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Financial Stability Issues and Stress Testing of the Insurance Sector

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Abstract

The purpose of this thesis is to provide an overview of risk and vulnerabilities for financial stability of the European Insurance sector. The methods and principles of risk assessment are examined, as well as their application for the insurance sector. The current macroeconomic situation and its impact on insurers' financial stability is described. Downward changes of interest rates are identified as the biggest current risk. This results from a system-wide stress test conducted by EIOPA (European Insurance and Occupational Pensions Authority), analysis of sensitivities published by several big European Insurers published on a yearly basis and finally from an econometric analysis of the relationship between market data and changes in macroeconomic variables.

Anotace (abstrakt)

Cílem této práce je poskytnout ucelený přehled hlavních rizik pro finanční stabilitu evropského pojistného sektoru. Jsou zkoumány metody a principy ohodnocení rizik a jejich aplikace pro pojistný sektor. Zároveň je popsaná současná makroekonomická situace a její dopad na finanční stabilitu pojišťoven. Jako největší současné riziko jsou určeny poklesy úrokových sazeb. Tento závěr vychází z výsledků zátěžového testu prováděného v roce 2014 společností EIOPA, (European Insurance and Occupational Pensions Authority), analýzy citlivostí publikovanými několika velkými evropskými pojišťovnami a nakonec z ekonometrické analýzy vazeb mezi tržními daty a změnami makroekonomických ukazatelru.

Keywords

financial stability, stress testing, insurance sector, insurance risks

Klíčová slova

finanční stabilita, zátěžové testování, pojistný sektor, rizika pojišťoven

73 288 characters

Declaration of Authorship

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

Prohlášení

Prohlašuji, že jsem svou práci napsala samostatně a výhradně s použitím citovaných pramenů.

Prague, May 10, 2015

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Signature

Acknowledgment

I would like to express my biggest gratitude to my thesis supervisor PhDr. Ing. Petr Jakubík for his time and patience, as well as his guidance and constant encouragement during the whole course of writing this thesis. I would also like to thank my parents for their unceasing support during all my studies.

Contents

Introduction

During the recent years, banking sector was subject to rigorous stress testing and many papers were devoted to the topic of its financial stability. Not nearly as much attention has been paid to the insurance sector, as it is considered less systemically relevant and is thought to absorb risks rather than be a source of instability in the financial sector as a whole. However, in the currently prevailing low-interest rate environment, the insurance companies may turn to riskier investments and insurance activities which increase to their systemic importance.

The purpose of this thesis is twofold. First, it is to provide the reader with a theoretical overview of risk factors that influence stability of the insurance sector and methods of assessment of their impact, such as stress testing and the concept of Embedded Value. Second, it seeks to portray the most pressing financial stability issues in the current macroeconomic environment and evaluate their possible effect on the companies.

The thesis is organized as follows. The first chapter clarifies the theoretical background. It assesses the systemic relevance of the insurance sector, tackles main risks the insurers have to face and explains the methods of determining their impact on a company's balance sheet. The most rigorous and complicated one is the technique of stress testing, which is increasingly performed by supervisory authorities. Individual companies can assess their stability by market consistent valuation of their balance sheets. Both of these approaches will be described in detail.

The second chapter is an empirical one and is divided into several blocks. First of all, current situation in financial stability is presented, along with the results of a system-wide Insurance Stress Test run by European Insurance and Occupational Pensions Authority (EIOPA) in 2014. Thus, main vulnerabilities of the insurance companies are identified, especially the response to prevailing low interest rates. Second, data on sensitivities of several big

European insurance companies to changes in economic environment are collected and the impact of these changes on the value of companies is analyzed. In the last section, an econometric model is built to assess the stock market's response to changes in basic macroeconomic variables and to evaluate possible differences in the impact of these changes on different financial sectors. The main hypotheses for this analysis will be formulated on the basis of findings from the previous sections.

The main conclusion is that there exists a positive relationship between changes in interest rates and performance of insurance companies. Insurers are thus negatively affected when interest rates decrease. The last subchapter will provide more insight into this topic and consequently accept or reject the main hypotheses.

1 Theoretical Part

1.1 Systemic relevance of the insurance sector

As has been mentioned before, more attention has been devoted to stress testing of the banking sector, as insurers are considered less systematically relevant. The insurance business is supposed to be dealing with uncertainty and thus contribute to the overall stability of the financial sector rather then trigger new shocks.

The insurers' business model differs from other financial institutions in several ways. First of all, they operate the so-called "inverted production cycle". This means that the premium payments are received upfront, while the service, i.e. the payment of claim, is delivered afterwards. This provides companies with a stable cash flow. The insured loss events cannot be triggered voluntarily by policyholders and are usually uncorrelated with market shocks and economic cycles. Therefore, insurers do not often face collateral calls or liquidity outflows (Jobst, Sugimoto & Broszeit, 2014).

Some of the core insurance activities actually help stabilize the economy. Insurance companies invest and also reinvest savings in long-term, stable portfolios of equities and bonds, playing a significant role in financial intermediation. Apart from thus providing liquidity to savers and borrowers, they also provide funding to many companies and institutions (Haefeli and Liedtke, 2012).

It is currently agreed in general that traditional insurance activities are not very systematically relevant. However, current low-interest rate environment drives insurers to pursue more non-traditional and non-insurance activities, which may represent financial risk, especially given the financial instruments modernization trends (International Actuarial Association [IAA], 2013). Such activities, such as credit default swaps transactions for other than hedging purposes, are more vulnerable to the market instabilities and therefore contribute to systemic relevance of the insurance companies

(International Association of Insurance Supervisors [IAIS], 2011).

1.2 Key risks faced by insurers

Compared to banks, insurers have a different balance sheet structure and thus need to be treated differently. The average maturity of the insurers' assets is shorter than that of their liabilities, mainly technical provisions for insurance claims (Trichet, 2005).

Regardless of their relatively low vulnerability to customers runs, insurance companies face various other risks both on the assets and liabilities side of the balance sheet. On the assets side, the insurers have to deal mainly with market, credit, liquidity, group, systemic and operational risks. These are characteristic also for other financial institutions and are correlated with the overall economic conditions (Jobst et al., 2014). On the liabilities side, they face primarily insurance risk.

Market risk results mainly from market movements that influence the value of insurers' assets. These could include interest rates movements due to economic downturn, currency devaluations, credit rating downgrades or changes in equity prices. Problems arise when the changes in the value of assets resulting from the market movements are not offset by a corresponding change on the liabilities side (IAIS, 2003).

Credit risk arises from the possibility of a debtor, borrower, broker, reinsurer or guarantor not meeting their obligations. Specific cases may include deterioration of a counterparty's creditworthiness, extent or quality of collateral, greater than expected losses caused by bed debts or high exposure to a single name (IAIS, 2003).

Operational risk results from a vast number of factors such as fraud, systems and management failure, issues with information technologies or process failure during business cycles.

Liquidity risk is such that the insurance companies will not be able to meet their own obligations when they fall due. It usually arises from mismatches between assets and liabilities and poor cash flow management. Cash flows from yet unearned premiums have to be invested in such a way that the payments of future claims can be made at all times. However, sufficiently long-term assets are hard to come by, which typically results in a negative duration gap for insurers (Jobst et al., 2014).

Group risk, sometimes known as contagion risks, arises from membership in a particular group of insurers. While this can be beneficial to the insurance company, there are factors that need to be considered, e.g. the need to financially support others, withstand pressure form a group's rating downgrade, face difficulties in closing off or selling a subsidiary when required or suffer lack of financial support from a parent in case of capital shortage.

A similar risk is systemic risks which, however, results from the whole insurance sector and not from a membership in a group. Thus, should an important insurance company suffer a failure or downgrading, others' marketing efforts and reputation could be endangered. The same can apply on an even larger scale to the whole financial sector (IAIS, 2003). On the other hand, the degree of interconnectedness with other financial institutions is rather low for insurance companies, as they are not participating in payments and clearing systems. This results in less severe negative externalities in case of failure but may present problems for larger insurance companies (Jobst et al., 2014).

Insurance risk is for the most part independent of the changes in economy. It is idiosyncratic and can be diversified, mainly through underwriting of negatively correlated risks or appropriate pooling of risks (Jobst et al., 2014). It is often separated into three different categories, namely underwriting risk, catastrophe risk and risk of deterioration of technical provisions.

Underwriting risk is directly related to the company's operations in providing insurance. Some of the main factors are appropriate pricing of products, more difficult in new or emerging markets with little information available for proper risk evaluation, sudden changes in portfolio volume, geographical mix, availability of reinsurance and changes in its rates, the uncertainty and frequency of claims (especially the large ones).

As is suggested by the term, catastrophe risk arises from catastrophic events that affect all lines of business. The risk factors are the ability to withstand a large simultaneous increase in the number of claims and unexpected exposures, exhaustion of reinsurance arrangements and even the quality of the models and assumption used for the calculation of probable maximum loss (IAIS, 2003).

The risk of deterioration of technical provisions lies mainly in social changes, changes in inflation and other economic, legislative or technological changes, but also in the size and frequency of large claims, increase in longevity affecting pension claims, uncertainty of outstanding claims and other underwriting provisions, such as those for unearned premiums and unexpired risks (IAIS, 2003).

The traditional insurance risks such as morbidity or fire risks are usually not correlated with each other and do not follow a business cycle. Therefore, the financial shocks are less of a concern to these types of insurers. On the other hand, non-traditional insurers focused on financial activities connected to securities and funds will be more vulnerable to business cycles and market risk.

While these are the risks that an insurer faces at any given time, recent market developments determine which specific risk factor will be particularly challenging. Financial Stability Report published by European Insurance and Occupational Pensions Authority in December 2014 sheds some light on the current situation.

Apart from the geopolitical tensions in Ukraine and Middle East, the biggest concern remains to be the low yield environment in the Eurozone.

Low inflation drives a strong investor appetite which further lowers yields. At the same time, many European countries face high public sector indebtedness and ever-increasing fiscal deficits. The low interest rate environment, along with the longevity growth, is an important risk factor to the insurers, particularly to life insurers with long-term obligations. Also, in the low yield environment, the risk of reinvestment increases, especially for insurers who offer guaranteed interest rates. Therefore, insurers tend to look for ways to increase their yields, which results in higher diversification and more investments into corporate bonds rather than sovereign and bank bonds (European Insurance and Occupational Pensions Authority [EIOPA], 2014a).

Credit risk spreads on insurance bonds are now decreasing. While this is an improvement compared to previous years, credit risk still remains significant as the fiscal deficits and indebtedness or sovereigns remain high (EIOPA, 2014a).

1.3 Stress testing

Stress testing is a technique used to estimate the potential impact of a change in one or more financial variables on the value of a portfolio. (IMF and World Bank, 2005) Most often, stress tests are applied to an individual portfolio or an institution as a risk management tool complementing internal models. They provide useful information to all levels of the organization. Namely, they can reveal the more vulnerable products at the trading level, enable comparison of different asset class riskiness at the managerial level and gauge the overall risk profile and aid in capital allocation decisions at the executive level (Blaschke, Jones, Majnoni & Peria, 2001). Increasingly, these techniques are also used for aggregate portfolios to evaluate the overall risk exposure of a financial sector or even a whole system to common shocks. In this case, the purpose of stress tests is financial surveillance rather than risk management and a lot of attention is devoted to channels of contagion (Čihák, 2004). Last but not least, stress tests have also been used as a crisis management tool, helping to boost market confidence during recent financial crisis (Schmieder, Puhr & Hasan, 2011).

Stress tests by insurers are in some aspects similar to the stress tests by banks, as the risks faced by both types of institutions are comparable. However, the insurance industry is specific in a sense that the business is, by definition, supposed to deal with uncertainty. As has been discussed previously, it is not considered to be a source of instability in the financial sector. Thus, some adjustments must be made. For example, some shocks, such as natural disasters, may be completely irrelevant for banks but may be crucial for insurers. On top of that, the banking industry is of a short-term character and the structure of its assets and liabilities changes often, which is not the case for insurance companies.

Currently, most firms use economic capital models, in which probabilities are assigned to possible future scenarios. The capital requirements are then determined based on these models. However, such internal models are often not sufficient as they usually disregard extreme conditions that have low probabilities of occurring but are still plausible. Stress tests should therefore focus on such scenarios and they should determine whether the companies would be able to absorb the financial losses occurring in such a case (IAA, 2013).

Three methodological approaches to stress testing are recognized. First, it is the sensitivity analysis, focusing more on an individual portfolio and single risks; second is the scenario analysis targeting financial institutions and their exposure to a specific plausible scenario; and last is the contagion analysis, assessing how a risk to a single institution may turn into a systemic risk and evaluating the channels of transmission (Čihák, 2004).

A sensitivity test establishes the impact of a change in one particular risk factor, or several of them in case they are closely linked. These could be for example interest rates, mortality and morbidity rates or level of required capital. As these factors come typically in a form of a shock, sensitivity tests tend to focus more on a shorter time horizon. It is less costly than other forms of stress testing and can thus be used more often to evaluate risk changes (Office of the Superintendent of Financial Institutions Canada, 2009).

A scenario stress test, on the other hand, involves simultaneous movements in several risk factors and are therefore more complicated. Scenarios used to evaluate risks are either historical or hypothetical. Historical scenarios evaluate the pattern of changes in risk factors that have previously occurred, such as the 2007-2009 crisis, an epidemic or an earthquake (IAA, 2013). The main disadvantage of this approach is that is backward looking. While it is plausible that these events could recur, over time their relevance decreases due to changing structure of financial institutions and markets (Blaschke et al., 2001). Hypothetical (or synthetic) scenarios focus on changes that have not occurred before but are nevertheless considered plausible. Here, one could ask what losses an insurer would face in case of a significant event in the development of technology, e.g. use of nanotechnology or a cure for cancer (IAIS, 2003). In a hypothetical scenario, market factors, correlations or volatilities can be shocked, revealing the risks factors to which the portfolio is the most vulnerable. Conversely, a scenario which would lead to biggest losses can be identified. The difficulty of the hypothetical scenario approach lies in determining the probability of an event actually occurring (Blaschke et al., 2001).

In practice, ideal risk scenarios should combine historical outcomes with the hypothetical ones. They should cover all risk factors relevant to the business and take into account main characteristics of the given insurance market, as the effects of macro-financial shocks on the insurer's balance sheets and profit and loss statements may differ depending on the country's jurisdiction and supervisory frameworks. Most common scenarios are the recessionary scenario, banking, financial and sovereign crisis, inflation scenario, life and non-life underwriting shocks. In the recessionary scenario, equity and property prices decline while credit spreads, lapse rates and number of mortgage defaults increase, offset by a decrease in interest rates. Inflation scenario presents the opposite situation, when interest rates rise, as well as equity and property prices. During the banking, financial and sovereign crisis, credit spreads rice, a large bank defaults and all asset classes, including sovereign bonds, are under stress. Finally, non-life underwriting shock is usually characterized by a large catastrophe claim that could be followed by a reinsurer's default or decreasing equity prices. Life underwriting shock occurs in case of a pandemic and could lead to high lapse rates (Jobst et al., 2014).

The decision sequence of conducting a stress test should thus be the following. First, the type of risk to be tested should be determined. Next, the type of stress test should be chosen, i.e. a sensitivity or a scenario test, along with the type of shock to be applied, meaning whether a market financial variable, a correlation or a volatility should be shocked. After deciding on the type of scenario (historical or hypothetical or even a Monte Carlo simulation, which is, however, out of scope of this thesis), the assets to be shocked, the size of shocks and time horizon should be determined as well (Blaschke et al., 2001).

While standardised stress test are sometimes required by supervisors, in general, each insurer should develop their own stress test taking into account the company's specifics and risk profile. Depending on the level of risk exposure, the effect on a specific firm may differ from the other firms in the industry. Apart from that, the frequency and nature of the stress tests will depend on several factors, such as the company's size, solvency, current position within the group and the market, its investment policy, business plan and business lines and, naturally, general economic situation (IAIS, 2003).

Stress tests should be carried out at least once a year, although in some cases they should be conducted more frequently, i.e. in case of low solvency, high risk profile or rapidly changing market and economic conditions. The time horizon in stress tests should be sufficiently long in order to evaluate all effects of the stress factor, at times lasting a whole economic cycle (IAIS, 2003).

A specific challenge in stress tests is presented by risk dependencies in the scenarios. As is evident from the risks described above, they are rarely completely independent. Therefore, their correlation should be taken into account. Moreover, historical data often are not sufficient in determining these correlations, as it has been shown that previously low correlation can increase over time (IAIS, 2003). Sometimes, risks factors are not correlated but they are nevertheless dependent, i.e. one triggers the other. For example, while market performance does not affect mortality rate, a sudden increase in the mortality rate may significantly influence the financial market (IAA, 2013).

International Actuarial Association distinguishes between several types of dependencies. First one is the immediate dependence of two directly linked factor. A change in one factor leads to a change in another at the same time, e.g. a price of a share and the share index. Second type of dependence is time-lagged, when a change in the second risk factor is delayed, such as a default of a financial institution and the following claim made to the insurance company. Alternatively, in case of a feedback, the second risk factor may trigger a change in another risk factor such as a market price of an instrument held by the insurer. The last type of risk dependency is the phase-shift. In this case, a change in a risk factor causes a change in another risk factor only after reaching a certain level. An example of this would be an earthquake causing an increase in mortality and equity prices (IAA, 2013).

System-wide stress tests are a bit different from the ordinary portfolio stress tests. By definition, they are applied to more institutions at once and their main objective is thus to identify the impact of common shocks to the stability of a group of institutions or a financial sector and determine common vulnerabilities. For this reason, these tests are sometimes called macrofinancial stress tests, as they seek to understand how the changes in macroeconomic environment affect the financial system as a whole. The greatest challenge presented is the aggregation of data, as two approaches can be employed - a bottom-up or a top-down approach (IMF and World Bank, 2005).

The bottom-up approach means that the stress tests of various shocks are performed at and individual portfolio level, with the results aggregated afterwards. This approach provides the benefit of better employing the individual portfolio data (IMF and World Bank, 2005). The drawback of this approach is the possible heterogeneity of individual portfolios and different methodologies and assumptions employed by different institution (Blaschke et al., 2001).

Under the top-down approach the portfolio data is collected from the institutions and the stress test is then performed by a supervisor by applying a common shock. This results in consistent methodology and a more meaningful aggregation (Blaschke et al., 2001). However, stress testing at the aggregate level poses the threat of overlooking the vulnerabilities at the individual institutions' level and a possible contagion to the whole financial system (Čihák, 2004).

Stress testing is often costly and thus should be conducted as effectively as possible. The main difficulties are the selection of risk factors for testing, determining how they should be tested, how extreme the values tested will be and what time horizon should be taken into account. It is desired that the tests be carried out by skilled personnel and ideally the risk factors should be chosen by those not directly involved in crucial business decisions. The results should be carefully analyzed and the level of their reliability should be determined.

However, the usefulness of a stress test depends on correct specification and relevance of the underlying model. If a model ignores the spillovers between economy and risks or, contrarily, tests risk not relevant to the current portfolio, the results may be invalid and misleading, possibly even causing firms to assume too great an additional risk (Blaschke et al., 2001).

The whole purpose of stress testing is not simply to obtain the numerical values but rather to draw conclusions and to learn from them. The analysis of results should enable the insurer to develop strategies and contingency plans focused on risk avoidance and mitigation (mainly through modifications of the business model and reinsurance), changes in capital, be it increasing collateral capital or raising more funds and/or decreasing dividend payout and mix of assets (IAA, 2013).

1.4 Solvency I, Solvency II and Embedded value

Having described the stress tests in general, it is important to discussed how they can be applied to a portfolio. The results of the stress test are projected to a company's balance sheet to see the impact of various risks on the value of assets (Jobst et al., 2014). Thus, it can be determined whether an insurer would be still solvent, i.e. able to pay its future claims when they fall due.

For an insurer to be considered solvent, the following has to hold:

$$TC \leq RBC, \tag{1.1}$$

where TC stands for Target Capital and RBC stands for Risk Bearing Capital (Wüthrich, Bühlmann & Furrer, 2007).

Risk Bearing Capital, also encountered as Available Solvency Surplus or Available Solvency Margin, is defined simply as the difference between value of assets and value of liabilities. Therefore, this is the actual real value. Target Capital, or sometimes Required Solvency Margin or Theoretical Capital Requirement, is a theoretical minimum amount of risk capital required by a supervisor so that the insurance companies can continue to run their business even in case of some adverse scenarios (Sandström, 2007).

Since its adoption by the EU Parliament in 2002, Solvency I directive is in place in the European Union. It consists of 74 articles and introduces capital requirements for insurance companies. For non-life insurance, Target Capital required is defined as

$$TC = 4\% \text{ of the mathematical reserves} + 0.3\% \text{ of capital at risk}, \quad (1.2)$$

where mathematical reserves reflect the market (financial) risk and capital risk reflects the insurance (technical) risk. For non-life insurance, Target Capital is defined simply as

$$TC = 16\% \text{ of premium}. \quad (1.3)$$

However, as can be seen, the Target Capital is not risk-adjusted (Wüthrich et al., 2007). Furthermore, the accounting basis approach to valuation is used under Solvency I . This means that only historical prices are used during the valuation. Under this approach, the book value of liabilities can be decomposed into three components: technical provision, Solvency I capital requirements and free surplus (Deloitte, 2010). As no risk is reflected in the value of the assets, stress tests are rendered inapplicable to the balance sheets, as the changes in market prices do not affect it (Jobst et al., 2014).

Solvency II, a new directive was adopted by the EU Parliament and the Council of the European Union in November 2009 and is to become applicable on 1 January 2016. Aware of the drawbacks of Solvency I, Solvency II will adopt several important changes. The framework consists of three pillars. Pillar 1 addresses the quantitative requirements and rules for valuation of assets and liabilities capital requirements calculation. Pillar 2 focuses on the supervisory process and risk management regulations and Pillar 3 is concerned with the transparency and reporting to authorities and the public (European Commission, 2015).

Under Pillar 1, the pillar of greatest relevance to this thesis, solvency capital requirements will be set based on a total balance sheet approach. Two capital requirements are proposed; once again, the Target Capital is the amount of capital needed by the insurer to be able to safely run the business and Minimum Capital Requirement is the threshold level of capital, which, if reached, will trigger significant regulatory action (Pitselis, 2009). Target Capital is risk-based in order to reflect the insurer's risk profile and is measured by the Solvency Capital Requirement (SCR) (Clarke, Mitchell & Phelan, 2014). The SCR is determined by the formula

$$SCR = BSCR - SCR_{op} - EP_{NL}, \tag{1.4}$$

where BSCR is the basic solvency capital requirement, SCR_{op} stands for operation risk and EP_{NL} is the next year's non-life expected profit (or loss) (Pitselis, 2009).

The total (or, alternatively, market-consistent) balance sheet approach reflects the risk-adjusted, economic, value of assets and liabilities (Clarke et al., 2014). Under this approach, assets and liabilities are valued at their market value. The difference of their market value then gives the Risk Bearing Capital, i.e. the own funds required to meet the SCR and MCR capital requirements. If the market values are unavailable, the assets or liabilities on the balance sheet must be revalued, which will significantly impact especially the liabilities side (Pitselis, 2009). The liabilities side can be once again divided into several components, namely technical provisions, SCR (including MCR) and free surplus[1] (Deloitte, 2010). In this case, however, the economic value of liabilities is calculated as a best estimate from the expected present value of future cash flows with the Risk Margin (RM) added to it to reflect the non-hedgeable risks. The Cost of Capital should be used

[1]For visual comparison of Solvency I and Solvency II balance sheets, see Appendix A.

for the risk margin calculation (Deloitte, 2010).

Because the Solvency I balance sheet does not capture the risks arising from adverse market movements, the firms started to apply the concept of Embedded Value for their internal balance sheet valuation. This will become unnecessary after the Solvency II regulatory framework comes into force, as it will be employed both for internal and regulatory purposes. However, as the Solvency II data is not available yet, embedded value will be used in the empirical part of this thesis. For this reason, the remainder of this chapter is devoted to a more detailed description of this concept.

Embedded value (EV), as well as Market Consistent Embedded Value (MCEV) measures the consolidated value of shareholder's interest in the covered business (CFO Forum, 2009). It is essentially similar to the actuarial appraisal value of a company evaluated for example during mergers and acquisitions, although there are several crucial differences. Namely, EV excludes the value of future new business contribution, uses generally lower discount rates and calculation assumptions that are more company specific. EV is already widely used in Europe and is also coming to the United States, as it is calculated by the subsidiaries of the international companies. Apart from assessing the value of the business, it is used for allocation of the capital among different business lines. The reporting of this information differed for different countries, complicating performance comparisons for investors. The CFO Forum published the MCEV guidance principles in October 2009, in order to unify the reporting and increase transparency.

Prior to MCEV, traditional embedded value (TEV) was used. However, it had several drawbacks. First of all, it allowed for subjective setting of the risk discount rates to determine the present value of future cash flows. CFO Forum defined the risk discount rate as a risk free rate plus a risk margin reflecting risks of distributional earnings that were not allowed for previously (CFO Forum, 2004). However, given the lack of guidance on the setting process, risk margin was usually determined in accordance with market practice resulting in lack of differentiation based on actual risk (Regional Committee FVG, 2012). Another technical limit lied in the subjective setting of projection assumptions, causing the numbers were still vulnerable to slight manipulation, as the higher the financial assumptions are, the higher will be the resulting embedded value Regional Committee FVG, 2012). Furthermore, traditional embedded value allowed for subjective setting of the financial options and guarantees to be deducted from the value of projected cash flows. Given the subjective setting of financial assumptions and the risk discount rate, this meant that the cost of guarantees did not have to be explicitly captured in the final value (Regional Committee FVG, 2012).

CFO Forum adressed some of these issues firstly by the European Embedded Value principles in 2004, where it required the financial options and guarantees allowance calculation by using stochastic techniques. Market consistent embedded value tackled the problem of subjective setting of the risk discount rates by requiring the use of discount rates consistent with those used on capital markets, or, if the cash flows are independent of the market, reference rates. Reference rates serve as a proxy for the risk free rate and CFO Forum recommends the swap yield curve to be used, with or without a liquidity premium, depending on the liquidity of the given liability (CFO Forum, 2009).

Tests comparing the real-world pricing approach, i.e. TEV, and the market consistent approach have been carried out and found the MCEV to be lower than TEV in most cases. However, this is viewed positively, as the market consistent value recognizes the costs of all risks (Junus et al., 2012).

Essentially, the MCEV computation can be summed up by the following equation:

$$MCEV = RC + FS + VIF, \tag{1.5}$$

where RC is the required capital, FS stands for free surplus and VIF means value of in-force (covered) business.

Required capital is defined as *"the market value of assets, attributed to the covered business over and above that required to back liabilities for covered business, whose distribution to shareholders is restricted"* (CFO Forum, 2009, p. 3). At a minimum, the amount should meet the level of solvency capital required by the supervisor. Free surplus, on the other hand, is the market value of the remaining assets, i.e. those not required to back the liabilities (CFO Forum, 2009). Value of in-force business is the most interesting component that consists of several elements. In formula form,

$$VIF = PVFP - TVFOG - FCRC - CRNHR, \tag{1.6}$$

where PVFP stands for the present value of future profits (after taxes), TVFOG stands for the time value of future options and guarantees, FCRC is the frictional cost of required capital and CRNHR is the cost of residual non-hedgeable risks.

Time value of future options and guarantees is an allowance made to reflect the options and guarantees possible future impact on the cash flow (CFO Forum, 2009). TVFOG can be quantified as the market price (i.e. market value) from which the intrinsic value of the option or guarantee is subtracted (American Academy of Actuaries [AAA], 2011). As has been mentioned before, value of the allowance is to be determined using stochastic techniques. Frictional cost of required capital is another allowance that has to be made. The cost of capital is calculated differently based on geographical location. In North America, weighted average cost of capital (WACC) is used to reflect the cost of equity as well as the cost of debt. In the UK, however, debt is not taken into account. In this case, the cost of capital can be obtained as

$$CoC_t = RC_{t-1} \cdot (RR_t - i_t), \tag{1.7}$$

where RR is the reference rate as described previously and i is the net post-tax investment rate of return. The frictional cost of RC is then obtained by discounting the cost of capital in projection for each period by the reference rate at the valuation date (AAA, 2011). Cost of non-hedgeable risks includes the cost of both financial and non-financial risks that have not been allowed for in PVFP and TVFOG. Usually, this means asymmetric risks such as mortality risk on participating business. Asymmetric means that gains from changes in mortality may be distributed to policy holders, but the shareholders bear the losses should they occur (AAA, 2011).

This is the so-called indirect, CFO Forum approach for MCEV calculation. In theory, however, a simpler approach exists, which is not used that often but is a bit easier to understand. The direct, balance sheet approach calculates MCEV by subtracting the market value of liabilities form the market value of assets of a company (Junus, Wang & Motiwalla, 2012).

The market consistent embedded value works only with the value of in-force covered business, while excluding the value of new business, i.e. new contracts and their renewals. Usually, MCVNB is reported alongside the MCEV. MCVNB is usually equal to the VNB, as no capital is required for new business and no free surplus exists. VNB is then calculated similarly to the value of in-force business, that is after tax and after subtraction of TVFOG, frictional costs of capital, costs of non-hedgeable risks and minority interest (CFO Forum, 2009).

Along with MCEV, CFO Forum requires reporting of sensitivities in three categories: interest rates and assets, expenses and persistency, and insurance risk. The sensitivities have to be reported at least annually (CFO Forum, 2009). MCEV and MCVNB reflect the company's risk exposure and vulnerability based on market valuation. The sensitivities serve as company-specific stress tests and reveal which factors the insurers are the most vulnerable to.

2 Empirical part

In this chapter, the topic of financial stability will be examined from a more practical point of view. First, the main current risks will be described. Next, as EIOPA (European Insurance and Occupational Pensions authority) has recently carried out a system-wide stress test that assesses those risks, its results will be presented. After that, information from annual reports of several European insurance companies will be used in evaluating the insurance risks using the concept of Embedded Value. Finally, the impact of key macroeconomic variables will be examined through an empirical analysis based on stock prices.

2.1 Current situation

In the theoretical part, key risks that insurance companies face have been outlined. Naturally, their relevance and importance change together with the current macroeconomic conditions and political events. In this section, a brief overview of the most important factors will be provided. EIOPA's (European Insurance and Occupational Pensions Authority) Financial Stability Report released in December 2014 is the most recent and most realiable source on this topic.

As of today, insurers face three significant risks. The first one arises from expected low aggregate demand, second is the low-interest rates environment and third is the credit risk.

The current macroeconomic environment in Europe remains weak. The GDP level of Germany and France has already surpassed their respective pre-crisis levels and UK is approaching, but for other countries it is still a long way to go despite the last-year growth (EIOPA, 2014a). The developments in the unemployment rates are not entirely optimistic and the declines are expected to be insignificant in the near future. Therefore, insurers should expect lower demand and adapt their business models accordingly (EIOPA, 2014a). Overall, however, the insurance sector represented by DJ STOXX Insurance exhibits significant growth in the stock market, substantially outperforming DJ STOXX Banks (EIOPA, 2014a).

Probably of the greatest current risks and challenges, is, as has been indicated before, the prevailing low yield environment. Market data suggests that this trend will persist in the future. (EIOPA, 2014a) Most vulnerable to low interest rates are the guaranteed life insurance businesses and some of the non-life businesses where profitability depends largely on investment returns (EIOPA, 2014b). For those offering high guarantees, the risk of reinvestment is especially high because of the duration mismatches typical for insurers. Companies are thus forced to move to products with lower sensitivity to interest rate movements and offer lower or more flexible interest guarantees (EIOPA, 2014a). Moreover, the efforts to increase profitability push insurance companies to take on greater risk, for example by investing in higher-yield bonds of lower quality and new, often riskier, asset classes, as has been discusses in the theoretical part of this thesis. This may partially explain why the investment return of insurance companies has been relatively strong in mid-2014, 4.3% on average for a median company (EIOPA, 2014a) However, given the expected further decrease in bond yields and prevailing low yield environment, the investment returns are also expected to decline. Another source of concern for insurers are the equity markets. Should they come under pressure and the value of assets to decline, the impact, combined with the low interest rates, would be significant. This scenario is referred to as the double-hit scenario.

Finally, the third greatest risk currently faced is credit risk. Even though some improvements have been observed, as measured by the decreasing credit spreads on insurance bonds, the future market expectations are less optimistic, reflecting the high current public sector indebtedness and ever-increasing budget deficits (EIOPA, 2014a).

The most rigorous instrument for assessing current risks in a given sector is the technique of stress testing, also introduced in the theoretical part. Unfortunately, stress testing requires a great amount of data which is not publicly available. However, EIOPA, as the insurance sector supervisor, has the power to carry out system-wide stress tests in order to assess the resilience of the sector to adverse market changes and to evaluate the possible increases in systemic risk caused by such events. The description of results of the most recent stress test will be provided in the next section.

2.2 EIOPA Insurance Stress Test 2014

The Stress Test was launched on 30 April 2014, comprising two rigorous modules and taking into account the updated knowledge of Solvency II regulatory framework. The persisting low interest rate environment led EIOPA to include a whole Low Yield Module alongside the Core Module, which concentrated on asset market shocks and insurance specific stresses. 167 insurance companies and individual undertakings have participated in the Core Stress Test Module, accounting for 55% of Gross Written Premium in the EU. In the Low Yield Module, 225 companies and undertakings took part, representing 60% of EU's Gross Technical Provisions (EIOPA, 2014c).

2.2.1 Core Module

The Core Module consisted of four different parts. The first two evaluated the impact of an asset market shock originating in the equity and corporate bond markets, respectively. The second scenario was complemented by a questionnaire for undertakings, which provided a qualitative analysis of the shock effect. Finally, EIOPA assessed single factor stresses specific to the insurance sector (EIOPA, 2014c).

Before any stress has been applied, the overall ratio of assets over liabilities was 110.1%. Even in the baseline scenario, 14% of participants reported the Solvency Capital Requirement ratio below 100% and 8% failed to meet even the Minimum Capital Requirement. (EIOPA, 2014c).

Under the first scenario, CA1, a shock originating in the equity market and spreading to corporate and government bonds market is assumed. The scenario is considered severe in terms of historical period of 2009-2013. The specific stresses were relative downward price shocks of 41% for equity investments, 49% for commercial property and 17% for residential property, accompanied by significant spread widening both for sovereign bond and corporate bonds with non-investment grade rating. The stress lowered the assets over liabilities ratio by 4 percentage points to 106%. It also caused the proportion of undertakings with SCR coverage ratio below 100% to rise to 44% from the original 14% (EIOPA, 2014c).

The second scenario, CA2, imposed a reversed situation, with the shock originating in the non-financial corporate bond market and spreading into sovereign and bank bond markets, as well as other market segments. The shock can also be viewed as a correction of prevailing low levels of corporate bond spreads. The specific stresses were an inverse interest rate shock, relative downward price shocks of 21% for equity investments, 18% for commercial property and 57% for residential property, as well as significant spread widening for corporate bonds with investment grade rating and for sovereign bonds (with focus on Nordic and east European countries). This was considered severe in terms of the 2007-2013 historical period. The results were better than in the previous case, as the assets over liabilities ratio fell only to 108.7% and the percentage of undertakings with SCR coverage ratio below 100% rose to mere 27% (EIOPA, 2014c).

The questionnaire accompanying the CA2 scenario sought to evaluate the undertakings' response to the stress scenario. The collected data established that even undertakings considered healthy after stresses felt the need to take actions, even to undergo and immediate restructuring in 66% of cases. The most often proposed actions for restoring capital levels were capital increases (40% of participants) and portfolio changes (30% of participants), while the most cited measures for maintaining profitability were cost control (20% of participants) and changes in asset composition and product mix (18% and 15%, respectively) (EIOPA, 2014c).

The specific insurance stresses were applied independently of the two core scenarios, because, as has been discussed previously, their correlation with market risk and movements is low. The stresses included 7 Natural Catastrophe (NatCat) scenarios, 5 of which were defined - North European Windstorm, US Hurricane, Turkey earthquake, Central and Eastern European flood and an airport crash - and 2 were left for each undertaking to define, provided they occurred once in 100 or 200 years. Apart from that, non-life stress comprised 2 scenarios of provisioning deficiency and life stress consisted of 2 longevity stresses and 2 mortality stresses. Finally, 2 mass lapse events were applied. The three most significant stresses turned out to be the non-life 3% provision deficiency, 18% decline in longevity and the 35% mass lapse event, however, neither resulted in an Eligible Own Funds[2] decline greater than 10%. The NatCat events did not cause great losses, except for smaller south European countries that demonstrated significant exposure[3] (EIOPA, 2014c).

2.2.2 Low Yield Module

The Low Yield module comprised two scenarios. The first one, "Japanese-like" scenario explored the impact of prevailing low interest rate environment and the second one, "inverse" introduced an uncommon change in the yield curve shape. This time, EIOPA examined not only the meeting of SCR requirements by participants after stresses, but also looked at mismatches in duration and internal rate of return (IRR) between assets and liabilities.

[2]EOF can be defined as the sum of surplus of assets over liabilities and the Solvency Capital Required

[3]For a detailed summary, see Appendix A.

Mismatches were calculated in the following manner:

$$\text{IRR mismatch} = IRR_{liabilities} - IRR_{assets} \tag{2.1}$$

$$\text{Duration mismatch} = Dur_{liabilities} - Dur_{assets}. \tag{2.2}$$

The only country with a positive IRR mismatch was Malta, whereas countries with duration mismatch that exceeded $(Avg + 1.5 \cdot std)$ were Austria, Germany and Sweden. Approximately 16% of participants had a SCR coverage ratio below 100% before any stress was applied, which represented about 8% of total assets in the sample (EIOPA, 2014c).

The results were milder for the Inverse stress scenario, with the percentage of undertakings not meeting the SCR ratio rising to 20%. After the Japanese-like scenario, this percentage rose to 24%, i.e. 8 percentage points. Similarly, a greater increase in mismatches in both IRR and duration was observed after the Japanese-like stress scenario[4] (EIOPA, 2014c).

To conclude, the Stress Test demonstrated significant exposure of the insurance sector to stresses in the equity market, with almost half of the participants failing to meet the Solvency Capital Requirements. Severe reversal in the markets could thus have a non-negligible impact on the undertakings' capitalisation. It also showed that the Japanese-like developments with persisting low interest rates could push almost a quarter of the insurance sector under the SCR margin. Smaller undertakings were shown to be more exposed to the stresses. It is also worth noting that the minority reporting a SCR coverage ratio below 100% would trigger an immediate supervisory action after 1 January 2016, when Solvency II regulation will become effective (EIOPA, 2014c).

[4]For detailed results, see Appendix A.

2.3 Sensitivities

A simpler form of stress testing can also be employed by individual companies in order to assess their own vulnerability to market factors. By calculating the sensitivities to changes in single variables, such as interest rates or equity prices, the insurers can obtain answers to basic questions about their stability and evaluate how their company's value could be affected. The concept of Embedded Value captures the effect of adverse market movements on the balance sheet and firms started to employing it in their internal valuations, parallel to the Solvency I regulatory framework. While the EV concept will not be needed after Solvency II becomes effective in January 2016, today, only the Embedded Value data are available.

Since 2009, when CFO Forum announced their MCEV Principles, several big European insurers have decided to publish their yearly reports in line with those standards. Some continue to disclose the older European Embedded Value. In both cases, sensitivities of a company's value to changes in variables such as interest rates are reported. By collecting and analyzing them, an insight into the sector's exposure to some of the market changes can be obtained, both current and historical.

From the European insurance companies with the largest USD premium, 12 companies who report either MCEV or EEV have been selected, including CNP Assurances, Allianz Leben and AXA Leben[5]. From those companies, sets of sensitivities published for years 2008-2014 have been collected.

The sensitivities are be divided into four categories according to CFO Forum principles. The first category, Interest Rates and Assets, includes (i) sensitivities to 100 basis point increase and decrease in the interest rate environment (ii) 10% decrease in equity/property capital values at the valuation date, (iii) 25% increase in equity/property implied volatilities at the valuation date and (iv) 25% increase in swaption implied volatilities at the

[5]See full list in Appendix B

valuation date. Expenses and Persistency category comprises (i) 10% decrease in maintenance expenses and (ii) 10% proportionate decrease in lapse rates. Insurance Risk category is composed of sensitivities to 5% proportionate decrease in base mortality and mortality rates for life assurance and annuity business and finally, the last category is the required capital to be equal to the level of solvency capital (CFO Forum, 2009).

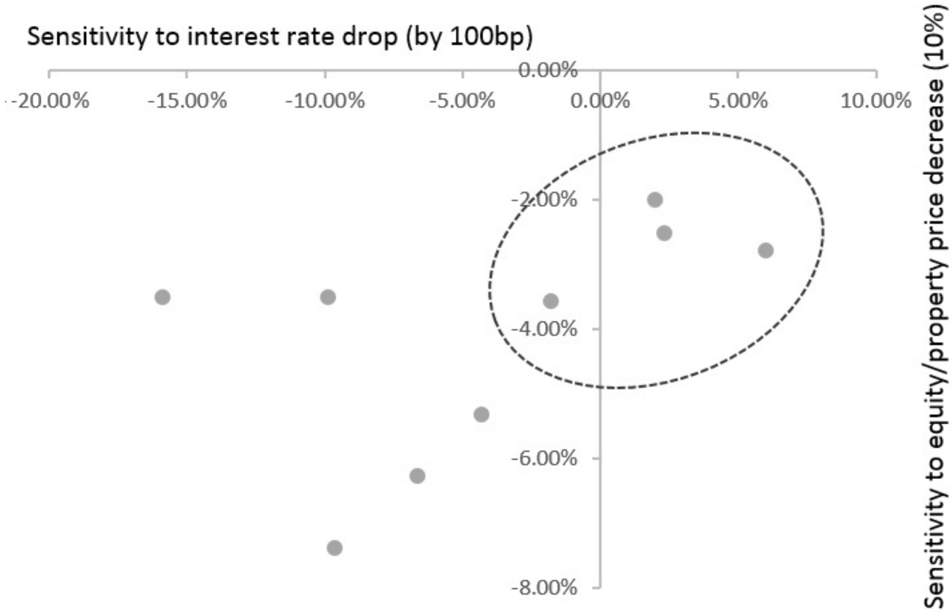
The data set collected is not perfect. The Expenses and Persistency sensitivities are missing for the companies disclosing EEV. Societe General Insurance and AEGON stopped reporting the sensitivities altogether in 2012 and some companies have opted for slight modifications in the magnitude of changes. In these cases, the values were treated as missing and were not included in the analysis.

Last year, EIOPA analysed the sensitivities to drops in interest rates and equity/property prices reported in 2013. It concluded that the insurance companies can be divided into two groups, one very sensitive to decreases in the interest rates and one mostly insensitive to changes in interest rates but equally sensitive to drops in equity prices[6] (EIOPA, 2014a).

The latest publicly available data showed that insurers are on average more sensitive to both the decreases in interest rates and fall in market prices. The two groups with varying sensitivities described by EIOPA are less evident in 2014. One group can be observed that is not very sensitive to either of the factors. The rest, however, is much more dispersed and sensitivities to both decreases in interest rates and market prices are much higher. Generali even reports a record -15.9% sensitivity to a 100bp decrease in interest rates, which it contributes to the presence of financial guarantees and options. (Assicurazioni Generali, 2014)

[6]See Appendix B for graphical representation.

Figure 1: Embedded value sensitivities to decreases in interest rates and equity/property price in 2014

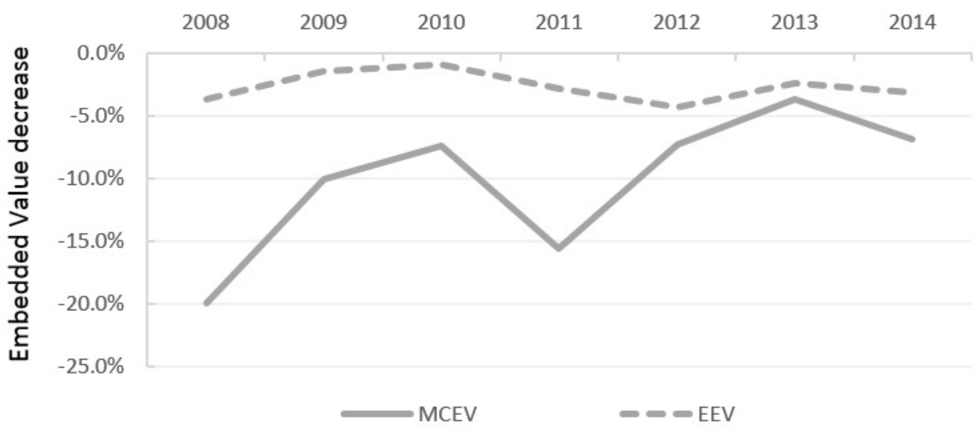


Source: Embedded value reports by a set of European insurers and author's calculations, EIOPA approach.

While the sensitivity of companies to drops in the interest rate environment decreased between 2012 and 2013, possibly due to lower guarantees (EIOPA, 2014a), it significantly increased again in 2014, probably as the prevailing low interest rates bite the companies with financial guarantees and options.

By calculating a weighted average of all companies' sensitivities in each year (using both EEV and MCEV), it can be concluded that over time, companies are on average most sensitive to downward changes in interest rates (-6.15%), followed by decreases in equity prices (-3.71%). In contrast, the insurers exhibited lowest sensitivity to changes in mortality and morbidity and changes in equity implied volatilities.

Figure 2: Embedded value sensitivities to 100bp decrease in interest rates between 2008 and 2013. (weighted average by embedded value)



Source: Embedded value reports by a set of European insurers and author's calculations, EIOPA approach.

2.4 Stock market's reaction to changes in macroeconomic variables

The impact of changes in macroeconomic variables on companies can also be assessed by analyzing the stock market's response to them. Thus, In this subsection, the relationship between some of the STOXX 600 Europe Index components and basic macroeconomic variables such as interest rates, gross domestic product, inflation and unemployment will be analyzed. The focus will be not only on the overall response of the stock index, but also on the differences in the reactions of different industry sectors.

This analysis seeks to find a connection that could also be assessed by using stress test techniques. However, the information necessary to perform such an analysis are publicly unavailable, hence the alternative approach described in this section is used.

The main hypotheses naturally emerge from the previous sections. First of all, life insurers are expected to be more sensitive to changes in interest rates than non-life insurers, due to higher presence of financial options and guarantees in their lines of business. Second of all, the insurance companies and their value are expected to move in the same direction as interest rates, i.e. if the interest rates fall, the value of a company declines as well.

2.4.1 Conceptual Framework

As is evident, the primary variable of interest are the interest rates. Despite the hypothesis that companies are hurt by decreasing interest rates, one must remember that in this case, a stock price reaction to interest rates is evaluated. A negative relationship between stock prices and interest rates has been observed in some studies (e.g. Alam & Uddin, 2009) and is explained in the economic theory by investors switching to riskier and more profitable assets classes, such as equities, when interest rates are low. However, stock prices also reflect the performance of a given company, so that its value decreases when its business is hurt by declining interest rates, as is the case with insurance companies. It remains to be seen which of these effects will prove to be stronger.

Other macroeconomic variables are almost sure to affect the values of stocks as well. The increase in gross domestic product will probably cause the stock value to increase, as a well performing economy will stimulate returns and drive the share price higher. Furthermore, investment is a component of the GDP, which further supports expectations of positive correlation. The effect of unemployment is hard to predict, as it can change along with the economic cycle. Boyd, Jagannathan & Hu (2001), for example, show that stocks react positively to the announcements of rising unemployment during economic expansion and negatively during economic contraction. Inflation is expected to negatively impact the stock prices, even more so in the case of insurers, as the higher inflation decreases profitability due to higher compensation that has to be paid. This applies especially to non-life insurance businesses.

2.4.2 The Data

STOXX 600 Europe is an index comprising stocks of 600 mid-sized companies in 18 European countries. It includes 19 supersectors, the daily prices of which are also reported separately and are publicly available on the STOXX website. Out of these, 4 have been chosen for the analysis, namely Insurance, Banks, Industrial Goods & Services and Real Estate. The first two sectors represent the financial sector, while the remaining two account for the rest of economy in the analysis. These supersectors consist of stocks of 22, 47, 110 and 25 companies, respectively. However, as the comparison of life and non-life insurance companies is of interest, the Insurance was further divided into Life Insurance (7 companies) and Non-Life Insurance (remaining 15 companies), also reported by STOXX. The daily prices are available from as far as 1987 for most sectors but not for Real Estate. This limited analysis to the period between 2001-2015, in order to preserve the balanced panel.

Data on the macroeconomic variables has been collected from the European Central Bank's Statistical Data Warehouse. The primary variable of interest are the interest rates. The yield on a German bond with 10 year maturity was selected to serve as a proxy for the European risk free rate, as it is the most stable. Gross domestic product (in billions of Euro) of the whole EU-28 area should represent the overall state of the economy. The data on unemployment as a percentage of labour force were available for the EU-18, while the data on inflation rate (HICP) were reported for the Euro area. Both should serve as representative for the whole European Union. Finally, to account for overall development of the financial sector over time, prices of S&P Index were obtained from the Yahoo! Finance website.

The data on GDP is seasonally adjusted, but imposes further restriction on the data set, as it is reported only quarterly. For this reason, other variables were obtained in the quarterly frequency as well, whether directly from the source or by simple averaging when unavailable.

This created a balanced panel data set with 10 variables and 280 observations. The variables, along with their names used in the model are presented in the *Table 1* below. The summary statistics for the STOXX, S&P 500 and GDP are displayed in the form of growth rates, so as to provide a more meaningful insight to the reader.

Table 1: Summary statistics

Variable	**Name**	**Form**	**Mean**	**Min.**	**Max.**
STOXX	*stoxx*	growth rate in %*	-0.5	-73.9	30.8
S&*P* 500	*sp500*	growth rate in %*	0.9	-29.5	13.9
GDP	*gdp*	growth rate in %*	0.3	-2.7	1.1
unemployment	*unemp*	in %	9.5	7.25	12.07
inflation	*infl*	in %	1.97	-0.4	3.8
DE 10y bond yield	*de*	in %	3.27	0.7	5.11

** Growth rate obtained using logarithmic differences.*

2.4.3 Econometric Models and Estimation Methods

First of all, the functional forms of the variables will have to be determined. The variables in the percentage form, such as inflation, German bond yield and unemployment will be kept in the level form, the variables in the form of an index or value (STOXX, S&P 500, GDP) will be transformed into logarithms.

It is highly important to test whether the time series are stationary. This will be done using the Augmented Dickey-Fuller test adopted for panel data, accounting for two lags for each variable. Most likely, the individual variable series will not be stationary, as we are dealing with stock indeces and GDP. If this is indeed the case, first differences of nonstationary variables will be calculated in order to obtain series integrated of order zero. All transformations will be summarized in the Results section.

Although the unobserved effects for each industry sector are most likely correlated with some of the explanatory variables and the necessary condition for random effects estimation would not be met, it still has to be proved. Theoretically, this could be done by estimating a simple model

$$stoxx_{it} = \beta_0 + \beta_1 \cdot gdp_{it} + \beta_2 \cdot de_{it} + \beta_3 \cdot infl_{it} + \beta_4 \cdot unemp_{it} + \beta_5 \cdot sp500_{it} + a_i + u_{it} \quad (2.3)$$

both by fixed effects and random effects and running a Hausman test to determine which estimation method should be applied. However, if the serial correlation in errors is present, Hausman test will not work with clustered data. In this case, an alternative, the auxiliary regression-based Hausman test will be run, as proposed by Wooldridge (2002) and programmed for Stata as a test for overidentifying restrictions by Schaffer (2010). Should the null hypothesis be rejected, fixed effects estimation will be used.

It also makes sense to test for serial correlation in errors in the static linear panel model, whether estimated by fixed or random effects. Should it be present, the assumptions for the fixed and random effects models will not be met and the t and F statistics will not be valid. To determine the presence of autocorrelation, Wooldridge test proposed by Wooldridge (2002) and programmed for Stata by David M. Drukker (2003) will be used. If the correlation is present, it will be corrected for by clustering the data by individual STOXX sectors and using the recalculated standard errors for t statistics.

Having thus determined the estimation method, more sophisticated models will be estimated.

In the first phase, all explanatory variables together with their two lags will be included in the model. The first equation to be estimated is therefore:

$$\begin{aligned} stoxx_{it} = \beta_0 + \beta_1 \cdot gdp_{it} + \beta_2 \cdot gdp_{i(t-1)} + \beta_3 \cdot gdp_{i(t-2)} + \\ \beta_4 \cdot de_{it} + \beta_5 \cdot de_{i(t-1)} + \beta_6 \cdot de_{i(t-2)} + \\ \beta_7 \cdot unemp_{it} + \beta_8 \cdot unemp_{i(t-1)} + \beta_9 \cdot unemp_{i(t-2)} + \\ \beta_{10} \cdot infl_{it} + \beta_{11} \cdot infl_{i(t-1)} + \beta_{12} \cdot infl_{i(t-2)} + a_i + u_{it} \end{aligned} \quad (2.4)$$

In the second phase, statistically insignificant explanatory variables will be removed from the model. Finally, dummy variables will be created to represent each STOXX sector. The Industrial Goods and Services will serve as the baseline scenario representing the economy as a whole. Then, interaction terms of the dummy variables and statistically significant explanatory variables will be added to capture the different effect of the variable on different sectors.

2.4.4 Results

To determine whether the series are stationary, the Fisher (Dickey-Fuller inspired) type test for panel data was run. Not surprisingly, all variables except for inflation turned out to be nonstationary. To obtain I(0) series, the variables (again, except for inflation) were differenced. As they were either in the form of logarithms or in the form of percentages, the percentage changes were thus obtained. All applied transformations are summarized in the *Table 2*.

Using the test for serial correlation in random and fixed effects models derived by Wooldridge (2002), the null hypothesis of no serial correlation was strongly rejected with p-value equal to 0.0001. Since serial correlation in panel data models causes biased standard errors, the results are not efficient and the significance of variables using the standard t and F tests cannot be determined, as the t and F statistics would not be valid. This was corrected for by clustering the data by sectors and using the recalculated robust standard errors for t statistics and F statistics.

Table 2: Transformations applied to individual variables

Variable	**Form**	**Differenced**
stoxx	log	yes
sp500	log	yes
gdp	log	yes
unemp	level	yes
infl	level	no
de	level	yes

As the data had to be clustered, the standard Hausman test could not be used. The alternative test was run using the xtoverid module programmed for Stata by Schaffer (2010). The null hypothesis was rejected with p-value of 0.0000. This proved that the main assumption for RE effect estimation $corr(u_i, X) = 0$ is not met. Hence the fixed effect model is appropriate, as it removes this correlation and produces unbiased and consistent estimates of coefficients.

Estimating the first model with 2 lags for every explanatory variables and *de* as a proxy for the risk free rate, the results in the first column of *Table 3* were obtained.

The coefficients on $\Delta unemp$ and it first two lags proved to be insignificant even at the 15% level and the hypothesis of joint insignificance could not be rejected, with p-value of 0.573. Furthermore, the correlation with GDP turned out to be very high, almost 0.8, suggesting some risks of multicollinearity. For these reasons, these explanatory variables were dropped from the model. The first two lags of $\Delta log(gdp)$ were also highly insignificant, both individually and jointly, so they were omitted as well. This fact suggests that the past economy performance does not significantly affect the current value of stocks. After estimating the model without the mentioned explanatory variables, the results in the second column of *Table 3* could be observed.

Table 3: Estimation results

	$\Delta log(stoxx)$		$\Delta log(stoxx)$		$\Delta log(stoxx)$	
$\Delta log(gdp)$	4.031*	(2.06)	3.871**	(2.21)	3.609*	(1.89)
$L.\Delta log(gdp)$	0.607	(0.45)				
$L2.\Delta log(gdp)$	0.225	(0.20)				
$\Delta log(sp500)$	0.883***	(8.46)	0.896***	(8.53)	0.894***	(8.74)
$L.\Delta log(sp500)$	0.228**	(2.68)	0.269***	(3.52)	0.269***	(3.28)
$L2.\Delta log(sp500)$	0.0654	(1.07)	0.0597	(0.78)		
$\Delta unemp$	-0.0181	(-0.44)				
$L.\Delta unemp$	0.0218	(0.43)				
$L2.\Delta unemp$	0.0336	(1.37)				
$infl$	-0.0471***	(-4.69)	-0.0449***	(-4.69)	-0.0287***	(-3.98)
$L.infl$	0.0294	(1.67)	0.0254	(1.35)		
$L2.infl$	0.0211***	(2.85)	0.0204**	(2.31)	0.0295***	(4.64)
Δde	0.0760***	(3.95)	0.0742***	(3.76)	0.0653***	(3.07)
$L.\Delta de$	-0.0346**	(-2.47)	-0.0360**	(-2.58)	-0.0251**	(-2.37)
$L2.\Delta de$	-0.0395***	(-3.11)	-0.0455***	(-3.43)	-0.0449***	(-2.94)
constant	-0.0398***	(-4.47)	-0.0309***	(-5.21)	-0.0289***	(-3.93)

265 observations, t statistics in parentheses

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.05$

Even after these modification, several lags of explanatory variables were redundant, namely the first lag of inflation and second lag of $\Delta log(sp500)$ and. Insignificance of the $\Delta log(sp500)$ after half a year (quarterly data were used) implies that the performance of the financial market as a whole affects the performance of a given index only in the short run. The interpretation of the insignificant first lag of inflation is more complicated, but could reflect the time it takes for inflation expectations to adjust. These explanatory variable proved to be jointly insignificant and the model was once again simplified. The final results can be seen in the third column of *Table 3*.

The coefficient on the $\Delta log(gdp)$ variable decreased slightly, along with the significance, but was kept in the model for control purposes. However, as the variable is still statistically significant at the 15% level, it can be concluded that a 1% increase in the GDP of European Union results in a 3.6% increase in the value of stocks. The positive relationship is not surprising, as the better state of the economy results in better performance of individual companies.

Similarly, the financial market performance affects the performance of individuals stocks, but as the market movements are rather quick and volatile, this effect decreases after one period and disappears altogether after 6 months. Both coefficients are also highly statistically significant.

The data used in the analysis clearly supports the negative relationship between inflation and stock prices. An explanation of this fact could be that with higher inflation, the value of future cash flows of the company decreases, along with the current value that is often estimated through discounting cash flows and dividends. Each percentage point of inflation would thus decrease stock prices by approximately 0.03%. The sign of the coefficient on the lagged variable is opposite, which could suggest that if inflation rate was high in the past, it is likely to be lower today and vice versa.

Finally, the impact of interest rates can be observed. All three coefficients are statistically significant. The positive sign of the coefficient on Δde implies that in the short run, the stock prices reflect the performance of the companies. This also goes in line with the findings of J. P. Morgan Asset Management (2015), who report a positive correlation between rising rates and rising stock prices, when government bond yields are below 5%, which is definitely the case for German bonds. While the impact on specific sectors is still to be seen, it can already be concluded that a 1% increase in the interest rates level causes the stock prices to rise by 0.07%. However, the signs on the lagged variables are negative. This could mean that if the risk free rates have been declining for some time, the investors could seek more profitable asset classes to invest in. If this is a mass occurrence, the stock prices would be pushed higher.

Having thus determined the appropriate amount of lags for each of the explanatory variables, dummy variables for each sector (except for the Industrial Goods and Services) were created along with their interaction terms with each of the explanatory variable and added to the model. The estimation results are reported in *Table 4* below. For the sake of simplicity, the name of original variable is reported in italic, with only individual sector names under it representing the interaction terms.

Table 4: Model with interaction terms, estimation results

	dlstoxx	
Δde	0.09659***	(7.7807e+13)
.life	0.02078***	(1.6756e+13)
.nonlife	-0.02960***	(-2.3747e+13)
.banks	-0.04715***	(-3.7735e+13)
.real estate	-0.1007***	(-8.0780e+13)
L.Δde	-0.04632***	(-1.5660e+14)
.life	0.03255***	(9.7612e+13)
.nonlife	0.004156***	(1.0875e+13)
.banks	0.05647***	(1.9114e+14)
.real estate	0.01313***	(2.8204e+13)
L2.Δde	-0.02467***	(-7.5515e+13)
.life	-0.04739***	(-1.4161e+14)
.nonlife	0.02418***	(6.4006e+13)
.banks	-0.05790***	(-1.6431e+14)
.real estate	-0.02020***	(-5.2223e+13)
$\Delta log(gdp)$	0.5112***	(3.9522e+12)
.life	5.8309***	(4.5022e+13)
.nonlife	-2.7422***	(-2.0953e+13)
.banks	6.5748***	(5.0793e+13)
.real estate	5.8266***	(4.4452e+13)

265 observations t statistics in parentheses

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.05$

	dlstoxx	
$\Delta log(sp500)$	0.7429***	(3.0874e+14)
.life	0.4262***	(1.3778e+14)
.nonlife	0.2797***	(8.0902e+13)
.banks	0.1899***	(7.9007e+13)
.real estate	-0.1422***	(-3.7187e+13)
L.$\Delta log(sp500)$	0.3023***	(6.7178e+13)
.life	-0.1646***	(-3.5148e+13)
.nonlife	0.2137***	(4.7032e+13)
.banks	-0.2492***	(-5.5310e+13)
.real estate	0.03585***	(7.4115e+12)
infl	-0.01649***	(-8.7924e+13)
.life	-0.02465***	(-1.1643e+14)
.nonlife	0.004769***	(2.0884e+13)
.banks	-0.03236***	(-1.6997e+14)
.real estate	-0.008958***	(-3.4235e+13)
L2.infl	0.01050***	(2.5566e+13)
.life	0.02863***	(6.6461e+13)
.nonlife	0.01181***	(2.7621e+13)
.banks	0.03573***	(8.6259e+13)
.real estate	0.01886***	(4.2233e+13)
constant	-0.02895***	(-1.5684e+14)

265 observations t statistics in parentheses

* $p < 0.15$, ** $p < 0.10$, *** $p < 0.05$

Although only some of the coefficients are of particular interest, all interactions terms were added to the model in order to produce consistent estimates. As can be seen, every single variable is very statistically significant at the 5% level. This means that differences in responses to changes in variables between individual sectors are significant, which could, of course, be expected from their nature.

Focusing now on the main topic of this analysis, interest rates, it can be seen that the initial hypothesis has been confirmed. Life insurance sector is indeed more sensitive to the changes in interest rates than non-life insurance sector. In absolute terms, 1% increase in the interest rates will result in approximately 0.12% increase in stock prices of the life insurance companies, compared to only 0.07% in the case of non-life insurance businesses. Stock prices of banks would rise even less, only by 0.05%. This can be explained by the presence of financial options and guarantees in the life segment and the short-term nature of non-life and bank businesses. Interestingly enough, in the longer run, the non-life segment appears to be almost insensitive to interest rates, as the coefficients on base variable and interaction term sum up to zero. The negative relationship of life insurance with interest rates further increases (in absolute terms) in time. A possible interpretation of this could be that if a technical interest rate is higher that the guaranteed rate for a longer time, the investors may switch to other investments.

The coefficients on inflation variables are in line with findings from the previous model, as for all sectors the coefficients are of the same sign (after aggregation). The life insurance business is once again more sensitive than non-life segment, although not as sensitive as banks. Each percentage point of inflation would decrease stock prices by 0.04% for life insurance companies, compared to 0.02% for non-life insurers.

All other remaining coefficients are of the expected sign, with stock prices rising together with the increasing performance of the financial market as a whole. The only dubious result is the coefficient on the interaction term on non-life segment and change in GDP, as it is negative.

To sum up, the main hypotheses could not be rejected. Therefore, it can be concluded that there exists of positive correlation between performance of insurance companies and interest rates and that the life insurance companies are more sensitive to changes in interest rates than other financial sectors, including non-life insurance. However, the presence of autocorrelation even after first differencing suggests that the static model is possibly not the most efficient. The dynamic model with lagged dependent variable could thus be a topic for further research, removing the problem of serial correlation and evaluating how the stock prices are affected by their own past performance.

Conclusion

The aim of this thesis was to provide an overall picture of financial stability of the insurance sector. In the first chapter, a theoretical overview of the topic was presented. The purpose of the second chapter was to identify key risks that insurers face, mainly in the context of current macroeconomic environment.

The most complex and rigorous tool for risk evaluation is the stress testing. However, as it was impossible to conduct a stress test due to unavailability of the necessary data, I have resorted to summarizing the results of a system-wide stress test conducted by EIOPA in 2014. Given the current macroeconomic situation, i.e. the prevailing low-yield environment, the movements in interest rates were identified as a key risk for insurance companies. Indeed, EIOPA has determined that almost a quarter of the insurers would fail to meet a 100% Solvency Capital Requirement threshold in a "Japanese-like" scenario of low interest rates.

This was confirmed also by analyzing the sensitivities published by several big European companies, which use the concept of Embedded Value as a simple risk management technique to evaluate their own financial stability. Under this approach, the market movements are projected to the company's balance sheet and their impact is assessed. It was confirmed that insurers are on average most sensitive to the downward changes in interest rates, with some insurers reporting that a 100bp decline in the interest rate environment would cause a decline in their value as high as 15.90%.

Finally, in order to find the connections that would otherwise be found in a stress test, I focused on the market data. By analyzing the relationship of STOXX 600 Europe index prices and macroeconomic variables such as GDP, inflation and interest rates in the period of 2001-2015, it was concluded that stock prices of insurance companies fall when interest rates fall. Furthermore, the life insurance companies are more sensitive to these changes than non-life insurance companies, due to longer-term nature of their business and the presence of financial options and guarantees. A 1% decrease in interest rates would thus result in 0.12% decrease of stock prices for life insurers and 0.07% decrease for non-life insurers. This further confirmed the findings from previous sections.

In summary, this paper identified the declining interest rates as the biggest current risk to insurers. Given the scarcity of literature on the topic of stress testing of the insurance sector, it could serve as an overall introduction to this subject, providing both theoretical and empirical insights.

References

[1] American Academy of Actuaries (AAA). (2011). Market Consistent Embedded Values. A public policy practice note. Retrieved from http://www.actuary.org/pdf/life/MCEV\%20Practice\%20Note\%20Final\%20WEB\%20031611.pdf

[2] Alam, M. & Uddin, G. S. (2009). Relationship between Interest Rate and Stock Price: Empirical Evidence from Developed and Developing Countries. International Journal of Business and Management, Vol. 4, No. 3, 43-51. doi: 10.5539/ijbm.v4n3p43. Retrieved from https://www.researchgate.net/profile/Md_Mahmudul_Alam/publication/41890900_Relationship_between_Interest_Rate_and_Stock_Price_Empirical_Evidence_from_Developed_and_Developing_Countries/links/09e41505a47293ed98000000.pdf

[3] Assicurazioni Generali. (2014). 2014 Life EV Supplementary Information. Retrieved from http://www.generali.com/330764/2014-FY-Life-EV-PDF.pdf

[4] Blaschke, W., Jones, M.T., Majnoni, G. & Peria, S. M. (2001). Stress Testing of Financial Systems: An Overview of Issues, Methodologies, and FSAP Experiences. IMF working paper, WP/01/88. doi: 10.5089/9781451851168.001. Retrieved from http://www.imf.org/external/pubs/ft/wp/2001/wp0188.pdf.

[5] Boyd, J.H., Jagannathan, R. & Hu, J. (2001). The Stock Market's Reaction to Unemployment News: Why Bad News Is Usually Good For Stocks. NBER working paper series, 8029. doi: 10.2139/ssrn.423982. Retrieved from http://www.nber.org/papers/w8092.pdf

[6] CFO Forum. (2004). European Embedded Value Principles. Retrieved from http://www.cfoforum.nl/letters/eev_principles.pdf

[7] CFO Forum. (2009). Market Consistent Embedded Value Principles & Guidance. Retrieved from http://www.cfoforum.nl/downloads/MCEV_Principles_and_Guidance_October_2009.pdf

[8] Clarke, S., Mitchell, S. & Phelan, E. (2014). Capital management in a Solvency II world. Millman Research Report. Retrieved from https://web.actuaries.ie/sites/default/files/event/2014/10/capital-management-solvency-II.pdf

[9] Čihák, M. (2004). Stress Testing: A Review of Key Concepts. Czech National Bank Research Policy Note No. 2/2004. Retrieved from http://www.cnb.cz/en/research/research_publications/irpn/download/irpn_2_2004.pdf.

[10] Deloitte. (2010). Technical Provisions under Solvency II. Retrieved from http://www.deloitte.com/assets/dcom-belgium/local\%20assets/documents/en/services/aers/actuarial\%20and\%20financial\%20risk\%20advisory/be-aer-fara-solvencyii-technicalprovisions-july2010.pdf.

[11] Drukker, D. M. (2003). Testing for serial correlation in linear panel-data. The Stata Journal, Vol. 3(2), 168-177. Retrieved from: http://www.stata-journal.com/article.html?article=st0039.

[12] European Commission. (2015). Solvency II Overview - Frequently asked questions. Retrieved April 22, 2015, from http://europa.eu/rapid/press-release_MEMO-15-3120_en.htm.

[13] European Insurance and Occupational Pensions Authority (EIOPA). (2014a). EIOPA Financial Stability Report, December 2014. EIOPA-FS-14/105. Retrieved from https://eiopa.europa.eu/Publications/Reports/EIOPA-FS-14-105\%20Financial\%20Stability\%20Report-\%20Autumn\%202014.pdf.

[14] European Insurance and Occupational Pensions Authority (EIOPA). (2014b). Low interest rate environment stock taking exercise. EIOPA-BoS-14/103. Retrieved from https://eiopa.europa.eu/Publications/Surveys/LIR\%20Stock\%20taking\%20exercise\%202014.pdf.

[15] European Insurance and Occupational Pensions Authority (EIOPA). (2014c). EIOPA INsurance stress test 2014. EIOPA-BoS-14/203. Retrieved from https://eiopa.europa.eu/Publications/Surveys/Stress\%20Test\%20Report\%202014.pdf.

[16] Haefeli, D., & Liedtke, P.M. (2012). Insurance and resolution in light of the systemic risk debate: a contribution to the financial stability discussion in insurance. The Geneva Association, iv. ISBN 29-700-3396-8. Retrieved from https://www.genevaassociation.org/media/99359/ga2012-insurance_and_resolution_in_light_of_the_systemic_risk_debate.pdf.

[17] International Actuarial Association (IAA). (2013). Stress Testing and Scenario Analysis. Retrieved from http://www.actuaries.org/CTTEES_SOLV/Documents/StressTestingPaper.pdf.

[18] International Association of Insurance Supervisors (IAIS). (2003). Stress Testing by Insurers. Guidance Paper No. 8.

[19] International Association of Insurance Supervisors (IAIS). (2011). Insurance and Financial Stability. Retrieved from http://forinsurer.com/files/file00400.pdf.

[20] International Monetary Fund and World Bank. (2005). Financial Sector Assessment: a handbook. Washington D.C.: The World Bank. ISBN-10: 0-8213-6432-4. Retrieved from: https://openknowledge.worldbank.org/bitstream/handle/10986/7259/337970rev0Fina10Assessment01PUBLIC1.pdf?sequence=1.

[21] Jobst, A., Sugimoto N., & Broszeit, T. (2014). Macroprudential solvency stress testing of the insurance sector. IMF working paper, WP/14/133. ISBN 9781498394253. Retreived from http://www.imf.org/external/pubs/ft/wp/2014/wp14133.pdf.

[22] Junus, N., Wang, D. & Motiwalla, Z. (2012). Report on Pricing Using Market Consisten Embedded Value (MCEV). Society of Actuaries. Retrieved from https://www.soa.org/Files/Research/Projects/research-report-pricing-report.pdf.

[23] J. P. Morgan, Asset Management. (2015). Guide to the Markets, U.S., 2Q 2015. Market Insights series. Retrieved from https://www.jpmorganfunds.com/blobcontentheader/202/900/1158474868049_jp-littlebook.pdf.

[24] Office of the Superintendent of Financial Institutions Canada. (2009). Stress Testing: Sound Business and Financial Practices. Guideline No E-18. Retrieved from http://www.osfi-bsif.gc.ca/eng/docs/e18.pdf.

[25] Pitselis, G. (2009). Solvency supervision based on a total balance sheet approach. Journal of Computational and Applied Mathematics 233 (2009), 83-96. doi: 10.1007/97890670463369.

[26] Regional Committee FVG. (2012). Principles and models for the Embedded Value calculation. Retrieved from http://www.ordineattuari.it/media/3227/ONA_FVG_EV_752.pdf.

[27] Sandström, A. (2007). Solvency - a historical review and some pragmatic solutions. Bulletin SAA, 2007/1, 11-34. Retrieved from http://www.actuaries.ch/images/getFile?t=bulletin&f=dokument&id=7.

[28] Schaffer, M.E., Stillman, S. (2010). xtoverid: Stata module to calculate tests of overidentifying restrictions after xtreg, xtivreg, xtivreg2 and

xthtaylor. Retrieved from http://ideas.repec.org/c/boc/bocode/s456779.html.

[29] Schmieder, Ch., Puhr, C. & Hasan, M. (2011). Next Generation Balance Sheet Stress Testing. IMF working paper, WP/11/83. doi: 10.5089/9781455226054.001 Retrieved from https://www.imf.org/external/pubs/ft/wp/2011/wp1183.pdf.

[30] Trichet, J.-C. (2005). Financial Stability and the Insurance Sector. The Geneva Papers, 30, 65-71. doi:10.1057/palgrave.gpp.2510021.

[31] Wooldridge, J. (2002). Econometric Analysis of Cross Section and Panel Data. MIT Press. ISBN 978-0262232586.

[32] Wüthrich, M.V., Bühlmann, H. & Furrer, H. (2007). Market-Consistent Actuarial Valuation. EAA Lecture Notes. ISBN 978-3-540-73642-4.

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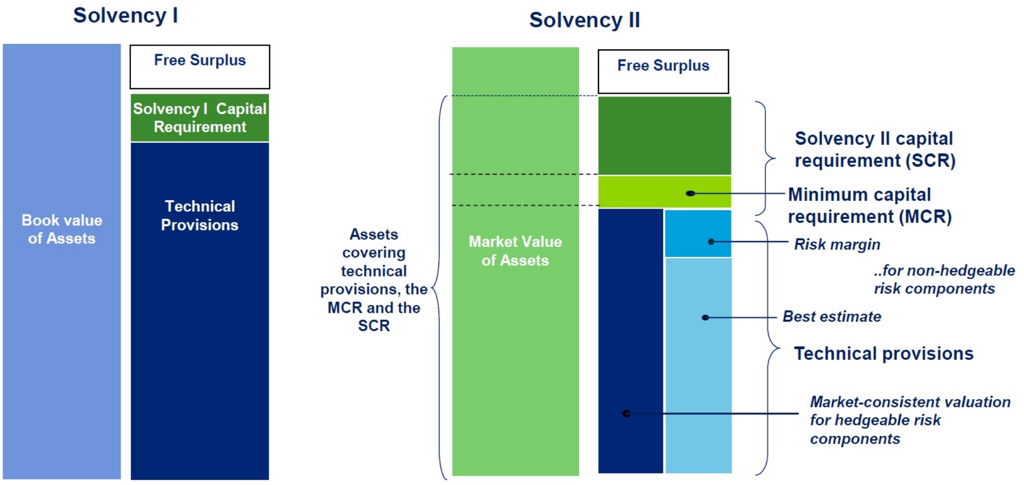
Appendix A

Solvency I and Solvency II balance sheet comparison



Source: Deloitte. (2010)

Summary of most severe single factor insurance stresses

Scenario	Loss as % EOF (gross)	Loss as % EOF (net of RI)	Loss as % EOF (net of RI & LAC)	Reinsurance rate	Initial sample size
Non-Life stress scenarios					
Nat Cat event (1-in-200)	10.9%	4.3%	3.7%	60%	105
Provision deficiency (+3%)	13.4%	10.0%	9.0%	25%	107
Life stress scenarios					
Longevity (18% uplift)	12.3%	11.4%	9.4%	8%	96
Mass Lapse (35%)	15.9%	15.9%	6.7%	0%	103

Source: EIOPA. (2014c)

Mismatches in IRR and Durations of assets and liabilities

Mismatch	IRR (IRR liab - IRR Assets)			Durations (Dur. liab - Dur.Assets)		
Country	BL	LYA	LYB	BL	LYA	LYB
AT	-0.86	-1.82	-1.53	10.09	11.33	10.35
BE	-0.07	-0.17	-0.17	1.37	1.78	1.49
BG	-0.55	-0.18	-0.26	3.27	3.77	3.59
CY	-0.41	-1.21	-0.34	6.20	7.07	6.18
CZ	-1.02	-0.57	-0.50	1.63	1.18	1.05
DE	0.43	0.33	0.24	10.70	11.32	10.87
DK	-0.08	-0.37	-0.32	4.74	5.42	5.21
EE	0.09	-0.35	-0.10	4.98	5.75	5.20
ES	-1.13	-1.20	-1.21	0.75	0.89	0.82
FI	-1.44	-1.02	-0.04	5.36	5.24	3.89
FR	0.56	0.42	0.34	4.82	5.58	5.12
GB	0.07	0.20	0.07	-1.05	-0.44	-0.30
GR	-1.55	-1.80	-1.72	1.98	2.47	2.20
HR	0.55	0.27	0.19	5.89	5.88	5.74
HU	0.43	0.23	0.23	3.03	3.08	2.98
IE	-1.31	-1.50	-1.40	-0.63	-0.80	-0.69
IT	-0.55	-1.00	-0.97	0.81	1.16	1.29
LT	-1.55	-1.70	-1.86	10.55	10.85	10.58
LU	-0.01	0.05	-0.10	5.47	5.20	5.29
MT	1.41	2.98	1.61	7.56	7.39	7.38
NL	-0.22	-0.57	-0.47	5.43	6.16	5.72
PL	0.33	-1.30	-0.97	3.44	4.55	3.95
PT	-1.27	-1.61	-1.13	1.32	1.55	1.38
RO	-1.15	-0.99	-0.96	0.81	0.61	0.66
SE	0.49	0.13	-0.28	10.54	11.78	11.25
SI	-0.69	-1.36	-0.97	8.34	8.98	8.56
SK	-0.82	-1.07	-0.99	-0.72	-0.07	1.08
Average	-0.28	-0.44	-0.54	4.21	4.63	4.38
Std.	0.86	1.08	0.96	3.62	3.83	3.58
Avg + 1.5*std	1.02	1.18	0.90	9.65	10.38	9.75
Avg+1*std	0.59	0.64	0.42	7.84	8.46	7.96
Avg-1*std	-1.14	-1.52	-1.50	0.59	0.80	0.80

Source: CF Analysis

Section IV of the EIOPA stress test report provides detailed information on the methodology applied in the cash flow analysis used as a basis to generate this table.

Note:

Mismatches in this table are calculated as the difference between the internal rate of return (IRR) and the durations of liabilities minus those of assets. Therefore negative mismatch implies higher IRR or duration for assets than for liabilities based on the cash flow reported by the participants in the low yield module on a country basis.

Notation:

IRR: internal rate of return
Dur. Duration
Liab. : liabilities
Avg.: Average
Std: Standard deviation
BL: Baseline
LYA: Low Yield scenario A
LYB: Low Yield scenario B

Colour code:

mismatch > (Avg+ 1.5*std)
(Avg + 1.5*std) > mismatch > (Avg + 1*std)
(Avg + 1*std) > mismatch > (Avg - 1*std)
mismatch < (Avg - 1*std)

Source: EIOPA. (2014c)

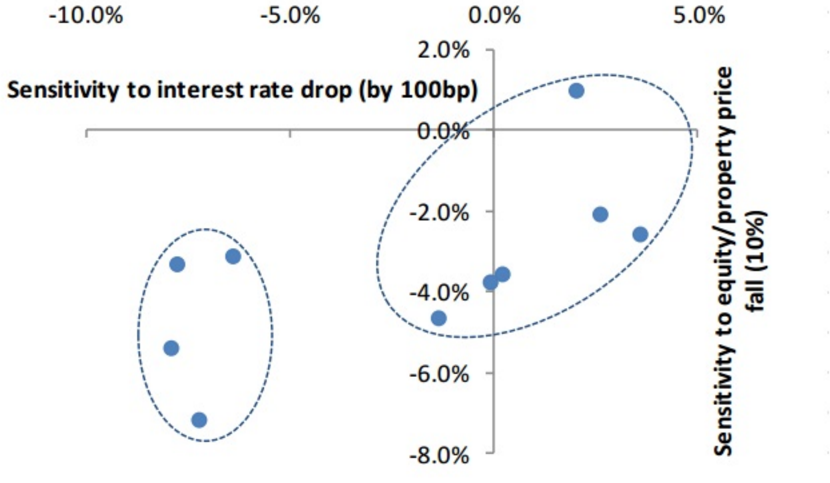
Appendix B

List of companies included in the sensitivity analysis

Company	EV type	EV value in 2014 (millions EUR)
1 AXA Leben	EEV	49,535
2 Prudential	EEV	39,317
3 Allianz Leben	MCEV	26,769
4 Generali	MCEV	25,082
5 AVIVA	MCEV	20,620
6 CNP Assurances	MCEV	17,530
7 Zurich Insurance Group	MCEV	17,168
8 Legal & General	EEV	14,816
9 Swiss Life	MCEV	10,628
10 Standard Life	EEV	6,784
11 Societe General Insurance	EEV	N/A
12 AEGON	EEV	N/A

Source: Embedded value reports by a set of European insurers)

Embedded value sensitivities to interest and property price changes in 2013



Source: EIOPA. (2014a)

Nadzeya Hauryliuk

THESIS PROPOSAL

Proposed Topic:

Financial Stability Issues and Stress Testing of the Insurance Sector

Topic Characteristics:

After the recent crisis, stress testing became more popular as a risk management technique and financial stability assessment tool. It can be employed to assess risks and vulnerabilities on firms' balance sheets and an ability to meet capital requirements under different stress test scenarios.

The purpose of this thesis is to examine methods and principles used in stress tests and their application for the insurance sectors. Sensitivities to some key macroeconomic indicators published by several biggest insurance companies can be collected and analysed. The results, along with the results of an EU-wide stress test conducted by European Insurance and Occupational Pensions Authority in 2014, can provide an overview of risks and vulnerabilities for financial stability of the European insurance sector.

Hypotheses:

1. What are the main risks that the insurers face?
2. What is the methodology of stress testing?
3. How do the changes in macroeconomic indicators affect the value of insurance companies?

Methodology:

Empirical data should be collected from the reports published by the insurance companies on a yearly basis. Thus econometric analysis of time series data can be employed.

Outline:

1. Introduction
2. Theoretical background
    a. Key risks of the insurance sector
    b. Stress testing methodology and implications
3. Empirical part
    a. Data collection and econometric model
    b. Analysis of the results
4. Conclusion

Bibliography:

CFO FORUM. *Market Consistent Embedded Value Principles*. Ottawa, October 2009.

ČIHÁK, M.: Introduction to Applied Stress Testing, IMF WP 07/59, 2007

EIOPA. *EIOPA Stress Test 2014: Specifications*. Frankfurt am Main, April 2014.

EIOPA. *Financial Stability Report*. May 2014, EIOPA-FS-14-044.

INTERNATIONAL ACTUARIAL ASSOCIATION. *Stress Testing and Scenario Analysis*. Ottawa, July 2013.

INTERNATIONAL ASSOCIATION OF INSURANCE SUPERVISORS. *Stress Testing by Insurers: Guidance Paper*. Singapore, October 2003.

KOMÁRKOVÁ, Zlatuše a Marcela GRONYCHOVÁ. CZECH NATIONAL BANK. *Research and Policy Notes: Models for Stress Testing in the Insurance Sector*. Prague, 2012.

Charakter bakalářské práce:

Po nedávné krizi se zátěžové testování stalo populárnější technikou pro řízení rizika a zhodnocení finanční stability. Může být použito pro posouzení rizik na účetních rozvahách společností a jejich schopnosti plnit kapitálové požadavky při různých zátěžových scénářích.

Cílem této práce je zkoumání metod a principů zátěžového testování a jejich aplikace pro pojistné sektory a následná analýza citlivosti na změny důležitých makroekonomických indikátorů, jež jsou publikovány největšími pojišťovnami. Výsledky, společně s výsledky zátěžového testu prováděného v roce 2014 společností EIOPA (European Insurance and Occupational Pensions Authority), by měly poskytnout přehled o rizikách pro finační stabilitu evropského pojistného sektoru.

Hypotézy:

1. Jakým hlavním rizikům čelí pojišťovny?
2. Jaké metody se aplikují při zátěžovém testování?
3. Jak změny makroekonomických veličin ovlivňují hodnotu pojišťoven?

Metodologie:

Empirická data budou shromážděna z ročních zpráv publikovaných pojišťovnami a zkoumána pomocí ekonometrické analýzy časových řad.

Osnova:

1. Úvod
2. Teoretická část
   a. Hlavní rizika pojišťoven
   b. Metody zátěžových testů a jejich důsledky
3. Empirická část
   a. Shromáždění dat a ekonometrický model
   b. Analýza výsledků
4. Závěr

V Praze dne 21.5. 2014 | Podpis řešitele | Podpis vedoucího