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Models for Stress Testing in the Insurance Sector

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Abstract

The project is focused on top-down stress testing of the Czech insurance sector. The aim of the present paper is to describe the advanced method for macro stress testing of insurance companies used by the CNB. We apply the presented stress test to eleven Czech insurance companies. The shocks applied are designed to replicate a macroeconomic scenario and to impact on both the asset and liability sides of the balance sheet. We consider both investment and insurance risks relating to the Czech insurance sector. An application of the simulated scenario to the Czech insurance sector illustrates that the sector is sufficiently resilient and stable.

JEL Codes: G22, G28, G33.

Keywords: Financial stability, insurance, risks, stress testing.

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Nontechnical Summary

Stress testing is becoming a widely used risk management tool for assessing potential vulnerabilities in a financial system. Insurance companies, like other financial institutions, face various shocks, some of which are correlated with the business and financial cycle. Insurance sector stress testing is therefore a useful tool enabling supervisors to ascertain whether insurance companies are financially flexible enough to absorb losses that could occur in various adverse economic scenarios.

The aim of this paper is to describe the methodology of the current system for stress testing the Czech insurance sector used by the Czech National Bank. For the purposes of the paper, the term "stress testing" includes both sensitivity testing and scenario testing over a one-year horizon. We analyze the impact of unlikely but not impossible adverse scenarios, i.e., certain events, on an insurer's financial condition. These scenarios involve simultaneous movements in a number of risk categories affecting all of the insurer's business lines. To measure the effect of atypical or extreme movements, the CNB uses a deterministic model. The results of our stress tests are expressed in terms of their impact on the solvency margin, i.e., the minimum surplus of an insurer's assets over its liabilities. We monitor the solvency ratio by comparing the available solvency margin with the solvency margin required by the regulation. After application of the scenarios' shocks, the financial position of insurance companies should not deteriorate significantly below the required solvency margin. Otherwise, it is a signal for the supervisor to take corrective action.

To demonstrate the methodology in practice, we applied it in the second part of the paper to the Czech insurance sector using two macro scenarios – a baseline and an adverse scenario. The Czech insurance sector is a traditional business model sector with a conservative approach, so the scenario design takes into account the typical investment and insurance risks. They include market risk and credit risk on the asset side, and motor insurance and catastrophe risk on the liability side. All assets in the financial placements of insurance companies are included in the stress test. On the liability side, the provision for the fulfillment of commitments from the technical interest rate and other calculation parameters and other liabilities sensitive to interest rate change are included. Although the adverse scenario was designed to be very severe, the stress test indicated that the Czech insurance sector is sufficiently resilient.

1. Introduction

Stress testing is 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. Although insurers – mainly using their traditional business – maintained relatively steady capacity, business volumes, and prices during the financial crisis (GA, 2010), the balance sheets of insurance companies, like other financial institutions, are vulnerable to various shocks that are correlated with the business and financial cycle. However, insurance companies play different roles than banks or brokers in market failures that cause financial crises. This is due to their rather different insurance business model, which has specific features, and to their different behavior in the financial market, which makes them more a source of stability than a source of instability in the financial system.

In some respects, insurance sector stress tests are structured in a very similar way to banking sector stress tests, because some of the risks the two sectors face are similar. Nevertheless, the nature of insurance and of the regulatory regime in which the insurance sector operates necessitates a number of adjustments. Firstly, some shocks (such as natural disasters) are significant for insurers but are 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. Thirdly, regulations and insurance contracts make the estimation of the impact of any stress independent of assumptions about the behavior of insurance companies and their policyholders. This is because the latter carry a great deal of the risk, and there are various degrees of freedom in the allocation of risk. Lastly, insurance regulatory regimes distinguish between life and non-life business and between different sorts of shocks.

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 behavior 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 can make them more vulnerable to financial market developments and, importantly, more likely to amplify, or 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.

The aim of this paper is to describe the methodology of the current stress-testing system for the Czech insurance sector. The Czech insurance sector is a traditional business model sector with a conservative approach. Czech insurance companies do not carry on non-traditional or non-insurance activities. The large and mid-sized insurance companies belong to large international financial groups with a strong capital base. A significant part of the sector consists of composite insurers offering a broad range of life insurance and non-life insurance products. The structure of financial placements of insurance companies in the Czech Republic is rather conservative. The

financial placement of assets is dominated by bonds and other fixed-income securities. Equity instrument are present to a limited extent. Czech government bonds currently represent roughly 50% of assets covering technical provisions. Thus, market risk and sovereign risk prevail on the asset side. Interest rate risk is especially significant for life insurers, because their product ranges usually include both traditional long-term products with guarantees and unit-linked policies. Non-life insurance risk has a large share in the risk profile of the sector, mainly due to catastrophe (flood) risk and underwriting risk in motor insurance. We are aware that the Czech insurance sector is subject to wider range of risks than those we test for in our stress-testing model. However, the aim of the CNB was not to develop a stress test encompassing all the risks that the Czech insurance sector is exposed to. Instead, through the stress test we focus on the essential ones and additionally provide some complementary sensitivity analysis to test the remaining risks. The current stress-test system is based on the Solvency I rules, but includes accessory components close to the Solvency II economic view, such as market valuation of the whole asset side and an economic view of the interest rate sensitivity of technical provisions. The paper discusses the steps needed to fully adjust the stress-test methodology for Solvency II purposes.

The paper is organized as follows. The next section describes the literature on solvency margins, while Section 3 explains the risks being stressed. Section 4 presents the methodology. In Section 5 the methodology is applied to the Czech insurance sector and the results are discussed. Section 6 considers issues of stress testing in the upcoming Solvency II regulatory regime. The last section contains the main conclusions.

2. Literature

Stress testing is becoming a widely used tool for assessing potential vulnerabilities in a financial system. Stress testing of insurers' balance sheets and income statements is not as well developed as stress testing of banks (Jones et al., 2004). This is mainly due to the fact that insurance companies represent a lower level of systemic risk than, for example, banks, as their liabilities have a different character (often a longer duration). It is not easy to refer to relevant previous research of stress testing in the insurance sector, as the available literature, especially for stress-test modeling, is thin on the ground. In particular, insurance risk stress testing has not been employed for financial stability purposes to the same extent as market risk testing, even though it is a strongly advisable tool for this type of exercise due to its ability to quantify this insurance phenomenon. However, some guidance and consultation papers have been published.

An IAIS guidance paper (2003a) sets out principles that should underlie solvency regimes for the regulation and supervision of insurers, including principles regarding the level of solvency. The paper discusses the important role of stress tests, outlines how supervisors can use stress testing to assess the prudential strength of individual insurers, and provides an overview of the various factors that need to be considered in designing and undertaking stress tests, including a discussion of possible modeling techniques that can be used. The FSA (2009) published a statement setting out how stress tests had been used within the prudential regulatory regime for insurers, including information on the macroeconomic parameters recently used. The Geneva Association (2010b) published a report examining the performance of the insurance industry during the crisis, assessing the application of the FSB's proposal on systemic risk to insurance, and developing initial recommendations to address current regulatory gaps and strengthen industry risk

management practices. Besides giving an introduction to the insurance industry, its economic role, its business model, and its stability during the current crisis, the report provides several case studies of troubled insurers (AIG) and describes the EU, U.S., and Swiss insurance regulatory regimes, including their solvency tests.

Alongside it, the CEIOPS paper (2009) *Building a European Stress Test for the European Insurance Sector* describes a stress-testing methodology applied to the largest European insurance groups. This exercise took place in 2009 and (i) assessed insurance undertakings' solvency position, focusing on the available capital before and after the stress test compared with the required solvency margin as a Solvency I measure, (ii) analyzed three "what-if" situations, known as scenarios, focusing on the development of "market prices" of corporate bonds, stocks, and technical provisions, (iii) included movements on both the asset and liability side of the balance sheet, and (iv) took into account five risks (interest rate, equity, property, credit spread, and lapse risk). A Europe-wide insurance stress test has recently been launched by EIOPA, which has also published a specification for that test (EIOPA, 2011).

The Czech National Bank started to stress test the Czech insurance sector from the financial stability point of view in 2006 (CNB, 2006). However, the original methodology was based on a simple sensitivity test of market risks (interest rate risk, equity risk, and currency risk) under Solvency I. The test did not include any insurance risks, liquidity risk, sovereign risks or real estate risk. In addition, the initial test involved very simplifying assumptions, such as balance-sheet averages of some asset items. The basis of our current methodology was taken from the pilot CEIOPS stress test used for both bottom-up and top-down stress testing (CNB, 2011, Box 12). Our current approach adds value to the existing CEIOPS/EIOPA paper mainly by incorporating insurance risks (pure underwriting risk in non-life insurance and catastrophe risk), sovereign risk, and adjustment of the methodology for interest rate risk for the top-down approach and a one-year time horizon instead of "what-if" situations.

However, it is important to take into account that, given current technology, macro stress tests are ill-suited as early warning devices, i.e., as tools for identifying vulnerabilities during seemingly tranquil times and for triggering remedial action (Borio, 2012). By contrast, stress tests can be quite effective as crisis management and resolution tools and, in addition, they can discipline thinking about financial stability.

3. Key Risks of the Insurance Sector

To design appropriate top-down stress tests for the insurance sector, supervisors have to consider insurers' risk profiles and the complexity of their business. Because insurance companies have a different balance-sheet structure to banks, stress tests of their balance sheets may present unique challenges (KPMG, 2002). On the liability side, insurance companies face mainly interest rate risk, catastrophe risk, underwriting risk, and risks on technical claims provisions. On the asset side, they face mainly market risk, credit risk, liquidity risk, operational risk, group risk, and systemic risk. Stress-testing design generally depends on the business spectrum of insurers and insurance groups. Traditional insurance is a business concerned with interests that meet the principles of insurability based on insurance techniques and that are subject to insurance accounting (IAIS, 2011). The majority of insurance business lines – such as mortality or

morbidity risk in life insurance or motor and fire risk in non-life insurance – meet these criteria. The bulk of traditional insurance risks are idiosyncratic. They tend not to be correlated with each other or with the business/financial cycle. Thus, insurance companies with traditional insurance business are less vulnerable to financial and economic shocks. This is in contrast to non-traditional (insurance-linked securities and financial guarantee insurance, for example) and non-insurance (CDS underwriting, investment banking, and hedge fund activities, for example) business activities, which have systemic relevance. One important experience of the current financial crisis is that the systemic relevance of insurance groups is correlated with the influence of activities outside of the traditional insurance business field (the AIG case).

In our scenarios we take into account market risk (equity, interest rate, and currency 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).

Pure underwriting risk, driven by mortality, morbidity, and longevity in life insurance, covers the risk of mis-estimation of the loss distribution, the risk of losses deviating adversely from those expected (frequency and/or severity), and the risk of unpredictable changes in risk factors (KPMG, 2002). It is always quite difficult to predict the impact of events such as longevity or morbidity with any degree of certainty. In addition, random events that can have a significant impact – such as floods – are often widespread in their effect. Random events are linked with catastrophe risk. 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, 2003b).

Market risk is concerned primarily with the adverse movement in the value of an insurer's assets and liabilities, both on-balance sheet and off-balance sheet, whose value may be affected by market movement. For insurers, it is the extent to which an adverse movement in the value of the assets as a consequence of market movements, such as interest rates, exchange rates, equity prices, etc., is not offset by a corresponding movement in the value of the liabilities (IAIS, 2003b).

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 non-life insurance, short-term changes in the interest rate can affect the rate of return on investments if investments are not held to maturity. But as non-life insurance contracts have short duration, the interest rate is not a major risk driver for this business line. However, in the context of solving the current debt crisis (e.g., financial repression; BdF, 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 not only driven 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).

Exchange rate risks can cause potential losses where there are significant foreign liabilities which are not matched by investments in the same currency (KPMG, 2002). Intuitively, this kind of risk is more significant for non-life insurance than for life insurance.

Credit or default risk relates to the possibility that a counterparty will fail to perform its obligations. Insurers' counterparties are usually debtors, borrowers, brokers, policyholders, reinsurers, and guarantors. Credit risk may also be assumed through guarantees and other financial instruments, such as derivatives and securitizations (IAIS, 2003b). Reinsurance default risk is quite an important driver of credit risk in the case of non-life insurance. Failure of the most important reinsurers would have a high financial impact in the overall loss experience for insurers (KPMG, 2002).

In traditional insurance lines, the risk of a liquidity shortage is small (IAIS, 2012). Liquidity risk is connected with the possibility that an insurer will be unable to liquidate assets when needed or will have to accept a lower price to fund its obligations as and when they fall due. In other words, it is fundamental that an insurer's cash flow is sufficient to meet its commitments to policyholders and other creditors. This risk is mainly related to the inability to sell held assets quickly, mainly due to the lack of market liquidity and the quality of the assets. Nevertheless, any mismatch between expected asset and liability cash flows can also be factor to consider (IAIS, 2003b; KPMG, 2002).

Group risk relates usually to contagion risk. Factors to take into account are for instance (i) the adverse impact if financial support is no longer being guaranteed by the parent or the insurer is unable to access additional capital or repatriate funds, (ii) the effect on the insurer of an impaired parent or affiliate within the group, e.g., the impact on funding sources available, such as lines of credit, intra-group funding or access to external capital, (iii) the pressure on the insurer to disadvantageously financially support other group members (IAIS, 2003b).

Systemic risk, such as the failure or downgrading of one or more significant systemic insurer, could have a widespread impact through behavioral or reputational risk on other insurers (IAIS, 2003b). Furthermore, a contagion effect can also be observed across the financial system from one financial sector to another. The banking sector is very vulnerable to the economic and financial cycle and to contagion within and across the financial system. If insurers hold a significant portion of bonds issued by banks, their asset side can be directly affected by any meltdown of the banking sector in a magnitude which is dependent on the recovery rates on exposures to the defaulted banks. Insurers' asset side can also be affected through impaired market conditions when banks are forced to sell securities, sometimes even as fire-sales, and values of assets significantly decline. The economic cycle can also influence the balance sheets of the whole insurance sector. Downturns in the economic cycle can increase the number of contract terminations (surrenders and lapses) due to inability to pay premiums. This factor can affect all life insurance companies. Increases in the unemployment rate can increase the number of losses due to theft and crime and affect non-life insurance companies (KPMG, 2002). It is clear that the economic cycle can have a pro-cyclical impact on the insurance sector as a whole.

There are many more risks in insurance operations, such as operational risks related to underwriting management, reinsurance risk in relation to the reinsurance program, provisioning

risk, and jurisdictional and legal risks (KPMG, 2002). Although they are important, we do not take them into account in modeling our stress tests.

4. Methodology for Stress Testing in the Czech Insurance Sector

In the CNB's top-down stress testing, 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. The basis of the methodology was taken from the pilot CEIOPS[1] stress-test paper for stress testing organized by CEIOPS in 2009 (a what-if type test for investment risks). The methodology was further developed, a one-year time horizon was incorporated, and insurance risks were added. A similar methodology for bottom-up stress tests conducted by the Czech National Bank and carried out individually by insurance companies was developed simultaneously.

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 impact of the scenarios on the required solvency margin is not examined because the bottom-up stress tests demonstrated that the sensitivity of the required solvency margin under Solvency I is usually negligible compared with the change in the available solvency margin. The outcomes of the stress test also enable 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). Additionally, solvency strength for composite insurers, i.e., insurers offering both life and non-life insurance, is assessed for the company as a whole, which is also close to the Solvency II approach.

4.1 Assets and Liabilities in the Stress Test and Their Valuation

All financial placement assets of insurance companies are included in the stress test. Assets not allocated to cover technical provisions are included as well, i.e., assets covering shareholders' equity are tested. Hedging instruments are also taken into account. In the case of collective investment vehicles (e.g., mutual funds), the look-through approach to underlying assets is applied to take into account inherent risk factors where underlying data are available. Assets covering life insurance technical provisions where the entire investment risk is borne by policyholders are excluded from the stress test.

On the liabilities side, the provision for the fulfillment of commitments from the technical interest rate and other calculation parameters and other liabilities sensitive to interest rate changes (e.g., derivative contracts with a negative present value, loans) are included. Statutory provisions are not included because their value is not sensitive to change in risk factors.

The methods of valuation of assets and liabilities in the stress test are consistent with the accounting valuation used to determine the available and required solvency margin in the Solvency I regulatory regime. Assets whose accounting valuation is not sensitive to changes in

[1] The European Insurance and Occupational Pensions Authority (EIOPA) replaced the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS) in January 2011.

risk factors (i.e., assets held to maturity and valued at amortized cost, short-term deposits subject to an insignificant risk of change, and assets valued at acquisition cost) record a zero impact on their accounting value in the stress test. As mentioned above, the methodology enables us to examine changes in the market value of assets and the fair value of liabilities (this is discussed below in the section dealing with interest rate risk).

4.2 Aggregation

The impacts of shocks are assessed at the level of insurance companies and then aggregated for the insurance sector. The impacts of shocks for individual risk factors are aggregated by simple summation at company level. The impact of the natural disaster scenario is assessed as a satellite scenario to the main financial 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.

4.3 One-year Horizon Assumptions

The stress test is designed for a one-year horizon. The instantaneous what-if stress test, i.e., the EIOPA stress-test approach (EIOPA, 2011), does not enable additional features besides shocks to be applied in the test. A longer horizon of more than one year, better capturing the long-term impact on life insurance, would require very complex dynamic modeling, including feedback effects on projected earnings among others, the reaction function of the insurance company, and new business assumptions. This has not been feasible, mainly due to a lack of available data and input information and moreover due to infeasibility and excessive complexity with respect to our aims. We therefore arrived at a compromise and chose a one-year horizon. This means we were able 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 gross profit produced at the one-year horizon and before the application of shocks is assumed to be at the same level as in the previous year. We are aware that it is adjusted for the impact of risk factors in the previous year and for any extraordinary accounting operations. Thus, the gross profit of the previous year is adjusted for the profit/loss on financial placement, for the profit/loss on the change in the provision for the fulfillment of commitments from the technical interest rate, for the loss on natural disasters, and for any extraordinary operations. The previous year's profit is also adjusted for the impact of profit sharing. The reason for this approach is the relative stability of the gross profit (adjusted for the impact of risk factors included in the stress test) of the Czech insurance sector in recent years. This assumption should be re-evaluated under a different situation in the sector.

The content of the investment portfolio is supposed to be immutable during the year. For simplicity, cash flows maturing during the year are considered to be risk-free. Management actions to mitigate the shock impacts are assumed not to taken place. The stress test uses the loss-absorbing capacity of the deferred tax item in the balance sheet. Dividend payouts announced by insurance companies to be realized over a one-year horizon are taken into account because they decrease the available risk margin. All impacts on the available solvency margin within the tested horizon are described schematically in Figure 1.

Figure 1: Impacts on the Available Solvency Margin Taken into Account in the Given Horizon

Available solvency margin at the reference date	
+	Adjusted projected earnings from insurance activities in the given horizon
-	Impact of shocks on earnings
+	Loss absorbing capacity arising from deferred tax
-	Planned dividends for payment in the given horizon
Available solvency margin at the horizon date	

4.4 Design of Scenarios

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 prediction model is calibrated, confidence intervals are not available, 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 simply overestimate the risks and underestimate the balance-sheet buffers.

Two macroeconomic shocks are obtained for the stress testing from the official DSGE g3 prediction model – a short-term interest rate shock and an exchange rate shock. The model does not include detailed yield curve modeling and uses only the three-month euro interbank rate and the three-month domestic interbank rate. Additional maturities, such as one-year to ten-year domestic and foreign interest rates (interbank rates for one-year maturity and the government bond yield for over one-year maturity), are estimated using the current level of short-term rates, a prediction of future shorter (3M) rates, and an expertly defined risk premium. The exchange rate forecast is based on uncovered interest rate parity. For the stress scenario, property prices are linked to macroeconomic developments via a satellite model of housing prices; the satellite model uses some macro variables calibrated by the CNB prediction model. The property price dynamics here are linked mainly to real wage growth, unemployment growth, and some longer-term demographic trends. The equity shock is set purely arbitrarily and takes into account historical events and the past volatility of equity prices.

The non-life insurance shocks are also set arbitrarily. However, while motor insurance risk is implicitly linked to worsening economic activity and higher volatility in financial markets, catastrophe risk is totally unrelated to economic or financial conditions. The occurrence of a catastrophe shock is viewed as a satellite scenario to the main financial stress scenario.

In general, stresses are seldom totally independent or totally related. It is therefore recommended to examine the correlation among various risks to assess the effects they may have on the models and assumptions used. However, there is evidence that in adverse situations, previously low levels of correlation can increase (IAIS, 2003b). Determining interdependency requires judgment, as

there may be no historical data that throws meaningful light on new social and economic conditions. This is particularly the case when determining tail-dependencies, where usually low levels of correlation between risks (a negative correlation between bonds and stocks or a catastrophic event and a stock market collapse) can occasionally and very quickly increase or change sign (e.g., a terrorist attack or loss of confidence). The CNB's defined stress-testing scenarios do not use a specific algorithm to determine the expected impact of shocks on a portfolio's return. We assume in our scenarios that all adverse developments occur simultaneously, so the risk correlation matrix for market, credit, and insurance underwriting risks is assumed to be one. This can be done because of the complex character of the stress scenarios, which are based on macroeconomic scenarios and capture together changes in economic activity and developments in financial markets and subsequent changes in non-life insurance. We consider this approach to be more prudent than incorporating correlations between investment risk factors and non-life insurance risk factors. As regards the combination of these risks and catastrophe risk, it is assumed they are not correlated.

4.5 Methodology for Individual Risks

Equity Risk

All equity instruments, direct and indirect, are included in the equity price shock. Different shocks can be applied according to geographic classification or type of equity instrument. Up to now two different categories have been defined: i) equity instruments from EEA and OECD countries, and ii) others. Private equity instruments, hedge funds, other alternative equity instruments, commodity instruments, and funds for which the look-through approach is not applicable are assigned to the category "others".

The change in the value of the equity instruments $\Delta A_{Eq\_Category}$ for both categories (EEA/OECD and others) is determined by

$$\Delta A_{Eq\_Category} = shock_{Eq\_Category} \cdot A_{Eq\_Category\_ref},$$

where $A_{Eq\_Category\_ref}$ represents the value of the equity instruments on the reference date for the given category, and $shock_{Eq\_Category}$ denotes the percentage decrease in the equity instruments' value for the given category according to the scenario.

Property Risk

Real estate instruments sensitive to change in real estate prices are subject to the real estate price shock. It covers real estate valued at market value inclusive of buildings for own use of insurance companies and direct and indirect shares in real estate companies generating income. It does not cover participations in real estate development or management companies.

The change in the value of the real estate instruments ΔA_{RE} is determined by

$$\Delta A_{RE} = shock_{RE} \cdot A_{RE\_ref},$$

where A_{RE_ref} represents the value of the real estate instruments on the reference date, and $shock_{RE}$ is the percentage decrease in the real estate instruments' value according to the scenario.

Interest Rate Risk

Insurance companies are significantly exposed to interest rate risk. In particular, a decrease in interest rates generally has a negative effect on the life insurance sector. Nevertheless, capturing this risk is the most problematic part of the top-down stress-testing methodology. The level of sensitivity differs according to the nature and complexity of insurance products. Generally, life insurance is more sensitive than non-life insurance, mainly because of the long-term nature of its products.

Insurance companies usually apply asset-liability management techniques in order to manage the interest rate sensitivity of assets and liabilities appropriately. The most common approaches used are Macaulay and modified duration, assuming the cash flow invariance to changes in interest rates. The approach used in the stress-test methodology is based on the same background. The economic (fair) value of assets and liabilities, determined by discounting of future cash flows, is affected by changes in the term structure of interest rates. The direction of movement is the same for both assets and liabilities, but the final impact depends on the mismatch between asset and liability cash flows.

The modified duration is approximately equal to the percentage change in price for a given finite change in yield. This measure (or an estimate thereof) for individual instruments is applied in order to roughly estimate the impact of the interest rate scenario on the market value of assets and liabilities (excluding technical provisions). However, we are aware that this is only a linear first-order measure of how the price of an instrument changes in response to interest rate changes. The determination of the duration takes the one-year horizon into account, so it is calculated from the horizon date. When the portfolio contains interest rate swaps, the duration of the relevant portion of bonds has to be properly adjusted to make it accord with the sensitivity of the whole portfolio. Assets and liabilities whose valuation is sensitive to change in the term structure of interest rates, e.g., fixed-income investments and loans, are subject to the stress test.

The change in the value of assets and liabilities ΔAL_{IR} after a shock to the swap interest rate is determined by

$$\Delta AL_{IR} = \sum_i - AL_{IR\_ref,i} \cdot MD_i \cdot shock_{IR\_Band}$$

where $AL_{IR\_ref,i}$ represents the value of the *i*-th asset or liability on the reference date, MD_i is the estimate of its modified duration, and $shock_{IR\_Band}$ denotes the shock to the swap interest rate (in pp) for the relevant time band according to the scenario. For instruments denominated in foreign currency, the corresponding swap interest rate shock for those currencies is applied and the conversion to CZK is carried out using the exchange rate on the reference date, so that the impact in respect of the interest rate shock does not comprise a change in the foreign currency exchange rate.

According to the Czech Solvency I regulation, the accounting values of insurance liabilities (technical provisions) are used for solvency purposes. The determination of the statutory life

premium reserve is based on discounting of cash flows by the technical interest rate, i.e., by the guaranteed participation in the yields on financial placements in life insurance. Insurance companies have to establish a provision for the fulfillment of commitments from the technical interest rate and other calculation parameters. This is known as the deficiency provision. For this purpose, insurance companies perform a liability adequacy test to compare the corresponding statutory provisions with the fair value of insurance liabilities. Under Solvency I, the fair value of insurance liabilities, or, more strictly speaking, the minimum value of insurance liabilities, is calculated as the present value of future cash flows using the risk-free interest rate. The assumptions on the best estimate level are adjusted for the market value margin. The deficiency provision then equals the positive difference between the fair value of liabilities and statutory provisions. So, if interest rates go down significantly, a deficiency provision is established (its size depends on the initial state), and if interest rates go up this provision is released. It is zero above some interest rate term structure corresponding to the state when the fair value of insurance liabilities equals statutory provisions.

In the top-down stress test, the sensitivities of the fair value of liabilities to upward and downward movements in the term structure of interest rates used for discounting and the values of statutory reserves are used to estimate the impact of the scenario on the value of liabilities at the one-year horizon. This input information is reported by insurance companies within the scope of the bottom-up stress test. For the sensitivities of the fair value of liabilities to a downward movement in interest rates of one percentage point the values were reported at the coarsest granularity, i.e., for the whole life portfolio without segmentation, and in the short, medium, and long-term maturity buckets. However, the coarsest granularity proved to be insufficient to properly capture the impact. The determination of the value of technical provisions in non-life insurance does not take into account discounting of liabilities, so non-life technical provisions were not included in the stress-test methodology.

So, the change in the deficiency provision in life insurance ΔDTP is determined by

$$\Delta DTP = \sum_i (\max(FVL_{i\_ref} - StatTP_i, 0) - \max(FVL_{i\_hor} - StatTP_i, 0))$$

where FVL_{i_hor} represents the minimum value of insurance liabilities (fair value) on the horizon date for the *i*-th segment, FVL_{i_ref} is the original minimum value of insurance liabilities on the reference date for the *i*-th segment, $StatTP_i$ represents the value of statutory provisions for the *i*-th segment on the reference date (it is supposed for simplicity that statutory reserves will be unchanged at the one-year horizon), and the sum is taken over the entire segment applied in the liability adequacy test in life insurance. FVL_{i_ref} is calculated using the reported sensitivities of the original minimum value for the *i*-th segment of liabilities to movements in the term structure of interest rates. If the sensitivities are reported broken down by maturity buckets of liability cash flows, the minimum value of the liabilities on the horizon date should be determined within the individual maturity buckets first and then aggregated. The range of the change in the term structure of interest rates differs according to the type of risk-free interest rate used by insurance companies to discount liabilities (swap rates or government bond rates). If government bond rates are used for discounting, the shocks have to encompass an additional movement in respect of sovereign risk.

The input data available in the stress test also enable us to take an economic view, similar to the Solvency II approach, of the sensitivity of assets and liabilities to change in the interest rate term structure. In that case, all assets are included in the stress test and valued at market value, i.e., including assets valued at amortized cost. For technical provisions, the change in the minimum value of insurance liabilities (fair value) is assessed solely under the economic approach and no deficiency provision is taken into account. Furthermore, the economic approach can also be used to assess sovereign and credit risk on the asset side.

Movements in interest rate level and volatility have an impact not only on the discounting of future cash flows arising from insurance liabilities, but also on the value of options and guarantees embedded in insurance policies. Traditional life insurance products typically include a guarantee of interest, a profit-sharing scheme, or an option to surrender the policy. Schematically, a traditional life insurance liability can usually be decomposed into a bond element and relevant options. Thus, the change in the value of insurance liabilities may not be linearly dependent on the change in the interest rate. In the case of material occurrence of optionality, insurance companies usually apply stochastic modeling to value options for individual insurance policies or model points. In the current stress-test framework, such nonlinearity is not treated and remains an unsolved issue. It is supposed that in the future, under Solvency II, attention should be paid to the possibility of developing a simplified methodology (probably based on factors or margins) capable of roughly evaluating the change in the value of options on the liability side. The asset side could contain interest rate options as well, although their occurrence is not currently material in the investment portfolios of the Czech insurance sector.

Currency Risk

All positions denominated in EUR and USD are subject to the currency shock. Positions in other currencies are immaterial in the sector, so they are not included in the stress test. Derivatives used to hedge foreign currency positions are taken into account (in nominal value in EUR or USD), so finally the net open foreign currency position is examined.

The change in the value of assets and liabilities denominated in foreign currency ΔAL_{FX} is determined by the difference

$$\Delta AL_{FX} = AL_{FX\_stressed} - AL_{FX\_ref}$$

where AL_{FX_ref} represents the conversion of the value of assets and liabilities into CZK on the horizon date (i.e., after the other shocks) using the exchange rate on the reference date, and $AL_{FX\_stressed}$ represents the conversion of this value using the exchange rate on the horizon date. This means that the currency shock for assets denominated in foreign currency is applied simultaneously with the other shocks for investment risk factors.

Credit Spread Risk

The shocks for credit spreads are applied to all assets whose value is sensitive to any change in the level of the credit spread over the risk-free interest rate curve (e.g., corporate bonds, structured

credit instruments). Government bonds and supranational bonds do not enter the credit spread stress test (government bonds are subject to the sovereign shocks separately). Changes in credit spreads are transformed directly into changes in the value of the instruments in the scenario. This approximation is based on the remaining time to maturity and the credit rating of the instrument. The remaining time to maturity is additionally sorted into maturity time bands. A function F that assigns to each credit instrument the percentage of the decrease in its value according to its rating and the remaining time to maturity is thus defined. This implies that the decrease is identical for instruments with the same ratings and remaining time to maturity belonging to the same maturity band. The function can be parameterized to capture implicitly both the change in credit quality and the default risk.

The change in the value of credit instruments ΔA_{Cred} is defined as

$$\Delta A_{Cred} = \sum_i A_{Cred\_ref,i} \cdot F(rating_i, maturity_i),$$

where $A_{Cred\_ref,i}$ represents the value of the *i*-th credit instrument on the reference date, $rating_i$ is the credit rating of its issuer (or the rating of the instrument itself), $maturity_i$ is the remaining time to maturity starting from the horizon date, and *F* is the function defined above. The sum is taken over all credit instruments in the financial placement.

Although credit ratings do not necessarily give the most perfect and up-to-date information on the creditworthiness of issuers, an assessment based on external credit ratings is sufficient. The limitations of credit ratings result primarily from the fact that they are opinions on the relative ranking of vulnerability to default and do not imply the credit spread value, assignment to the same rating category may not fully reflect slight differences in the credit risk of issuers, and credit quality can be reduced by events that were not taken into account at the time the rating was issued. We think that such imperfections may be more serious when an individual issuer is being assessed, but in the case of top-down stress testing they will not have a significant impact on the final result. So, we do not think a model using market data as an input for creditworthiness is necessary for the purposes of our stress test. External ratings issued by Standard & Poor's, Moody's, and Fitch Ratings are assigned, and the second-best one is taken into account. Issuers with no external rating are assigned to the "unrated" category. Structured credit instruments are assigned to the "unrated" category regardless of any external rating they might have.

Sovereign Risk

All government bonds in the financial placement whose valuation is sensitive to change in sovereign risk premia in the government bond yield over the swap interest rate are subject to the shock. Similarly as in the case of the credit spread, a function G assigning the decrease in the value of the government bond is defined according to the remaining time to maturity. The function G can potentially give different shocks to different countries according to their riskiness, but this feature has not been utilized due to the similar riskiness of government bond exposures in the financial placements of the Czech insurance sector.

The change in value of government bonds ΔA_{GovB} is determined by

$$\Delta A_{GovB} = \sum_i A_{GovB\_ref,i} \cdot G(maturity_i),$$

where $A_{GovB\_ref,i}$ denotes the value of the *i*-th government bond on the reference date, and $maturity_i$ is the remaining time to maturity calculated from the horizon date. The sum is taken over all government bonds of EU countries in the financial placement.

Non-life Insurance Risk – Motor Insurance

Worsening economic activity and higher volatility in financial markets can induce a deterioration in insurance underwriting risk factors. Motor insurance, i.e., motor third party liability insurance (MTPL) and motor own damage insurance (Casco), is considered to be the most sensitive line of business in non-life insurance to worsening economic conditions. Thus, the methodology contains shocks to written premiums in motor insurance, while claims and costs are supposed to be kept at the same level as on the reference date.

The decrease in the gross profit at a given horizon is determined by

$$\Delta NPW_{MotorLoBs} = shock_{MotorLoBs} \cdot NPW_{MotorLoBs\_ref},$$

where $NPW_{MotorLoBs\_ref}$ denotes the volume of earned premiums on the reference date in motor lines of business (MTPL, Casco) net of reinsurance, and $shock_{MotorLoBs}$ is the percentage decrease in net earned premiums according to the scenario.

Non-life Insurance Risk – Catastrophe Risk

The occurrence of natural disasters (floods) is considered in the satellite scenario. Catastrophe risk is one of the most significant risks in non-life insurance. The insurance sector is exposed not only to the severity of the risk, i.e., the size of the impact of a catastrophic event, but also to the risk of frequency of catastrophic events over a given horizon. Insurance companies use reinsurance to protect themselves against catastrophic losses by ceding a part of their risk to reinsurers. Therefore, the stress test examines the quality of such reinsurance programs in both aspects of reinsurance coverage, i.e., severity and frequency protection.

The decrease in gross profit caused by catastrophic events is determined by

$$NatCatCosts = -\sum_i OwnRetention_{Event_i} - \sum_i ReinstatementCosts_{Event_i},$$

where $Event_i$ represents individual floods according to the scenario, $OwnRetention_{Event_i}$ denotes the amount of claims which the insurance company retains for its own account in respect of the *i*-th event, and $ReinstatementCosts_{Event_i}$ represents the costs of reinstating the reinsurance program after the occurrence of the *i*-th event.

Intra-group Transactions

The methodology includes an assessment of whether the insurance sector is significantly jeopardized by the credit default risk of parent companies. The examination of links to groups is based on an overview of intra-group transactions and exposures. Exposures to the group include equity instruments, bonds, deposits, loans, and reinsurance receivables, which are revalued to zero. The assessment is carried out as a separate assessment in addition to the what-if scenario.

The lapse rate risk in life insurance could also be taken into account. This risk is also sensitive to adverse economic conditions. However, the impact of a change in the lapse rate on available capital in the short term (one year) is very small (under the Solvency I rules) because in most cases the statutory reserve is higher than the surrender value of the insurance policy. The CNB's current stress-test methodology does not include shocks to the lapse rate, as it is obvious that the impact on profitability is more significant in the longer term than within a one-year horizon.

5. Application to the Czech Insurance Sector

5.1 Data

The stress-test methodology was applied to the Czech insurance sector as represented by eleven insurance companies whose aggregate market share exceeded 90% in respect of gross premiums written in 2011, excluding branches. The data used are those reported by Czech insurance companies to the Czech National Bank for regulatory purposes on a regular basis (balance sheets, profit and loss statements, complementary information to financial statements, selected indicators in life insurance, selected indicators in non-life insurance, details of financial placements). Financial placements are reported in detail, asset by asset, and with the parameters of the instruments. Information provided by insurance companies in the bottom-up stress test organized once a year (e.g., sensitivities, catastrophe impacts, dividend proposals) is also employed in the top-down stress testing. The top-down stress test was run using December 2011 data, i.e., the reference date was 31 December 2011.

5.2 Scenarios

For the purposes of this paper, two main stress scenarios are applied – a baseline and an adverse scenario. Both scenarios contain balance-sheet stresses to interest-rate-sensitive assets and liabilities, to the equity portfolio, corporate bonds and sovereign bonds, to exchange-rate-sensitive assets and liabilities, and to residential and commercial property. The severity of the market and credit risk shocks varies between the two scenarios. In addition to these asset-related stresses, this exercise includes insurance-related shock scenarios in order to test the resilience of the insurance sector to catastrophic or severe insurance events. Two insurance shocks are taken into account – motor insurance risk and risk of floods[2] – and they are included only in the adverse scenario. All

[2] The top-down stress test exploits data regarding natural disaster costs reported by insurance companies in the bottom-up stress testing. We have chosen this peril as it is among the most frequent and costly natural disasters in terms of loss in Central and Eastern Europe.

these shocks should be regarded as shocks that occur in a year (i.e., in 2012). Table 1 provides an overview of the proposed stress-test parameters:

Table 1: Key Variables in the Individual Scenarios

Types of risks / Scenario		Baseline	Adverse
Interest rate risk(CZK; SYC)	0 – 1 Y	-0.2 p.p.	+2.4 p.p.
	>1 – 5 Y	-0.3 p.p.	+2.0 p.p.
	>5 – 10 Y	-0.4 p.p.	+2.2 p.p.
	>10 Y	-0.2 p.p.	+1.5 p.p.
Interest rate risk (CZ; GYC)	0 – 1 Y	-	+2.4 p.p.
	>1 – 5 Y	-	+3.0 p.p.
	>5 – 10 Y	-	+3.7 p.p.
	>10 Y	-	+2.8 p.p.
Interest rate risk (EUR, USD and others; SYC)	0 – 1 Y	-0.6 p.p.	+1.7 p.p.
	>1 – 5 Y	-1.0 p.p.	+2.3 p.p.
	>5 – 10 Y	-1.3 p.p.	+2.5 p.p.
	>10 Y	-0.8 p.p.	+1.3 p.p.
Equity risk		-5%	-40%
Property risk		-2.91%	-20%
Credit risk spread		0	F
Sovereign risk (EEA)		0	G
Currency risk (USD, EUR)		-2.25%	13%

Note: SYC as swap yield curve; GYC as government yield curve; in respect of curency risk (-) as appreciation and (+) as depreciation.

Price revaluation of corporate bonds (the F function)

F (rating $_i$, maturity $_i$)	AAA	AA	A	BBB	BB	NR
>1 – 3Y	-0.20%	-0.40%	-0.50%	-0.80%	-1.50%	-1.00%
>3 – 5Y	-0.50%	-0.80%	-1.10%	-1.60%	-3.10%	-2.00%
>5 – 7Y	-0.70%	-1.20%	-1.60%	-2.40%	-4.60%	-3.00%
>7 – 10Y	-1.00%	-1.70%	-2.30%	-3.40%	-6.50%	-4.20%
>10Y	-1.10%	-2.00%	-2.70%	-4.00%	-7.70%	-5.00%

Price revaluation of sovereign bonds (the G function)

G (maturity $_i$)	
>1 – 5Y	-1.90%
>5 – 10Y	-8.40%
>10Y	-11.70%

Losses from catastrophic flood damage (in CZK billions)

Round of floods	Total losses of insurance sector
1st flood	2
2nd flood	2
3rd flood	20

The baseline scenario corresponds to the CNB's official February macroeconomic forecast published in Inflation Report I/2012.[3] It assumes stagnation of the Czech economy in the

[3] http://www.cnb.cz/en/monetary_policy/inflation_reports/2012/2012_I/index.html

following year and headline inflation temporarily just above 3% due to a VAT increase. The baseline scenario also assumes gradual appreciation of the exchange rate from its current weakened level, stable short-term interest rates in the near future, and fiscal stability. The baseline then assumes a 5% decline in stock prices and a 2.9% fall in the value of property (see Table 1).

The adverse scenario, which is purely a crisis scenario, was initially designed for Financial Stability Report 2011/2012 (CNB, 2012, p. 85). It assumes a long-lasting adverse trend in economic activity in the Czech Republic's main export partners as a result of persisting uncertainty regarding a credible resolution of the debt crisis in the euro area, intensive deleveraging, and new regulations curbing the credit supply of the banking sector. The assumed strong and persistent recession affects the Czech economy, leading to a sustained decline in GDP, rising prices and unemployment, depreciation of the Czech koruna, and substantial loan repayment problems. As prices are assumed to rise through the depreciation channel, the central bank is supposed to react promptly by increasing the short-term interest rate. Owing to the loan repayment problems, banks tighten their credit standards and longer-term interest rates increase. The rise in unemployment and decline in wages due to the sustained decline in economic activity reduces demand for mortgages and thus also real estate prices. Moreover, a loss of investor confidence and growth in risk aversion are taken into account. Not only indebted countries, but also the Czech capital market is affected by "flight-to-quality and liquidity" effects that lead to sales of investment assets in the affected countries. Prices of equities and bonds decline and interest rates on bonds increase. The investment risks examined are asset and liability interest rate risk, real estate risk, foreign exchange risk, equity risk, and the risk of a decline in government and corporate bond prices (see Table 1). The non-life insurance risks were motor vehicle insurance premium risk (a 10% decline in premiums written for motor vehicle insurance at the same level of costs as in the previous year) and the risk of claims due to natural disaster in the form of floods. The extended scenario contained a series of three floods, two of them local with claims corresponding to a roughly five-year return period and one with claims corresponding to a 50-year return period. As the stress test is a what-if-in-one-year test, we assume an expected annual profit of the insurance sector of CZK 15.5 billion and also planned dividend payouts of around CZK 9 billion.

Recently, we have seen a drop rather than an increase in interest rates in response to declining economic activity both at home and abroad. However, even if it currently seems unlikely, the presented scenario could happen in the case of a small open economy. We should add that macroprudential policy targeting financial stability focuses on so-called tail events, so most of the adverse scenarios have a very low probability of occurrence. The CNB carries out insurance sector stress testing every year, and every year a different adverse scenario is designed.

5.3 Results

The investment risks examined in the top-down stress test performed in 2012 were equity risk, asset and liability interest rate risk, real estate risk, foreign exchange risk, credit risk, and sovereign risk. The non-life insurance risks tested were motor vehicle underwriting risk and catastrophe risk.

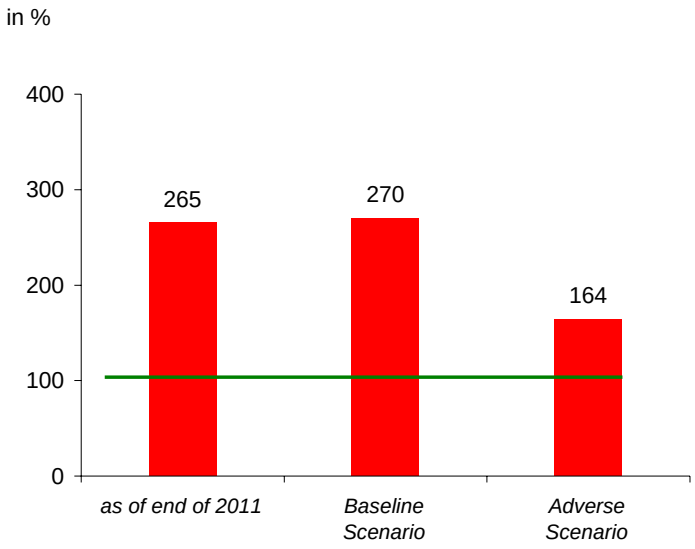
Table 2: Results on the Insurance Sector Stress Tests

	Baseline Scenario	*Europe in Depression and Loss of Confidence*
Gains/losses arising from interest rate risk of assets		
CZK billions	-1.54	-13.17
% of available solvency margin	-3.02	-25.94
Gains/losses arising from interest rate risk of technical provisions		
CZK billions	0.00	1.51
% of available solvency margin	0.00	2.98
Gains/losses from sovereign risk		
CZK billions	0.00	-4.58
% of available solvency margin	0.00	-9.02
Gains/losses from credit risk		
CZK billions	0.00	-0.52
% of available solvency margin	0.00	-1.02
Gains/losses from changes in equity instruments		
CZK billions	-0.61	-4.51
% of available solvency margin	-1.20	-8.89
Gains/losses arising from property risk		
CZK billions	-0.14	-0.51
% of available solvency margin	-0.27	-1.00
Gains/losses arising from currency risk		
CZK billions	0.05	-0.23
% of available solvency margin	0.09	-0.46
Gains/losses from fall in non-life insurance premium		
CZK billions	0.00	-2.31
% of available solvency margin	0.00	-4.55
Claims arising from floods		
CZK billions	-2.69	-2.69
% of available solvency margin	-5.30	-5.30
Impact of risks on earnings 2012		
CZK billions	-4.92	-27.00
% of assets	-1.39	-7.61
Projected earnings from insurance activities in 2012		
CZK billions	15.53	15.53
% of assets	4.38	4.38
Other impacts (tax)		
CZK billions	-0.74	1.13
% of assets	-0.21	0.32
Planned dividends for payment in 2012		
CZK billions	-8.97	-8.97
% of assets	-2.53	-2.53
Available solvency margin (as of end of 2011)		
CZK billions	50.75	50.75
% of assets	14.31	14.31
Required solvency margin (as of end of 2011)		
CZK billions	19.14	19.14
% of assets	5.40	5.40
Available solvency margin (as of end of 2012)		
CZK billions	51.65	31.45
% of assets	14.57	8.87
Solvency buffer (CZK billions)		
as of end of 2011	31.62	31.62
as of end of 2012	32.52	12.31
Solvency ratio		
as of end of 2011	265%	265%
as of end of 2012	270%	164%

Source: CNB

In the adverse scenario, the cumulative impact of all the risks considered on the available solvency margin in this scenario would be CZK 27.0 billion, or 7.6% of the assets of the institutions tested. Given the expected profit of CZK 15.5 billion in 2012 and planned dividends of around CZK 9 billion, the available solvency margin would drop from CZK 50.8 billion (14.3% of assets) to CZK 31.5 billion (8.9% of assets). As a result, the aggregate solvency ratio would decline from 265% to 165%. The ratio of coverage of technical provisions by assets decreased from 118% to 109%. The aggregate results show that thanks to sufficient available capital, the sector as a whole, represented by the participating insurance companies, would absorb the impacts of large movements in risk factors, including simultaneous floods. The sector stays relatively high above the 100% solvency threshold even after the application of significant shocks (see Figure 2).

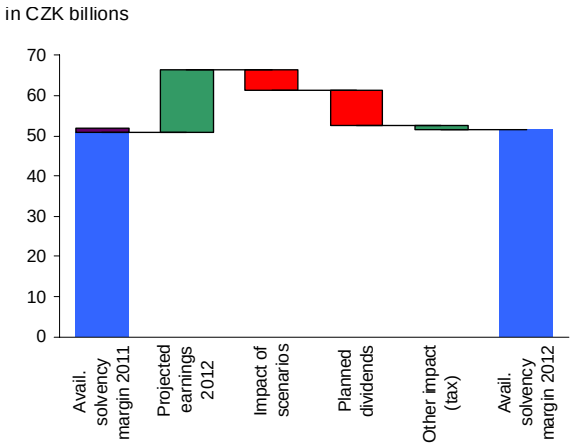
Figure 2: Solvency Ratio



Source: CNB

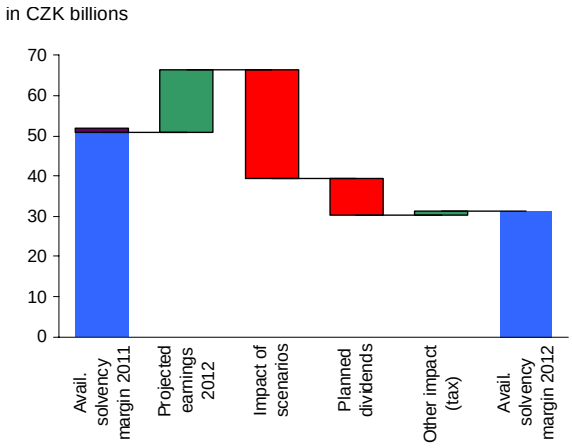
The resulting available solvency margin at the one-year horizon was affected significantly not only by the impact of the shocks in the test and by the loss of insurance companies so generated, but also by the value of dividends planned to be paid in 2011 (see Figure 3).

Figure 3: Change in Available Solvency Margin Baseline Scenario



Source: CNB

Figure 4: Change in Available Solvency Margin Europe in Depression and Loss of Confidence

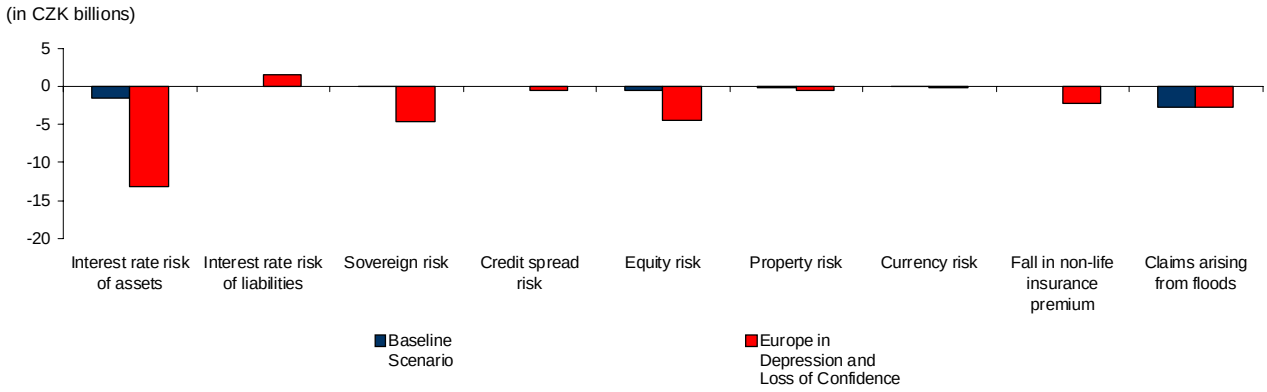


Source: CNB

The solvency positions of individual insurance companies are calculated and analyzed in the CNB, but individual results are not disclosed. In the event of adverse market developments, two insurance companies could fall below the regulatory solvency minimum and would have to top up their capital. The necessary capital injections would amount to CZK 320 million (i.e., less than 0.01% of GDP). The ability to cover technical provisions by assets proved to be correlated with solvency strength for these two insurance companies, because their coverage ratio was found to be about 100%. The mean of the impacts of all the risks considered on the available solvency margin for individual institutions in the adverse scenario would be 6.9% of assets (median 6.5%). The standard deviation would amount to 3.0% of assets.

In the adverse scenario, insurance companies would be hit hardest by losses of around CZK 12 billion arising from interest rate risk, then by losses of CZK 4.6 billion caused by sovereign risk and losses of CZK 4.5 billion arising from a decline in the value of equity instruments (see Table 2 and Figure 5). The asset-side impact of these shocks for individual insurance companies depends largely on the proportion of bonds classified as held to maturity valued at amortized cost. The interest rate sensitivity of the value of technical provisions under Solvency I is relatively low. The significance of the impact of sovereign risk is related to the fact that government bonds account for approximately 50% of the investment portfolio of the participating insurance companies. Although the volume of equity positions is low, its impact is also significant owing to the size of the equity shock. The minimal impact of currency risk confirms that insurance companies hedge their foreign currency position. The relatively low result of the shocks for the risk of floods compared to the other risks shows that insurance companies have well-structured reinsurance programs for catastrophic claims caused by floods in respect of the tested scenario.

Figure5: Impact of Individual Risks on the Decrease of the Available Solvency Margin



Source: CNB

Stability can be expected in this sector under the baseline scenario (see Table 2). Losses from interest rate risk and equity risk and losses arising from floods should be offset by retained earnings. Therefore, the aggregate solvency ratio at the end of the test horizon should be similar to that observed at the end of 2011 (see Figure 4).

It is apposite to remark that during the assessment of the results, the reported portfolio granularity level (the coarsest granularity) for the downward shift in the interest rate curve proved to be insufficient to capture the impact of interest rate movements on the portfolio for different interest rate scenarios, because different lines of business or types of products included in the life portfolio (e.g., traditional endowment products, unit-linked products, riders) can have different sensitivities and ultimately different scenario impacts.

Intra-group Transactions Assessment

The intra-group exposures were examined separately. The intra-group exposures amount to CZK 17.3 billion (34% of the available solvency margin – see Table 3). Repayment failure would exhaust the buffer of CZK 12.3 billion remaining after the adverse scenario (see Table 2). We should emphasize, however, that 71.6% of intra-group exposures consists of receivables to group reinsurers. It is normal for groups to use their own reinsurance company to collect reinsurance in order to optimize reinsurance costs. A part of the risks collected is kept within the group due to diversification effects, but a significant part is usually ultimately ceded to reinsurers outside the group. Intra-group transactions other than reinsurance (bond, loans, deposits) equal CZK 4.9 billion (10% of the available solvency margin). Moreover, some decline in the value of these exposures had already been applied according to the stress-test scenario.

Table 3: Intra-group Exposures

	Exposure		
Asset class	**in CZK billions**	**in % of available solvency margin**	**in % of exposure to group**
Bonds	3.52	6.93	20.39
Deposits	1.06	2.08	6.11
Equities	0.23	0.45	1.32
Loans	0.10	0.20	0.58
Reinsurance receivables	12.36	24.35	71.60
Total	**17.26**	**34.01**	**100.00**

Source: CNB

6. Considerations Regarding the Upcoming Solvency II Regulatory Regime

The upcoming new Solvency II regulatory framework for the insurance sector is based on risk assessment and imposes market-based valuation of assets and liabilities. Available capital in the Solvency II balance sheet is equal to the difference between assets at market value and technical provisions. 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. Insurance companies can calculate their capital requirements using either a standard formula or an internal model. The Solvency II regulation is codified by Directive 200/9/138/EC, which will be extended to include the Omnibus II Directive, for which negotiations are still ongoing. At the time of writing, the Omnibus II proposal sets the date of entry into force of Solvency II at 1 January 2014.

The stress-test methodology is planned to be adjusted for Solvency II by the date of entry into force of Solvency II. In the first pilot run, we envisage applying top-down stress testing only to available capital (the difference between assets at market value and technical provisions). So, the solvency capital requirement (SCR) will not be subject to stress scenarios in the pilot run. In contrast to Solvency I, however, the SCR, because it is risk based, will be significantly sensitive to change in risk parameters. Thus, we need to consider whether the methodology should in subsequent runs be extended to include an evaluation of the impact of stress scenarios on the SCR as well. This means that the solvency position, as measured by the solvency ratio (or capital buffer), would be subject to top-down stress testing. Moreover, it is necessary to point out that large, systemically significant insurance companies will very probably use internal models for the SCR calculation. So, in the future we need to examine if it will be possible in top-down stress testing to adopt scaling approaches based on the outcomes of the standard-formula SCR calculation in the case of companies using internal models.

There will be almost no need to change the methodology in respect of market risk, credit risk, and sovereign risk on the asset side in the testing of available capital changes due to simultaneous valuation of assets at market value applied in the current methodology. As planned, credit risk should be extended to include credit risk to reinsurers. The stresses currently applied to insurance

premium risk in the car insurance and natural disaster scenarios could very probably be treated in a similar way. However, other insurance risks, e.g., lapse risk in life insurance, should presumably be suitable for inclusion in the stress-testing methodology in respect of their impact under Solvency II.

In the testing of changes in available capital under Solvency II, the methodology for interest rate risk in respect of insurance liabilities has to be changed. The value of technical provisions must be equal to the sum of a best estimate and a risk margin. The best estimate must correspond to the probability-weighted average of future cash-flows, taking account of the time value of money (i.e., the expected present value of future cash-flows) using the relevant risk-free interest rate term structure. So, the impact of the scenarios on the best estimate of technical provisions will be evaluated and the transformation to the deficiency provision will no longer be taken into account. Discounting will be applied to non-life cash flows as well, thus non-life technical reserves could be included in the stress testing, although given their short-term nature their interest rate sensitivity is expected to be low. As described above, embedded options and guarantees in life insurance should be included in the methodology considerations. It is noteworthy that the value of options and guarantees in the best estimate of technical provisions at a given horizon can depend via investment returns not only on the interest rate, but also on other market risk factors. Additionally, the stress-testing methodology will possibly have to take into account the matching premium (applied to "matched" assets and liabilities), the counter-cyclical premium (allowing companies to use a higher discount rate for their liabilities only in times of financial stress), and the setting of the ultimate forward rate. These concepts in Solvency II are still under discussion and have not been finalized.

7. Conclusion

Stress testing is a key risk management tool that helps supervisors to ascertain whether insurers are financially flexible enough to absorb losses that could occur in various adverse scenarios. Insurers are exposed to unique risks, such as insurance underwriting risks, most of which are not correlated with the business cycle and financial market risks. However, they engage not only in traditional activities, but also to some extent in quasi-banking activities, which can make them more vulnerable to financial market developments and, importantly, more likely to amplify, or contribute to, systemic risk. Furthermore, there are some more systemic implications concerning the insurance sector, such as the contagion effect from other sectors, including banking risk and sovereign risk. For that reason, insurers and their supervisors should undertake regular stress testing for a range of adverse scenarios in order to assess the adequacy of capital resources.

The Czech National Bank started to stress test the Czech insurance sector from the financial stability point of view in 2006. The original methodology was simple and insufficient. The aim of this paper was to describe the more sophisticated methodology of the current system for stress testing the Czech insurance sector. The basis of our methodology was taken from the pilot CEIOPS stress test used for bottom-up stress testing of European insurance companies. Our approach adds value to the existing CEIOPS stress test as it covers insurance risk, sovereign risk, and adjustment of the methodology for interest rate risk and a one-year time horizon instead of "what-if" situations.

The stress-test methodology was applied to Czech insurance sector as represented by eleven insurance companies whose aggregate market share exceeded 90% in respect of gross premiums written in 2011, excluding branches. In our two scenarios (a baseline and an adverse scenario), we took into account market risk, credit risk, including sovereign risk (only the adverse scenario), intra-group risk, and systemic risk. In addition, we included in the tests two insurance risks in the case of non-life insurance: underwriting risk for motor insurance (only the adverse scenario) and catastrophe risk in respect of all insurance companies.

The stress tests of insurance companies indicate that the sector is sufficiently resilient. In the adverse scenario, insurance companies would be hit hardest by losses of around CZK 12 billion arising from interest rate risk, then by losses of CZK 4.6 billion caused by sovereign risk and losses of CZK 4.5 billion arising from a decline in the value of equity instruments. The cumulative impact of all the risks considered on the available solvency margin in this scenario would be CZK 27.0 billion, or 7.6% of the assets of the institutions tested. Given the expected profit of CZK 15.5 billion in 2012 and planned dividends of around CZK 9 billion, the available solvency margin would drop from CZK 50.8 billion (14.3% of assets) to CZK 31.5 billion (8.9% of assets). As a result, the aggregate solvency ratio would decline from 265% to 165%, but would stay above the regulatory minimum of 100%. In the event of adverse market developments, two insurance companies could fall below the regulatory solvency minimum and would have to top up their capital. The necessary capital injections would amount to CZK 320 million (i.e., less than 0.01% of GDP). Despite these losses, the insurance company sector can be assessed as stable and resilient to adverse developments.

While the current CNB model is already relatively advanced, we nevertheless plan further improvements, mainly due to the upcoming new Solvency II regulatory framework. Several 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 the matching premium and counter-cyclical premium if they are approved in the Solvency II regulation.

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