# ECONOMIC RESEARCH BULLETIN

Stress-Testing Analyses of the Czech Financial System
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## EDITORIAL

Appropriate modelling of financial stability risks is crucial for guiding central bank policy actions. Stress tests of financial sector resilience should exhibit two important characteristics to avoid giving rise to a false sense of security. First, they should be calibrated conservatively. Second, sufficiently adverse macroeconomic scenarios should be assumed to test the stability of financial sector.

This edition of the Research Bulletin presents four articles that introduce the modelling framework of the various stress tests used regularly by the Czech National Bank. The first article focuses on the methodology of the current stress tests employed to assess the stability of the banking sector. It explains the links between the core and satellite models and how various adverse scenarios are generated to test the stability of the Czech banking sector. It also provides guidelines on how stress-test parameters should be calibrated. Concerns about liquidity played an enormous role in the recent financial crisis, and the second article therefore focuses specifically on the liquidity risk of the banking sector. It presents a well-defined methodology used also by other central banks, but tailors it to the specific conditions of the Czech banking sector. The third article presents a recently developed methodology for assessing the ability of Czech households to pay their debts. Using detailed household-level data, it quantifies how different adverse events, such as unemployment and higher interest rates on debt repayment, affect households' incidence of becoming financially distressed. The fourth article introduces stress-test models for the insurance sector. It discusses the specificities of the stress tests developed for this sector. It also sets out how to extend these already advanced tests to align them with changes going on in the regulatory framework.

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## IN THIS ISSUE

# Dynamic Stress Testing: The Framework for Testing Banking Sector Resilience Used by the Czech National Bank[1]

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Stress tests are used by commercial financial institutions, regulators and central banks as a means of testing the resilience of individual portfolios and institutions or the entire sector to adverse changes in the economic environment. Our study describes in detail the methodology of the "macro" stress-testing framework used by the Czech National Bank (CNB) to assess the resilience of the Czech banking sector. We focus primarily on solvency stress tests, i.e. on stress tests that capture the risk of a large part of the banking sector becoming insolvent due to a shortage of regulatory capital.

Macro stress tests have become a standard tool among central banks and regulatory authorities for assessing the vulnerabilities of the banking sector as a whole (Foglia, 2009; Drehmann, 2009). The earliest banking sector stress-testing models, which were initially based on simple historical scenarios linking macroeconomic developments with financial sector variables (e.g. Blaschke et al., 2001), have been developed into more sophisticated models integrating market, credit and interest rate risk and capturing inter-institution contagion and some feedback effects between the financial sector and the real economy (Aikman et al., 2009).

Nevertheless, the global financial crisis uncovered deficiencies in the stress-testing methodologies used in many countries. Before the crisis, many tests had been wrongly indicating that the sector would remain stable even in the event of sizeable shocks (Haldane, 2009; Borio et al., 2012). These deficiencies were related not only to the configuration of the adverse scenarios used, which had initially seemed implausibly strong but were often exceeded in reality, but also to the shock combination assumed, which had not been adequately anticipated in the scenarios (Ong and Čihák, 2010; Breuer et al., 2009). To tackle the recent deficiencies, Basel Committee on Banking Supervision (BCBS, 2012) has emphasised the need to overcome the potential downward bias of risk prediction when using models estimated on calm-period data, proposed using a longer time horizon for stress tests, such as three to five years, recommended more extensive use of granular data (such as on large exposures and interbank exposures) and much more conservative estimation of bank pre-provision profits for stress periods than suggested by models, and called for continued integration of solvency and liquidity tests. All of these recommendations are important components of the CNB's current stress-testing framework.

[1] This article is based on Geršl et al. (2012).

The CNB started stress testing in 2003, and the initial banking sector stress-testing methodology was based on the IMF methodology used for Financial Sector Assessment Program missions (Čihák, 2005; Čihák and Heřmánek, 2005; Čihák at al. 2007). In 2006, the CNB switched from testing historical ad-hoc scenarios defined by a combination of shocks (e.g. a 20% rise in non-performing loans, a 15% exchange rate depreciation and an increase in interest rates) to using consistent macroeconomic scenarios generated by the CNB's prediction model on a one-year horizon. The framework also included a contagion module within which a failure of a bank could cause a domino effect and impact the whole network of interconnected banks. In parallel, credit risk and credit growth satellite models were estimated to link macroeconomic developments with non-performing loans (NPLs) and credit growth (Jakubík and Heřmánek, 2008).

In 2009, the CNB further updated its banking sector stress-testing methodology. First, the tests were "dynamised", in the sense of switching to quarterly (instead of annual) modelling of shocks and their impacts on banks' balance-sheet items, controlling also for stock-flow consistency. In addition, the horizon was lengthened to two, and in 2011 to three years. Second, in the credit risk area, there was a changeover to "Basel II terminology" based on the standard parameters probability of default (PD) and loss given default (LGD), with risk-weighted assets evolving along these parameters, too. Finally, the framework featured some additional innovations in terms of the risks tested, such as the risk associated with changed capital-targeting behaviour of banks (e.g. a decrease in the bank-specific targeted capital adequacy ratio via the payout of extraordinary dividends). Given the possibility of modelling the banking sector at quarterly frequency in the new updated stress-testing framework, stress tests could be run at higher frequency (quarterly rather than just annually or semi-annually), which has proved very useful during the current financial crisis period.

Alternative macroeconomic scenarios serve as the starting point for stress testing in the current methodological framework. Stress (or adverse) scenarios are constructed based on the identification of risks to the Czech economy in the near future as seen by the CNB Financial Stability Department. To compare the stress outcome with the most probable outcome, a baseline scenario, i.e. the current official macroeconomic prediction of the CNB, is also used. All the scenarios are designed using the CNB's official "g3" macroeconomic prediction model. In practice, the stress scenarios are generated by assuming certain shocks to key macroeconomic variables, which then endogenously feed through the g3 model to generate the trajectories for all relevant macro variables. A typical shock would be, for example, a drop in (effective) euro area GDP growth (which serves as proxy for the demand for Czech exports), which feeds through the g3 model, causing a drop in domestic GDP growth (mainly due to lower net exports) and potentially lower inflation, lower domestic interest rates and some depreciation of the domestic currency. On average, the size of the shocks in the CNB's stress tests is regarded as large (IMF, 2012; Franta et al., 2014).

The satellite models link the evolution of the main macroeconomic variables and key risk parameters in the banking sector. They use as explanatory variables only those macro variables which are projected by the g3 model, but in principle they could also use financial variables which are themselves products of other satellite models or the stress-testing framework itself. In the current framework, the satellite models are used to forecast PD/default rates and LGD (credit risk models), credit growth, property prices, pre-provision profit (so-called adjusted operating profit) and longer-term yields. Given the inherent uncertainty in predicting financial variables, the

model forecasts are often adjusted by expert judgment to reflect all available information about developments in the banking system, and also to ensure a conservative (i.e. worse than predicted by the model) estimate.

Credit risk testing is the most important area of stress testing. This testing is based on the use of PD and LGD for each of the four main segments of the loan portfolio (corporate, mortgages, consumer loans and other). An increase in PD and LGD has two main effects on individual banks. First, the expected loan losses (in CZK millions), against which banks will create new provisions of an equal amount and record them on the expenses side of the profit and loss statement as impairment losses, are calculated as the product of PD, LGD and the volume of the non-default part of the portfolio (i.e. excluding non-performing loans) for each credit segment and quarter. To better reflect the industry composition of individual banks' corporate portfolios, we take into account the industry-level PD at individual banks, with the corporate portfolio PD at each bank being a weighted average of the PDs of the individual industries to which the bank is exposed. Second, the Basel II IRB formula based on PD and LGD is used to calculate capital requirements for credit risk (or risk-weighted assets, RWA). Given that the largest banks in the Czech Republic apply this approach, this relation is applied to all banks for the sake of simplicity. If a constant non-default portfolio volume, i.e. exposure at default (EAD), was assumed, an increase in PD and LGD would result in an increase in RWA and a decrease in capital adequacy. However, this impact interacts with the forecast of the credit growth model, which usually gives a decline in credit, thus mitigating or eventually even reversing the impact of the higher PDs and LGDs on total RWAs.

Starting from 2010, as a consequence of the escalated sovereign crisis in the euro area, the stress-testing methodology in the severe scenarios used additional assumptions to incorporate current sovereign riskiness, and 50% impairment of the Czech banking sector's exposures to both governments and private institutions vis-à-vis five indebted EU countries[2] was assumed. Later, in August 2011, the impairment was even increased to 100%. In 2012, the methodology for testing sovereign risk was revised and a more general methodology of haircuts for particular indebted states was developed. Since then, the adverse scenario usually assumes haircuts on the government bonds of all EU countries whose government debt exceeds the "Maastricht" limit of 60% of GDP, and not only for the most indebted EU countries.

Besides sovereign risk, the stress-testing framework enables us to test specific exposures of interest (ad-hoc risks) which may represent some additional risk in the banking sector. For these exposures, a certain loss rate is assumed. In the past few years, exposures to large developers, some "risky" industries (such as construction and real estate), exporters and solar energy plan investors have been tested assuming losses of between 50% and 100% of the exposure. Moreover, Czech banks – given their foreign ownership and good liquidity position serving as net creditors to the banking groups to which they belong – have exposures vis-à-vis their parent banks or other banks in the banking group. These exposures were tested, too, assuming a rather large haircut of 50%. Similarly, a concentration risk test is performed, assuming (as part of the adverse scenario) that the three largest debtors at each bank go into default with a certain loss. The framework takes into account both the current balance-sheet exposure of the largest debtors to the bank as well as the potential increase arising from commitments and guarantees.

[2] Ireland, Italy, Portugal, Greece and Spain.

The CNB has always put an emphasis on conservative calibration of risks. The need to systematically err on the conservative side is supported by the uncertainty related to possible changes in the estimated relationships and elasticities during stress times in models estimated on mainly calm periods. Being prudent in stress testing is in line with the general macro-prudential approach adopted by policymakers and supervisors worldwide, and erring on the side of pessimism is preferred to possible underestimation of the losses and capital needs of banking systems in crisis, which can have large negative effects on public budgets, on general public perceptions of banks' health, and back onto the economy.

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# Bank Liquidity Stress Testing[3]

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The severity of the global financial crisis reminds us how important it is to investigate banks' liquidity risks. The balance-sheet liquidity of banks can be analysed by assessing the evolution of balance-sheet ratios or using various market-based indicators reflecting balance-sheet liquidity tensions, for example from bidding in the central bank's open market operations. The new Basel III regulatory framework for banks also recently proposed the introduction of two harmonised liquidity standards in order to reinforce banks' resilience to liquidity risks – the liquidity coverage ratio and the net stable funding ratio. However, to obtain a more complete picture of an institution's liquidity risk profile, advanced stress tests are a useful instrument to analyse and understand vulnerabilities of both individual banks and the banking industry as a whole. Liquidity stress tests provide a suitable tool for evaluating the importance of various risk factors for banks' liquidity positions in different scenarios. The Czech National Bank (CNB) has been developing its liquidity stress-testing model since 2007 and results from the model are regularly included in its financial stability reports.

We were inspired by several studies that have presented liquidity stress-testing models. Van den End (2008) introduced a liquidity stress-testing framework based on re-counting of liquidity buffers after the impact of several different types of shocks. It combined both the market and funding liquidity risks of banks, with feedbacks between them driving the second-round effects of market disturbances on banks. However, the banks' reactions in Van den End's model, besides the sale of tradable securities, are assumed to take the form of the issuance of additional securities or the substitution of some assets or liabilities with other items. On the other hand, in our model we consider – as in the IMF's stress test (2011) – a frozen interbank money market due to higher counterparty and default risks or liquidity hoarding by banks and investors, and a fire sale of assets. Thus, in our model the feedback effect is simulated by an attempt by banks to meet immediate obligations only by selling assets. In addition, like Wong and Hui (2009) we take into account three channels through which asset price shocks are transformed into banks' liquidity risk: (i) mark-to-market losses increase banks' default risk and induce deposit outflows, (ii) the ability to generate liquidity from asset sales evaporates due to significant asset price declines, and (iii) due to more stressful financial environments, the likelihood of drawdowns on banks' irrevocable commitments increases.

The CNB's liquidity stress-testing framework is directly linked to its solvency stress-testing model, as some bank-specific liquidity shocks (such as deposit withdrawals and haircuts on

[3] This article is based on Komárková et al. (2011).

illiquid assets such as loans, which banks may consider selling at times of liquidity tensions, too) are dependent on the results of those banks in the solvency stress tests (e.g. banks whose profitability declines most when facing credit and market shocks also experience larger deposit withdrawals). This is in line with the recent emphasis on integrating solvency and liquidity stress testing such as in Wong and Hui (2009), where market risk arising from a prolonged period of negative exogenous asset price shocks increases credit risk, which subsequently impacts on banks' liquidity position.

The CNB's model is based on a top-down approach and is estimated using bank-level data. It captures both liquid assets and liabilities in the banks' balance sheets and includes on-balance-sheet items as well as selected off-balance-sheet ones. Unfortunately, due to a lack of data, the model uses only stock variables and does not include predictions about cash inflows and outflows that are related to standard banking business. In its simplest form, the model assumes that banks normally have a liquidity reserve consisting of liquid securities or cash to cope with unexpected cash outflows driven by a loss of confidence, market turbulence, excessive use of credit facilities by companies or deposit withdrawals. The main aim of the model is to examine if the banks' liquidity reserves are sufficiently large and liquid to withstand those outflows.

The CNB's model assumes three subsequent steps that are logically interlinked: (i) the formation of a balance-sheet liquidity shortfall, (ii) the reaction by banks, and (iii) the feedback effects of shocks. With each step we re-count the liquidity asset buffer (at the beginning, after the first round of shocks, and after the second round of shocks) and examine whether the banks hold a sufficiently large amount of liquid assets to be able to survive the liquidity tension in their balance sheets.

Firstly, the initial liquidity buffer is calculated for each bank, with assets priced to initial market conditions. Second, the first round of shocks is applied, including (i) a liquidity shortfall due to an increase in bank lending amid higher drawdowns of credit lines and efforts to keep credit market shares, (ii) a decline in the value of liquid assets held in banks' balance sheets, owing to a deterioration in market sentiment and a decrease in asset prices such as government bonds, and (iii) a loss on certain non-traded liquid assets (such as interbank deposits) due to increased counterparty credit risk in the interbank market, with the latter two shocks leading to a decrease in the initial liquidity buffer. If the available cash and cash-like instruments (such as reserves at the CNB) that banks hold are not high enough to cover the liquidity gap, then tradable assets have to be sold in financial markets. In the absence of a sufficient amount of liquid assets it is assumed that banks will try to liquidate less liquid or even non-tradable claims even though very high haircuts are applied to them.

The banks' response will reduce the impact of the first-round shocks on their balance-sheet liquidity. However, it will simultaneously increase the reputational risk of each responding bank (suffering from a potential stigma premium) and systemic risk through the simultaneous response of the banks on the financial markets. The increase in these two risks feeds back to banks' balance sheets (as a further decline in asset prices and deposit withdrawals), constituting a feedback effect. The market stress on the banks' balance sheet will be larger if more banks react in the markets, the reactions on the markets are more similar, and the reacting bank is larger. Therefore, the non-reacting banks are affected only by systemic risk through additional haircuts, whereas banks that react in order to fund their liquidity shortfall face both a reputational risk and

a systemic risk. It follows that the impact of the second round of shocks must be stronger for responsive banks. Market liquidity also plays a relevant role in our model. In the case of asset liquidation on liquid markets (such as government bond markets) the feedback impact is smaller than in the case of asset liquidation on illiquid and shallow markets. The market conditions (market liquidity) are expressed by a state variable that is derived from standardised distributions of risk aversion indicators expressed by the implied stock price volatility and corporate bond spreads.

The impact of the two rounds of shocks depends on the predefined scenario and the banks' types of business model as reflected by the balance-sheet and maturity structures. Nevertheless, in the model, banks that are funded at long maturities and have assets that are of high quality and are easy to sell score better, while banks that are funded at short maturities (especially wholesale funding) and have only too risky or illiquid assets (loans to the private sector) score worse.

It is obvious that the CNB model has some limitations and does not provide a complete picture of banks' liquidity risk. First, it does not take fully into account the business model and confidence in the bank, for example, which usually play a significant role in financial market trading. Second, interbank contagion via direct interbank borrowing and possible contagion via domino effects are also not captured in this framework, although they are captured in the solvency stress tests. Third, only stock variables are used for the simulations, disregarding the expected inflows and outflows of funds, as these are not available via standard bank reporting to the central bank. Therefore, the CNB plans further improvements. These would focus mainly on (i) including the domino effect using a matrix of interbank market exposures, building on the existing contagion module in the solvency stress tests, (ii) the dynamics of the individual shocks over time (effectively introducing third- and higher-round effects) and (iii) the endogenisation of some of the shocks. Moreover, as liquidity issues are coming to the forefront of regulators' attention given the new Basel III regulation on liquidity, further work will be devoted to recalibrating the model along the new Basel III metrics, i.e. incorporating the net stable funding ratio and the liquidity coverage ratio.

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# Stress Testing the Private Household Sector Using Micro Data[4]

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The financial crisis of 2008–2009 underlined the importance of monitoring and assessing risks in the household sector caused by the excessive accumulation of debts. In the pre-crisis period, household indebtedness increased to historical highs in a number of OECD countries. The growth was driven by favourable financial conditions, easier access to credit for lower-income borrowers due to supply-side innovations in credit markets, and buoyant housing markets (Girouard et al., 2006). These developments leveraged households' balance sheets and increased their sensitivity to interest rates and house prices. While in the pre-crisis period most of the debt had been held by higher-income households, which are better able to service their debts, the importance of the indebtedness of lower-income households and spillovers to the rest of the economy increased during the crisis of 2008–2009.

This experience highlights 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. Moreover, excessive credit growth and overly relaxed credit standards before the crisis gave rise to sharp growth in the credit risk of the banking sector during the crisis. As a result, financial regulators are developing tools for monitoring systemic risk in the household sector and for stress testing household balance sheets.

In our paper (Galuščák et al., 2014) we develop and improve the methodology used in the Czech National Bank (CNB) for stress testing the private household sector using micro data, building on the approach of Johansson and Persson (2006) and Albacete and Fessler (2012). The methodology is based on identification of financially distressed households, who may fall into difficulties in repaying their debts. We associate distress with a fall in the financial surplus – defined as net household income minus debt repayments and essential living costs – into negative values. We investigate the impact of macroeconomic shocks on the financial surplus and thus on households' ability to service their debts. In particular, we consider shocks to the unemployment rate, which affect the surplus through net household income, shocks to the interest rate affecting debt instalments, and shocks to prices changing households' essential expenditure. We also illustrate the impact of specific macroeconomic scenarios on financial distress among households.

[4] This article is based on Galuščák et al. (2014).

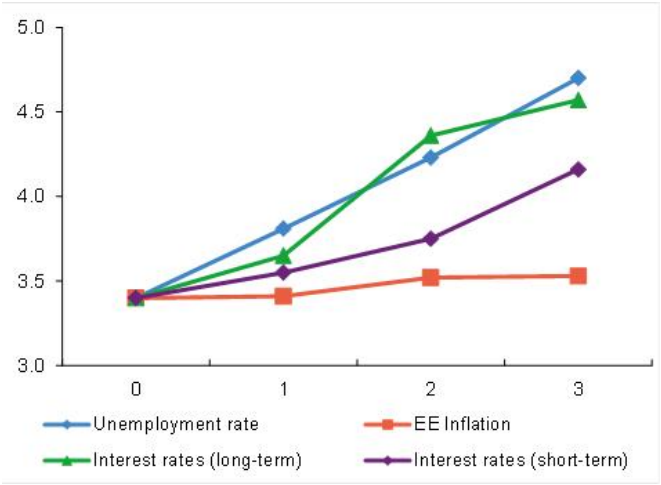
Our approach is data driven, as the available dataset, the Household Budget Survey, does not contain individual household balance-sheet data.[5]

The key concept in the unemployment scenario is the probability that a person is unemployed. We extend the approach of Johansson and Persson (2006) and Albacete and Fessler (2012) by allowing for transitions not only from employment to unemployment, but also from unemployment to employment. Another extension to the aforementioned studies is that, thanks to data availability, we consider the impact of the unemployment shock on household heads as well as their spouses. We estimate the unemployment probability model and predict the probability of unemployment for each person. The unemployment shock is then simulated by increasing the constant in the model until the rate of unemployment based on the whole set of households reaches the required level. While the non-work income of persons becoming unemployed is determined using eligibility criteria, we assign a wage for non-workers using the Heckman (1979) sample selection model.

In the interest rate shock scenario, we consider instalments on housing loans, consumer loans and other loans. We assume short-term effects, defined as a one-year horizon, where part of housing loans and all loans in the category of other loans are renegotiated, and long-term effects, where the shock affects all loans and instalments are recalculated accordingly. In the essential expenditure price shock we consider shocks to prices affecting groups of consumer goods which are typical for essential expenditure: food, energy, health and rents. We use available estimates of the price and income elasticity of demand from Dybczak et al. (2010).

**Figure 1.** Percentage of distressed households in response to macroeconomic shocks

(% on y-axis; standard deviations on x-axis)




**Source:** Household Budget Survey 2011 and 2012; authors' calculations.
**Note:** Average ratio of distressed households relative to the end of 2012 in the event of shocks of the size of 1–3 standard deviations. Shocks to the unemployment rate, the interest rate (short-term and long-term effects) and essential expenditure (EE) are considered. Values at zero on the x-axis correspond to the starting point at the end of 2012.

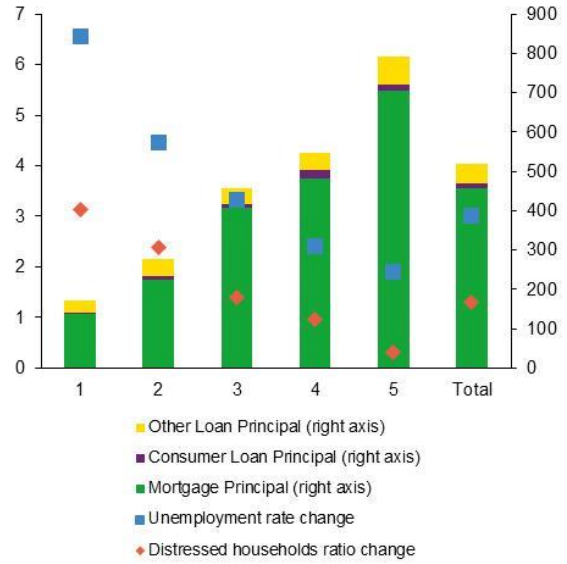
[5] Values of interest rates and loan maturities are imputed based on population averages.

We consider the impact of shocks of the size of 1–3 standard deviations computed over the period January 2002–December 2012. The results in Figure 1 suggest that the largest increase in the share of distressed households is observed for the unemployment shock. For the long-term effects of the interest rate shock, the effect on household distress is higher for shocks of 2–3 standard deviations and is comparable with the impact of the unemployment shock. On the other hand, the short-term effects of the interest rate shock are smaller, while the impact of the shock to prices of essential goods is very small and increases only mildly for more sizeable shocks.[6] The results also suggest that the impact of shocks is concentrated particularly on households in lower income quintiles.

In order to illustrate which households are affected by adverse shocks, we compare in Figure 2 our estimates of the average residual principals of all three types of loans included in the stress tests (mortgage, consumer and other loans) with the change in the share of distressed households and the change in their specific unemployment rate under the most sizeable unemployment rate shock. Households in the two lowest income quintiles face the highest increase in financial distress, while they are also the most likely to be affected by higher unemployment. On the other hand, the indebtedness of those households is lower than for other households, as indicated by the estimated sum of the average residual principals. The results also show that the highest debt burden among Czech households is in mortgages.

**Figure 2.** Reaction of households to a three-standard-deviation shock to the unemployment rate versus average residual principal by income quintiles

(percentage points; CZK thousands)




**Source:** Household Budget Survey 2011 and 2012; authors' calculations.
**Note:** Other loans are mainly leasing loans.

Although the impact on financial distress is similar for the unemployment shock and for the long-term effects of the interest rate shock, the effect on the financial surplus is more pronounced for

[6] The effect of price shocks is mitigated by the use of non-zero price and income elasticities of demand.

the interest rate shock. This is because the interest rate shock impacts mainly on higher-income households, which are less likely to become distressed, while the unemployment rate shock mainly affects lower-income households, which are closer to the zero threshold identifying household distress. The results also suggest that the absolute change in the financial surplus increases along the income distribution and is largest for households in the highest quintile for all the types of shocks we consider.

We compare our results with the available evidence for other countries, in particular with Johansson and Persson (2006) for Sweden and with Albacete and Fessler (2010) for Austria. We find that the impact on household distress due to the unemployment rate shock is larger than in Sweden and Austria. This might be due to the fact that we include household heads as well as their spouses in our estimation. On the other hand, the impact of the interest rate shock is similar as in Austria, while it is much lower in Sweden. The lower impact of the interest rate shock in Sweden may be caused by a lower debt burden expressed as the interest ratio.

In our paper (Galuščák et al., 2014) we illustrate the use of our approach to stress testing the incidence of financial distress under macroeconomic scenarios from the CNB's official forecast and from the CNB's Financial Stability Report. The results underscore the importance of using microeconomic data in the analysis of the effects of macroeconomic shocks to households' ability to pay their debts. We show that although the debt is concentrated among higher-income households, lower-income households are more vulnerable to adverse economic developments. Our results may be used to estimate households' average probability of default, which could serve as an input to the CNB's bank stress tests.

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# Insurance Sector Stress Testing[7]

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Stress tests of insurers' balance sheets may present unique challenges because insurers have a different balance-sheet structure to banks (KPMG, 2002). Insurers play different roles than banks or brokers in market failures that cause financial crises. As we show later, this is due to their rather different insurance business model, whose specific features make them more a source of stability than a source of instability in the financial system. However, although insurers – mainly using their traditional insurance business – maintained relatively steady capacity, business volumes and prices during the financial crisis (GA, 2010), their balance sheets, like those of other financial institutions, are vulnerable to various shocks correlated with the business and financial cycle. Therefore, stress testing serves as a key risk management tool enabling both insurers and supervisors to ascertain whether insurance companies are financially flexible enough to absorb losses that could occur in various adverse scenarios. The Czech National Bank (CNB) has been developing its insurers' stress-testing model since 2006, and results from the model are regularly included in its financial stability reports.

The nature of insurance and of the regulatory regime in which the insurance sector operates necessitates some adjustments compared with the banking sector stress tests. Firstly, some shocks (such as natural disasters) are significant for insurers but are largely irrelevant for banks, and vice versa (e.g. credit risk in banks' loan portfolios). Secondly, insurance is essentially a longer-term business where the structure of assets and liabilities does not change rapidly, in contrast to investment banks, for example, whose business is shorter term in nature. Lastly, insurance regulatory regimes distinguish between life and non-life business and between different sorts of shocks. Clearly, there are many other shocks, but these are the most representative in terms of distinguishing between the insurance and banking sectors.

In general, insurers usually carry on traditional insurance activities. On the liability side, they face interest rate risk, catastrophe risk, underwriting risk and risks on technical claims provisions. On the asset side, they mainly face market risk, credit risk, liquidity risk and operational risk. Both sides of the balance sheet face group risk and systemic risk. However, as the financial system changes, insurance companies can also change their behaviour to some extent and engage in non-traditional and non-insurance activities (such as financial guarantees, CDS writing and/or trading, leveraging assets to enhance investment returns, and securities lending). Such non-insurance activities make them more vulnerable to financial market developments and, importantly, more likely to contribute to systemic risk. The different kinds of activities that insurers can carry on should be taken into account in the stress-test framework and scenario design.

[7] This article is based on Komárková and Gronychová (2012).

Catastrophe risk, underwriting risk and interest rate risk play the most important role. Random events linked with catastrophe risk represent one of the most significant risks in non-life insurance. This kind of risk refers to the ability of the insurer to withstand catastrophic events (floods or pollution for example), increases in unexpected exposures, latent claims or aggregation of claims (IAIS, 2003). Changes in interest rates are a key risk driver in life insurance, since they affect the valuation of assets and liabilities (KPMG, 2002). They can also have an indirect effect on policyholders, as in the case of interest rate growth, policyholders experience an increase in the cost of borrowing, which can lead to decisions to lapse or surrender their policies. In the context of the current financial crisis (Banque de France, 2012) it is necessary to take into account that insurance companies can be particularly exposed to the risk of a long-lasting period of low interest rates. Such a scenario is driven not only by the instantaneous shock of a downward movement of the yield curve, but also by a pronounced flattening and a persistence of such a situation. This could lead to material reinvestment problems and influence the ability of participating groups and undertakings to finance, for example, performance guarantees given for specific pools of insurance contracts. This, in turn, could negatively impact the capital position of insurers who are exposed to these risks (EIOPA, 2011).

In the stress-test methodology developed in the CNB we focus on the essential risks the Czech insurance sector is exposed to and additionally provide some complementary sensitivity analysis to test the remaining risks. We test the impact of significant changes in risk parameters (shocks) at the one-year horizon on the value of the assets and liabilities of the insurance sector. Changes in the value of assets and liabilities drive the final available solvency margin and consequently the solvency ratio, so an assessment of the solvency position is the main output of the stress test. The outcomes of the stress test also allow us to assess the impact of the shocks on the insurance sector's ability to cover technical provisions with a sufficient volume of assets. The principles of the calculation for the determination of available capital currently applied are based on the Solvency I regulatory regime. However, the methodology enables us to take an economic view of the impact of shocks (close to the future Solvency II regulatory approach).

The basis of the methodology was taken from the pilot CEIOPS stress-test paper (a what-if type test for investment risks; CEIOPS, 2009) and was further developed. A one-year time horizon was incorporated and insurance risks were added. The one-year horizon enabled us to incorporate other assumptions and features into the test, such as the profit/loss produced during the year, the repeated occurrence of natural disasters and planned dividend payments. The impacts of shocks are assessed at the level of insurance companies and then aggregated for the insurance sector.

In our scenarios we take into account market risk (equity, interest rate, currency and property risk), credit risk (including sovereign risk), intra-group risk and systemic risks in respect of the Czech insurance sector. In addition, we include in the tests two insurance risks in the case of non-life insurance: underwriting risk (motor insurance) and catastrophe risk (occurrence of floods). The impact of the natural disaster scenario is assessed as a satellite scenario to the main stress scenario, so that the resilience of the insurance sector to the simultaneous occurrence of changing conditions in the economy and markets and (severe but plausible) natural disasters is judged. In developing the stress scenarios, due consideration was given to aligning the macroeconomic assumptions with those applied in stress tests of the Czech banking sector (Geršl et al., 2012). The CNB's stress-testing framework for the insurance sector incorporates the macroeconomic scenarios generated by the CNB's DSGE g3 prediction model (Andrle et al., 2009; Brázdik et al.,

2011) and by the satellite model for Czech house prices estimated in Hlaváček and Komárek (2009). The two models are accompanied by some expertly defined shocks.

The g3 prediction model is calibrated, confidence intervals are not provided, and the scenarios thus represent central forecasts given the shocks assumed for selected variables in the model. As the prediction model does not include all the macro and market variables that are used for stress testing, additional expertly defined risk shocks need to be added. From a prudential perspective, a conservative approach is preferred, so the various expertly defined shocks rather overestimate the risks and underestimate the balance-sheet buffers.

While the current CNB model is already relatively advanced, we nevertheless plan further improvements due to the upcoming Solvency II regulatory framework. Solvency II, which will enter into force on 1 January 2016, is based on risk assessment and imposes market-based valuation of assets and liabilities. The solvency capital requirement will have to be calculated so as to ensure that all quantifiable risks to which an insurance company is exposed are taken into account. It will have to correspond to the Value-at-Risk of the basic own funds of an insurance company subject to a confidence level of 99.5% over a one-year period. Several other adjustments to the system stress-test methodology are planned: (i) the incorporation of an evaluation of the impact of the stress scenario on the solvency capital requirement, (ii) the inclusion of lapse risk in life insurance, (iii) a change to the methodology for interest rate risk in respect of insurance liabilities, and (iv) the inclusion of matching adjustment and volatility adjustment concerning the risk-free interest rate.

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## Forthcoming Journal Publications

Baxa, J., Horváth, R. and Vašíček, B. (2014): How Does Monetary Policy Change? Evidence on Inflation Targeting Countries. *Macroeconomic Dynamics*, forthcoming.

Derviz, A. (2014) Collateral Composition, Diversification Risk, and Systemically Important Merchant Banks. *Journal of Financial Stability*, forthcoming.

Franta, M., Horváth, R. and Rusnák, M. (2014): Evaluating the Changes of the Monetary Transmission Mechanism in the Czech Republic. *Empirical Economics*, forthcoming.

Geršl, A. and Brechler, J. (2014): Political Legislation Cycle in the Czech Republic. *Constitutional Political Economy*, forthcoming.

Geršl, A. and Jašová, M. (2014): Measures to tame credit growth: Are they effective? *Economic Systems*, forthcoming.

Havránek, T., Horváth, R. and Valíčková , P. (2014): Financial Development and Economic Growth: A Meta-Analysis.*Journal of Economic Surveys*, forthcoming.

Horváth, R., Weill, L. and Seidler, J. (2014): Bank Capital and Liquidity Creation: Granger Causality Evidence. *Journal of Financial Services Research*, forthcoming.

Skořepa, M. and Seidler, J. (2014): An Additional Capital Requirement Based on the Domestic Systemic Importance of a Bank. *Journal of Economic Sciences*, forthcoming.

## CNB Research Open Day

The tenth CNB Research Open Day will be held in the Czech National Bank's Commodity Exchange (Plodinová Burza) building on **Monday, 12 May 2014**. This half-day conference will provide an opportunity to see some of the best of the CNB's current economic research work, to learn about the CNB Call for Research Projects 2015 and to meet CNB researchers informally.

Please note that places will be subject to availability owing to the limited capacity of the conference facility. To secure your place please register at www.cnb.cz, direct link: http://www.cnb.cz/en/research/seminars_workshops/research_open_day_2014_form.html

### Programme

Monday, 12 May 2014
The Czech National Bank's Commodity Exchange (Plodinová Burza) building,
Senovážné nám. 30, Praha 1

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|---|---|
| 8.30 | Registration & Morning Coffee |
| 9.00 | Introduction and ERD Award 2014: Kamil Janáček, Bank Board Member, CNB |
| 9.10 | CNB Research in 2014, Kateřina Šmídková, Executive Director, ERD, CNB |
| | Chair: Kateřina Šmídková |
| 9.20 | "*Nowcasting Czech GDP in Real Time*," by Marek Rusnák |
| 9.40 | Discussion: Fabrizio Venditti, Bank of Italy |
| 9.55 | Q&A |
| 10.05 | "*Evaluating Links Between the Financial and Real Sectors in a Small Open Economy: The Case of the Czech Republic*," by Tomáš Konečný, Oxana Babecká Kucharčuková |
| 10.25 | Discussion: Michał Rubaszek, National Bank of Poland |
| 10.40 | Q&A |
| 10.50 | Coffee |
| | Chair: Kamil Galuščák, CNB |
| 11.15 | "*Inflation and the Steeplechase Between Economic Activity Variables*," by Jaromír Baxa, Miroslav Plašil and Bořek Vašíček |
| 11.35 | Discussion: Luca Onorante, Central Bank of Ireland |
| 11.50 | Q&A |
| 12.00 | "*Collateral Composition, Diversification Risk, and Systemically Important Merchant Banks*," by Alexis Derviz |
| 12.20 | Discussion: Wolfgang Gick, Harvard University |
| 12.35 | Q&A |
| 12.45 | Lunch (venue: bank club) |
| 14.00 | Information Meeting for Prospective Authors of CNB Research Projects (venue: bank club) |

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