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The household stress test

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THE HOUSEHOLD STRESS TEST

Jiří Gregor, Hana Hejlová[1]

This article presents the methodology of the new stress test for households with a mortgage loan which the CNB uses to analyse the sector's resilience. Thanks to granular data on new mortgage loans and a forward-looking approach to simulating the overall mortgage portfolio, the test has a broad application for assessing the impacts of macroeconomic scenarios and calibrating macroprudential instruments. The article describes the main starting points and assumptions of the test. It also presents an application of the stress test using a three-year adverse scenario, for which the share of loans potentially at risk of default and, in turn, the share of non-performing loans are estimated.

I. INTRODUCTION

The aim of stress testing is to assess the resilience of economic sectors to a hypothetical scenario simulating adverse developments in the economy. The CNB currently performs stress tests of banks, insurance companies, pension funds, public finances, non-financial corporations and households.[2] The results of these tests enable the CNB to assess risks to financial stability and help it optimally configure its macroprudential policy instruments.

This article presents the methodology of the new stress test for households with a mortgage loan (hereinafter also referred to as "households") which the CNB currently uses in its analyses. The main advantage of this approach over the previous one[3] is that it uses granular data on mortgage loans (hereinafter also referred to as "loans" or "mortgages") taken from a survey conducted by the CNB since mid-2015. The data contains detailed credit information, such as loan size, interest rate, maturity and period of fixation, and information on individual applicants, such as income, age and number of dependants. The granular assessment of credit risk eliminates the deficiencies of the original test based on Household Budget Survey (HBS)[4] data. The HBS is available only with a significant lag and contains very limited information on loan characteristics.

The new stress test allows the CNB to simulate a broad range of sensitivity analyses while taking into account individual loan characteristics. Among other things, this helps it refine the outputs of its analyses so that it can optimally configure related macroprudential instruments[5], which – as is most often the case in international practice (IMF, 2018) – have been based up to now solely on assessing the risks associated with new loan inflows (see Hejlová et al., 2018). The new test incorporates an estimate of the risks associated with the entire mortgage portfolio, including loans provided during the scenario to be tested.[6]

The advantages of the new stress test also include its high flexibility and the option of adjusting the input parameters to current and expected economic conditions. For example, the test can take into account all the specific coronavirus crisis-related measures affecting households (such as the temporary loss of income) and concerning loans themselves (such as the moratorium on loan repayments).

The test itself focuses primarily on households with mortgages, not on the entire population of households.[7] The key financial stability aspect is an analysis of the risk associated with mortgages and additional debt taken on by households. The significance of this risk increases as the share of mortgage loans in banks' portfolios rises. Mortgage loans accounted for almost 40% of all loans provided at the end of 2019,[8] thus exceeding the quantity of credit provided to non-financial corporations. 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 consumption and related consequences for the real economy.

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2 The test methodology and results can be found in the financial stability section of the CNB website (https://www.cnb.cz/en/financial-stability/stress-testing/).
3 The previous approach to stress testing households is described in Hlaváč et al. (2013).
4 The Czech Statistical Office conducts the Household Budget Survey once a year.
5 Since 2015, the CNB has progressively introduced caps on the loan-to-value (LTV), debt-to-income (DTI) and debt service-to-income (DSTI) ratios. For more details, see the CNB's *Recommendation on the management of risks associated with the provision of retail loans secured by residential property* (https://www.cnb.cz/en/financial-stability/macroprudential-policy/recommendation-limits-applicable-to-mortgage-loans/).
6 A scenario of 3–5 years is usually assumed in the stress test.
7 Households with mortgage loans are stress tested. All the additional debt of such households is also taken into account. Indebted households without mortgage loans are not stress tested.
8 The total amount of mortgage credit stood at roughly CZK 1,240 billion at the end of 2019.

The article is organised as follows. Section II describes how the stress testing is conducted, section III presents stress test results based on a model example, and section IV concludes.

II. APPROACH TO STRESS TESTING

Granular loan data are used to compile a portfolio of all mortgage loans, and the characteristics of those loans are changed over time depending on the test scenario. The mortgage portfolio contains all loans existing at the time of the start of the test and is gradually expanded to include loans simulated in each year of the test scenario. The changes in the loan characteristics implied by the scenario are used to identify potential non-performing loans based on: (i) the financial reserve concept, as used most often in international practice (Bilston et al., 2015; Giordana and Zeigelmeyer, 2019; Meriküll and Room, 2020), and (ii) the concept of the hypothetically repayable loan under stress. Potential non-performing loans, i.e. those which borrowers are having difficulty repaying from their current income, are identified as "loans at risk of default". However, such loans do not take account of any liquid assets that households can use to bridge a temporary loss of income. If, though, those assets prove to be insufficient relative to the amount owed, the loan is eventually (after 90 days) identified as "non-performing".

In the interests of feasibility, the test is based on a number of assumptions. These include compliance with the macroprudential policy caps during the test period, no option of early repayment, and a constant period of fixation over the entire repayment term. However, all the assumptions can be changed at any time in order to reflect changing realities more faithfully. The test settings can also be changed for the purposes of sensitivity analyses.

II.1 COMPILATION OF THE MORTGAGE PORTFOLIO

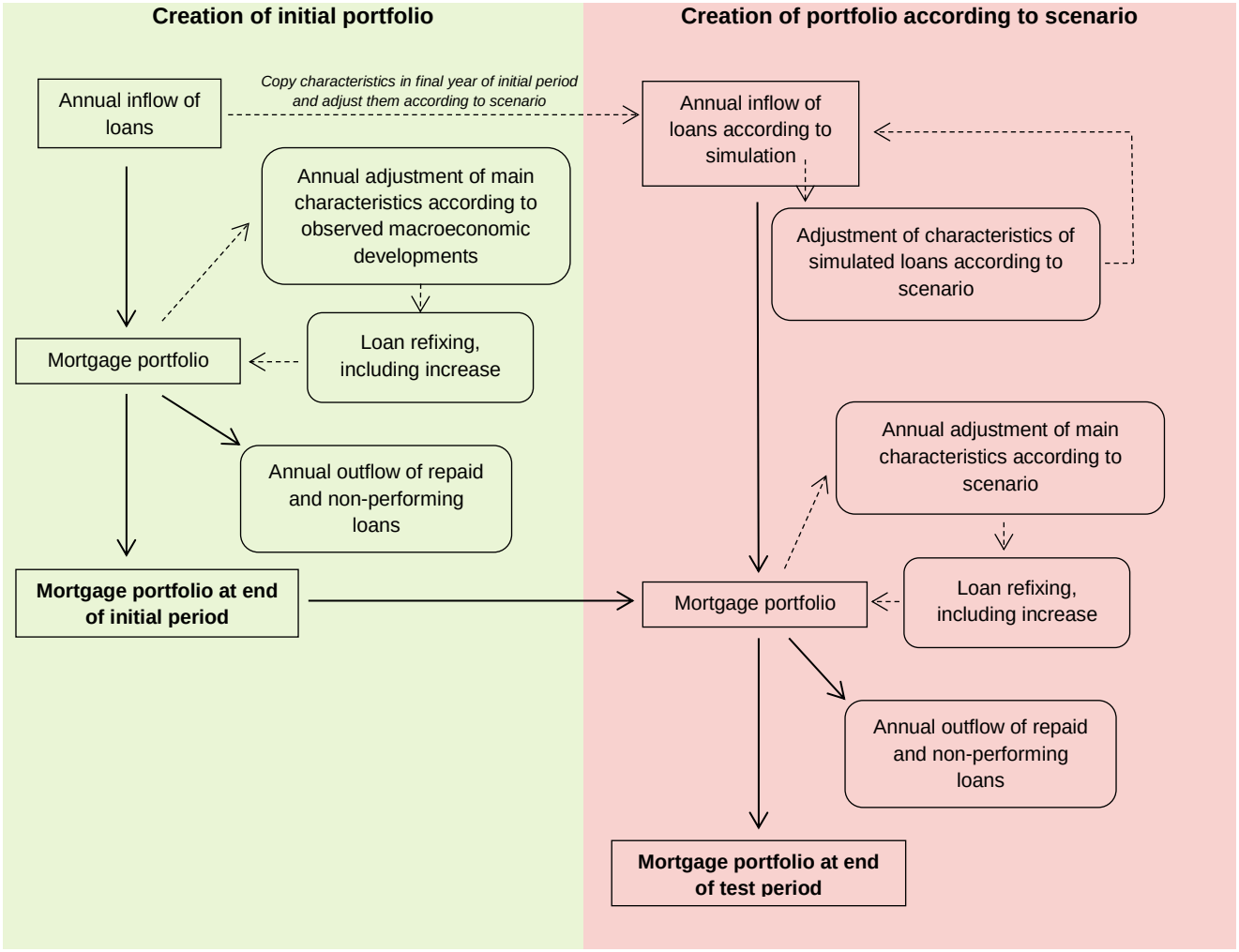
The process of creating the mortgage portfolio can be divided into three main steps: (i) compile a portfolio of the mortgage loans existing at the start of the test (the initial portfolio), (ii) simulate new loans over the stress test horizon, with the numbers and individual characteristics of the loans determined by the macroeconomic conditions of the scenario, and (iii) adjust the loan characteristics (such as repaid principal, client income characteristics and collateral value) in the course of the stress period as the macroeconomic variables in the scenario change.[9] The change in the portfolio in the individual scenarios makes it possible to estimate the potential impacts on the share of defaulting households and assess the level of credit risk. Figure 1 summarises the entire process of creation of the mortgage portfolio and its characteristics.

The initial portfolio is compiled from real data, available from 2015 onwards, and model data for 2005–2015.[10] The portfolio itself was compiled sequentially on an annual basis, with new mortgages being added progressively to the portfolio based on the available or modelled characteristics, and repaid and non-performing loans conversely being removed (Figure 1, left-hand part: *Creation of initial portfolio*). At the same time, the characteristics of the individual applicants, such as their income, estimated housing costs and necessary expenditures and the value of their collateral, were adjusted in each year. The residual maturity and principal of the loan were also updated. For loans subject to refixing in the given period,[11] all the loan characteristics were adjusted. Refixing thus gives rise to a change in the interest rate and, in turn, the instalment amount.[12] 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.[13]

The initial portfolio is then expanded to include loans provided in the test period (Figure 1, right-hand part: *Creation of portfolio according to scenario*). The mortgages simulated for the given year are progressively added to the portfolio. The loan characteristics structure matches that for loans provided in the previous year. 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 interest rate and the collateral value thus change in line with the projections for property prices and interest rates. However, it is assumed that mortgage loan applicants will keep the same preferences regarding the repayment term and the period of fixation.

9 Levina et al. (2019) adopt a similar approach to modelling the mortgage portfolio.
10 Data suitable for simulating loans are not available for the years preceding 2005.
11 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 were refixed on an annual basis.
12 Regular instalments are assumed.
13 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.

Figure 1: Creation of the mortgage portfolio



The simulation also assumes compliance with the recommended caps on the credit ratios monitored.[14] If a simulated loan fails to comply with the LTV, DTI or DSTI 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 possible length, i.e. 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 caps would try to find property costing 10% less.[15] This means that the property value and, in turn, the mortgage loan size are recalculated, while the down payment remains unchanged.[16] If the simulated loan fails to meet the ratio limits even after this adjustment, it is definitively removed from 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 creation of the portfolio according to the scenario is based on a similar principle to the creation of the initial portfolio (Figure 1, right-hand part: *Creation of portfolio according to scenario*). However, instead of being adjusted according to the actually observed macroeconomic developments, the individual client and loan characteristics are adjusted according

14 The stress test in this thematic article uses the April 2020 macroprudential instrument settings. The conditions of a DSTI ratio of no more than 50% and an LTV ratio of no more than 90% are thus respected in the loan simulation.
15 The same approach is applied in Levina et al. (2019).
16 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.

to the evolution of the macro indicators in the test (stress) scenario. The portfolio compiled in this way can then be used to estimate the share of households at risk of default and the share of households actually defaulting.

II.2 IDENTIFICATION OF LOANS AT RISK OF DEFAULT

One of the important stress test outputs is the identification of households whose loans are at risk of default. Such loans are determined using the concepts of the hypothetically repayable loan under stress and the financial reserve under stress (Hejlová et al., 2018).

The hypothetically repayable debt under stress (HRL_S) is the debt the household would be able to service over the longest possible repayment term if its monthly repayments were at the maximum possible level relative to its income. After paying such instalments, along with housing costs and necessary expenditures, the household would be left at the financial reserve threshold (FR_{TH}) of 10% of net income:[17]

$$HRL_S = \{[(1 - FR_{TH})(\text{net income}_S)] - \text{housing costs} - \text{necessary expenditures}\} \times \text{max. maturity}\ ^{18} \quad (1)$$

The subscript *S* denotes variables that are subjected to the stress and are changed in accordance with the adverse scenario tested. Besides the evolution of wages assumed in the scenario, the stress to households' incomes is increased by a rise in the probability of temporary loss of employment, in the event of which households' incomes fall to the legally defined level of unemployment benefit.[19] Housing costs are energy consumption costs plus property maintenance costs (see Appendix 1). Necessary expenditures are a function of the number of dependants, the number of economically active persons and the age of the main mortgage loan applicant. The main applicant's remaining period of economic activity up to the age of 65, or 30 years, whichever is the shorter, is taken as the longest possible repayment term.

Individual loans are at risk of default if the true debt is higher than HRL_S. The test based on the level of *HRLs* thus tests the household's ability to service its debts fully, taking into account the possibility of changing the payment schedule, and is closely linked with the DTI ratio of individual households.

The financial reserve under stress (FR_S) is the net income the household will be left with after loan repayments, housing costs and necessary expenditures are deducted:

$$FR_S = \text{net income}_S - \text{loan repayments}_S - \text{housing costs} - \text{necessary expenditures} \quad (2)$$

In the case of loan repayments, the subject of the stress is a rise in interest rates due to growth in the risk premium or normalisation of monetary policy. The actual period of fixation and maturities of individual loans are respected when testing for the rise in interest rates. So, if a loan has a rate fixed for three years, the increase 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 (FR_S) is negative. Unlike the hypothetically repayable debt under stress concept, the financial reserve concept does not require the maintenance of a minimum reserve. The estimate of the share of loans at risk is therefore lower under this concept. Overall, the FR_S test focuses on households' ability to keep to the payment schedule and is closely linked with the DSTI ratio of individual loans.

II.3 DEFINITION OF NON-PERFORMING LOANS

Loans identified as being at risk of default do not necessarily become non-performing. To evaluate actual default, we additionally need to take into consideration holdings of liquid assets, which can be used to cover a short-term drop in current income. We do not know the actual level of liquid assets for individual households, so we had to model it on the basis of simplifying assumptions. In the stress test, liquid assets are composed of two parts: (i) the level of liquid assets when taking out the loan, and (ii) the level of liquid assets when repaying the mortgage. The level of liquid assets 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. If the loan is collateralised with one property, it is assumed that the household used all its liquid assets for the down payment in order to meet the LTV condition for obtaining the mortgage. In such case, the

17 The said 10% is roughly the average long-term household saving rate observed in the Czech Republic.
18 We present here only a simplified equation for the calculation of HRL_S. When applying it, however, we also take into account the interest rate assuming annuity repayment (see Appendix 1).
19 For households that become unemployed, it is assumed that the duration of unemployment is three or six months and that the household will receive only 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.

level of liquid assets is equal to just one month's savings from current income (after taking into account repayments of all loans).[20] If the loan is secured by more than one property, it is assumed that instead of making a down payment, the household used the additional collateral to satisfy the LTV condition. In this case, the household's assumed level of liquid assets after purchasing the property is equal to twelve times its monthly savings in the period before it obtained the mortgage:

$$\text{liquid assets} = \begin{cases} (\text{APS} - \text{DSTI}) \times \text{net income} & if \quad \text{no. of securing props.} = 1 \\ 12 \times \text{APS} \times \text{net income in year before mortgage} & if \quad \text{no. of securing props.} > 1 \end{cases} \tag{3}$$

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 (see Appendix 1). DSTI denotes households' ratio of debt service to net income.

The level of liquid assets after obtaining the mortgage loan is then increased in each period depending on the size of the financial reserve. In the case of a positive financial reserve, liquid assets are increased by the value of monthly savings up to a maximum of twelve times those savings. In the case of a negative financial reserve, liquid assets are reduced by the negative part:

$$\text{total liquid assets} = \begin{cases} \text{current liquid assets} + (\text{APS} - \text{DSTI}) \times \text{net income} & if \quad \text{FRs} \geq 0 \\ \text{current liquid assets} + \text{FRs} & if \quad \text{FRs} < 0 \end{cases} \tag{4}$$

A loan is identified as non-performing (i.e. the probability of default, *PD*, is equal to 1) if the households' liquid assets fail to cover the negative part of the financial reserve repeatedly over a period of three months:

$$\text{PD} = \begin{cases} 0 & if \quad \text{total liquid assets} \geq 0 \\ 1 & if \quad \text{total liquid assets} < 0 \text{ for 3 months} \end{cases} \tag{5}$$

III. APPLICATION OF THE STRESS TEST

The first step in stress testing is to design the adverse scenario. To do so, one needs to define the type of risk to be tested (in our case the risk of default by indebted households, i.e. credit risk) and the degree of stress to be simulated (Dent and Westwood, 2016). In this article, we use a three-year stress scenario to illustrate the principle of the new test. The scenario is based largely on the possible course of the coronavirus pandemic, which broke out in full at the end of the first quarter of 2020[21] and is expected to resurge in the fourth quarter (see section II.1.3 of *Financial Stability Report 2019/2020*). GDP will thus fall by as much as 18% year on year in 2020. The rate of inflation will steadily go down, reaching the inflation target at the year-end. Mortgage interest rates will also start to rise slowly, due to growth in the risk premium. Property prices will drop appreciably in the stress scenario, decreasing by as much as 16% year on year. The coronavirus crisis will also have a sizeable impact on the labour market. The initial effects will be reflected in wage growth, which is expected to fall sharply year on year. With a slight lag, the unemployment rate will begin to increase as well, peaking in mid-2021. The economy will gradually return to normal in the following years. Annual GDP growth will turn positive again and, after briefly dipping to the lower bound of the tolerance band around the inflation target, the inflation rate will return to the 2% target in mid-2021. Mortgage rates, however, will continue to rise moderately, reaching 4%. Property prices will also record renewed growth, reaching the end-2018 level at the end of the stress period. The unemployment rate will remain unfavourable, staying at 8% right up to the end of the stress period. However, wages will return to relatively brisk growth.

III.1 LOANS AT RISK OF DEFAULT

Were the scenario described above to materialise, an average of 4% of all households with a mortgage loan would experience difficulties paying their debts each year during 2020–2022 according to the financial reserve indicator. The hypothetically repayable debt under stress concept indicates a substantially higher proportion of households at risk (just over 8%; see Chart 1). However, this difference arises from the different design of the two indicators (see section II.2 for

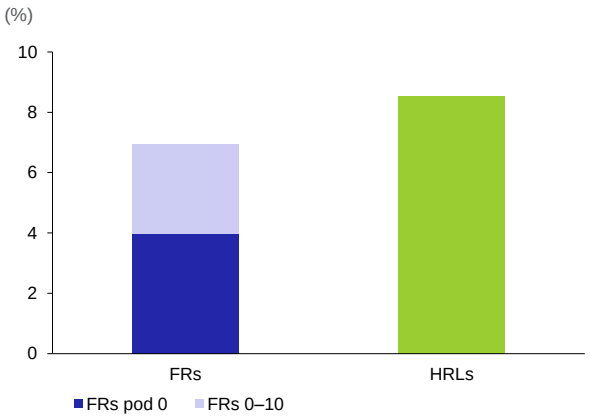
20 It is assumed in the test that if the household uses all its liquid assets to make the down payment, it is able – depending on the size of the DSTI ratio for the loan – to save part of its income immediately in the first month after obtaining the loan.

21 In this period, we simulate an additional stress outside the general macroeconomic scenario reflecting the situation during the state of emergency. In 20% of households containing an employed loan applicant, income is reduced to 80% of the pre-coronavirus period level. This is meant to characterise the transition to part-time work or the reduction in income due to obstacles on the employer's part. Stricter conditions were set for households containing a self-employed loan applicant. In 80% of such households, income was reduced to the level of the government-guaranteed direct support defined in the "25" programme. It was also assumed in the stress test that in the period from the declaration of the state of emergency up to the end of June, the net monthly income of households with children would be equal to the care allowance.

details). For comparison, the charts thus also show for the financial reserve concept the fraction of households at risk if households with a financial reserve of less than 10% of their net income were also to rank among those at risk. This would correspond in principle to the design of the hypothetical repayable debt indicator.

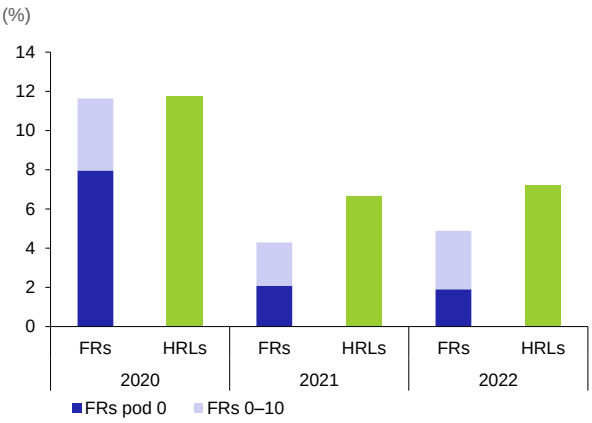
A closer look at the time structure reveals that the scenario implies very different impacts in different years (see Chart 2). The most serious seems to be the situation in 2020, when the simulated crisis escalated. The share of households at risk of default could climb as high as 12% this year according to both of the concepts defined above (FR_S and HRL_S). The DSTI distribution of loans indicates that all categories except the lowest will have payment difficulties this year. Households with a DSTI ratio of over 40% will be harder hit (see Chart 3). According to the DTI ratio, the risk of default is spread more evenly across the loan categories, and loan repayment problems could arise in various households regardless of their total debt relative to their net income (see Chart 4).

Chart 1 Average share of households at risk of default at the stress horizon according to FR_S and HRL_S



Source: CNB

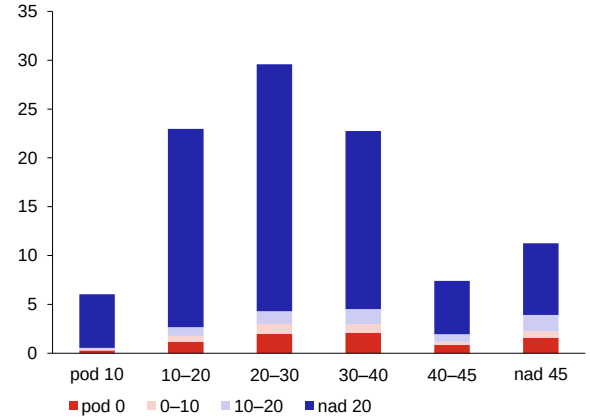
Chart 2 Average share of households at risk of default in each year of stress according to FR_S and HRL_S



Source: CNB

Chart 3 Distribution of loans by DSTI and financial reserve in the first year of stress

(share of loans in %; x-axis: DSTI ratio in %)

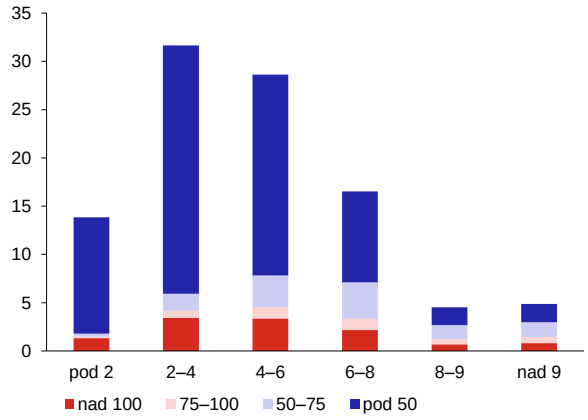


Source: CNB

Note: The colours reflect the size of the financial reserve in per cent of net income (colour scale below the chart).

Chart 4 Distribution of loans by DSTI and DTI and ratio of the loan provided to the hypothetically repayable loan in the first year of stress

(share of loans in %; x-axis: DTI ratio in number of net annual incomes)



Source: CNB

Note: The colours indicate the ratio of the loan provided to the hypothetically repayable loan (colour scale below the chart).

III.2 HOUSEHOLDS IN DEFAULT

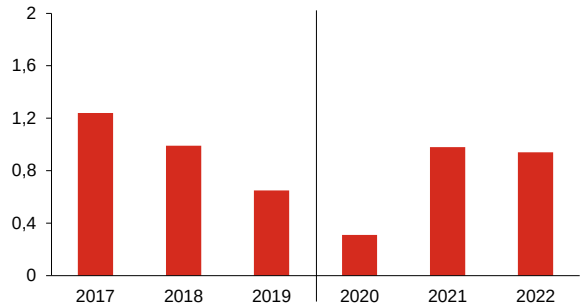
In normal times, the share of households at risk of default would be reflected directly, though not fully, in the overall default rate. Owing to the loan moratorium in place in the second and third quarters of 2020, however, the default rate follows a very different course. The possible deferral of loan instalments helped some households at risk to bridge the

period of highest risk, thereby preventing them from potentially defaulting. Nevertheless, for the group of households with a sustained drop in income, the moratorium merely postponed their insolvency. This became fully apparent in the second year of stress. Despite that, the overall default rate did not climb to a significantly higher level and stayed at 1% (see Chart 5).[22] Households with a DSTI ratio of over 40% and a DTI ratio of over 8 were harder hit by default (see Chart 6 and Chart 7).

Overall, despite the relatively severe stress scenario, the household sector turns out to be highly resilient to adverse economic conditions, and the materialisation of credit risks associated with household default is relatively low. This is largely also a result of the macroeconomic measures introduced to mitigate potential risks in the expansionary phase of the financial cycle.[23]

Chart 5 12M default rate according to the *Stress Scenario*

(share of non-performing loans in %)

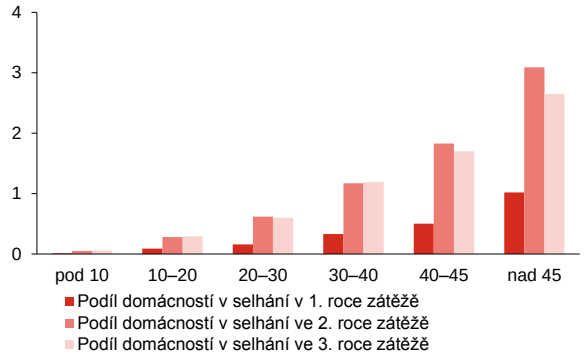


Source: CNB

Note: A loan is indicated as non-performing if the household records a negative financial reserve which it is unable to cover from its liquid assets for a period of 90 days.

Chart 6 Non-performing loans by DSTI ratio

(share of non-performing loans in given category in %; x-axis: DSTI ratio in %)

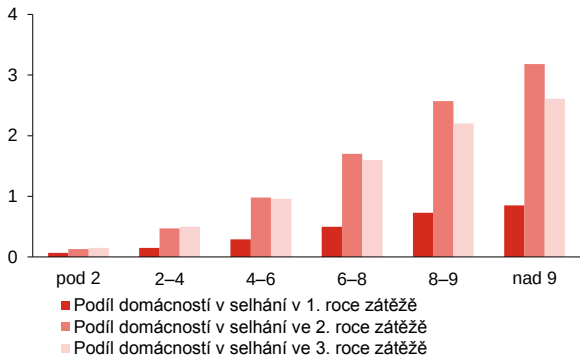


Source: CNB

Note: A loan is indicated as non-performing if the household records a negative financial reserve which it is unable to cover from its liquid assets for a period of 90 days.

Chart 7 Non-performing loans by DTI ratio

(share of non-performing loans in given category in %; DTI ratio in number of net annual incomes)



Source: CNB

Note: A loan is indicated as non-performing if the household records a negative financial reserve which it is unable to cover from its liquid assets for a period of 90 days.

22 Owing to a different methodology, the default rates may differ from those used in the CNB's macro stress tests.
23 A DTI cap of nine net annual incomes and a DSTI cap of 45% were set in June 2018 (for details, see https://www.cnb.cz/en/financial-stability/macroprudential-policy/recommendation-limits-applicable-to-mortgage-loans/). After the coronavirus crisis broke out in April 2020, the macroprudential instruments were relaxed. The DSTI cap was raised to 50% and the recommended DTI cap was abolished.

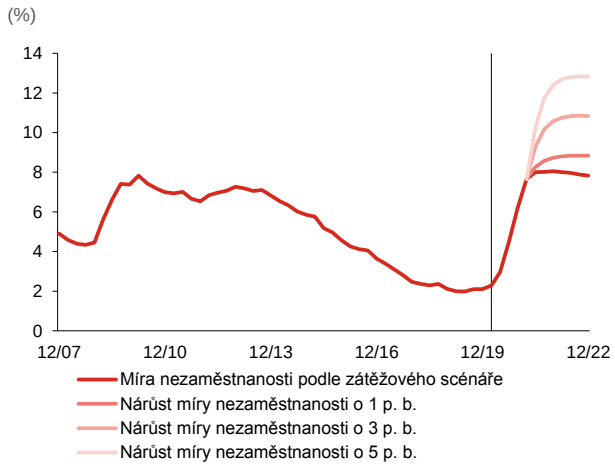
III.3 SENSITIVITY ANALYSIS

The current stress testing framework makes it possible to simulate a whole range of related sensitivity analyses. These can be used to test households' resilience to additional shocks. The variant of an additional increase in the unemployment rate and in mortgage rates of 1, 3 and 5 pp attained in the final quarter of the scenario is presented below for illustrative purposes. The unemployment rate does not deviate significantly from the original stress scenario until mid-2021, when a continuing sharp rise from the first year is simulated. In the most pessimistic variant, this peaks just below the 13% level (see Chart 8). For interest rates, we simulate a sharp rise starting in mid-2020 and peaking at levels exceeding 5%, 7% and 9% depending on the size of the shock (see Chart 9).

In the sensitivity analysis, it is assumed that indebted households with a mortgage loan have a strong incentive to find a new job, so the duration of unemployment among indebted households is only short. Given a temporary loss of employment, households would thus be able to cover the short-term loss of income from their liquid assets. The default rate thus seems relatively low in the event of an additional increase in the unemployment rate. In the event of a greater increase in the unemployment rate, the default rate among households with a DSTI ratio of between 40% and 45% will increase by just 0.8 pp and that among households with a DSTI ratio of over 45% by 1 pp (see Chart 10).

Maintenance of the period of fixation is assumed in the event of a change in interest rates. A rise in interest rates will thus only affect households that were forced to refix their loans in the given period. Despite that, an additional increase in interest rates will pass through more strongly to the default rate than in the case of the unemployment rate, as the rise in interest rates and the ensuing increase in instalments is of a long-term nature and cannot be permanently covered from households' liquid assets. The difference is particularly visible for the most pessimistic variant of a rise in interest rates, where the default rate among households with a DSTI ratio of over 45% will increase by almost 3 pp (see Chart 11).

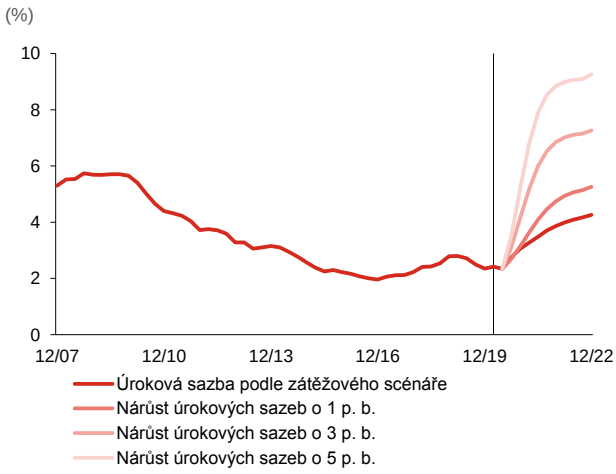
Chart 8 Additional increase in the unemployment rate



Source: CNB

Note: The increase in the unemployment rate corresponds to the level attained in the final quarter of the stress period.

Chart 9 Additional increase in interest rates

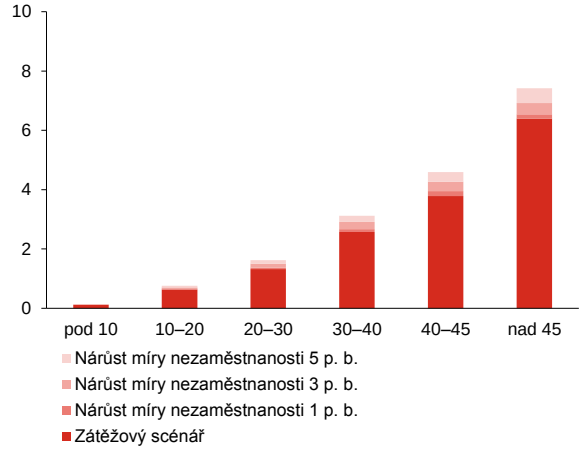


Source: CNB

Note: The increase in interest rates corresponds to the level attained in the final quarter of the stress period. The average rate on new mortgage loans is used as the interest rate.

Chart 10 Shares of non-performing loans by DSTI ratio given an additional increase in the unemployment rate

(share of non-performing loans in %; x-axis: DSTI ratio in %)

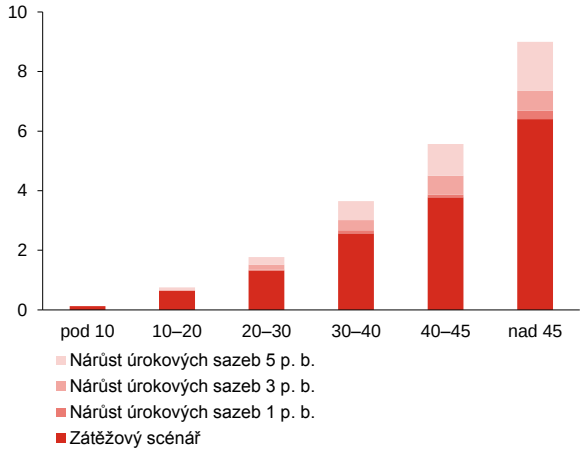


Source: CNB

Note: The chart presents the cumulative default rate for 2020–2022.

Chart 11 Shares of non-performing loans by DSTI ratio given an additional increase in interest rates

(share of non-performing loans in %; x-axis: DSTI ratio in %)



Source: CNB

Note: The chart presents the cumulative default rate for 2020–2022. The simulation of growth in interest rates maintains the contractual fixed-rate terms negotiated when the mortgage agreement was concluded.

IV. CONCLUSION

This article presented a new method for stress testing the household sector using granular data on mortgage loans. The key part of the new stress test methodology is the creation of a mortgage portfolio that is based on the above data and takes into account the properties of individual loans. The first step is to compile the portfolio as of the end of the initial period. The portfolio is then adjusted for the net inflow of loans during the stress period. The share of households at risk of default is estimated on the basis of this portfolio using the concepts of the financial reserve and the hypothetically repayable debt under stress. Further to this, the share of households actually defaulting is estimated by means of a stress test. The subsequent part of the article describes the application of the stress test based on a model example, including a simulation of related sensitivity analyses.

The stress test results indicate that the mortgage portfolio is highly resilient to adverse shocks. Significant mortgage repayment problems were only identified in the first year of stress, when, according to the scenario, a substantial proportion of households suffered a loss of income. However, the moratorium assumed by the scenario helped households bridge this adverse situation. As a result, the default rate was greatly reduced in the first year of stress. Credit risk increased in the second year of stress, when households for which the moratorium merely shifted their financial problems into the next period defaulted. Households with a DSTI ratio of over 40% and a DTI ratio of over 8 were hardest hit. Overall, however, the default rate did not reach excessively high levels despite rising during the second year of stress. This reflects banks' cautious approach to mortgage lending in recent years. The latter is partly a result of the CNB's credit ratio recommendations, which have significantly limited the room for excessive credit risks to form in the mortgage portfolio.

REFERENCES

Bilston, T, Johnson, R., Read, M. (2015): Stress testing the Australian household sector using the HILDA survey. Research Discussion Paper, No. 1.

Dent, K., Westwood, B. (2016): Stress testing of banks: An introduction. Bank of England Quarterly Bulletin, 2016 Q3.

Giordana, G., Zeigelmeyer, M. (2019): Stress testing household balance sheets in Luxembourg. Working Paper Series, No. 2254, European Central Bank.

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

Hlaváč, P., Jakubík, P., Galuščák, K. (2013): Household stress tests using microdata. Thematic Article on Financial Stability, Financial Stability Report 2012/2013, pp. 114–120, Czech National Bank.

IMF (2018): Technical note – Calibration of a debt service-to-income limit in Romania – Evidence from microdata. IMF Country Report No. 18/161.

Levina, I., Sturrock, R., Varadi, A., Wallis, G. (2019): Modelling the distribution of mortgage debt. Bank of England. Staff Working Paper No. 808.

Meriküll, J., Room, T. (2020): Stress tests of the household sector using microdata from survey and administrative sources. International Journal of Central Banking, Vol. 16, No. 2. pp. 203–248.

APPENDIX 1 DEFINITIONS OF INDICATORS USED

Indicator	Calculation	Data source
Hypothetical loan (HRL_S)	$\mathrm{HRL}_{S_i} = \{[(1-\mathrm{FR}_{\mathrm{TH}})(\text{net income}_{S_i})] - \text{housing costs}_i - \text{necessary expenditures}_i\} \times \frac{1-\frac{1}{(1+\text{mthly int. rate at origination}_i)^{\text{max.maturity}_i}}}{\text{mthly int. rate at origination}_i}$	CNB survey
	• $\mathrm{FR}_{\mathrm{TH}} = 0.1$	FSR 2017/2018
	• Net income changes in the event of unemployment, for which a duration of three or six months is assumed. The level of income is derived from the benefit defined in the Employment Act. It is assumed that the household's new level of income on returning to employment will be 90% of its original income after three months of unemployment and 80% of its original income after six months of unemployment.	Czech Ministry of Labour and Social Affairs
	• $\text{housing costs}_i = \text{energy}_i + \text{property maintenance costs}_i$	
	$\text{energy}_i = f(\text{no. of persons in household}_i)$	Parameters estimated using HBS data
	$\text{property maintenance costs}_i = f(\text{length of period with loan}_i)$	Parameters estimated using HBS data
	• $\text{necessary expenditures}_i = f(\text{no. of children, no. of EA persons, applicant's age, applicant's age}^2)$	Parameters estimated using HBS data
	• The monthly interest rate is equal to the interest rate the household received when obtaining or refixing the mortgage loan.	CNB survey
	• $\text{max. maturity}_i = \begin{cases} (65 - \text{applicant's age}_i) \times 12 & if \quad (65 - \text{applicant's age}_i) \times 12 \leq 360 \\ 360 & if \quad (65 - \text{applicant's age}_i) \times 12 > 360 \end{cases}$	CNB survey
Financial reserve (FR_S):	$\mathrm{FRs}_i = \text{net income}_i - \text{loan repayments}_i - \text{housing costs}_i - \text{necessary expenditures}_i$	
	• $\text{loan repayments}_i = \text{mortgage repayment}_i + \text{consumer credit repayment}_i$	CNB survey
Liquid assets:		
• Liquid assets at origination of mortgage	$\text{liquid assets}_i = \begin{cases} (\mathrm{APS}_i - \mathrm{DSTI}_i) \times \text{net income}_i & if \quad \text{no. of securing props.}_i = 1 \\ 12 \times \mathrm{APS}_i \times \text{net income year before mortgage}_i & if \quad \text{no. of securing props.}_i > 1 \end{cases}$	CNB survey
	• $\mathrm{APS} = f(\text{no. of children, no. of EA persons, applicant's age, applicant's age}^2)$	Parameters estimated using HBS data
• Monthly adjustment of liquid assets	$\text{total liquid assets}_i = \begin{cases} \text{current liquid assets}_i + (\mathrm{APS}_i - \mathrm{DSTI}_i) \times \text{net income}_i & if \quad \mathrm{FRs}_i \geq 0 \\ \text{current liquid assets}_i + \mathrm{FRs}_i & if \quad \mathrm{FRs}_i < 0 \end{cases}$	CNB survey
Probability of default (PD)	$\mathrm{PD}_i = \begin{cases} 0 & if \quad \text{total liquid assets}_i \geq 0 \\ 1 & if \quad \text{total liquid assets}_i < 0 \text{ for three months} \end{cases}$	CNB survey
Default rate in portfolio (DR)	$\mathrm{DR} = \frac{\text{no. of NPLs}}{\text{total no. of loans}}$	CNB survey

Note: The index *i* denotes the i-th household. Necessary expenditures comprise consumption spending on food, non-alcoholic beverages, tobacco, health, social care, transport, communication, maintenance of the house and education.

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