ČNB ČESKÁ NÁRODNÍ BANKA

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The household stress test[1]

Contents

1 The methodology in effect since 2020, based on Gregor, J., Hejlová, H. (2020). *The Household Stress Test*, Thematic Article on Financial Stability, CNB.

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1. Introduction

The aim of household sector stress testing is to assess the resilience of indebted households in a hypothetical scenario simulating adverse economic developments. The test focuses primarily on households with mortgage loans.[2] Given the importance of these loans in credit institutions' balance sheets, analysis of the risks associated with mortgage loans is of key importance from the financial stability perspective. The potential financial stress on other households is associated more with the indirect risk to financial stability, which would manifest itself through a decline in their consumption and related consequences for the real economy.

The household stress test consists of three steps. In the first step, a mortgage portfolio is compiled. It changes in size and nature over the test horizon depending on the scenario applied. In the second step, potential problem loans, or loans at risk of default, are estimated based on the portfolio. Loans at risk of default are estimated using the financial reserve under stress concept. In the third step, the loans at risk of default are used to estimate the total mortgage default rate, taking into account households' holdings of liquid assets.

2. Stress test scenarios

The first step of the test is to design the macroeconomic scenario, which determines the type of the risk to be tested and the degree of stress to be simulated. The adverse macroeconomic scenario (stress) reflects the most significant risks, which, were they to materialise, would have major impacts on the household sector and the financial system. A baseline macroeconomic scenario based on the CNB's official projection model in the first two years is also used in the stress tests to compare the impact of the stress with the most likely scenario. Its output is complemented with projections of selected financial variables, generated using satellite models. The test uses the 3-month PRIBOR, the unemployment rate, the inflation rate and nominal wage growth from the official projection model. Property prices, the number of new mortgages, interest rates on house purchase loans and on consumer credit, and an estimate of the probability of inflows into unemployment enter the test from the satellite models.

3. Mortgage portfolio

The primary data source for the test is the *Survey of new loans secured by residential property*, which CNB has been conducting across credit institutions operating in the Czech Republic twice a year since mid-2015. This data is used to create the mortgage portfolio. Depending on the scenario tested, the credit characteristics of the portfolio (interest rate, collateral value, instalment size, etc.)

2 Given the general purpose of stress testing, i.e. to estimate the impact of adverse macrofinancial shocks on the stability of financial institutions, only households with mortgage loans are tested, while all their additional debt is also taken into account. In other words, in view of their only small effect on the stability of financial institutions, indebted households without mortgage loans and households without debt are not stress tested.

are adjusted over time (see the worked example in Table P.1). The portfolio is gradually expanded in each successive year of the test to include the mortgage loans simulated.

BOX 1: Creation of the mortgage portfolio

The mortgage portfolio is created in three steps. First, a portfolio of the mortgage loans existing at the start of the test is created (the initial portfolio).[3] The initial portfolio is compiled from real data, available from 2015 onwards, and from model data for 2005–2015.[4] The portfolio is compiled sequentially on a quarterly basis. In each quarter new mortgages are added progressively to the portfolio based on the available or modelled characteristics, and repaid and non-performing loans are removed. The credit characteristics of the mortgage applicants, such as their income, estimated housing costs and necessary expenditures and the value of their collateral, are adjusted each year in line with macroeconomic developments. The residual maturity and principal of the loan are also updated. For loans subject to refixing in the given period,[5] all the loan characteristics are adjusted. Refixing thus gives rise to a change in the interest rate and, in turn, the instalment amount. The period of fixation is assumed to stay constant over the entire loan repayment term. So, if a client has a loan agreed for 30 years with a rate fixed for five years, it is assumed that the rate will be refixed every five years. It is also assumed that the client will be able to increase the existing unpaid principal of the loan when the rate is refixed.[6] For illustration, the appendix (see Table P.1) lists a worked example of adjustment of mortgage and borrower characteristics from the entry of a loan into the portfolio until its full repayment, i.e. its exit from the portfolio.

In the second step, new mortgage loans are simulated over the scenario horizon. Using an estimate of the aggregate mortgage debt over the scenario horizon and also the average mortgage loan size in the same period, the number of mortgages hypothetically provided is calculated. Based on the calculated number, hypothetical new mortgages are simulated. They copy the characteristics of mortgages provided in the previous year. The distribution of the individual characteristics is thus maintained. The characteristics are subsequently linked to selected variables in the stress scenario in such a way that, as well as keeping lending standards the same, they reflect the changing macroeconomic and financial conditions. The sizes of the individual loans, the collateral value and the interest rate thus change in line with the projections for property prices and interest rates. However, it is assumed that mortgage applicants will keep the same preferences regarding the repayment term and the period of fixation.

3 The test starts a year before the publication of the new Financial Stability Report.

4 Data suitable for simulating loans ((the sizes and prices of mortgages) are not available for the years preceding 2005.

5 For loans with a fixed-rate term of less than one year, i.e. for loans with a de facto variable interest rate, the rates are refixed on an annual basis.

6 According to the available data on individual loans, approximately one-third of households increase their mortgage by at least CZK 200,000, or 10% of the residual value of the loan, when refinancing. This fact was also taken into account in the simulation of new loans in the stress scenario. Should a change in behaviour be observed in the data, this assumption can be adjusted further.

The simulation also assumes compliance with the caps on the LTV, DTI and DSTI ratios recommended by the CNB.[7] If a simulated loan fails to comply with the recommended caps (taking into account the set exemptions), it is adjusted. In the event of non-fulfilment of the DSTI caps, it is assumed in the first phase that the mortgage loan applicant would in this situation extend the repayment term to the maximum of 30 years (or to 64 years of age, whichever is the shorter). If it turns out that extending the repayment term still does not lead to compliance with the caps, or if the repayment term cannot be lengthened due to the applicant's age, another form of loan adjustment is performed. It assumes that half of the mortgage loan applicants not meeting the DTI, DSTI or LTV caps would try to find property costing 10% less. This means that the property value and, in turn, the mortgage loan size are recalculated, while the down payment remains unchanged.[8] If the simulated loan fails to meet the ratio limits even after this adjustment, it is not included in the portfolio. The other half of the mortgage loan applicants, who would not seek a cheaper property, would defer the purchase of the property to the future and the loan is thus likewise ultimately removed from the simulated portfolio.

The loan characteristics are adjusted in the last step similarly as in the first step (see Table P.1), the only difference being that the scenario-based values of the macroeconomic variables are used instead of the actual variable values.

4. IDENTIFICATION OF RISKS IN THE STRESS TEST

Credit risk is assessed in the test using the household default ratio (*DR*). This is linked to the estimate of loans at risk of default. The estimate of loans at risk of default is based on the concept of the financial reserve under stress (*FRs*).[9] This financial reserve is calculated for each quarter and is defined as the level of net income the household will be left with after loan repayments, housing costs[10] and necessary expenditures[11] are deducted (see equation 1).

$$\mathrm{FR}_S = \text{net income}_S - \text{loan repayments}_S - \text{housing costs} - \text{necesary expenditures} \qquad (1)$$

7 The caps effective as of the test date are applied. They are expected to be constant over the scenario horizon.

8 One can imagine a situation where a mortgage loan applicant is interested in buying a property costing CZK 5 million, while their net annual income is CZK 480,000 and they are capable of making a down payment of CZK 450,000 (implying a loan of CZK 4.55 million). In this situation, the DTI ratio would be 9.5 and the LTV ratio 91% and the applicant would thus satisfy neither the DTI nor the LTV limit. However, it is assumed that the applicant can partially adjust and finds a property costing 10% less, i.e. CZK 4.5 million. The value of their liquid assets is unchanged at CZK 450,000, so the requested loan falls to CZK 4.05 million. In this new situation, the DTI ratio would be 8.4 and the LTV ratio 90%. Given the permitted 10% exemption for loans with an LTV of 80%–90%, this means the loan could be granted.

9 Hejlová, H., Holub, L., Plašil, M. (2018): *The introduction and calibration of macroprudential tools targeted at residential real estate exposures in the Czech Republic*. Financial Stability Report 2017/2018, pp. 126–135, Czech National Bank.

10 Housing costs are energy consumption costs plus property maintenance costs. Estimates of these costs are based on the *Survey of Income and Living Conditions* (SILC) conducted by the Czech Statistical Office. They ranged between CZK 1,700 and CZK 16,800 per month in 2019.

11 Necessary expenditures comprise expenditure on food, non-alcoholic beverages, tobacco, health, transport, communication, education, maintenance of the house, and social care. The estimate of these expenditures is based on Household Budget Statistics data (Czech Statistical Office) and is a function of the number of dependants, the number of economically active persons and the age of the main mortgage applicant. Necessary expenditures were estimated to lie in the range of CZK 2,800 and CZK 17,100 per month in 2019.

The subscript *S* denotes variables that are subjected to the stress and are changed in accordance with the scenario tested. Besides the evolution of wages assumed in the scenario, households' net income also reflects the change in the probability of temporary loss of employment. The test assumes that households' incomes can fall to the legally defined level of unemployment benefit in a strongly adverse scenario.[12] In the case of loan repayments, the subject of the stress is a change in mortgage interest rates due to a change in the client risk premium or the monetary policy rate. The actual period of fixation and maturity of individual loans are respected when testing for the change in mortgage interest rates. So, if a loan has a rate fixed for three years, the change in interest rates will manifest itself suddenly only in the third year and will affect the subsequent instalments only up to the level of the unpaid part of the loan. If the loan has a maturity of three years, the rise in interest rates will not affect it.

Individual loans are deemed to be at risk of default if the calculated financial reserve ($FRs < 0$) is negative. However, loans identified as being at risk of default do not necessarily become non-performing. To evaluate a mortgage default, we need to take into consideration the household's liquid reserve (*LR*), i.e. the sum of cash and deposits on current and savings accounts. The test assumes that households can use the liquid reserve to offset a negative financial reserve in the short term. However, we do not know the actual level of the liquid reserve for individual households, so we have to model it on the basis of simplifying assumptions.

In the stress test, the household's liquid reserve is observed at two stages: when it takes out the loan and when it repays the mortgage. The level of the liquid reserve at the time of purchasing the property is determined depending on whether the household collateralises the loan with one property or more than one property (see equation 2). If the loan is collateralised with one property, the test assumes that, when taking out the loan, the household has a liquid reserve approximately equal to the difference between the value of the collateralised property and the size of the mortgage loan (*1 – LTV x value of secured property*). This implies that the household uses all (or almost all) its liquid reserve for the down payment in order to meet the LTV condition. The household is thus left with a minimum reserve amounting to one month's savings from its net income for the next period (quarter) after it purchases the property.[13] If the household secures the mortgage with more than one property, the liquidity reserve is not exhausted and, instead of making a down payment, the household uses the additional collateral to satisfy the LTV condition. In this case, it is assumed that the household's liquid reserve after purchasing the property is equal to annual savings in the period before it obtained the mortgage.[14]

12 For households that become unemployed, it is assumed that the duration of unemployment is three or six months and that the household will receive 90% (in the case of unemployment lasting three months) or 80% (in the case of employment lasting six months) of its original wage when it returns to employment.

13 This assumption can be adjusted as necessary. The current test assumes that the household's liquid reserve when taking out the loan does not drop to zero because the household keeps at least a minimum reserve available for precautionary reasons. Nevertheless, in order to make the test tougher, a zero balance can be assumed after the down payment is made.

14 Annual savings refers to a potential level of savings which households aim to attain in the long run.

$$LR_t = \begin{cases} \dfrac{\text{APS}_{t-k} \times \text{net income}_t}{3} & if \quad \text{no. of securing props.} = 1 \\ 4 \times \text{APS}_{t-k} \times \text{net income}_{t-k} & if \quad \text{no. of securing props.} > 1 \end{cases} \tag{2}$$

LR_t is the size of the liquid buffer when taking out the mortgage. *APS* stands for the average propensity to save and its value is derived from the number of dependants, the number of economically active persons and the age of the main mortgage loan applicant. The index *t* refers to a quarter and the index *k* refers to the number of quarters with a mortgage, which means that t–k refers to the period immediately before taking out the mortgage loan.

The size of the liquidity reserve is adjusted over the course of repayment of the mortgage depending on the size of the financial reserve in a given quarter (see equation 3). In the case of a positive financial reserve (*FRs* $\geq$ *0*), the liquid reserve is increased by the value of quarterly savings up to a maximum of one year savings, which is considered the target level of savings. In the case of a negative financial reserve (*FRs* < *0*), the liquid reserve is drawn on in an amount equal to the negative part of the financial reserve.

$$\text{LR}_t = \begin{cases} \text{LR}_{t-1} + \left(\text{APS}_{t-k} - \dfrac{\text{DSTI}_t}{2}\right) \times \text{net income}_t & if \quad \text{FRs}_t \geq 0 \\ \text{LR}_{t-1} + \text{FRs}_t & if \quad \text{FRs}_t < 0 \end{cases} \tag{3}$$

LR_t is the size of the liquidity reserve in the given quarter. *DSTI* denotes the household's ratio of debt service to net income.[15]

A mortgage is identified as defaulting, i.e. the probability of default (PD) is equal to one, if the household's liquidity reserve fails to cover the negative part of the financial reserve in the current and previous quarter even after the repayment schedule has been adjusted[16] (see equation 4).

$$\text{PD}_t = \begin{cases} 0 & if \quad \text{LR}_t \geq 0 \;\; | \;\; \text{LR}_t < 0 \;\wedge\; \text{LR}_{t-1} \geq 0 \\ 1 & if \quad \text{LR}_t < 0 \;\wedge\; \text{LR}_{t-1} < 0 \end{cases} \tag{4}$$

Having defined the probability of default, we can now estimate the total default rate in the mortgage portfolio:

$$\text{DR} = \frac{\sum_{\text{i}}^{\text{n}} \text{PD}_{\text{i,t+1}} \times \text{EAD}_{\text{i,t+1}}}{\sum_{\text{i}}^{\text{n}} \text{volume of loans}_{\text{i,t}}}, \tag{5}$$

where *EAD* is the size of the non-performing exposure, comprising the residual principal of the mortgage plus accrued interest, default interest and fees. The default rate is the end output of the household stress test. It is used to assess the level of credit risk in the mortgage portfolio.

15 The test assumes that the average propensity to save before taking out a mortgage is reduced by one half of the DSTI ratio in the loan repayment period. The average propensity to consume is reduced by the other half of the DSTI ratio.

16 In the event of repayment difficulties, it is assumed that the bank first restructures the borrower's mortgage, that the restructuring is permanent and the loan term may not exceed 360 months or the borrower's expected period of economic activity.

Appendix 1: Worked example

Table P.1

Worked example of adjustment of borrower and mortgage characteristics in initial portfolio.

	Creation of loan → entry into portfolio		**First year after loan is concluded**		**...**	**Refixing**		**First year after loan is refixed**		**...**	**Loan repayment → exit from portfolio**	
	initial year t (e.g. 2005)		year t+1 (2006)		...	year t+5 (2010)		year t+6 (2011)		...	year t+10 (2015)	
Adjustment of values each year	Net monthly income	CZK 35,000	Net monthly $income_t$ × nominal income $growth_{t+1}$	35,000×1.072 = CZK 37,520	...	Net monthly $income_{t+4}$ × nominal income $growth_{t+5}$	44,634×1.024 = CZK 45,705	Net monthly $income_{t+5}$ × nominal income $growth_{t+6}$	45,705×1.03 = CZK 47,076	...	Net monthly $income_{t+9}$ × nominal income $growth_{t+10}$	49,315×1.042 = CZK 51,386
	Age	35	Age	36	...	Age	40	Age	41	...	Age	45
	Collateral value	CZK 2,000,000	Collateral $value_t$ × property price $growth_{t+1}$	2,000,000×1.133 = CZK 2,266,000	...	Collateral $value_{t+4}$ × property price $growth_{t+5}$	2,816,760×1.00 = CZK 2,816,760	Collateral $value_{t+5}$ × property price $growth_{t+6}$	2,816,760×0.992 = CZK 2,794,226	...	Collateral $value_{t+9}$ × property price $growth_{t+10}$	2,880,206×1.045 = CZK 3,009,815
	Loan size	CZK 1,500,000	Principal	CZK 1,374,832	...	Principal	CZK 822,592	Principal	CZK 671,478	...	Principal	0
	Loan term	10 years	Loan term	9 years	...	Loan term	5 years	Loan term	4 years	...	-	-
Adjustment of values only when refixing	Interest rate	3.89%	Interest rate	3.89%	...	Interest $rate_t$ + (mortg. $rates_{t+5}$ - mortg. $rates_t$)	3.89+0.28 = 4.17%	Interest rate	4.17%	...	-	-
	Instalment	CZK 15,108	Instalment	CZK 15,108	...	Instalment	CZK 15,212	Instalment	CZK 15,212	...	-	-
	Fixation period	5 years	-	-	...	Fixation period	5 years	-	-	...	-	-

Note: The worked example uses the 2020 three-year stress scenario for illustration. It is assumed for this worked example that the mortgage applicant was employed for the entire period and did not increase her mortgage. Property price growth and nominal income refers to the year-on-year change on the aggregate level. For mortgage rates, the difference between the average interest rate on the aggregate level at the time of refixing and the average interest rate on the aggregate level at the time of purchase (or previous refixing) is calculated in each case.