HOUSEHOLD STRESS TESTS USING MICRODATA

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This article sets out to describe an expanded and refined framework for stress testing the household sector. In contrast to the original tests conducted by the Czech National Bank since 2011, the new framework incorporates modelling of transitions between employment and unemployment at the level of individual household members. Another advance is the incorporation of interest rates into the stress tests, with growth in rates affecting monthly loan instalments. As well as discussing the approaches to this issue used in other countries, the article presents empirical results from the expanded framework expressing the percentage of distressed households in each income group following the application of the macroeconomic scenarios considered.

1. INTRODUCTION

The financial crisis underscored the importance of monitoring and assessing the systemic risk of the household sector. Household distress in advanced economies and excessive credit growth in developing economies were major phenomena of the pre-crisis period. Overly relaxed credit standards before the crisis gave rise to sharp growth in credit risk during the crisis. This experience illustrates the importance of conducting microeconomic analyses of the household sector to capture the different impacts of a deterioration in the macroeconomic environment on different income groups of the population. For these reasons, the Czech National Bank (CNB) conducts stress tests of households to identify this risk and evaluate its potential impacts. In this way, the overall resilience of the household sector to adverse macroeconomic scenarios can be tested in the same way as in the case of the banking sector. The output of these tests is the percentage of households that are financially distressed. This result can then be used to estimate households' average probability of default, which serves as an input to bank stress tests.

The next section provides a review of related literature, focusing on approaches used in other countries. Section 3 then describes the CNB's stress test methodology for the Czech household sector. Section 4 presents the results obtained from the currently available data. The final section concludes.

2. STUDIES OF HOUSEHOLD FINANCIAL DISTRESS

There are many studies in the literature dealing with the identification of household financial distress and its macroeconomic implications. Some studies focus on the key determinants of the risk of insolvency or distress and the links between these risks and developments in the macroeconomic environment, while others examine the impacts of various macroeconomic scenarios on household consumption. In the past, insufficient attention was devoted to these issues owing to limited availability of statistics covering households' structured balance sheets and household consumption. The recent financial crisis has sparked interest in this issue among regulators and financial institutions that lend to households.

This article is based on stress testing of the household sector by central banks in the macroprudential context. Herrala and Kauko (2007) describe the model used by the Finnish central bank to forecast distress in the household sector. Distress is defined as a situation where the net income of households minus essential living costs and debt service payments is too low. The model inputs are the macroeconomic forecast and a micro data set of households. The authors simulate the impacts of shocks to unemployment, interest rates and housing prices on the level of distress. Shocks to interest rates have a larger impact than changes in unemployment and housing prices, because most household loans bear variable interest rates.[1]

Johansson and Persson (2006) simulate the risks of default by Swedish households in the event of a rise in unemployment, a rise in interest rates and a fall in asset prices. Distress is associated with a negative financial margin, defined as the household's income net of debt service costs and essential living costs. The calculation of the potential losses of the banking sector assumes that a negative margin is covered by households up to the value of their assets. The authors conclude that a 1 pp rise in interest rates would have practically no impact on the credit risk of the banking sector, and that even a 3 pp

1 The model is used to simulate the impacts of one-standard-deviation shocks added to a basic scenario. The standard deviations of the variables are calculated for the period 1986–2005. The authors admit that the impact of the interest rate shock is larger because rates were higher and more volatile in the run-up to Finland's accession to the EMU in 1999.

increase in rates would not cause the Swedish banking sector any significant problems in the form of credit losses.[2] The effects of rising unemployment are simulated using a Monte Carlo approach assuming that employed persons have an equal probability of becoming unemployed and that loss of employment means a fall in the income and margin of the household. It is apparent from the results that rising unemployment entails a lower risk of default than rising interest rates. The Danish central bank published a similar household stress test methodology in its financial stability report (Danmarks Nationalbank, 2007).

Albacete and Fessler (2010) describe the household stress test methodology of the Austrian central bank. Combining different household microdata sources, the authors assess the impacts of macroeconomic scenarios (changes in interest rates, the unemployment rate, asset prices and the exchange rate) and thereby test households' ability to pay their debts. The scenario of rising unemployment is quantified for employed household heads by modelling the probability of becoming unemployed in relation to demographic and socio-economic characteristics. The results reveal that rising interest rates have a larger negative impact on households' ability to repay than rising unemployment, due to the fact that approximately two-thirds of Austrian debtors have variable rate loans. The banking sector's potential losses resulting from the shocks considered do not compromise financial stability, but a risk is identified in the case of foreign currency loans due to potential exchange rate changes. Stress test methodologies of other central banks are presented, for example, in Holló and Papp (2007) for Hungary, Karasulu (2008) for Korea and Djoudad (2010) for Canada.

The indebtedness of Czech households over the period 2000–2008 is described in Bičáková et al. (2010) using Household Budget Survey (HBS) data. The authors construct a debt ratio defined as the ratio of loan repayments to household income minus the living minimum.[3] The results are compared with the Statistics on Income and Living Conditions (SILC), which contain an indicator of loan repayment difficulties. Such difficulties are consistent with a debt burden ratio in the HBS statistics of above 30%. The authors propose this cut-off point as an indicator of overindebtedness. Jakubík (2010) also addresses stress testing of Czech households, but unlike Bičáková et al. (2010) has only limited microeconomic data available and so simulates some data using assumptions about their distributions. To define distressed households, the study uses the financial margin, defined as net monthly income minus debt service costs and essential living costs.

All the non-Czech studies described above work with microeconomic data and analyse how households' distress – usually defined using their financial margin – changes in response to shocks to unemployment and interest rates. In some cases, other types of shocks – such as a change in the exchange rate – are considered, but the most well-developed and discussed scenario is that of a rising number of distressed households due to rising unemployment. Our chosen approach to stress testing reflects the microdata available in the Czech Republic and is based mainly on Albacete and Fessler (2010) and Johansson and Persson (2006). In the change in unemployment scenario, these studies only consider the case of employed individuals becoming unemployed, whereas in our methodology we also consider transitions from unemployment to employment.[4] The household micro data we use also allow us to model transitions between labour market states for all adults in a household. The following section gives a more detailed description of the stress test methodology used at the CNB.

3. HOUSEHOLD STRESS TEST METHODOLOGY AT THE CNB

The household stress tests conducted at the CNB since 2011 (see FSR 2010/2011, section 2.3, p. 37) use the Household Budget Survey (HBS) for 2011 as their main data source. The other data sources include publicly available macro-indicators and the Statistics on Income and Living Conditions (SILC) for 2011. The HBS contains household-level data. This means that our methodology is microeconomic in nature, although it does allow us to make conclusions for the entire sector. The tests are based on a sample of 2,904 households, of which 1,069 were servicing some sort of loan in 2011.[5] Table 1 presents the average characteristics of households with and without debt. These numbers reveal that households with debt have

2 The authors assume that 40% of loans to households are variable rate loans. The effects of shocks to interest rates are quantified in the short and long term. In the short term a change in rates only affects variable rate loans, while in the long term it affects the entire debt stock.

3 The living minimum is declared by the Ministry of Labour and Social Affairs and covers minimum living costs in relation to the demographic composition of the household.

4 Shocks to unemployment influence not only the probability of becoming unemployed, but also unemployed persons' chances of returning to work.

5 Loans are broken down into three categories: housing loans, consumer loans and other loans.

TABLE 1

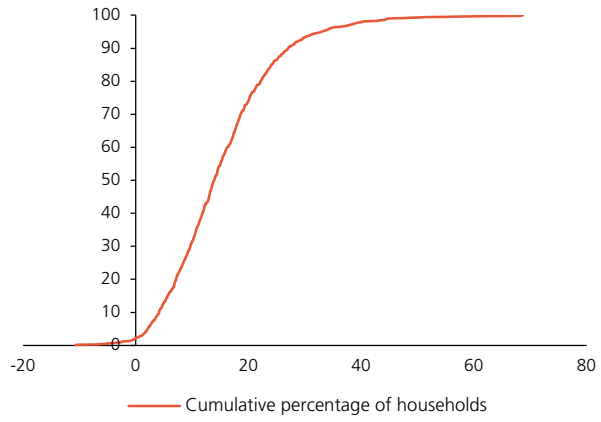
AVERAGE CHARACTERISTICS OF HOUSEHOLDS WITH AND WITHOUT DEBT
(Average for 2011

Indicator (average)	Households	
	With Debt	Without Debt
Net income (CZK/month)	33,733	26,043
Instalments (CZK/month)	4,634	0
Principal (CZK)*	479,121	0
Essential expenditure (CZK/month)	13,223	11,609
Financial surplus (CZK/month)	15,876	14,434
Age of head**	44.3	54.2
No. of persons**	2.80	2.14
No. of children**	0.98	0.49
With mortgage**	49.6%	0.0%
Unemployment rate**	5.1%	7.9%
No. of households in HBS	1,069	1,835

Source: HBS 2011
Note: * Estimate only ** As of 31 December 2011

CHART 1

FINANCIAL SURPLUS DISTRIBUTION FUNCTION
(FS in CZK thousands/month on x-axis; % on y-axis)



Source: HBS 2011, authors` calculations
Note: Only includes households with debt. Outliers excluded.

a larger financial surplus, defined as net monthly income minus essential expenditure and debt service costs. The main reasons for this larger surplus include higher job income if employed and a lower unemployment rate.

The HBS does not contain household balance sheet data. This limits the stress test methodology to some extent. In particular, it is not possible to simulate a shock in the form of a fall in housing prices, as data are not available on the value of the property owned by households. However, the majority of Czech households use their property as their own place of residence. This limits the potential impacts of a fall in prices of real assets on their budgets.[6] The methodology also excludes the impacts of an exchange rate shock, but this is not a substantial limitation either. Exchange rate changes negatively affect household budgets primarily via foreign currency debt. However, Czech households have virtually no foreign currency loans. Consequently, Czech households, unlike their counterparts in some other European economies, are not exposed to the risk of domestic currency depreciation and subsequent growth in the domestic currency value of debt.

The risk of the Czech household sector transforms into credit risk of the financial sector via household debt. These stress tests therefore try to quantify this risk using an estimate of the percentage of distressed households. Here, distress is linked with the probability that the household will fall behind on its debt payments, and is defined with the aid of the "financial surplus" (FS):

$$FS = NI - EE - INST, \qquad (1)$$

where NI is the household's net monthly income, EE is its essential monthly expenditure and INST are its monthly instalments. We identify the household as distressed if this indicator is negative following the application of the chosen scenario.[7] The sensitivity of the percentage of distressed households to the position of the distress threshold can be illustrated using a distribution function (see Chart 1). At FS values only just above CZK 0/month, we observe a very rapid increase in the slope of the distribution function. This means that with such a distress threshold there would be a relatively high risk of incorrectly determining the percentage of distressed households. However, our chosen threshold lies in the band of low sensitivity of distressed households to the FS. This reduces the risk of inaccurate simulations.

Three types of shocks are simulated in the stress tests. Each of them has an impact on the variables entering the financial surplus calculation in equation (1). Shocks to unemployment influence households' wages and therefore also their net income (NI). Shocks to interest rates affect instalments (INST). And finally, shocks to prices affect essential expenditure (EE), defined as the sum of

6 The impacts of changes in property prices are studied in detail in this Report in Brůha, Hlaváček and Komárek (2013).

7 A zero distress threshold is also used, for example, in Albacete and Fessler (2010) and Johansson and Persson (2006).

expenditure on food, energy, transport, health and, where applicable, rent. In contrast to last year's household stress tests (FSR 2011/2012), we determine distress using the absolute financial surplus rather than the previously used ratio of debt to disposable income reduced by essential expenditure.[8]

The simulation of shocks to unemployment is based on a breakdown of all adults in the HBS into three categories by economic activity: working (state E), unemployed (state U) and economically inactive (state O). We assume that the number of economically inactive persons is constant.[9] The simulations are conducted on data covering the heads and second adults of households. Transitions between labour market states are calculated using model (2), where a dummy for unemployment of the given person u_i enters as the dependent variable.

$$p(u_i|x_i) = \phi(z_i)$$
$$z_i = \alpha + \beta x_i, \qquad (2)$$

where $p(u_i|x_i)$ is the probability that person i is unemployed (given their reported characteristics x_i), α is a constant, β is a vector of coefficients and ϕ is the cumulative distribution function of the standard normal distribution. Persons outside the labour market, such as students and women on maternity leave, do not enter the estimate of the coefficients of this model and are assumed to remain economically inactive over the time period considered. This assumption is broadly consistent with the evidence (especially in the short run). As an explanatory variables we use socio-demographic and partly also financial variables contained in the HBS: education, gender, age, demographic characteristics, labour market state and net income of other household members, and dummies for region, housing type, mortgage repayment, ownership of durables (e.g. a car) and social income as main source of income. The resulting model assigns a probability of unemployment to each person based on the existing data.

A rise in unemployment is simulated by increasing the constant α of model (2) until the rate of employment of the entire set of households reaches the required level.[10] The simulation of changes in unemployment assumes transitions from employment to unemployment and vice versa. In the case of becoming unemployed, we assume that the person's net work income is replaced by unemployment benefit while the income of other household members remains constant. The amount of unemployment benefit is determined by previous net work income and by demographic characteristics (age).[11]

For the simulation, we need to assign a potential wage to those who find jobs. This wage is determined using the standard Heckman (1979) model, which takes selection into employment into account. The model is expressed in the first equation by a regression relationship between the logarithm of the wage and socio-demographic variables. In addition, it contains a variable relating to the probability of the person being unemployed. This variable is obtained from the second equation of the model, referred to as the selection equation.[12] In this way, persons whose wages we do not know, i.e. unemployed persons, are also taken into account in the estimates of the coefficients for the wage calculation.

After applying the relevant scenario, we assign to each person a probability of being unemployed after the shock to unemployment. For every possible combination of employment and unemployment for the household head and the second adult, we calculate the household's net income (NI) and the resulting financial surplus (FS) and use the this to assess whether the household in the given state is distressed (a binary variable taking a value of either 0 or 1).[13] The resulting distress is calculated for each household as the average of these binary variables weighted by their probability of occurrence.

To apply the interest rate shock we need to know the maturities of, and interest rates on, each household's debt. This information, however, is not available, so in both cases we use average characteristics based on aggregate CNB data. The new instalment amount is determined by applying the new rate and the average maturity. We assume that households pay their debts in monthly instalments,

8 We abandon the INST/(NI-EE) ratio conceptually similar to that used in Bičáková et al. (2010).
9 Labour market flows between employment and unemployment on the one hand and inactivity on the other are relatively small.
10 The same approach was used in Albacete and Fessler (2010) and Johansson and Persson (2006).
11 Simulation of changes in net household income given a transition between employment and unemployment is used, for example, in Galuščák and Pavel (2012).
12 The model contains dummies for education, gender, age, presence of a second adult in the household and their labour market state, and region. The variables identifying selection into employment are net income of other household members and dummies for children, mortgage repayment, ownership of selected durables and social income as main source of income.
13 We simultaneously assume that the change in labour market state is independent in the case of two adults in one household.

TAB. 2

MACROECONOMIC SCENARIOS

Scenarios	Unempl. Rate	Wages	Inflation	Interest rates
2011	6.7	2.4	1.9	6.6
2012	7.3	2.7	3.2	6.3
2013 Baseline Scenario	7.9	1.2	1.7	6.0
2013 Protracted Depression	8.5	-1.0	1.7	6.1

Source: Inflation report II/2013, Stress test of banks
Note: Interest rates are weighted average rates on the stock of loans for each segment (housing, consumer, other). The weights are based on data from the HBS. "Wages" refers to average nominal wage growth.

TAB. 3

STRESS TEST RESULTS

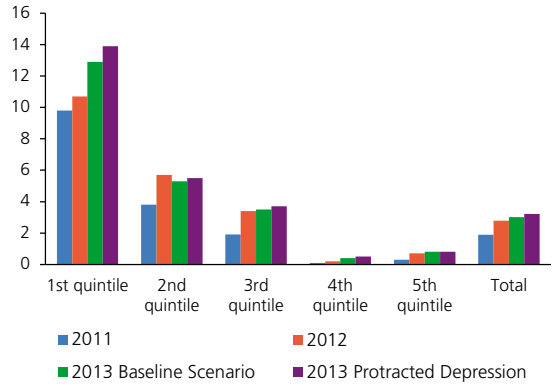
	2011	2012	2013	
			Baseline Scenario	Protracted Depression
Distressed households (%)	1.9	2.8	3.0	3.2
Average FS (CZK/month)	15,921	16,351	16,482	15,829

Source: HBS 2011, authors` calculations

a simplification that largely fits the facts. The HBS contains instalments broken down by housing loans, consumer loans and other loans. The average residual maturity is assumed to be 18 years for housing loans, 2 years for consumer loans and 5 years for other loans. The average weighted residual maturity for all loan types was thus set at 13 years. The rise in rates of newly granted loans is not reflected fully and immediately in the instalment amount of each loan, because in reality the rates on most loans are fixed for some period. For housing loans, the average residual fixation period is assumed to be 18 months. This figure was used to estimate the coefficient determining the percentage of mortgages subject to re-fixation over the next year at 0.66.[14] For consumer loans, the rate is assumed to be fixed over the entire life of the loan. For other loans, by contrast, we assume that the change in rates is reflected immediately and fully in the instalment amounts. The price shock is modelled by increasing essential expenditure (EE) by the rates of inflation of the individual consumer basket items. The essential expenditure items are assumed to be price inelastic.

CHART 2

PERCENTAGE OF DISTRESSED HOUSEHOLDS BY INCOME QUINTILES



Source: HBS 2011, authors` calculations

4. STRESS TEST RESULTS

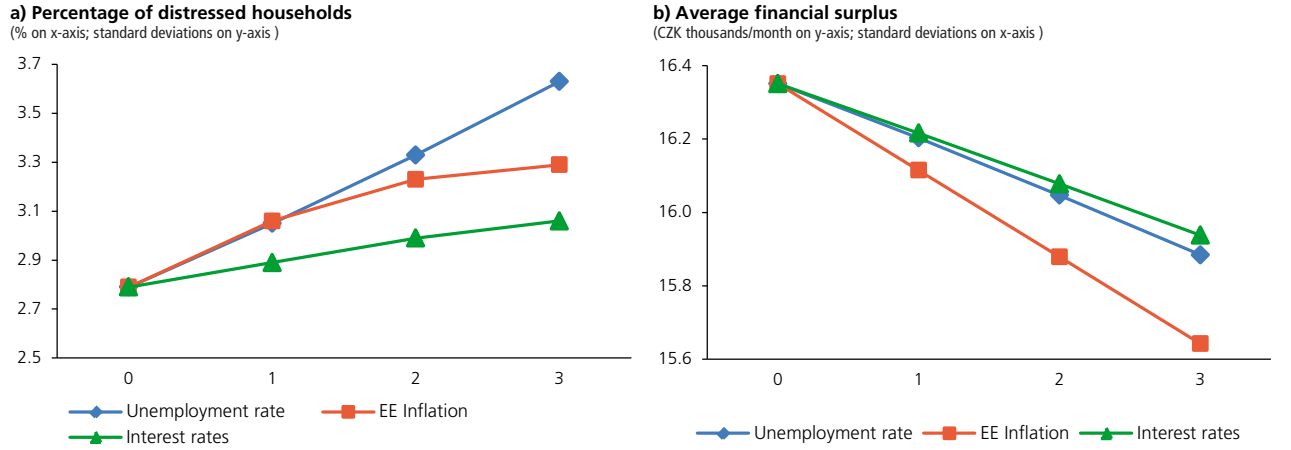
At the time of publication of this Financial Stability Report the HBS had a lag of almost a year and a half, so we need to consider changes in household distress that occurred between the end of 2011 and the end of 2012, to which the impacts of the scenarios for 2013 are related. To do so, we use publicly available macroeconomic data; for all households, prices of essential goods are increased by their rate of inflation, while interest rates on the individual loan types and the unemployment rate are changed according to the actual situation in 2012 (see section 3). In the case of realisation of the Protracted Depression and Baseline Scenario in 2013, however, the simulation of future distress is not performed by applying the above methods to the 2012 simulation results. This is because the 2012 calculations do not provide an unambiguous assignment of household members' labour market state or income; they only give the probabilities of each state. The 2013 results are thus obtained by calculating the cumulative changes in the variables under study for the entire period from the end of 2011 to the end of 2013 in one step. The additionally calculated results for 2012 are thus not used as an input for the subsequent simulation. Table 2 presents the macroeconomic scenarios for the stress tests of the household sector. Both the Baseline Scenario and the Protracted Depression correspond to the scenarios from the bank stress tests for 2013.

The impact of the shocks on households is assessed by comparing the percentage of distressed households before

14 This coefficient is employed for one-off shocks only (see Chart 3a). In the case of the macroeconomic scenario simulations, the average interest rates on the stock of loans are known directly (see Chart 2).

CHART 3

HOUSEHOLD RESPONSES TO MACROECONOMIC SHOCKS



Source: HBS 2011, authors` calculations
Note: EE stands for essential expenditure. The charts plot the variables' reaction relative to the end of 2012 in the event of a 1–3 standard deviation shock to the individual variables. Zero on the x-axis therefore corresponds to the starting point at the end of 2012.

and after the simulation[15] in the individual income quintiles.[16] Low-income households are most sensitive to the stress scenario. The percentage of distressed households increases in reaction to the stress scenario in the other income quintiles as well. Household distress has been edging up since 2011. The level of distress is lower than the results published in FSR 2011/2012 because of its different definition. Table 3 and Chart 2 summarise the stress test results.

We now examine the question of what influence the individual types of macroeconomic shocks under consideration have on household distress. In this case, our starting point is the end of 2012, with which we compare the level of distress after a 1–3 standard deviation shock to unemployment, inflation of essential expenditure and interest rates.[17] The overall increase in the percentage of distressed households in the event of an increase of three standard deviations in the variable under consideration would be largest for a shock to the unemployment rate, smaller for a shock to essential goods inflation and smallest for a shock to interest rates on loans to households (see Chart 3a). These results are due to the negative impacts of the said shocks on the average financial surplus of households (see Chart 3b).

5. CONCLUSION

This thematic article presents a stress test methodology and stress test results for Czech households. The tests allow us to simulate the effects of macroeconomic shocks to employment, interest rates and inflation. Growth in these variables has a negative effect on indebted households, reducing their available financial surplus as a result of a fall in income, an increase in debt service costs or an increase in essential living costs. These factors lead to a rise in the percentage of distressed households, i.e. households having difficulties paying their debts. The stress tests indicate that low-income households are the most vulnerable group with regard to both the level of distress and its sensitivity to macroeconomic shocks. The presented methodology can be used alongside the currently employed macroeconomic credit risk model as an alternative way of calculating households' average probability of default, which enters the bank stress tests. This methodology is a significant refinement of the one presented in FSR 2011/2012.

15 This percentage cannot be compared directly with the non-performing (NPL) loan ratio mainly because of households that are behind on their debt payments are not weighted by loans' principals.
16 The quintiles are determined according to the income of the entire sample of households regardless of whether or not they hold a loan. For this reason, the number of households in the individual quintiles shown in Chart 2 is not the same, as they contain only households with loans.
17 The standard deviations are computed for the period January 2002–December 2012. One standard deviation equals 1.39 pp for the unemployment rate, 1.73 pp for EE inflation and 0.74 pp for interest rates. Assuming a normal distribution, the probability of a shock of one, two and three standard deviations is 15.9%, 2.3% and 0.1% respectively.

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