGD, %)							
Non-financial corp.	45	45	45	45	55	56	54
Loans for house purchase	22	22	22	22	28	44	53
Consumer credit	55	55	55	55	59	67	75
Asset markets (%)							
3M PRIBOR	0.3	0.5	1.1	2.4	0.3	0.3	0.3
5Y yield	-0.1	0.7	1.6	2.9	1.6	2.9	3.3
3M EURIBOR	-0.3	-0.3	-0.2	0.0	-0.3	-0.2	0.0
5Y EUR yield	-0.6	-0.5	-0.4	-0.2	-0.3	0.2	0.2
Change in residential property prices	10.1	14.5	11.1	8.7	-1.2	-15.2	-8.3
Change in share prices	-3.6		-5.0			-34.0	
Banks' earnings							
Adjusted operating profit (y-o-y %)	-0.2	-1.8	0.7	0.4	-11.7	-20.5	-27.3

Source: CNB, BRCI

premium and the portfolio effect (see Charts IV.1 and IV.2). An estimate of the historical relationship between these components and the variables entering the CNB's scenarios is then modelled. On the basis of this estimate and some expert inputs, the paths of the individual components consistent with the *Baseline Scenario* and the *Adverse Scenario* are simulated. Finally, the simulation of the components is used to back-derive the scenario for Czech government bond yields (the sum of all four components) and swap rates (the sum of the risk-neutral yield and the term premium).

The *Baseline Scenario* assumes a rise in yields…

This year's *Baseline Scenario* involves an increase in the risk-neutral yield in line with the rise in PRIBOR rates (see section 2.1). The exit from a narrow band of low yields also results in greater uncertainty about the future interest rate path. This is reflected in an increase in the term premium. These two components cause Czech government bond yields and swap rates to rise (see Chart IV.1). Czech government bond yields continue to be affected by the credit risk premium, which remains low in the *Baseline Scenario*. They are also affected by the portfolio effect, which increases (becomes less negative) in the scenario. This is consistent with a gradual decrease in the amount of Czech government bonds held by non-residents following the exit from the exchange rate commitment. The negative gap between government bond yields and the swap rate thus closes gradually over the scenario horizon.

…the *Adverse Scenario* also assumes a rise in yields, but for different reasons

In the *Adverse Scenario*, the return to recession results in a smaller increase in the risk-neutral yield and the term premium than in the *Baseline Scenario* (see Chart IV.2). The swap rate, which is the sum of these two components, thus rises only slightly. By contrast, the Czech government bond yield rises more sharply in the *Adverse Scenario*. This is due to a concurrent rise in the credit risk premium (connected with a renewed escalation of the EU debt crisis) and the portfolio effect, which reflects a mass outflow of foreign investors from the Czech government bond market as a result of a general increase in financial market uncertainty.[5] At the three-year horizon, the five-year Czech government bond yield thus exceeds 3% in both scenarios. However, the scenarios differ in both the speed and the causes of the increase.

The bank stress test methodology was otherwise unchanged

The bank stress tests saw no other major methodological changes. As usual, the test parameters were refined using satellite models, which were re-estimated using the most recent time series. Unlike in the

5 In the *Baseline Scenario*, foreign investors reduce their holdings of Czech government bonds gradually, in line with the maturity of the bonds held. A substantial proportion of investors thus wait for the principal to be repaid instead of selling the bonds. The *Adverse Scenario*, by contrast, assumes that foreign investors are unwilling to wait to make speculative profit. This leads to a sell-off of bonds, which can lead to a potentially significant drop in their value on a market with limited liquidity.

previous Report, the banking sector tests were performed on data as of the end of 2016 Q4.[6]

In the *Baseline Scenario* credit risks stagnate and the sector's profitability continues to decline

Stress tests are traditionally one of the most important tools for assessing the resilience of the banking sector to potential risks to the stability of the Czech financial sector. Particular attention is paid to credit risk, which has long been the most important risk in the Czech banking sector. The evolution of credit risk is closely linked with developments in the corporate and household sectors. The continuing economic recovery is reflected in the *Baseline Scenario* in a greater ability of corporations and households to repay their debts, i.e. a lower level of credit risk (see sections 2.2 and 2.3). The default rate – a key indicator of credit risk – remains low in both the non-financial corporations and household sectors (see Table IV.1). The persisting environment of low interest rates reduces banks' traditional interest income. Given the expected developments, RoA is expected to fall from 1.2% to 1.1% in 2019 in the *Baseline Scenario*.[7]

The banking sector remains very well capitalised in the *Baseline Scenario*

Despite the worse profitability outlook,[8] the banking sector remains resilient over the entire three-year test horizon and has sufficient capital reserves (see Table IV.2). The sector's aggregate capital ratio is around 16.9%, i.e. well above the regulatory minimum of 8%. The Tier 1 capital ratio is only about 0.4 pp below the total capital ratio, illustrating the high quality of the capital structure. Nevertheless, one bank (which, however, accounts for only a marginal share of the sector's assets) gets into a situation of insufficient capital adequacy in the *Baseline Scenario*. This could imply a need to adjust its business model or top up its capital.[9]

The *Adverse Scenario* would imply significant accounting losses for the banking sector...

The *Adverse Scenario* assumes that seriously negative developments in the EU would result in a sizeable decline in economic activity in the Czech Republic, a surge in unemployment and financial market turbulence, leading to a significant jump in EU government bond yields. Since this negative shock would result in a contraction of the domestic economy

TABLE IV.2

Impact of the alternative scenarios on the banking sector

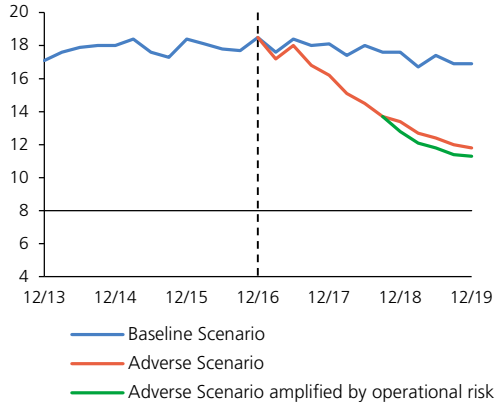
	Baseline Scenario			*Adverse Scenario*		
	2017	2018	2019	2017	2018	2019
Expected credit losses						
CZK billions	-25.3	-29.3	-33.7	-67.1	-85.3	-91.2
% of assets	-0.4	-0.5	-0.5	-1.1	-1.5	-1.6
Profit/loss from market risks						
CZK billions	-9.0	-5.3	-9.3	-16.3	-5.0	-1.6
% of assets	-0.1	-0.1	-0.1	-0.3	-0.1	0.0
Earnings for covering losses (adjusted operating profit)						
CZK billions	73.9	74.4	74.7	66.4	52.8	38.4
% of assets	1.2	1.2	1.1	1.1	0.9	0.7
Pre-tax profit/loss						
CZK billions	39.6	39.8	31.7	-16.9	-37.6	-54.4
% of assets	0.6	0.6	0.5	-0.3	-0.6	-1.0
Capital ratio at end of period in %						
Total	**18.1**	**17.6**	**16.9**	**16.2**	**13.4**	**11.8**
Tier 1	**17.6**	**17.1**	**16.5**	**15.7**	**13.0**	**11.4**
Capital injections						
CZK billions		0.2			12.5	
% of GDP		0.01			0.3	
No. of banks below 8% capital ratio		1			8	

Source: CNB
Note: Losses are expressed with a minus (-) sign.

6 End-Q4 data are also used for supervisory stress tests. Last year's Financial Stability Report used data as of 2016 Q1.
7 Adjusted operating profit comprises net interest income and net income from fees and commissions less administrative expenses, depreciation and amortisation. Adjusted operating profit is largely the same as pre-provision profit but does not include the impacts of market (interest rate and exchange rate) gains/losses.
8 Compared to FSR 2015/2016. Income increases in the *Baseline Scenario* in 2018 and 2019, but so do expected losses. Because assets rise at the same time, profitability as measured by RoA also declines.
9 A bank may also get into a situation of an insufficient capital ratio because the stress test methodology assesses its business model as unsustainable even if this is not necessarily true. This is because the methodology is based on a universal bank model and may not be entirely accurate for specialised banking institutions. The CNB therefore takes institutions' specific characteristics into account when assessing the test results.

CHART IV.3

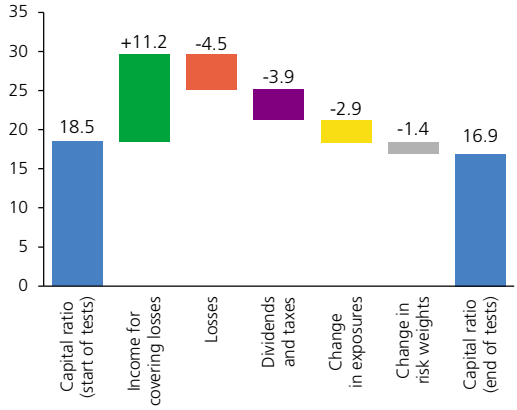
Capital ratios of the banking sector depending on scenarios
(%)



Source: CNB

CHART IV.4

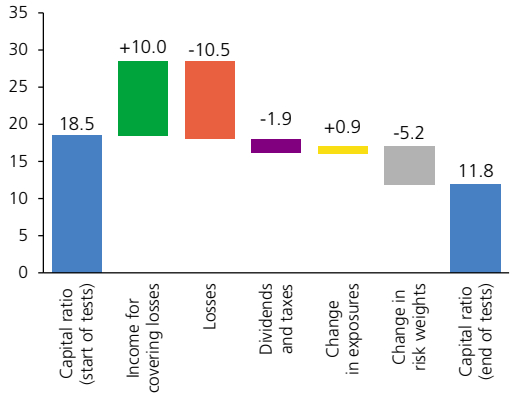
Decomposition of the change in the capital ratio of the banking sector in the *Baseline Scenario*
(%)



Source: CNB

CHART IV.5

Decomposition of the change in the capital ratio of the banking sector in the *Adverse Scenario*
(%)



Source: CNB

over the entire test horizon, the financial reserves of some corporations and households would be exhausted and debt repayment by the real sector would deteriorate. This would be reflected in a sizeable rise in the default rate in both the non-financial corporations and household sectors. The banking sector's overall credit losses would be roughly three times larger than in the *Baseline Scenario* at the three-year horizon. Given the expected rise in government bond yields in the Czech Republic and other EU countries, banks would also record market losses due to a decline in the value of these debt instruments (see Table IV.2). These credit and market losses in the sector, combined with a decline in its operating profit, result in an accounting loss of the sector and a sizeable fall in its capital ratio.

…but the sector's overall capital ratio would remain sufficiently above the regulatory threshold

Despite these adverse developments, the capital ratio of the banking sector does not drop below 11% in the *Adverse Scenario* (see Chart IV.3). Although the aggregate capital ratio stays sufficiently above 8%, eight banks – representing about 14% of the sector's assets – record a fall in capital adequacy below the regulatory minimum and have to top up their capital. The necessary capital injections total around CZK 12.5 billion, i.e. about 0.3% of GDP (see Table IV.2). Relative to the size of the banking sector, this figure is not significant enough to jeopardise its stability. The banking sector's stability is based on its high capital ratio, which went up by a further 0.1 pp compared to 2015, and on its ability to generate income to cover losses even in the event of highly adverse developments.

The capital ratio falls in the *Adverse Scenario* mainly because of high losses and a sharp rise in risk weights

A decomposition of the change in the capital ratio clearly illustrates the impacts of the main factors underlying the evolution of the capital ratio in the stress tests. In the *Baseline Scenario*, the Czech banking sector's income increases the capital ratio by as much as 11.2 pp over the test horizon[10] (see Chart IV.4). Part of this income is used to cover expected credit and market losses (-4.5 pp) and to pay dividends and taxes (-3.9 pp). The growth in economic activity leads to a rise in banks' exposures, lowering the capital ratio by 2.9 pp. A change in risk weights due to a change in the structure of lending reduces the capital ratio by a further 1.4 pp to 16.9% at the end of the three-year test horizon.[11]

Even in the *Adverse Scenario*, banks are able to generate income to cover their losses (+10 pp, see Chart IV.5). However, this income is not sufficient to cover all the expected losses over the test horizon (-10.5 pp). Dividends and taxes, paid mainly from profits for 2016, make a negative

10 The income used to cover losses includes profits for 2016 and expected income in 2017, 2018 and 2019.
11 Stronger growth in loans to households than in loans to corporations is expected in the *Baseline Scenario*. Loans to households, especially consumer credit, are riskier (have higher default rates), which leads to an increase in the average risk weights.

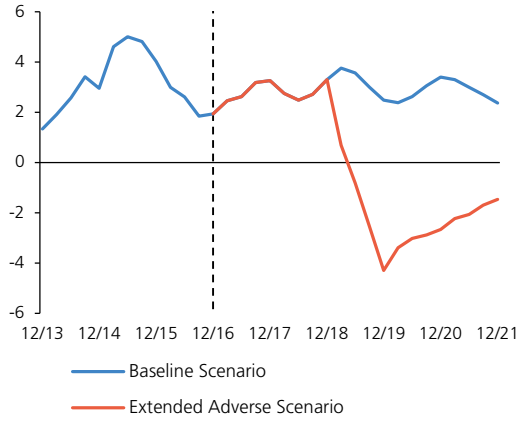
contribution to the capital ratio of 1.9 pp. Banks then react to the worse situation by lowering the amount of loans, which reduces the fall in the capital ratio by 0.9 pp. The deterioration of the economic environment and the materialisation of credit risk increase the risk weights, fostering a marked drop in the banking sector's capital ratio of 5.2 pp to 11.8% in the final period of the test.

A combination of the baseline and stress scenarios was used to model the impacts of the stress test over a five-year horizon

Loan growth in a favourable phase of the business and financial cycles, where the Czech Republic now finds itself, can lead to an accumulation of risks. Materialisation of those risks will reduce banks' capital ratio by more than assumed in the current *Adverse Scenario* with a three-year horizon. To assess this possibility, we present in Box 3 the results of a macro stress test with a five-year horizon. In the first two years, the economy continues to grow as assumed in the *Baseline Scenario*, and then a contraction occurs in the following three years according to the *Adverse Scenario*. The results suggest that under certain assumptions the capital ratio could drop closer to 8%, underscoring the need for prudent forward-looking macroprudential and microprudential policies in the area of capital buffers.

CHART IV.3 BOX

Alternative scenarios: real GDP growth
(year-on-year change in %)



Source: CNB

BOX 3: TAKING INTO ACCOUNT THE GROWTH PHASE OF THE FINANCIAL AND BUSINESS CYCLE IN A STRESS TEST MODEL WITH AN EXTENDED HORIZON

The traditional macro stress tests of banks used by the CNB have a three-year horizon,[12] during which the adverse scenario passes through to the financial results and subsequently the capital ratio of banks. The pass-through of the scenario immediately follows the latest known facts about their capital, balance sheets and profit and loss accounts. In some situations, this stress-testing framework may lead to a more favourable assessment of the banking sector's resilience, as it may not fully capture the accumulation of risks emerging in periods when further growth in the financial and business cycle is expected. This phase of the cycle is usually characterised by rapid loan growth, an easing of credit standards, rising debt of non-financial corporations and households, and the formation of asset price bubbles (not only in the real estate sector – see section 5.3.1). In the current conditions of easy monetary policies worldwide, it is also being accompanied by low interest rates and a lack of investment opportunities, resulting in search for yield and underestimation of risks assumed. These factors create sources of systemic risk which may not materialise until a few years later.

12 Like most central banks in other countries. The UK central bank has started to apply a five-year horizon. See Bank of England *Stress testing the UK banking system: 2015 results*.

TABLE IV.1 BOX

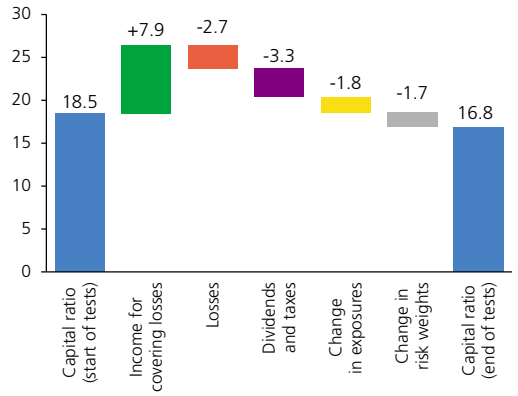
Selected variables in the *Adverse Scenario*
(averages for given years)

	Actual value	Extended *Adverse Scenario*				
	2016	2017	2018	2019	2020	2021
Default rate (PD, %)						
Non-financial corp.	1.8	1.8	2.7	4.9	5.6	6.2
Loans for house purchase	1.7	1.6	2.7	4.4	4.6	4.8
Consumer credit	4.9	5.5	7.4	10.5	11.5	12.2
Loss given default (LGD, %)						
Non-financial corp.	45	45	45	56	59	59
Loans for house purchase	22	22	22	34	48	57
Consumer credit	55	54	54	58	67	77

Source: CNB, BRCI

CHART IV.4 BOX

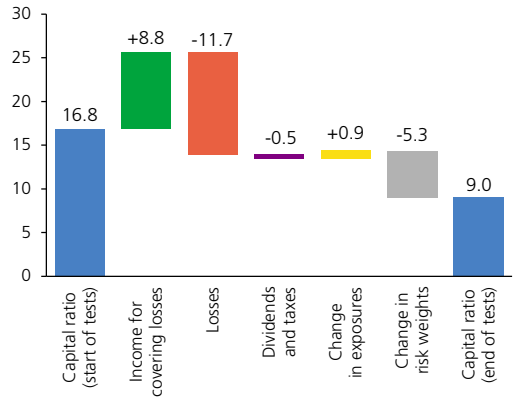
Decomposition of the change in the capital ratio of the banking sector in the extended *Adverse Scenario* 2017–2018
(%)



Source: CNB

CHART IV.5 BOX

Decomposition of the change in the capital ratio of the banking sector in the extended *Adverse Scenario* 2019–2021
(%)



Source: CNB

This Box presents the result of a macro stress test with an extended horizon of five years. It aims to illustrate the extent of the possible underestimation of the adverse impacts of risks accumulating over a sustained period of favourable economic developments. In the first two years, the favourable economic developments are mostly in line with the *Baseline Scenario* (see Chart IV.3 Box). The economy grows in real terms and some imbalances increase. Later in the second half of the second year, the first signs of rising credit risks begin to appear as PD rises. However, GDP is still in line with the *Baseline Scenario*. In the following three years, a turnaround occurs and the *Adverse Scenario* materialises, amplified by the risks accumulated in 2017–2018. Compared to the *Adverse Scenario*, PD and LGD thus record slightly higher growth (see Table IV.1 Box).[13]

Banks' loan portfolios rise by 15% in the first two years of the growth phase compared to the end of 2016. Banks' dividend policy is a key element leading to a decrease in the capital ratio at the end of the growth phase (see Chart IV.4 Box). This policy takes advantage of the space created by the persisting high profitability of banks (RoA of 1.2% in both 2017 and 2018). Despite a slight increase in PD at the end of the period, the degree of risk as expressed by PD and LGD remains relatively low. The change in risk weights therefore has a smaller impact on the capital ratio. At the end of 2018, the banking sector records a decline in its total capital ratio of 1.7 pp to 16.8% compared to the end of 2016. Property prices continue to rise at double-digit rates in this period, and their overvaluation also increases. The debt of non-financial corporations and households relative to GDP rises by 1.8 pp and 2.4 pp respectively.

In the third year, the economy starts to contract and credit losses start to increase due to the pass-through of shocks from the real economy (a decline in economic activity, a rise in unemployment, flat or falling income and a drop in property prices) to the quality of banks' loan portfolios (see Table IV.1 Box). Credit losses begin to significantly outweigh the income used to cover them (see Chart IV.5 Box). A limited ability to top up capital from profits is accompanied by a marked rise in capital requirements owing to an increase in risk weights as a result of a larger amount of NPLs. Together, this leads to a drop in banks' total capital ratio at the five-year test horizon of 9.5 pp to 9.0%, i.e. 2.8 pp more than in the three-year macro stress test (see Chart IV.6 Box). The stronger impact at the five-year horizon is due mainly to a decline in the capital surplus in the growth phase caused by an increase in

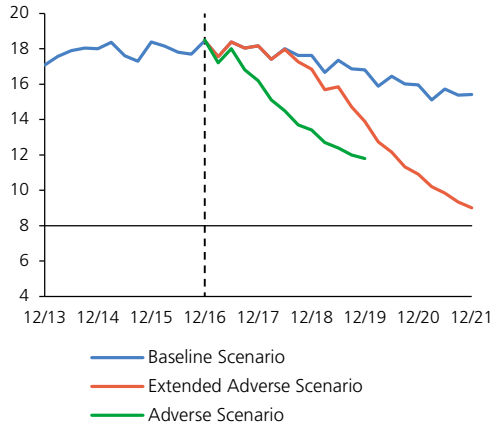
13 To prepare the stress test scenarios for the longer horizon, the CNB uses the official prediction model supplemented with satellite models (see Box 2).

banks' loan portfolios and dividend payments. The higher risks accumulated during the growth phase also have an effect. The weight of the shock impacts in the area of market risks is relatively low.

The test results illustrate that a prolonged growth phase of the financial and business cycle may become a source of increased risks. In such case, the banking sector's high resilience from the perspective of the standard macro stress test approach may actually be lower under certain circumstances. When applying capital macroprudential instruments in the future, the CNB intends to take into account the indications of stress tests with an extended horizon, and plans to further develop the modelling system for such tests. Extending the test horizon involves a number of challenges but supports the forward-lookingness of macroprudential policy. Such forward-lookingness is essential for reducing cyclical risks as well as structural risks accumulating over a longer time horizon.

CHART IV.6 BOX

Capital ratios of the banking sector depending on scenarios
(%)



Source: CNB

An additional sensitivity analysis in the *Adverse Scenario* analyses the impacts of losses arising from operational risk

Owing to an increase in risks in the areas of information security and compliance with legislative rules ("conduct risk"), an assessment of banks' operational risk is added to the stress test. For the end of the second year of the tests in the *Adverse Scenario*, banks are assumed to have incurred losses equivalent to double the average of the three historically highest losses arising from operational risk in 2005–2015.[14] The sector's capital ratio remains above 11.3% over the test horizon (see Chart IV.3, *Adverse Scenario* amplified by arising losses from operational risk), while two more banks fall below the 8% threshold and the capital injections increase to CZK 16.3 billion (around 0.3% of GDP).

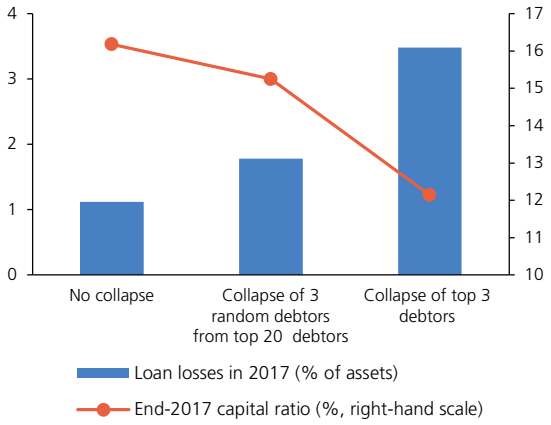
The portfolio concentration test represents a strong shock…

The final sensitivity analysis in the *Adverse Scenario* focuses on testing concentration risk and assumes default by the largest debtors of each bank. Although the concentration of client loan exposures (as measured by the share of the three largest exposures in the portfolio of loans to legal entities) has long been relatively constant at around 17%, the largest loans may not be sufficiently collateralised in some cases. This is evidenced by the fact that the share of uncollateralised loans in loans to

14 The historical data on losses arising from operational risk are obtained from the banks participating in the joint stress tests, which accounted for almost 90% of the sector's assets at the end of 2016 Q4. An alternative approach was used for the other banks. It assumes that the losses are equal to the capital requirement for operational risk (see the fall-back option in the methodology of the 2016 EU-wide stress tests).

CHART IV.6

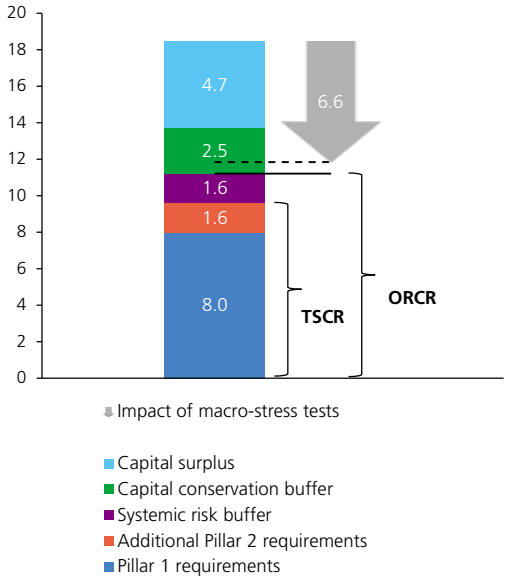
Impact of the collapse of the top three debtors of each bank in the *Adverse Scenario*
(%; LGD = 50 %)



Source: CNB

CHART IV.7

Structure of bank capital requirements in the Czech Republic and impact of macro stress tests
(average for sector as of end of 2016)



Source: CNB
Note: The illustration assumes a zero countercyclical capital buffer.

the top three debtors was 60% at the end of 2016.[15] If these debtors default, banks' credit losses could reach high levels.

…but the banking sector is resilient to this major shock, too

The concentration test is performed in two variants. The first assumes the collapse of three random debtors from the top 20 debtors of each bank. The other, stricter one assumes the collapse of the top three debtors of each bank. Given the above share of uncollateralised loans in loans to the largest clients, a 50% haircut on these exposures is considered in both cases. This shock has a big effect on the banking sector's credit losses and capital ratio. The capital ratio falls to 15% at the end of 2017 for the collapse of three random large debtors. The collapse of the top three debtors of each bank would cause an even sharper fall in the capital ratio, to 12.1% (see Chart IV.6). The concentration test represents a very strong stress scenario, and the resulting banking sector capital ratio based on such a large shock can therefore be assessed as positive.

The effect of the stress test results on the capital requirements

Banks must meet the total capital requirement (TSCR) given by the sum of the Pillar 1 requirements and the Pillar 2 requirements at all times. If the supervisory authority decides that a bank cannot use one of the capital buffers to absorb a stress test shock, its total requirement is increased by the amount of that buffer. In this form it is referred to as the other relevant capital requirement (ORCR). The CNB defines the ORCR as the sum of the TSCR and the systemic risk buffer. This is because the purpose of the systemic risk buffer is to prevent long-term non-cyclical systemic risks, not to absorb the losses of individual banks in adverse phases of the economic cycle.

Chart IV.7 shows how fulfilment of the relevant capital requirement would look if the impact of the *Adverse Scenario* of the macro-stress test on the banking sector as a whole were to be factored in. The capital surplus and the capital conservation buffer would together be sufficient to cover the decrease in capital in the *Adverse Scenario*. Supervisory stress testing in the SREP process is used to evaluate whether a bank has sufficient capital to meet the relevant capital requirement (see Box 4: *Joint stress testing by the CNB and selected banks*).

BOX 4: JOINT STRESS TESTING BY THE CNB AND SELECTED BANKS

In addition to top-down macro stress tests of the banking sector, the CNB has been performing bottom-up micro stress tests in partnership with selected Czech banks since 2009. Such testing was also performed by the ECB in 2016 for the largest EU banks.

15 The share of uncollateralised claims on non-financial corporations in loans to the three largest borrowers was 55% at the end of 2015.

The micro stress tests differ from the macro stress tests mainly in that the impacts of shocks on banks' capital ratios are calculated by the banks themselves based on their credit portfolios at the one-year horizon. They thus use much more detailed information on individual portfolios than that available to the CNB for its macro stress tests. However, the most probable scenario (*Baseline Scenario*) and the adverse scenario (*Adverse Scenario*) for the macroeconomic environment are the same as in the macro stress tests (for details see section 2.1).

Since the horizon of the micro stress tests is only one year, the results of the two types of test are not fully comparable. As in the macro stress tests, the assumed macroeconomic developments in the *Baseline* and *Adverse* scenarios are reflected in the credit risk parameters. However, faster transmission of credit risks to banks' balance sheets is assumed in the micro stress tests. Ten domestic banks and building societies, representing 77% of the assets of the Czech banking sector, took part in the thirteenth round of micro stress tests using end-2016 data. As usual, the focus was on testing credit risk, which is the largest risk for the Czech banking sector. Since 2014 the micro stress tests have also included a sensitivity analysis of interest rate risk for the banks' entire balance sheets and specific interest rate risk for domestic government bonds.

In the *Baseline Scenario*, a constant level of credit risk in the case of corporate exposures and a marginal increase in credit risk in the case of retail portfolios can be observed (see Table IV.2 Box). In the *Adverse Scenario*, considerably higher credit risk is visible, reflecting the hypothetical adverse evolution of economic activity. This is expressed by a broad rise in both the probability of default (PD) and the loss given default (LGD) in all the credit portfolios tested except central government, for which the PD remains at zero.

The results of the micro stress tests for the *Baseline Scenario* point to a year-on-year fall in profit of 18% and a rise in the capital requirements of banks (see Table IV.3 Box). The aggregate Tier 1 capital ratio of the banks tested would increase slightly to 18.8%. In the *Adverse Scenario*, profit declines by 44% and the capital requirements rise by 40%. Despite these adverse developments, the aggregate Tier 1 capital ratio of the banks tested remains well above the 8% threshold at the one-year horizon, dropping to 13.5%.

The micro stress test results confirm that the banks tested are highly resilient to the *Adverse Scenario*, in line with the results of the macro stress tests of the banking sector. The results and individual parameters, however, are not fully comparable because

TABLE IV.2 BOX

Risk parameters for the credit segments and scenarios tested
(%; weighted by EAD)

	Actual value 31. 12. 2016		*Baseline Scenario* 31. 12. 2017		*Adverse Scenario* 31. 12. 2017	
	PD	LGD	PD	LGD	PD	LGD
Corporate exposures	1.3	35.4	1.3	35.4	2.2	43.0
- large enterprises	1.0	36.6	1.0	36.1	1.6	44.3
- small and medium-sized enterprises	2.0	33.6	1.9	33.4	3.2	40.8
- specialised credit exposures	1.5	36.8	1.5	36.7	2.5	45.1
Retail exposures	1.9	29.7	2.0	29.8	2.9	37.4
- real estate SMEs	5.4	34.3	5.4	34.3	9.1	44.0
- loans for house purchase	1.3	22.8	1.3	22.8	1.9	29.3
- revolving loans	2.6	58.2	2.8	58.4	4.0	70.8
- other loans to individuals	3.1	51.1	3.5	51.6	4.6	62.1
- other loans to SMEs	4.7	40.4	4.7	40.2	7.8	50.2
Institutions	0.2	21.2	0.2	21.2	0.3	24.4
Central governments	0.0	9.9	0.0	9.9	0.0	14.8

Source: CNB

TABLE IV.3 BOX

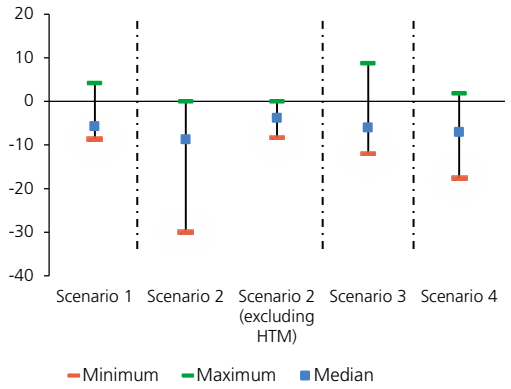
Banks' capital requirements and capital ratios
(%)

	Actual value 31. 12. 2016	*Baseline Scenario* 31. 12. 2017	*Adverse Scenario* 31. 12. 2017
Net profit after tax (year-on-year change)	-	-18.0	-43.7
Capital requirements (year-on-year change)	-	2.5	40.2
Regulatory capital (year-on-year change)	-	5.0	2.5
Tier 1 capital ratio	18.5	18.8	13.5
Capital ratio, total	18.9	19.4	13.8

Source: CNB

Chart IV.7 Box

Interest rate risk sensitivity analysis
(% of regulatory capital)



Source: CNB
Note: Banks included in micro stress tests, excluding building societies. In Scenario 2 (excluding HTM), accounting principles are taken into consideration and so CZK government bonds held to maturity are not marked to market. HTM = held to maturity.

of the different samples of institutions tested, different calculation methods and different test horizons, which lead to different assumptions about the speed of transmission of risks to banks' balance sheets.

In addition to the *Baseline* and *Adverse* scenarios, a sensitivity analysis of general interest rate risk and the specific interest rate risk for koruna government bonds was performed. The economic logic of the test was applied in the interest rate risk testing and the effect of accounting categories on the revaluation of assets and liabilities was suppressed. The sensitivity analysis thus covered the entire portfolio (the banking and trading books) and used four scenarios. *Scenario 1* assumed a 3 pp parallel shift of the yield curve, *Scenario 2* assumed a 3 pp widening of the koruna government bond spread vis-à-vis the IRS yield curve,[16] *Scenario 3* assumed a larger increase in the slope of the yield curve[17] and *Scenario 4* contained a combination of a more moderate increase in the slope of the yield curve and a 2 pp widening of the koruna government bond spread vis-à-vis the IRS yield curve.[18]

The results of the sensitivity analysis show that a rise in interest rates would have mixed impacts across the banks tested (see Chart IV.7 Box). In *Scenario 1*, the impact of a parallel shift of the yield curve would be between -8.7% and 4.1% of capital. In *Scenario 3*, banks' sensitivity to rotation of the yield curve increases further, with the impact on the banks' capital ranging from -12.0% to 8.7%. *Scenario 2* assumes a widening of the koruna government bond spread because of a rise in the yield demanded by investors. The strongly negative impact of this scenario (between -30.0% and 0.0%) is due to the significant exposure of domestic banks to koruna government bonds. However, if we move away from a purely economic perspective and take accounting principles into consideration, the impact of the test is significantly smaller (-8.3% to 0.0%), since domestic banks hold a significant proportion of their koruna government bonds in the "held to maturity" accounting category and do not mark debt securities included in that category to market. In *Scenario 4*, the impact is between -17.6% and 1.8%. If the

16 A variant of *Scenario 2* in which accounting principles are taken into consideration and so koruna government bonds held to maturity are not marked to market was also considered for comparison.
17 A 5 pp shift was assumed for maturities of over 5 years, the curve was left unchanged for maturities of up to 3 months, and linear interpolation was used for the shift for maturities of over 3 months and up to 5 years.
18 *Increase in the yield curve slope*: a 3 pp shift was assumed for maturities of over 5 years, the curve was left unchanged for maturities of up to 3 months, and linear interpolation was used for the shift for maturities of over 3 months and up to 5 years. *Widening of the koruna government bond spread*: a 2 pp shift was assumed for maturities of over 5 years, and linear interpolation was used for the shift for maturities of over 3 months and up to 5 years.

Adverse Scenario and the interest rate risk sensitivity scenarios were to materialise together, the aggregate capital ratio of the banks tested would fall by a further 0.3–2.1 pp.[19]

The stress tests of pension management companies assess the sector's resilience at the one-year horizon

The stress tests of pension management companies (PMCs) focus on assessing the risks to transformed funds (TFs) managed by PMCs at the one-year horizon. Besides the *Baseline Scenario*, the sector's resilience to the *Adverse Scenario* was also tested; this variant captures adverse economic developments coupled with a drop in asset prices in financial markets (see section 2.1).

The PMC stress-testing methodology underwent further changes

The PMC stress-testing methodology was further refined in this year's tests. The scenario for general interest rate risk (evolution of swap curves) and the credit spread risk for Czech koruna government bonds is now prepared using forecasts for the yield curve components.[20] The scenarios for credit spread risk for other bonds in the *Adverse Scenario*, which are derived from the historical volatility of yields on government or corporate bonds with the relevant credit rating and maturity, have also changed.[21] In general, stronger shocks are applied to bonds with lower ratings and longer maturities.

Transformed funds are mainly sensitive to interest rate risk…

The effect of the risks considered on the results of transformed funds (TFs) is summarised in Table IV.3 and Charts IV.8 and IV.9. As TFs mostly invest in high-quality government bonds, general interest rate risk and credit spread risk for government bonds have the most significant effect. A rise in swap curves leads to a decline in total assets of 0.6% in the *Baseline Scenario* and 1.4% in the *Adverse Scenario*. An increase in the credit spread for government bonds results in a drop in assets of 1.9% in the *Baseline Scenario* and 3.9% in the *Adverse Scenario*. Credit spread risk for corporate bonds leads to a decrease in assets of less than 1.0% in both scenarios. TFs holding a large proportion of their assets in fixed-rate koruna bonds with longer residual maturities are hit hardest by the materialisation of all three types of interest rate risk. TFs reduce the impact of a potential interest rate shock by holding bonds to maturity (28% of the portfolio) and investing in floating-rate bonds (a further 27% of the portfolio[22]). By contrast, derivative hedging of interest rate risk is applied by TFs to only a limited extent and would reduce the total

TABLE IV.3

Results of the stress tests of PMCs

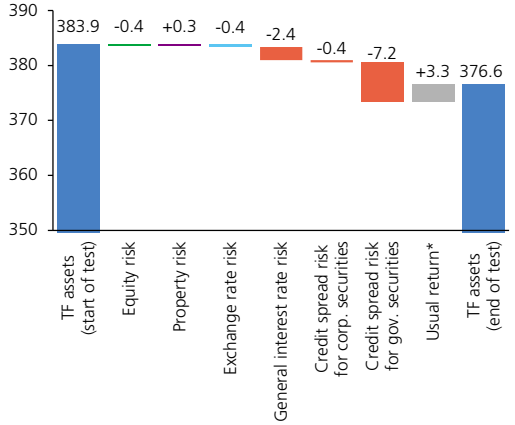
		Baseline Scenario	*Adverse Scenario*
PMC Equity (start of test)	CZK billions	8.9	8.9
Capital ratio (start of test)	%	126.8	126.8
Change in TF asset value - general interest rate risk	CZK billions	-2.4	-5.3
	% of TF assets	-0.6	-1.4
Change in TF asset value - credit spread risk for corporate securities	CZK billions	-0.4	-3.8
	% of TF assets	-0.1	-1.0
Change in TF asset value - credit spread risk for government securities	CZK billions	-7.2	-15.2
	% of TF assets	-1.9	-3.9
Change in TF asset value - exchange rate risk	CZK billions	-0.4	0.5
	% of TF assets	-0.1	0.1
Change in TF asset value - equity risk	CZK billions	-0.4	-3.1
	% of TF assets	-0.1	-0.8
Change in TF asset value -property risk	CZK billions	0.3	-0.4
	% of TF assets	0.1	-0.1
Total impact of risks on TF assets	CZK billions	-10.6	-27.2
	% of TF assets	-2.8	-7.1
Profit of transformed funds	CZK billions	1.9	-0.6
PMC Equity (end of test)	CZK billions	8.1	-2.6
Capital ratio (end of test)	%	112.3	-35.4
Capital injection	CZK billions	0.6	9.9

Source: CNB
Note: Start of test: end of 2016; end of test: end of 2017. TF stands for transformed funds.

19 *Scenario 2* would have the biggest impact (-2.1 pp).
20 The decomposition methodology is described in detail in the thematic article *Decomposition of the Czech Government Bond Yield Curve* in this Report.
21 For details see *Macro-stress tests of the pension management companies sector* on the CNB website.
22 Floating-rate bonds held to maturity are not included in this 27%.

CHART IV.8

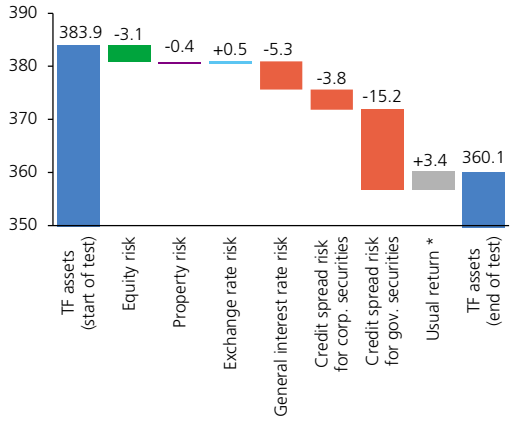
Change in the value of assets of transformed funds due to the individual types of risk in the *Baseline Scenario*
(CZK billions)



Source: CNB
Note: * The assumed rise in value that would occur even without market revaluation of assets in the *Baseline Scenario*. It represents dividend income, bond coupons and the return on the HTM portfolio. A usual return of 0.9% of the book value of assets at the start of the test is considered for all TFs. This equals the average return (net profit/assets of TFs) in recent years.

CHART IV.9

Change in the value of assets of transformed funds due to the individual types of risk in the *Adverse Scenario*
(CZK billions)



Source: CNB
Note: * The assumed rise in value that would occur even without market revaluation of assets in the *Adverse Scenario*. It represents dividend income, bond coupons and the return on the HTM portfolio. A usual return of 0.9% of the book value of assets at the start of the test is considered for all TFs. This equals the average return (net profit/assets of TFs) in recent years.

losses caused by a rise in swap rates by just 10.1% on average across both scenarios.

…and other types of risk have a limited impact

Losses due to equity and real estate risk increased slightly compared to the previous stress test. This was due to a rising share of these investments in TFs' portfolios and a more severe calibration of these shocks. In terms of amount, however, the losses due to these two risks are insignificant. In the *Baseline Scenario*, TFs suffer exchange rate losses due to expected appreciation of the koruna. In the *Adverse Scenario*, by contrast, depreciation of the koruna leads to exchange rate gains. Despite a considerable amount of foreign currency investment and slight year-on-year growth in such investment (to 16.1% of assets), the effect of the exchange rate on TFs' results is limited due to currency hedging. However, the degree of exchange rate risk hedging fell in most TFs compared to the previous stress test.

In the *Adverse Scenario*, risk also affects pension fund clients

The change in the value of TFs' assets has only a limited impact on their accounting profit, as only some investments are realised in the relevant period. Therefore, assuming realisation of 15% of potential profit, even the 2.8% decrease in asset value in the *Baseline Scenario* results in the generation of an accounting profit by all TFs and non-zero returns for their clients. If the *Adverse Scenario* were to materialise, however, the drop in asset value would be so sharp that most TFs would post a loss and their clients would receive zero returns.

In both the *Baseline Scenario* and the *Adverse Scenario*, the capital adequacy of some PMCs would fall below the required minimum

PMCs guarantee non-negative returns for the clients of their TFs by law. If a TF's assets decline below its liabilities, the relevant PMC has to top up the TF's assets. This is the case for three PMCs in the *Baseline Scenario*. As a result of topping up the TFs' assets, the capital adequacy of these PMCs falls below the required level. The PMC owners would have to inject capital of CZK 0.6 billion in order for their PMCs to meet the capital adequacy requirement. In the *Adverse Scenario*, all eight PMC have to top up the assets of their TFs. All of them see their capital adequacy decline below the required level, and four of them end up with negative capital. The owners would have to inject capital of CZK 9.9 billion in order for their PMCs to satisfy the capital adequacy requirement.

4.2 BANK LIQUIDITY STRESS TESTS AND LIQUIDITY REGULATION

Banks having their registered offices in the Czech Republic passed the liquidity tests. Both the CNB's macro-stress test and the liquidity coverage and net stable funding ratios indicate that domestic banks are highly resilient to liquidity shocks. This is due to their strong client deposit base and high capitalisation on the liabilities side and to a significant proportion of high-quality government bonds and exposures to the CNB on the asset side.

The liquidity coverage ratios confirmed the domestic banking sector's resilience to a short-term liquidity shock…

Resilience to a short-term liquidity shock is regularly tested using the liquidity coverage ratio (LCR[23]). The aggregate LCR for the entire sector was 188%[24] at the end of 2016, well above the regulatory requirement of 80% (see Chart IV.10). Although it dropped by 4 pp year on year, all domestic banks were also compliant with the regulatory limit of 100% required as from 2018. Domestic banks continued to hold almost all their assets from the LCR liquidity buffer in the form of claims on the CNB and government bonds (around 95% of the buffer), to which no haircuts are applied. Given the one-month horizon of the stress considered, the highest aggregate LCR was achieved as usual by building societies, which, compared to the other groups of banks, had a significantly lower share of deposits included in the expected outflows (see Table IV.4).

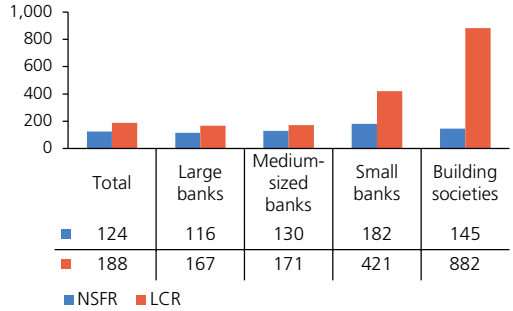
…and the net stable funding ratios confirmed sufficient stable funding

The aggregate Basel III net stable funding ratio (NSFR[25]) for the banking sector as a whole was 124% at the end of 2016 (see Chart IV.10). This figure illustrates sufficient available stable funding relative to required stable funding. The estimated NSFR differed across the bank groups monitored, but in all cases was above the regulatory limit of 100% scheduled to take effect in 2018. In addition to a strong client deposit base and solid capitalisation, the sufficient NSFR level was due to a high share of highly liquid assets (28% of the sector's total assets; see Table IV.4) with a low stable coverage need. As in the case of the LCR results, building societies had the highest estimated NSFR. Long-term deposits with a contractual maturity of over one year, which are considered 100% stable, accounted for a relatively large share of their funds (see Chart IV.11). However, building societies had the largest coverage need relative to the other groups of banks. More than 50% of their balance sheet required stable funding at the end of 2016 (see Chart IV.12), with loans to natural persons requiring funding with a higher stability weight, or longer maturities, making up the largest part.

23 The LCR is a requirement to cover a net liquidity outflow over a 30-day horizon with liquid assets. It is calculated as the ratio of the liquidity buffer to the net liquidity outflow.
24 The aggregate results take liquidity subgroups into account and exclude state-owned banks.
25 The NSFR is a structural liquidity requirement and is monitored over a one-year horizon. It is defined as the ratio of available stable funding (see Chart IV.11) to required stable funding (see Chart IV.12).

CHART IV.10

Regulatory indicators of bank balance-sheet liquidity
(%; as of 31 Dec. 2016)



Source: CNB
Note: The LCR is the ratio of the liquidity buffer to the net liquidity outflow of banks over a 30-day stress horizon as defined by EC Regulation 2015/61. The NSFR is the ratio of available stable funding to required stable funding as defined by Basel III. The results take liquidity subgroups into account and exclude state-owned banks.

TABLE IV.4

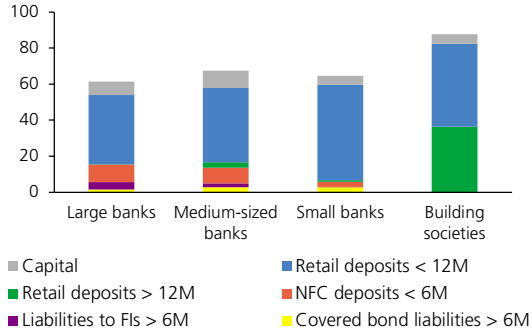
The LCR for groups of banks
(% of total assets of individual groups of banks as of 31. 12. 2016; rates in %)

	Banks			Building societies	Total
	Large	Medium-sized	Small		
Liquidity buffer	30	22	41	20	28
Liquid assets	30	22	41	20	29
Weighted average rate of eligibility after application of haircuts*	100	100	100	99	100
Expected outflows	23	15	12	4	19
Balances of outflows	94	63	91	25	81
Weighted average rate of outflow*	24	24	13	18	24
Expected inflows	5	2	2	2	4
Balances of inflows	16	6	17	3	13
Weighted average rate of inflow*	31	41	12	76	31
LCR	167	171	421	882	188

Source: CNB
Note: * The extent to which items subject to haircuts, outflows or inflows in the stress period are represented in balance sheets. The results take liquidity subgroups into account and exclude state-owned banks.

CHART IV.11

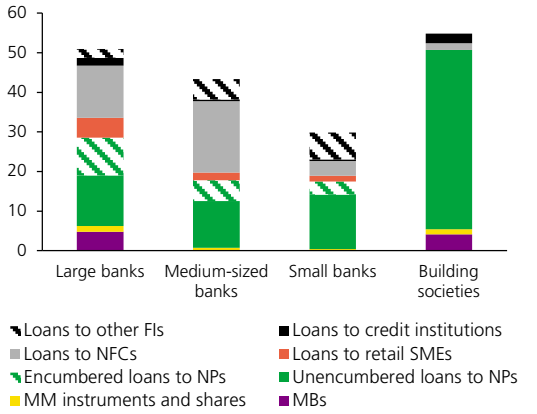
Structure and amount of items ensuring stable funding
(% of balance sheet as of 31 Dec. 2016)



Source: CNB
Note: The Chart contains items whose weights exceed 2% in any of the groups of selected banks. M: month; FIs: financial institutions; NFC: non-financial corporations.

CHART IV.12

Structure and amount of items requiring stable funding
(% of balance sheet as of 31 Dec. 2016)



Source: CNB
Note: The Chart contains items whose weights exceed 2% in any of the groups of selected banks. MBs: mortgage bonds; NPs: natural persons; NFCs: non-financial corporations; MM: money market; FIs: financial institutions.

TABLE IV.5

Scenario type and shock size in the liquidity stress test
(%)

Balance-sheet item / Maturity bands	<3M	3M–6M	6M–9M	9M–12M
	Interest rate and equity shock			
1. Liquidity buffer				
1.1 Q-o-q change in yield curve in pp*				
1Y PRIBOR	0.3	0.0	0.0	0.0
5Y GB yield	1.0	0.6	0.5	0.4
1Y EURIBOR	0.2	0.0	0.0	0.0
5Y EUR GB yield	0.0	0.2	0.3	0.2
1.2 Haircuts from value of capital instrument	30.0	-	-	-
	Size of deduction from expected inflow			
2. Inflows				
2.1 Secured claims	0.9	0.9	0.9	0.9
2.2 Unsecured claims due**				
on NPs	2.1	2.2	2.4	2.6
on NFCs and retail SMEs	1.1	1.2	1.2	1.2
	Expected outflow rate			
3. Outflows				
3.1 Drawdown of credit lines	5.0	5.0	5.0	5.0
3.2 Issued debt securities	100.0	100.0	100.0	100.0
3.3 Retail deposits				
insured	3.2	3.5	3.2	3.1
others	6.3	7.0	6.4	6.3
3.4 Liabilities to NFCs				
secured	12.6	14.1	12.9	12.5
other	25.3	28.2	25.8	25.0
3.5 Liabilities to FIs				
secured	12.6	14.1	12.9	12.5
others	31.6	35.2	32.2	31.3
3.6 Growth in new loans, of which***				
secured claims	0.0	1.4	1.3	1.0
due to NPs	0.0	1.0	0.6	0.4
due to NFCs and retail SMEs	2.4	0.0	0.7	0.0

Source: CNB
Note: The parameter values are the averages to those applied to individual banks. M: month, Y: year, NPs: natural persons, NFCs: non-financial corporations, FIs: financial institutions, GB: government bonds.
* The haircut is determined by multiplying the change in the yield curve by the duration of the bond portfolio.
** Due claims on financial institutions were not subject to deductions in this scenario.
*** The credit growth assumption is calculated using satellite models in macro stress tests of bank solvency.

Funds in other banks were more diversified and had shorter residual maturity. By contrast, these banks held a larger liquid asset buffer (see Table IV.4).

The CNB also assesses the banking sector's liquidity using its own macro stress test…

Besides assessing short-term balance-sheet liquidity, the CNB conducts its own macro stress test.[26] The sufficiency of a bank's liquid asset buffer relative to the net liquidity outflow, i.e. the difference between expected outflows and inflows of liquidity, is tested using this indicator over a one-year horizon (four maturity bands).[27] Their level is derived from bank's funding stability and the maturity mismatch in its balance sheet. The model thus incorporates the main features of the LCR and NSFR regulatory requirements. The model is a two-round one and takes into account the links between balance-sheet and market liquidity and the feedback reaction of the banking sector. The banking system is first hit by scenario-defined exogenous shocks, which banks react to under certain assumptions. Those reactions then change the reputational risk of each reacting bank and the systemic risk in the banking sector as a whole (endogenous shocks). Banks have a limited ability to increase their balance-sheet totals over the entire test period. Compared to the LCR or NSFR, the liquidity macro stress test allows for better testing of the impact of scenarios with lagged pass-through of the adverse economic situation to the quality of banks' loan portfolios and to the financial markets.

The stress test was applied to 20 banks having their registered offices in the Czech Republic using the *Adverse Scenario* (see section 2.1.3 and Table IV.1) and the end-2016 data.[28] In the first round of stress, a liquidity outflow was generated for each maturity band by increasing the asset funding requirement (see Table IV.5, lines 3.1 and 3.6) amid lower sources (lines 3.2–3.5). At the same time, the inflow of expected liquidity (lines 2.1 and 2.2) for the relevant maturity band was lowered, and also the value of some assets in the liquidity buffer[29] (lines 1.1 and 1.2). The second round of stress captures the consequences of the rise in reputational and systemic risk brought about by banks' efforts to cover the net outflow and is expressed through additional losses arising from the sale of assets from the buffer.

…which confirmed their high resilience over a longer stress period

The test results reveal that the banking sector as a whole would withstand the simulated stress and would be able to cover a net outflow

26 For details see the thematic article in Financial Stability Report 2015/2016: *The Relationship between Liquidity Risk and Credit Risk in the CNB's Liquidity Stress Tests.*
27 The expected inflows of liquidity are limited from above so that the minimum net outflow is 10% of the expected outflow.
28 State-owned banks, which have a specific business model, were not included in the stress test. The test takes liquidity subgroups into account.
29 Two liquidity buffer levels are monitored in the stress test. The level 1 liquidity buffer is defined as the sum of cash, claims on the CNB (excluding minimum reserves) and government bonds. The level 2 liquidity buffer additionally includes corporate securities other than those held as loans.

of liquidity lasting even one year (see Chart IV.13). The impacts of the negative shocks on the balance sheets of the groups of banks monitored were mixed. When the impact was measured using the aggregate decline in the total liquidity buffer, large and medium-sized banks were hit hardest (a decline of more than 70%). A smaller impact was apparent for building societies (a decline in the total buffer of around 60%) for similar reasons as in the assessment of the LCR and NSFR results. Three banks would exhaust their entire buffer during the test, although not before the final quarter. The cause was the same for all of them: their liquidity buffer was not sufficient in relation to the maturity mismatch in their balance sheets and their funding stability. It was the lowest relative to total assets compared to the other banks.

Domestic banks' balance-sheet structure changed partially as a result of the CNB's monetary policy…

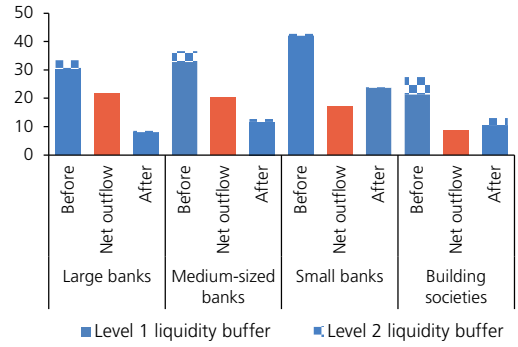
The use of the exchange rate as a CNB monetary policy instrument from early November 2013 resulted in an increase in koruna liquidity (see section 2.1, Chart II.10), which is held largely by non-resident banks. These are mostly parent institutions of domestic banks (see section 3.4, Chart III.29). Non-resident banks with no access to CNB facilities usually placed korunas in Czech government securities (see section 2.1, Chart II.9) or in short-term time deposits with domestic banks (see Chart IV.14). The high interest of non-resident banks in koruna assets was reflected in an increase in their share in the financing of domestic banks, a rise in their share in holdings of Czech koruna government bonds (see Chart II.11) and a decrease in yields on those bonds to negative levels (see section 2.1, Chart II.5). This led to a change in the structure of liquid assets held by domestic banks. They gradually reduced their holdings of Czech government securities and deposited free koruna liquidity with the CNB at a rate of 0.05% (see Chart IV.15). Non-residents' interest rose sharply in early 2017 as expectations of an exit from the CNB's exchange rate commitment intensified.

…but their liquidity position remained stable and strong

Despite the changes in the foreign exchange, money and bond markets caused by the CNB's interventions, the liquidity position of the domestic banking sector remained stable and strong. This was due mainly to an increasing share of liquid assets in balance sheets and a large excess of client deposits over client loans (excluding credit institutions). Loans from non-resident credit institutions rose from 5% of total assets (January 2013) to almost 16% (February 2017). However, these loans were deposited with the CNB, claims on which grew from around 9% to 26% of the balance sheet (see Chart IV.15). Before the CNB's exchange rate commitment was introduced, client loans accounted for around 48% of the balance sheet (January 2013) and client deposits about 65% (see Chart IV.15). Client loans accounted for 45% and client deposits for more than 60% of the balance sheet at the end of February 2017. The ratio of client deposits to loans thus fell slightly from 139% to 135% in the period under review (see Chart IV.14). However, it remained high and well above the EU average (around 85%).

CHART IV.13

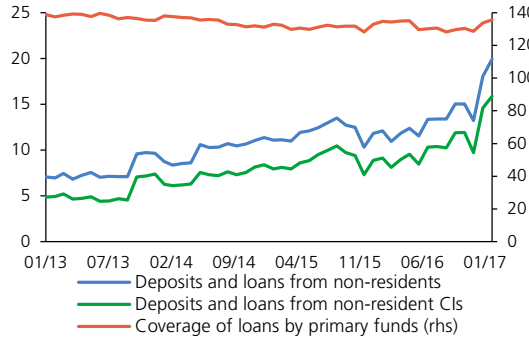
Results of the bank liquidity stress test
(% of total assets of individual groups of banks)



Source: CNB
Note: The column "Before" represents the pre-stress size of the liquidity buffer and the column "After" the post-stress size of the liquidity buffer. The column "Net outflow" represents the outflow of liquidity over the one-year horizon taking the liquidity inflow into account. The inflows are limited from above, i.e. a minimum net outflow of 10% of the expected outflow is assumed.

CHART IV.14

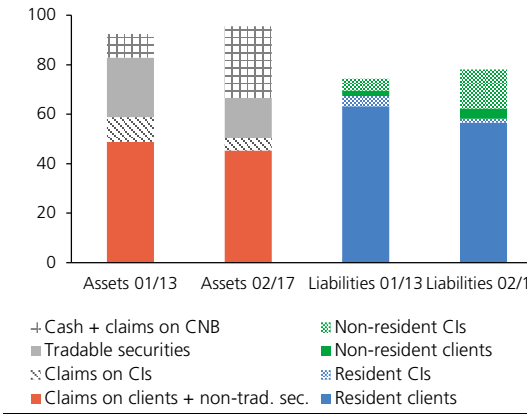
Selected funding sources of the domestic banking sector
(% of balance sheet; right-hand scale: %)



Source: CNB
Note: Coverage of loans by primary funds characterises the coverage of a bank's lending activities to non-bank clients by primary funds, i.e. deposits, loans and similar client liabilities. Claims on CNB and CIs are excluded. CIs: credit institutions.

CHART IV.15

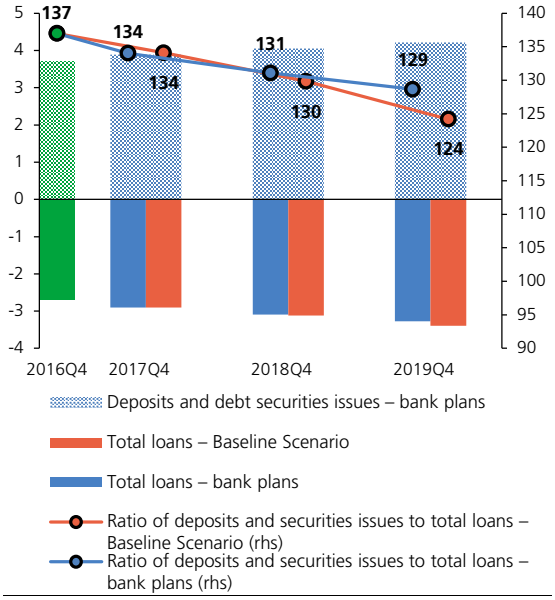
Selected balance-sheet items of the domestic banking sector
(% of balance sheet)



Source: CNB
Note: CIs: credit institutions.

CHART IV.16

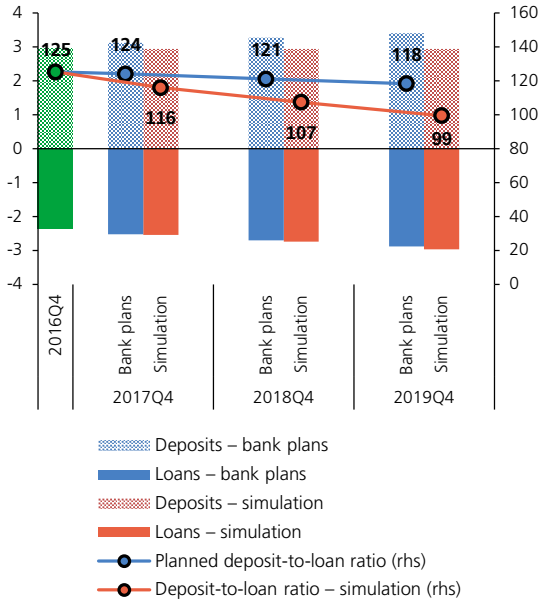
Funding plans of domestic banks
(CZK trillions; right-hand scale: %)



Source: CNB
Note: Includes loans and deposits to the private sector defined as households, non-financial corporations and financial institutions. Also includes debt securities with maturities equal to or more than three years. The green columns denote the position as of 2016 Q4; positive values are deposits and negative values are loans.

CHART IV.17

Comparison of planned and encumbered client deposits and loans
(CZK trillions; right-hand scale: %)



Source: CNB
Note: Clients comprise households and non-financial corporations. The simulation involves 8% year-on-year growth in loans and unchanged deposits. The green columns denote the position as of 2016 Q4; positive values are deposits and negative values are loans.

According to banks' plans, coverage of loans by primary funds will remain high in the future

In their end-2016 funding plans, domestic banks expect loans to the private sector to increase on average by 6.5% year on year, from CZK 2.7 trillion to around CZK 3.1 trillion at the three-year horizon (see Chart IV.16). They are planning to increase private sector deposits and issuance of debt securities with maturities of at least three years by almost 4.5%, from CZK 3.7 trillion to CZK 4.2 trillion. The planned funds of banks would sufficiently exceed their planned loans and would even cover credit growth over the entire three-year horizon in the *Baseline Scenario* (see section 2.1.3, Table IV.1 and Chart IV.16). The three-year outlook for the ratio of client deposits to loans, i.e. the coverage of loans by primary funds, also remains high (see Chart IV.17). This ratio would drop below 100% assuming slightly higher-than-planned growth in client loans (8%) and unchanged client deposits. Banks would be forced to cover the higher growth in loans with other funds, which might increase their costs. Following the planned amendment of the Act on Bonds,[30] issuance of covered bonds (mortgage bonds under the current law) could be a comparable alternative to retail deposits. The new law should provide holders of covered bonds with a higher degree of certainty that they will receive due claims in time and in full. This source of funding is currently not significant for the domestic banking sector.[31] At the end of March 2017, it amounted to around 8% of total liabilities on average for the banking sector as a whole (or around 3.5% excluding banks with specific models). The amendment should result in an increase in the credit quality of covered bonds and thereby boost investor interest.

30 A draft law amending Act No. 190/2004 Coll., on Bonds, as amended, and other related laws, in particular the Insolvency Act and the Recovery and Resolution Act, was approved by to the government on 13 March 2017 and submitted to the Chamber of Deputies of the Parliament.

31 The exception is banks with specific business models, whose sole source of funding is issuance of covered bonds. Issues often take place within bank groups and are not held for trading.

4.3 THE HOUSEHOLD STRESS TEST

The household stress test confirms that low-income households and borrowers with a DSTI ratio of over 40% are highly sensitive to unfavourable economic developments and an increase in loan interest rates. Households with mortgages are especially vulnerable.

The household stress tests are based on the *Adverse Scenario* amplified by an increase in loan interest rates

The household stress test[32] focuses on the risk of overindebtedness households, whose potential debt service problems could transform into financial sector credit risk. Household overindebtedness here means an increased probability that a household will fall into arrears with its debt servicing obligations. It is defined with the aid of the ''financial reserve'', which represents households' net monthly income minus essential expenditures and loan instalments. A household is referred to as overindebted if its financial reserve is negative after the chosen scenario is applied. The pre- and post-shock shares of overindebted households are calculated for individual income groups.

The household stress test framework was used to simulate the impacts of the *Adverse Scenario* amplified by an increase in loan interest rates (*Amplified Adverse Scenario*). This scenario assumes the same evolution of macroeconomic variables as the *Adverse Scenario* in the banking sector macro stress test as of the end of 2017 (see section 4.1). It also assumes loan interest rates rise by 3 pp with a 40% mortgage refixation rate (see Table IV.6). The 40% refixation rate corresponds to the percentage of mortgages with a residual fixation period of up to and including one year.

Low-income households with mortgages are especially sensitive to financial stress

The results of the household stress test confirm the higher sensitivity of low-income households to potential adverse shocks. At the end of 2016, the pre-shock share of overindebted households with a net monthly income of less than CZK 25,000 was about 12%; households with mortgages accounted for about half of this figure (see Chart IV.18). After the *Amplified Adverse Scenario* was applied, the share of overindebted households with a monthly income of less than CZK 25,000 increased to about 16%. This was caused almost exclusively by a rise in the overindebtedness of households with mortgages. In other income groups, too, debt service problems in the event of adverse economic developments were encountered above all by households with mortgages. The increase in household overindebtedness is due to a combination of a fall in their net income and a rise in loan instalments.

32 The household stress test is conducted using data for individual households from the Household Budget Statistics. The most recent available data are for 2015; the 2016 data are estimated. The methodology is described in detail in Galuščák, K., Hlaváč, P. and Jakubík, P. (2014): *Stress Testing the Private Household Sector Using Microdata*, CNB Working Paper 2/2014.

TABLE IV.6

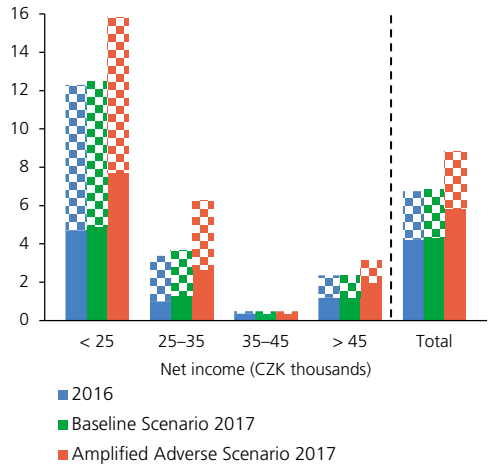
Key variables in the individual scenarios of the household stress tests
(end of period)

	2016	*Baseline Scenario* 2017	*Amplified Adverse Scenario* 2017
General unemployment rate (%)	3.8	3.6	5.5
Nominal wage growth (y-o-y, %)	4.7	5.4	-7.3
Inflation (y-o-y, %)	1.4	2.6	-0.6
Interest rate on mortgage loans (%)	2.7	2.7	5.7
Interest rate on consumer loans (%)	12.2	12.2	15.2
Interest rate on other loans (%)	3.8	3.8	6.8
Share of refixed mortgage loans (%)	40	40	40

Source: CNB
Note.: The 40% refixation rate corresponds approximately to the percentage of mortgage loans with a residual fixation period of up to and including one year.

CHART IV.18

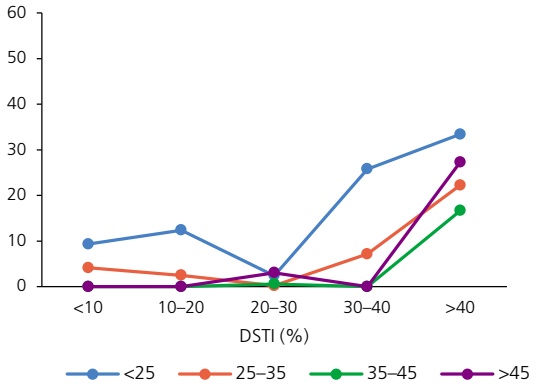
Shares of indebted households by income group
(%; averages in individual income groups)



Source: CNB, CZSO
Note: Shares of households with loans. The solid part denotes the share of overindebted households with mortgages and the patterned part the share of overindebted households with loans other than mortgages.

Chart IV.19

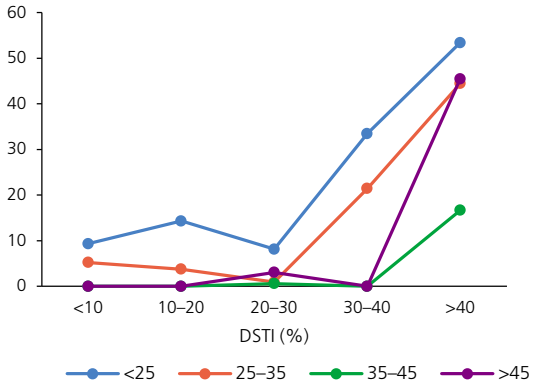
Shares of overindebted households by DSTI ratio and income group in the *Baseline Scenario*
(%; averages in individual groups)



Source: CNB, CZSO
Note: Shares of households with loans. The individual curves divide households into income groups according to the net monthly income of the entire household in CZK thousands.

Chart IV.20

Shares of overindebted households by DSTI ratio and income group in the *Amplified Adverse Scenario*
(%; averages in individual groups)



Source: CNB, CZSO
Note: Shares of households with loans. The individual curves divide households into income groups according to the net monthly income of the entire household in CZK thousands.

The significant growth in overindebtedness in the lowest income group is caused mainly by a low or zero pre-stress financial reserve.

Borrowers with a DSTI ratio of over 40% are also highly vulnerable to financial stress

In its Financial Stability Reports, the CNB regularly assesses the ability of debt-burdened households to repay their obligations in the event of extremely adverse economic developments. These analyses focus among other things on the impact of the simulated stress on households' debt service to income (DSTI) ratio. Previously, however, the analyses did not examine what debt burden can be considered excessive, or at what DSTI level Czech households become extremely sensitive to financial stress. For this reason, the stress test has been extended to include an analysis of the DSTI distribution of overindebted households.

The results reveal that the share of overindebted households with a DSTI ratio of over 40% is relatively high even before the stress scenario is applied (see Chart IV.19). Their sensitivity to the simulated stress is significantly higher than that of households with lower DSTI ratios, regardless of their net monthly income (see Chart IV.20). Loans provided to borrowers with a DSTI ratio of over 40% can therefore be regarded as highly risky. This conclusion is in line with the analyses of other central banks[33] and was used in the update of the *Recommendation on the management of risks associated with the provision of retail loans* (see section 5.3.1).

33 See ESRB (2017): *A Review of Macroprudential Policy in the EU in 2016*.

4.4 THE PUBLIC FINANCE STRESS TEST

The CNB assessed credit institutions' exposures to the Czech government as being systemically important. However, given the favourable results of the Czech public finance stress test, the CNB will not require these credit institutions to meet an additional capital requirement to cover the risk of concentration of these exposures over a three-year horizon.

The CNB reviews and evaluates the risks of concentration of sovereign exposures

Since 2015, based on its internal methodology, the CNB has been annually reviewing and evaluating the risks of concentration of exposures to sovereign issuers in balance sheets of credit institutions having their registered offices in the Czech Republic.[34] In its Financial Stability Reports it informs the market about which sovereign exposures it has identified as systemically important and whether it will require the relevant credit institutions to meet an additional capital requirement to cover the risk of concentration of these exposures over a three-year horizon. The methodology defines an important sovereign exposure as an exposure to a sovereign issuer with a minimum ratio of 100% to the credit institution's eligible capital. It becomes systemic if the assets of credit institutions with important sovereign exposures exceed 5% of the total assets of all the credit institutions included. It is indicated that an additional capital requirement must be met if the three-year outlook for the credit risk indicator of the sovereign issuer (sovereign risk indicator, ISR) exceeds one of its thresholds.[35] The CNB requires additional capital where the credit institution holds exposures in excess of the limit and this above-limit exposure is not already sufficiently covered by capital.[36]

The Czech public finance stress test methodology has been refined

The CNB partly adjusted the Czech public finance stress test methodology, which is used for projecting the main variables entering the ISR. The main change concerned the modelling of some types of government spending. Government expenditure (excluding pensions, unemployment benefits and interest expenditure) is now fixed at the level assumed by the CNB's fiscal forecast (see Table II.2.4, p. 20, Inflation Report I/2017) in the first year of the stress scenario.[37] These components of government expenditure therefore do not fall in the first year of the test even if adverse economic developments are expected. Conversely, indexation of current pensions may be lower than in the fiscal forecast, or even zero, in the second and third years of the stress scenario. These

34 The internal methodology is described in FSR 2014/2015 and on the CNB website: *Internal CNB methodology for the review and evaluation of sovereign exposure concentration risk*.

35 The CNB primarily monitors two thresholds for the sovereign risk indicator (ISR): a soft threshold of 5% indicating the creation of an additional capital requirement where an additional expert analysis proves this to be necessary, and a hard threshold of 8% indicating unconditional creation of an additional capital requirements.

36 The above-limit part of a sovereign exposure is determined using the ISR where this indicator exceeds its thresholds. The ISR provides a simplified assessment of the risk of default on a sovereign exposure. The threshold separating the limit and above-limit parts of a sovereign exposure gradually falls as this indicator increases. As a result, the above-limit part rises. The highest effective limit is 222% and the lowest is 0%.

37 Inflation Report I/2017.

TABLE IV.7

Public finance stress test

	2016#	*Adverse Scenario* 2017	2018	2019	Critical limit
Macroeconomic variables					
Real GDP growth (%)	2.4	-2.3	-2.5	-1.1	< -2.3
Current account balance (% of GDP)	1.1	1.9	1.2	0.6	< -1.8
Gross national savings (% of GDP)*	28.1	28.1	28.1	28.1	< 19.3
External debt (% of GDP)*	74.7	74.7	74.7	74.7	> 99.6
Difference between real 10Y GB yield and real GDP growth (pp)	-2.7	3.0	7.5	4.5	> 6.3
Fiscal variables					
Government debt (% of GDP)	37.6	41.8	48.7	55.6	> 64.7
Primary balance (% of GDP)	1.0	-1.2	-3.0	-4.7	< -3.2
10Y government bond yield (%)	0.4	1.7	2.5	3.2	> 10.8
Government debt maturing within one year (% of GDP)	5.6	7.8	8.7	9.3	> 19.0
Share of government debt maturing within one year (%)	15.0	18.8	17.8	16.7	> 21.7
Share of foreign currency debt (%)	15.3	15.1	11.1	9.9	> 27.1
Share of non-residents in debt holdings (%)*	48.8	48.8	48.8	48.8	> 34.9
Institutional variables					
Government effectiveness (WGI score)*	1.1	1.1	1.1	1.1	< 1.0
Political stability (WGI score)*	1.0	1.0	1.0	1.0	< 0.8
Rule of law (WGI score)*	1.1	1.1	1.1	1.1	< 1.2
Banking crisis*	No	No	No	No	= Yes
Past sovereign defaults*	No	No	No	No	= Yes
Sovereign risk indicator (ISR, %)	**-**	**0.12**	**0.37**	**0.27**	

Source: CNB, CZSO, ECB, World Bank

Note: The symbol > (< or =) denotes that a higher (lower or equal) value means breaching of the critical limit and indication of increased risk. The figures are rounded. Indications of breaching of the critical limit are based on unrounded figures. Where the limit is breached, the relevant variables are further indicated in red.

* Variable not modelled; last known value assumed in projection.

\# The data used are the values known when Inflation Report I/2017 was prepared.

changes brought the government's expected reaction in the stress scenario closer to its actual behaviour and increased the conservatism of the government debt and primary balance values included in the fiscal variables (see Table IV.7).

Exposures to Czech government debt were assessed as systemically important…

The CNB assessed domestic credit institutions' investments in Czech government bonds as a systemically important sovereign exposure. Although the value of these exposures dropped by CZK 281 billion at the end of 2016, at CZK 605 billion it still accounted for around 8.5% of these institutions' total assets and around 137% of their total capital. The assets of institutions with above-limit exposures accounted for 66% of the total assets of all the credit institutions under review. Exposures to other governments, the EU and the EIB were not found to be systemically important.

…but their riskiness did not exceed the thresholds

The ISR was estimated for systemically important exposures. Its three-year outlook was 0.27% (see Table IV.7) and did not exceed the supervisory thresholds of 5% and 8%. The CNB will therefore not require credit institutions having their registered offices in the Czech Republic to meet an additional capital requirement to cover the risk of concentration of exposures to the Czech government.

Few of the variables under review exceeded the critical limit…

Of the variables included in the ISR, the critical limit was exceeded not only by rule of law and the share of foreign holders of government debt (see section 2.1, Chart II.11), but also by real GDP growth and the difference between the real government bond yield and the rate of GDP growth (see Chart IV.21). The combination of a decline of the domestic economy and growth in interest rates resulted in the ISR peaking at 0.37% in 2018. However, a slowdown in the decline in GDP to 1.1% in 2019 caused the two macroeconomic variables to return below the critical limit. The ISR went down in 2019 even though the deficit increased and the primary balance, at -4.7%, exceeded the critical limit. The total government debt increased to 55.6% of GDP at the three-year test horizon. This deterioration in government finances primarily reflected lower tax revenues during the strong recession assumed in the *Adverse Scenario* (see section 2.1.3 and Table IV.1). The deterioration in public finances was also due to the reaction of financial markets in the form of growth in nominal yields on Czech government bonds, especially at the longer end of the koruna yield curve. The ten-year government bond yield rose to 3.2% at the three-year test horizon. However, the higher debt service costs had a relatively limited effect on growth in the total government debt due to its relatively low initial level.

…and the lower ISR level was also due to more favourable evolution of Czech government finances

Czech government debt recorded a year-on-year decline at the end of 2016. In relative terms, it has been decreasing since 2013, from 44.9% of GDP to 32.2% of GDP in 2016[38]. Since 2014 this decrease has been fostered by renewed economic growth and in 2016 also by a decrease in debt service costs (see section 2.1). The favourable trends in these variables reduced the impacts of the stress scenarios (see Chart IV.22) and were reflected in the three-year outlook for the ISR. It dropped from 1.27% in 2015 to 0.27% in 2017. The Czech government CDS spreads, which should reflect market perceptions of its credit risk, also decreased.

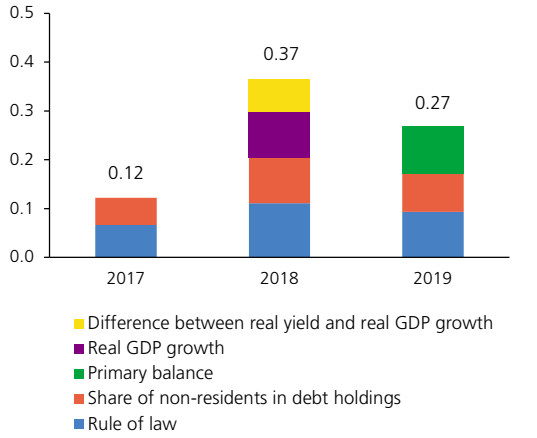
Regulation of exposures to sovereign issuers remains part of the international debate

The international debate about the regulation of banks' exposures to sovereign issuers continued within the BIS in 2016. A working group dealing with proposed changes to the treatment of sovereign exposures in international regulations has been active within the Basel Consultative Group (BCG) since 2015. A working sub-group tasked with surveying the treatment of sovereign exposures in emerging economies in the Pillar 1, 2 and 3 prudential regimes was set up under this group. The CNB joined this working sub-group in 2016 and was actively involved in the survey. The results were presented at the BCG meeting in Prague in October 2016. The heterogeneity identified in perceptions of sovereign risk across these countries requires further discussion.

A debate continues at EU level regarding the proposal to create sovereign bond-backed securities of EU Member States issued in euros. The debate includes preferential treatment of such securities in the regulatory framework in relation to government bonds issued by individual EU Member States. A related ESRB working group was established in 2016. The main task of the group, in which the CNB is represented, is to analyse the feasibility of this proposal. The CNB sees two sources of risks in the proposal. The first is the potential threat of market distortion if the regulations treat the proposed securities more favourably than government bonds of individual Member States without proper economic justification. The second is the high cost of changing the existing financial sector regulations if such a financial product is created.

CHART IV.21

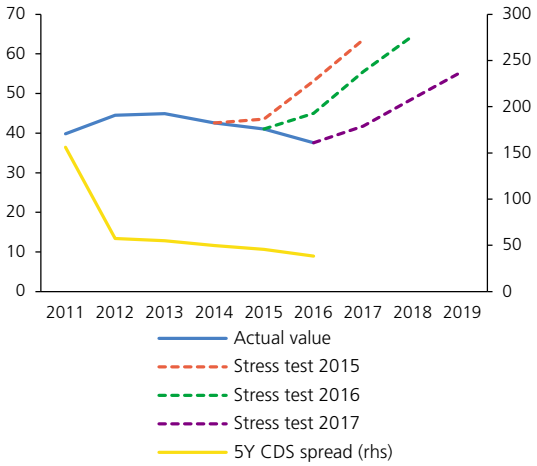
Decomposition of the sovereign risk indicator in the Adverse Scenario
(%)



Source: CNB, World Bank

CHART IV.22

Comparison of the trajectories of public debt in the public finance stress tests
(% of GDP; right-hand scale: bp)



Source: CNB, Bloomberg, Thomson Reuters
Note: Year-end data.

38 The difference from the 2016-end value used in the stress test (Table IV.7) is caused by subsequent statistical data revisions.