Dealing with the ORSA
A Dynamic Risk-Factor Based Approach for the Small, Swedish Non-Life Insurer

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Att handskas med ORSAN
En dynamisk riskfaktor-baserad metod
för små, svenska skadeförsäkringsbolag

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Abstract
The Own Risk and Solvency Assessment, ORSA, is referred to as the heart of the regulation to be for European insurance companies - Solvency II. The aim of the ORSA process is to provide an overall and holistic view of the insurer’s risks by analyzing their current financial status and business strategy at hand. There is no predefined way to implement this process, which means that the companies are forced to develop a model themselves, as they see fit. In collaboration with a regional insurance company in Sweden we develop a structure and framework for an ORSA-model, flexible enough to be used by similar insurers yet standardized enough to overcome the issue of constrained resources within these smaller organizations. We apply a risk-factor based approach and tie together a balance sheet projection and stress testing, designed to be further developed as the individual insurer see fit. The suggested approach yields partially satisfying results and we consider the model to be particularly well-suited for assessing risk in the context of the small, non-life insurer.

Key-words: Solvency II, ORSA, Capital requirement, DFA, Market Risk, Insurance Risk, Correlation, Concentration Risk, Qualitative Assessment, Quantitative Assessment, ERM, Factor model.
**Sammanfattning**


**Nyckelord:** Solvency II, ORSA, Kapitalkrav, DFA, Marknadsrisk, Försäkringsrisk, Koncentrationsrisk, Korrelation, Kvalitativ utvärdering, Kvantitativ utvärdering, ERM, Faktormodell.
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List of Abbreviations

BSCR – Basic Solvency Capital Requirement

BSP - Balance Sheet Projection

CEIOPS - Committee of European Insurance and Occupational Pensions Supervisors

CLR – Classic Linear Regression Model

DFA - Dynamic Financial Analysis

EEA – European Economic Area

EIOPA - European Insurance and Occupational Pensions Authority (Former CEIOPS)

FSA – Financial Services Authority

LTGA – Long Term Guarantee Assessment

OECD – Organisation for Economic Co-operation and Development

ORSA – Own Risk and Solvency Assessment

QIS – Quantitative Impact Study

SCR – Solvency Capital Requirement
1. Introduction
The chapter holds a brief introduction to the intricate nature of the insurance industry leading up to the current situation and the identified quintessential problem on which this thesis is based. The aim and purpose is defined and the chapter is concluded with an outline of the remainder of the thesis as well as a simplified overview of the suggested model construct.

1.1. Background
The insurance industry constitutes a critical part of our socio-economic construct. Through insurance, individuals as well as corporations can receive economic protection against different types of risks. This being the fundamental idea behind insurance; to share the risks that large groups of people are exposed to. During 2012, Swedish insurance companies generated €27.2bn in premium revenue and invested a gross amount of €367.2bn in the global economy (SCB, 2013). A number that corresponds to approximately 89% of the Swedish annual GDP.\(^1\)

Due to the fact that the insurance industry is such a vital part of the economy, large problems arise when an insurance company defaults. Despite these severe implications, approximately 1100 impairments have occurred in the US alone since 1970 (A. M. Best, Inc., 2011). In order to increase the stability in the insurance business and protect the policyholders’ interests, the industry has been faced with continuously revised and tightened regulations over the years. On an EU-level the common regulatory framework has however had some quite obvious weaknesses, and a number of European countries have over the years developed their own plans and models of how to overcome some of these flaws (Hull, 2009).

Although considered a banking crisis, the latest financial crisis statues perhaps the most apparent example of the extreme effects a defaulting insurance company may have on the society as a whole. In 2008, the American insurance corporation AIG had placed fallible bets on credit default swaps’ (CDS’s) and sold insurance on obscure asset-backed securities. AIG was heading for bankruptcy before eventually being bailed out by the government (Schich, 2009). At its peak, the US government had committed as much as $182bn in order to prevent liquidation of the company, making this the largest bail-out yet in the private sector (Wall Street Journal, 2012). This event, among others, more than ever actualized and highlighted the weaknesses of the current regulatory framework.

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\(^1\) Total Swedish GDP 2012 amount to €412.6bn. [http://www.scb.se/Pages/ProductTables____22918.aspx](http://www.scb.se/Pages/ProductTables____22918.aspx)
1.1.1. Current Development and Focus
Julian Adams (2013), the Director of Insurance at the FSA, UK, stated recently that one of the main lessons to be learned from the financial crisis for the insurance industry regulators is that it is imperative for the regulatory capital regime to appropriately capture the risks assumed. Currently, the introduction of the new regulation framework for European insurers, Solvency II is approaching rapidly. Solvency II has a quite different focus from its predecessor Solvency I which is based around predefined rules concerning capital requirements (FSA, 2012). Instead it includes requirements for risk management and has a clear overall risk- or principle-based approach where assets and liabilities are valued according to a market-consistent “economic” approach. More accurately, it is stated that the “solvency requirements should be based on an economic valuation of the whole balance sheet” (CEIOPS, 2009).

Due to updated implementation dates, focus has recently shifted within the different parts of the new regulatory framework and is now mainly directed towards a process dubbed Own Risk and Solvency Assessment (ORSA). Within the ORSA, emphasis is put on developing risk management procedures and involving the insurer in identifying and quantifying risks, and ultimately making the assessment of how resilient their business is to extreme financial distress, or insolvency. Clearly an important step in the right direction towards rectifying the apparent weaknesses of its predecessor. The question is however; at what cost?

Insurance companies acting on the European market are expected to face a non-negligible amount of difficulties in their process of conforming to the Solvency II regulations. Certain parts, or modules, of the ORSA are intricate by nature and may be developed to be extremely complex and resource demanding. Although this adaptation will require a substantial effort from all insurers, the relative implications for smaller organizations will be particularly severe. Hence this thesis target insurers classified by the European insurance supervisory authority, EIOPA (2011.1) as “small”, i.e. insurers with less than €100M in annual premium revenue. This type of organization is typically too small to allocate staff devoted to the ORSA process.

Taking the target group of small, Swedish non-life insurer’s perspective into close consideration, an overall approach based on a risk factor model is to be developed and implemented on a case study object. The idea is to establish a flexible foundation from where to proceed with the implementation of the quantitative parts of the ORSA process. To be able to apply a more straightforward and simplified approach while at the same time producing relevant and realistic results is thus of great importance for the overall relevance of the thesis.
1.2. Problem Statement and Research Questions
The identified main concern regarding the ORSA is closely related to the more quantitative parts of the process including a balance sheet-projection, stress-testing and sensitivity analysis.

- How should an interlinked and flexible model framework be structured that is suitable for the target insurer when assessing their risk exposure under the ORSA?

1.3. Aim & Purpose
The purpose of this thesis is in other words to develop a flexible and transparent model intended for small, non-life insurers in the otherwise complex and resource-consuming process. To fulfill this purpose we suggest an approach based around a risk-factor model, enabling this particular group of insurers to overcome problematic issues concerning the implementation of the ORSA. The aim is for this tool to be complex enough to produce accurate, relatively detailed and credible output while at the same time being comprehensible for members throughout the organization, presumably with varying backgrounds and competencies.

1.4. Delimitations
Given the scope of this thesis as well as the complexity and magnitude of the ORSA-process, certain delimitations had to be made. Even though the model constructed here is considered to be dynamic and flexible in many ways, it is not to be considered appropriate for all insurers placed under the regulation of the Solvency II framework. Rather it has to be appropriately adapted for a predefined type of insurers with a number of common traits that define them. This set of common denominators include size, business diversity, type of insurance provided and to a certain extent also a geographic aspect in terms of the markets where the insurer is active.

The model to be constructed here focus’ solely on non-life insurers since life-insurance undertakings entail another dimension of complexity, primarily due to long claim durations. This requires a slightly different focus when developing an ORSA.

1.5. Outline
In order to fulfill our stipulated research question and develop an appropriate foundation for the target insurer to proceed from when carrying out their ORSA, our work can be divided into four steps:
• Review previous research and identify relevant methods as well as research gaps in order to establish the relevance of this thesis
• Position the thesis in the context of the regulatory framework and adjust the suggested approach in this respect
• Develop and implement an appropriate model based on previous findings
• Analyze and evaluate the results from the implemented model

The outline for the remainder of this report is in short as follows:

Chapter 2 includes an overview of the ORSA highlighting some guidelines and requirements regarding content. This is followed by a literature review in chapter 3 where previous research is covered, identifying relevant methods and techniques as well as research gaps.

Chapter 4 includes a concise walkthrough of the development of the current regulatory framework as well as the upcoming regulation, Solvency II as well as a closer look at the ORSA. In chapter 5 we proceed with an introduction to the Swedish insurance industry and a brief presentation of the case study object used in the thesis. Based on these previous findings, an appropriate approach calibrated to fit the target insurer is developed.

![Figure 1.1 – Initial Overview of the Suggested Model Construct](image)

The figure presents our initial view of the model we plan to construct. The schematic overview show the basic components in our model leaving out the details. The three basic components are the input data application (upper right), the projection model(upper left) and calculation module (low center).
Key theoretical concepts implemented in the suggested model are presented in chapter 6, Theoretical Framework. In the following Methodology chapter (7), the developed approach is explained in great detail, giving a precise outline of the implementation of our approach.

In chapter 8 the results from the implemented model on our case study object are presented, followed by an analysis and discussion. Finally, in chapter 9 the report is ended with a conclusion regarding the obtained results along with suggestions for further research and a recommended development of our model.
2. A Brief Overview of the ORSA
Below follows a brief introduction and overview of the ORSA process. The ORSA is put in the wider context of the Solvency II regulations, and specific implications for the insurers of the implementation of the ORSA are discussed.

2.1. The Process
The ORSA is often referred to as “the heart of Solvency II” (Bernardino, 2011) and as the name suggests, this process is at the core of the new principle-based set of regulations. Insurers within the European Union are required, within Solvency II, to document and report their ORSA to their respective national financial services authority. This documentation provides a holistic perspective over the processes and routines that are used to identify, evaluate, monitor, manage and report the short and long term risks that an insurance company is exposed to or may face (EIOPA, 2011.2). It should also evaluate and determine the amount of capital that is sufficient to ensure that the company’s solvency requirements are met at all times, including under stressed scenarios (EIOPA, 2011.3). The intention with this part of the regulation is in short to increase the level of transparency and self-awareness from the insurer’s point-of-view from a risk perspective. The board of directors as well as management should take active part in this process. The first ORSA is expected to be reported, according to the current time schedule, during 2014.

The ORSA process should include the following steps shown in Figure 2.1

![Figure 2.1 – Components of the ORSA Process](source)

The figure describes the different steps and sub-processes that should be included in the ORSA process. Own compilation based on Bernardino’s presentation (2011).

To handle some of the problems that arise when applying such a common extensive regulation to several markets and companies of different size, EIOPA have designed a proportionality principle. The inclusion of this principle aims to at least partially cope with the
problem of the extensive differences not only in between markets but also between actors on these markets. For example in Sweden, where five of the largest insurers have 83 per cent of the market share, there are big differences between a large and a small insurance company. The proportionality principle states that a small insurer does not have to make as extensive modeling as a large corporation, yet instead choose one appropriate in relation to the nature, scale and complexity of the risk that is measured (EIOPA, 2013.1). Even despite this proportionality principle, it is argued that the larger corporations are handed an unfair competitive advantage within Solvency II with the inherent resources the size of their organizations bring (Svenska Försäkringsföreningen, 2011).
3. Literature Study
In the literature study, previous relevant research is presented. The chapter is mainly concerned with previous work regarding the Solvency II regulation, its effects and implications on the industry as well as approaches for calculating risk in the context of the regulatory framework. A gap in the previous research has been identified as risk measurement models in this context are rarely adjusted to fit the targeted group of insurers specifically.

3.1. An Overview of Solvency II and its Effects
A defaulting insurance company entails extensive harm not only to individual policyholders but on a socioeconomic and societal level as well. To address these problems and to prevent defaults in the industry from occurring, different guidelines of risk and solvency assessment as well as capital regulations have been developed by regulators for quite some time.

One central question addressed in early studies is how solvency regulations will affect and benefit consumers. Munch and Smallwood (1980) and Lee’s re-examination (Lee, 1994) found that most forms of solvency regulations do not have significant preventive effects on insolvency. Furthermore, studies have also found that even in those cases when solvency regulations are effective, consumers might still disbenefit, since these requirements usually lead to raised premiums (Doherty & Schlesinger, 1990).

Using a quantitative approach in their study, Rees, Gravelle & Wambach (1999) show that if the customer is fully informed of the insurer’s insolvency risk, the insurer will always provide enough capital to ensure solvency. They conclude that regulators should focus on increasing transparency in the industry rather than imposing capital requirements.

Munch and Smallwood (1980) find that capital requirements are a particular burden for small insurers, and that these requirements reduce the number of insolvencies only by reducing the number of small firms. This conclusion gain support, e.g. from van Rossum (2005), who also highlight the fact that with increasing regulations come increasing compliance and administrative expenses, something that typically will have a particularly strong effect on smaller insurers. In a longer perspective, this implicates an increased probability of mergers and acquisitions within the industry, resulting in weakened competition and hence fewer alternatives for the costumer.
Previous literature has provided a solid overview of the new Solvency II regulation (Eling, et al., 2007; Steffen, 2008; Doff, 2008) covering the background and construction of the regulatory framework as well as providing critical analyses, highlighting gaps and flaws. The interpretation and implications of the proportionality principle for small insurers is dealt with specifically by Steffen (2008) as he concludes that this sub-group is subject to exemptions and simplifications. Esson and Cooke (2007) discuss various aspects of harmonization that is conducted with Solvency II, such as convergence of solvency assessment and general international financial reporting. Additionally, Karp (2007) and Mankiewicz (2007) also emphasize the convergence of solvency regulation around the world. A most up-to-date example can be found in the United States where the National Association of Insurance Commissioners (NAIC) is presently adopting the European Commission’s ORSA model. The ORSA is planned to be taken into effect in the US during 2015 (NAIC; Financial Condition (E) Committee, 2013).

3.2. Risk Modeling in the Context of Solvency II
While only a few approaches of a standard model under Solvency II have been discussed, internal risk models on the other hand appear frequently and in great variety in the literature (Liebwein, 2006; Sandström, 2006; Schubert & Grießmann, 2007). For instance, Schmeiser (2004) develops an internal risk model for property-liability insurers based on the concept of Dynamic Financial Analysis (DFA).

To analyze future potential financial effects for non-life insurers, two primary techniques are used today - scenario testing and stochastic simulation, also known as DFA. In scenario testing, an insurers business results are projected under a selected, deterministic future scenario. A flaw with this technique is hence that these results are valid only for the, at forehand chosen scenario. When applying a pure DFA approach, thousands of different scenarios are generated stochastically (Kaufmann, et al., 2001). The concept of DFA borrows many concepts from economics and statistics and embraces a systematic approach on how to model the financial status of an insurer. Projections under a variety of possible scenarios illustrate how outcomes are affected by changing internal as well as external factors (Tsiah & Hsieh, 2005; Kaufmann, et al., 2001). Such a model captures the future potential trajectory of the entire balance sheet by incorporating internal risk factors, macroeconomic factors as well as the company’s business plan (Tsiah & Hsieh, 2005; Eling & Parnitzke, 2007; Schmeiser, 2004; Casualty Actuarial Society, 1995).
If we translate Eling and Pamitzke’s description (2007) into more general terms, the process of implementing a DFA-model can be expressed in the following way:

1. **Modeling stage** – Risk drivers and/or factors are being identified. Dependencies between these drivers/factors are incorporated into model framework.
2. **Generation stage** – The modeled business is run through various possible paths, dependent on the modeled stochastic variables.
3. **Analysis stage** – Analysis of results. Critical scenarios are identified and highlighted.
4. **Interpretation stage** – Based on the results in the analysis, the outcomes are interpreted and conclusions are reached regarding how to avoid particularly dangerous scenarios. Proper use of the information retrieved here may act as effective supportive material for management to use in decision-making.

DFA is regarded as a valuable instrument for solvency control and evaluation (Eling & Parnitzke, 2007). The methods used for implementing a DFA varies widely in the literature, partially because of the different areas of use.

In a case study by Schmeiser (2004), he develops a simulation technique based on empirical data to model risk factors identified as being central for a non-life insurer. He argues that by using simulation techniques, one could straightforwardly take into account the correlations between differently distributed random variables. The key risk factors identified by Schmeiser were

- Real estate (domestic)
- Money market
- Stocks (domestic, European, worldwide)
- Bonds (domestic)
- With the insurer affiliated enterprises
- Mortgages (domestic)

These central risk factors were assigned relevant indices (when applicable) from where empirical distributions and key parameters were assessed.

Other approaches include the use of multi-stage stochastic programming models using tree structures (Kouwenberg, 2001) and the concept of copulas to model dependencies in the case of extreme events (Eling & Toplek, 2009; Hult, et al., 2012). The use of copulas is mainly a
response to earlier critique of solely considering linear correlation when modeling dependence structures between heavy-tailed and skewed risks (Embrechts, 2002; Lindskog, 2000).

It should be noted that many smaller or special purpose insurers are exposed to a significantly less complex range of financial risks. Such circumstances should most certainly be taken into consideration when implementing a custom DFA (Casualty Actuarial Society, 1995).

3.3. Stress Testing
Stress testing is a term that describes a range of techniques used to measure the sensitivity of a portfolio under an extreme but plausible shock-scenario. The authors Jones, Hilbers & Slack (2004) also define the objective of a stress test as to understand the sensitivity of the portfolio in relation to changes in various risk factors.

A common approach when designing stress tests is to use deterministic, historical events. An advantage is that these are generally more intuitive than hypothetical scenarios. It is however argued that a macroeconometric model is preferred as a basis of stress testing scenarios. A macro model provides a forward-looking framework for analyzing linkages between the financial system and the real economy (Jones, et al., 2004; Peura & Jokivuolle, 2003). Determining the macroeconomic consequences for a single entity is however a complex task (Peura & Jokivuolle, 2003).

3.4. Contribution
Previous research identifies the small insurer as particularly exposed when regulations are tightened. There is however a gap in the literature concerning how to mitigate these negative effects for this type of insurers. DFA is rather frequently used in the literature to project and analyze future potential financial effects within the insurance industry. This approach in a pure form may not be appropriate for the small, non-life insurer as it requires large resources to implement and interpret.

Our research will contribute with a suggested approach that combines the incorporation of risk factors and a complete projection of the balance sheet with the more straightforward and transparent technique of scenario testing. Such an approach effectively takes into account the risk complexity typically present in the small, non-life insurer’s exposure
4. Background of Regulatory Framework

This section provides a walkthrough of the historical development of the common regulatory framework within the European Union. Particular focus is put on the current development regarding Solvency II and the ORSA process. The chapter is concluded with a discussion on why the ORSA is an especially pressing topic.

4.1. Solvency I

The foundation of the common European regulatory framework was created in 1973 with the “First Non-Life Directive”. A few years later a similar directive was created for the life insurance industry. Over time, extended directives for both Life and Non-Life insurances were developed and in 2002 these were composed into the joint regulatory framework Solvency I - a minimum harmonization directive focused on capital adequacy (FSA, 2012).

With Solvency I, more realistic minimum capital requirements were established, although critique has been uttered regarding that the requirements still do not reflect the true risk faced by the insurers. Furthermore the solvency requirements have been regarded as set too low, leaving policyholders without adequate protection in the event of a deteriorating economy. Another drawback concerns the simplistic set-up of the framework where solvency requirement calculations are mainly based on the corporation’s technical provisions. This leads to a set of regulations that do not effectively promote lower risk per se, as higher provisions in the context of Solvency I will result in a higher solvency margin. (Islam, 2006).

4.2. The Traffic Light System

After the stock market crash during 2000-2002 and the subsequent drop in interest rates, the corporations’ financial positions were severely weakened. To avoid this from reoccurring, the Danish Financial Service Authority developed a stress-testing system called the Traffic Light System in 2001 as a complement to the Solvency I regulations. The procedure is constructed as a two-step process where the insurer may receive a red, yellow, or a green light status. This status stands in direct relation to how two predefined scenarios, stressing a combination of equities, interest rates and real estate are managed (Hull, 2009). Similar procedures were later adopted by different Financial Service Authorities in Europe (Finansinspektionen, 2005).

The Swedish equivalent measures and stress’ an insurer’s risks on both the asset and liability side, indicating the level of capitalization and how well the financial risks and undertakings are managed (Finansinspektionen, 2012). Stressed parameters in the Swedish version include
- Financial risks (interest rate risk, equity risk, property risk, currency risk and credit risk),
- Insurance Risks (outstanding claims, unearned premiums and catastrophe risk) (Finansinspektionen, 2012).

4.3. Solvency II
The Solvency II framework ultimately aims to further increase the protection of policy holders. This is achieved by providing incentives for insurance companies to use modern risk management practices. These practices should be customized appropriately to fit the individual company in terms of size as well as the nature of their business. The aspiration is to reduce the possibility of consumer loss or market disruption in insurance (FSA, 2006). In particular, focus has been intensified in the area of customizing risk measurements and hence allowing for more flexibility for the individual insurer. It is also emphasized that the previous standardized and fixed detailed rules on how to measure assets, liabilities or capital or how to calculate e.g. capital requirements are to become of less importance in favor of a principal-based approach. This would lead to an assessment more closely related to economic market reality (FSA, 2006) and a potentially better understanding of the insurers own risk exposure.

Solvency II, in similarity with the Basel III banking regulations, is organized under three pillars.

![Figure 4.1 – Structural Overview of the Solvency II Regulation Framework](image)

The figure displays the tree different pillars that form the basis of the Solvency II regulatory framework. The figure is an own compilation based on information given by Hull (2009).
4.3.1. **Pillar I – Quantitative Requirements**
Under pillar I, the financial requirements of the Solvency II set of regulations are covered. It mainly revolves around capital adequacy. The method of calculating the capital requirements are substantially regulated (FSA, 2012). Firms are required to calculate two types of capital requirements

- **Solvency Capital Requirement (SCR)** is the level of capital required to cover liabilities over the following 12 months at a confidence level of 99.5%
- **Minimum Capital Requirement (MCR)** is the level required to convince national regulatory supervisors that the liabilities over the following 12 months will be covered at a confidence level of 85%.

(FSA, 2012)

Hence is the MCR a lower requirement whereas the SCR acts as the key solvency control level. However, a breach of the MCR would trigger the ultimate supervisory intervention leading to the withdrawal of authorization (Central Bank of Ireland, 2012).

The method of calculating the above capital requirements are quite firmly regulated. There is either a standard formula for insurers to follow, which is designed to capture the standard risks a generic European firm may face. There is however a possibility for firms to use an internal model, either full or partial, that allows for a more tailored assessment of the company’s risk (FSA, 2012).

4.3.2. **Pillar II - Quantitative Assessment and Risk Management**
Under Pillar II the attention is turned to the individual firm to a greater extent and in particular how the insurer is assessing their own (firm-specific) risks and how they have implemented a system for risk management. An important aspect in pillar II is also the integration of risk awareness and regulatory demands into policies and strategies. The focal point of pillar II is the ORSA process (FSA, 2012).

4.3.3. **Pillar III – Disclosure and Transparency**
The third pillar deals with risk reporting and the aim is to ensure greater transparency through a series of standardized reports. One of which is public while the other is held private between the firm and the national supervisor (FSA, 2012).
4.4. Own Risk and Solvency Assessment

The ORSA process is an extensive process that involves large parts of the organization. It is at the core of Solvency II where emphasis is put on developing risk management procedures. Unlike the Pillar I capital requirements there is no predefined way to implement the ORSA process, neither is it clearly defined within the Solvency II regulations. The point with the loose specification is to force the insurers to assess and analyze their unique own risks and solvency. There are neither currently any plans on instating any instructions on how the ORSA is supposed to be framed and reported. Instead, EIOPA have drawn up a number of guidelines and recommendations that will aid insurance companies on how to design their ORSA. Partly because a key purpose with the ORSA is to connect the strategic plan of the business to the insurers overall solvency requirements, the ORSA will still need to be tailor-made after the companies own unique exposure and business model. The insurer is therefore still liable for developing a customized ORSA as they see fit. By including the strategic plan in the risk and solvency assessment, the management will become increasingly aware of the impact their actions have.

The insurance company’s or group’s board of directors are the official owners of the ORSA process. By making the board of directors solely responsible, the Solvency II framework force management on all levels to fully understand the company’s risks - something that will require involvement from the same in the actual, ongoing process. This also entails that the board needs to understand the potential implications of their actions on the business. Consequently, the ORSA documentation by necessity has to be comprehensible also for a non-actuarial board member.

As a result of the properties stated above, one of the main areas of use for the ORSA is to function as a major administrative tool for the board and management within the company. Even though the documentation of the ORSA provides good insight into the risks the company face, the process at hand forces the company to acquire a good understanding of the risks they are exposed to as well as how different actions may affect those risks. Hence, the ORSA is in this way additionally a great tool for decision-making and strategic analyses.

The process of methodically assessing the risks within the ORSA is recommended by the EIOPA chairman Gabriel Bernardino (2011) to include the following steps
• Identifying relevant risk types
• Decision on which risks are mitigated by capital or by management actions respectively
• Quantification and development of management actions
• Sensitivity analyses
• Formulate specific and external stresses
• Identify key assumptions behind going concern
• Evaluate impact on capital requirement

The time period to be taken into account varies from different companies depending on their exposure and business, however for non-life insurers the relevant planning period is in general between three and five years (Bernardino, 2011). To take longer perspectives into account raises problems with accurately projecting the future success of the strategic business plan. Furthermore the investment horizon for a non-life insurer is typically within this range given an appropriate match between assets and liabilities.

4.4.1. Why Focus on the ORSA?
Although the official implementation date for the Solvency II framework is set to the 1st of January 2014, the capital requirement calculations from Pillar I are expected to be postponed to sometime in 2015-2016 (Bernardino, 2012). This is due to disagreements within the European Commission as well as between national regulators on how the calculations for the different risks should be carried out. But a more urgent matter for the insurance companies was raised in a press release on the 20th of December 2012; the ORSA requirement in Pillar II will still be implemented as scheduled in January 2014 (EIOPA, 2012). This means that the insurance companies now need to calculate capital requirements without the assistance of the standardized calculations within Pillar I. The focus has therefore shifted from the previous uncertainties of the timeframe and instructions within Pillar I to the process of making the ORSA in Pillar II. This will be very resource-demanding and require broad as well as in-depth knowledge in several areas such as law, mathematics and not only insurance risk but also financial risks. Even though a proportionality principle will be applied for the smaller insurance companies, a complete ORSA is required for all the insurers and reinsurers. This will make the process especially challenging for smaller undertakers since they seldom have the resources required given the tough time-constraint at hand.
5. The Swedish Insurance Industry

The following section provides a brief overview and introduction to the Swedish insurance industry. Non-life insurance is described in particular together with a description of the typical Swedish non-life insurer’s asset-portfolio.

5.1. Overview

The insurance industry is often divided into two main types, non-life and life insurance. The life insurance industry covers products that are based on the policy holder’s life and health risk exposures. These products have an important role in the Swedish pension system. The non-life, or general insurance industry covers products covering a large variety of risks, such as automotive, home, travel, property and other types of causality insurance.

The Swedish insurance industry is comprised of 443 active insurers and insurance groups. The market shares are highly concentrated to a few larger companies and insurance groups. Within non-life insurance the five largest companies constitute 83 per cent of the market. The corresponding number for life-insurers adds up to 52 per cent. The international presence has increased during the last ten years and today there are 38 international insurance companies active on the Swedish market.

5.2. Types of Insurance Companies

The legal definition of an insurance company in Sweden allows for two principal types of insurers; proprietary and mutual. A proprietary insurance company is run similar to any other stock-company regardless of their line of business, seeking to maximize profit for their equity investors. A mutual insurance company is instead collectively owned by its policy holders. Hence do the possible earnings of the mutual insurer benefit the policyholders directly, either through some form of dividend or in form of a premium discount. A common criticism towards the mutual insurer construct is that in the case of an unfortunate event, it is problematic to raise capital for these organizations.

5.3. Non-Life Insurance on the Swedish Market

There are 281 non-life insurance companies in Sweden, out of which 182 are local actors (Svenska Försäkringsföreningen, 2011). 132 of these were classified as small, i.e. those with yearly premium revenue of no more than €100M.
Swedish non-life insurers had €7.44bn in yearly premium revenue and investments worth a total of €58bn at the end of 2012 (Finansinspektionen, 2013). The present asset allocation for the industry is mainly allocated in domestic markets with 55% invested in Swedish stock and bonds. For smaller insurance companies, the domestic exposure is even more extensive.

**Figure 5.1 – The Asset Allocation of the Swedish Non-Life Insurers**

The figure illustrates the asset allocation for Swedish non-life insurers. The different major assets classes are presented colorwise with sub-classes divided into slices. The capital invested in each sub-class is shown.

**Figure 5.2 – Relative Asset Allocation in Domestic and Foreign Exposure for Swedish Non-Life Insurers**

The figure presents the relative asset allocation divided into domestic and foreign exposure. The blue (bottom) layer represents the domestic exposure and the red (top) represents the foreign exposure.

Figure 5.1 and Figure 5.2 show the aggregated composition of investments as of 2012-12-31. Total amount €58bn.

Source: SCB (2013)
5.4. A Small, Swedish, Non-Life Insurer
In this thesis, a case study object is used to implement and evaluate our model on an actual insurer within the target group. The case study object is a regional, mutually owned non-life insurer in Sweden. Non-life insurers in general have low exposure to long-duration investments and liabilities. For our case study object, 83% of the interest-bearing financial investments have duration of less than 3 years.

A considerable part of our case study objects financial assets in stocks and shares are private equity. These include significant stakes in the parent company as well as another corporation in the real estate business.
6. Theoretical Framework

This section presents an overview of known relationships between variables and theoretical concepts and models used in this thesis. The theoretical framework consists of three main parts: linear regression, optimization and risk quantification. Linear regression is used in the risk factor model constructed in this thesis while the optimization method is integrated in the reversed stress test construct. The last part describes the predefined method of quantifying risk under Solvency II that may also be used in the ORSA. In this thesis, all risk exposures are measured and evaluated according to this predefined set of calculations.

6.1. Classical Linear Regression (CLR) model

The term econometrics was coined by Ragnar Frisch (1933) and defined as the relation between economic theory, statistics and mathematics. A basic tool in econometrics is regression analysis.

A regression model is composed of three parts, a set of unknown parameters, a set of independent variables and the dependent variable. A standard regression model expresses a dependent variable \( Y \) as a function of independent variables (or covariates) \( X \) and unknown parameters \( \beta \).

\[
Y \approx f(X, \beta)
\]  

(6.1)

Typically an econometrician has a set of measurements including a number of variables available. This set of measurements is usually called a sample. The task is then to quantify the impact of one set of (independent) variables on another (dependent) variable (Hansen, 2013). In many cases, this sought after relation between variables is linear and generates a regression model on the form

\[
Y = \beta X + e
\]  

(6.2)

To solve such an equation for the set of unknown parameters, \( \beta = \begin{pmatrix} \beta_1 \\ \vdots \\ \beta_n \end{pmatrix} \) the most common approach is to use the ordinary least squares estimator (Kennedy, 2011).
The CLR model relies on five assumptions

1. The dependent variable can be calculated as a linear function of a specific set of independent variables.
2. Expected value of the error term is 0
3. The error terms have the same variance and are not correlated (homoskedasticity)
4. Observations on the independent variable can be considered fixed in repeated samples
5. Number of observations is greater than the number of independent variables (Kennedy, 2011)

6.1.1. Ordinary Least Squares (OLS)
The OLS estimator will produce estimates of the unknown parameters $\beta$ by minimizing the sum of the squared residuals between the observed sample and the predictions from the linear approximation.

I.e. the OLS estimator of $\beta$, $\hat{\beta}$, is the value that minimizes $\hat{\epsilon}^t \hat{\epsilon} = |\hat{\epsilon}|^2$ where $\hat{\epsilon} = Y - X\hat{\beta}$. To find the OLS estimator we solve the normal equations for $\hat{\beta}$.

\[ Y = \hat{\beta}X + \hat{\epsilon} \Rightarrow X^t Y = X^t (\hat{\beta}X + \hat{\epsilon}) = X^tX\hat{\beta} + X^t\hat{\epsilon} \] (6.3)

With the assumption that $E[X^t\hat{\epsilon}] = X^tE[\hat{\epsilon}] = 0$ we can write

\[ X^t Y = X^tX\hat{\beta} \Rightarrow \hat{\beta} = (X^tX)^{-1}X^t Y \] (6.4)

The OLS is considered a preferred, optimal estimator in a standard situation. It produces an optimal solution w.r.t. minimizing least squares, yielding the highest $R^2$ and the best unbiasedness (smallest variance-covariance matrix). (Kennedy, 2011)

6.1.2. $R^2$
The $R^2$ statistic is used as a measure of “goodness of fit” and is referred to as the coefficient of determination. It represents the proportion of the variation in the dependent variable “explained” by variation in the independent variables. Hence it is equal to the square of the (sample) correlation between $y$ and $x\hat{\beta}$. (Lang, 2011; Kennedy, 2011) More formally, the sample variance of $y$, $\text{Var}(y)$, can be decomposed into:

\[ \text{Var}(y) = \text{Var}(x\hat{\beta}) + \text{Var}(\hat{\epsilon}) \] (6.5)

The $R^2$ statistic is equal to

\[ R^2 = \frac{\text{Var}(x\hat{\beta})}{\text{Var}(y)} = 1 - \frac{\text{Var}(\hat{\epsilon})}{\text{Var}(y)} \] (6.6)
The OLS maximizes $R^2$ and although there is no generally accepted answer to what a high $R^2$ is, Ames & Reiter (1961) found that an $R^2$ in excess of 0.5 could be obtained by regression on 2-6 variables. However, for cross-sectional data this number is significantly lower (Kennedy, 2011).

6.1.3. Root Mean Square Error (RMSE)

The RMSE, or standard error of the estimate is the standard deviation of the residuals.

$$RMSE = \sqrt{\frac{\sum(y_i - \hat{y}_i)^2}{n}}$$  \hspace{1cm} (6.7)

6.1.4. Multicollinearity

Multicollinearity arises when two or more independent variables are perfectly or approximately linearly dependent (Lang, 2011). This may cause severe estimation problems such as high variances of the OLS estimates. In other words, the estimates become unprecise (Kennedy, 2011). There are a number of ways that multicollinearity can be detected. For instance, if variables with low t-statistics have a high collective F-statistic multicollinearity may be an issue. Further, a correlation matrix can identify paired correlation coefficients between independent variables.

![Figure 6.1 – Illustration of Dependence between Independent Variables](image)

The figure illustrates the explanatory force from the independent variables on the dependent variable. The red intersection between IV 1 and IV 2 indicates the presence of multicollinearity.

Kennedy (2011) suggests a number of possible remedies for dealing with multicollinearity if and when it arises. His first suggestion is however to apply a “rule of thumb” to determine the severity of the problems implicated by multicollinearity. It is suggested that the econometrician should perform regressions on one independent variable, using the others. If
the R2-values from the original regression are all higher than the R2 values from any independent variable regressed on the others, one should proceed by “doing nothing” as multicollinearity will not pose a severe problem.

6.1.5. Stationarity

A time series \( \{X_t, t = 0, \pm 1, \ldots \} \) is said to be (weakly) stationary if

\[
E(X_t) \text{ is independent of } t
\]

and

\[
\gamma_X(t + h, t) = Cov(X_{t+h}, X_t) \text{ is independent of } t \text{ for each } h
\]

(Brockwell & Davis, 2002)

Economic time series are normally subject to a long term trend since they grow over time. This will cause the times series mean to vary (grow) with \( t \). Hence, most unfiltered economic time series in their original form are in fact non-stationary. Running regressions on non-stationary data could produce misleading, or spurious, results in form of delusively high R2 values and large t-statistics. This can cause the econometrician to fallaciously conclude that a meaningful relationship exists between the regression variables (Kennedy, 2011).

There are several methods of testing time series for (non-)stationarity. A common approach is to perform a unit-root test and a wide variety of these tests have been developed recently. However, none of them are very powerful. Box and Jenkins suggest a more qualitative approach where stationarity is assessed through visual inspection of the autocorrelation plot, also known as a correlogram (Kennedy, 2011). If the autocorrelation, specified as

\[
\rho_X(h) = \frac{\gamma_X(t+h, t)}{\gamma_X(t,t)} = Cor(X_{t+h}, X_t)
\]

decays quickly and converges towards zero, this can be used as an indication of non-stationarity (Brockwell & Davis, 2002).

6.1.6. Homoskedasticity

A basic assumption in the CLR model is that all of the error terms have the same variance, i.e. the variance does not depend on \( x \). This assumption enables a model with only one error term instead of \( i \) error terms, where \( i \) equals the number of independent variables used in the regression.

\[
Var(e_i | X) = Var(e) = \sigma^2
\]

(6.8)
This is called homoskedasticity, and may at times be a rather unjustified assumption (Lang, 2011). The complementary notion is called heteroskedasticity and leads to the following model specification

\[ y_i = \sum_{j=0}^{k} x_{ij} \beta_j + e_i, \ i = 1, ..., n \]  

(6.9)

where

\[ E[e_i | X] = 0 \text{ and } Var(e_i | X) = \sigma_i^2 \]  

(6.10)

A model misspecified as homoskedastic yield inconsistent variances of the parameter estimates. It also renders the F-test invalid.

6.1.7. T-Test
A t-test is a statistical test where the test statistic follows a student’s t-distribution. Under the assumption that our regression model follows a normal distribution

\[ y(X) \sim N(\beta X, \sigma^2) \]  

(6.11)

the parameter values \( \beta_i \), can be tested for a given mean value with a t-test.

\[ t_i = \frac{\hat{\beta}_i - \mu}{\sigma} \]  

(6.12)

Here, \( t_i \) follows a Student’s t-distribution. With the null hypothesis \( H_0 = 0 \), we can test whether the parameter value has a statistically significant value other than 0 by evaluating the p-value associated with the t-variable.

6.1.8. P-Value
Under the null hypothesis, the p-value equals the probability of obtaining a value at least as extreme as the test statistic.

\[ p = 2 \Pr(Z \geq |t|) \]  

(6.13)

where \( Z \) and \( t \) are identically distributed.
6.1.9. F-Test for Joint Null-Hypothesis

To test the null-hypothesis that $m$ number of the parameters $\beta_i$'s are all equal to zero, an F-test may be used. If the error terms are assumed to follow a normal distribution, then the F-statistic can be expressed as

$$F = \frac{SSR_r - SSR_{ur}}{m} \times \frac{n - k - 1}{SSR_{ur}} = \frac{n - k - 1}{m} \times \frac{SSR_r - SSR_{ur}}{SSR_{ur}}$$

(6.14)

In case $m=k$, we can rewrite the formula as

$$F = \frac{n - k - 1}{m} \times \frac{SSR_r - SSR_{ur}}{SSR_{ur}} = \frac{n - k - 1}{k} \times \frac{\sum |\hat{\epsilon}|^2 - \sum |\hat{\epsilon}|^2}{\sum |\hat{\epsilon}|^2}$$

$$= \left\{ Var(x) = \frac{1}{k} \sum (x_i - \bar{x})^2 \right\} = \{ E[\hat{\epsilon}] = E[\hat{\epsilon}] = 0 \}$$

$$= \frac{n - k - 1}{k} \times \frac{Var(\hat{\epsilon}) - Var(\hat{\epsilon})}{Var(\hat{\epsilon})}$$

$$= \left\{ Var(y) = Var(x\hat{\beta}) + Var(\hat{\epsilon}) \right\}$$

$$= \left\{ Var(\hat{\epsilon},) = Var(y) - Var(x\hat{\beta}) = Var(y) \right\}$$

$$= \frac{n - k - 1}{k} \times \frac{Var(x\hat{\beta})}{Var(\hat{\epsilon})} = \frac{n - k - 1}{k} \times \frac{Var(y)}{Var(\hat{\epsilon})}$$

$$= \frac{n - k - 1}{k} \times \frac{R^2}{1 - R^2}$$

where

$SSR_r =$ SSR for the restricted model, i.e. with all regressors with coefficients set to zero excluded

$SSR_{ur} =$ Sum of squared residuals for the unrestricted original model

The variable F has a $F(k, n - k - 1)$ distribution under the null hypothesis, so we reject this hypothesis if F is large.

6.1.10. Restricted Least Squares

If incorrect extraneous information is included in the regression model, the estimator will become biased. Removing information will on the other hand cause the variance of the model
to increase. The econometrician is at this point facing a trade-off between bias and variance. The RMSE can be broken down into the sum of the variance and the square of the bias and can thus be used as an aid in this consideration (Kennedy, 2011).

6.2. The Simplex Method
The Nelder-Mead simplex search method, commonly referred to as the simplex method, is a local optimization method originally proposed by John Nelder & Roger Mead (1965). It is an iterative search algorithm starting from an initial simplex (Xiong & Jutan, 2003). The method uses four basic procedures to rescale the initial simplex; reflection, expansion, contraction and shrinkage (Fan & Zahara, 2007). The Nelder-Mead simplex method has been applied in a wide range of different fields (Xiong & Jutan, 2003; Fan & Zahara, 2007).

The simplex method can be used to solve linear optimization problems in their standard form, i.e.

$$\min_{i} Z = c * x \quad (6.16)$$

Subject to

$$Ax = b, x_i \geq 0$$

where

$$x = (x_1, ..., x_n), \quad c = (c_1, ..., c_n)$$

6.3. Solvency Capital Requirement
The Solvency Capital Requirement (SCR) is the main capital requirement that is enforced by Pillar I in the Solvency II framework. Under Pillar I, the insurers have the option of using a predefined standard model for quantifying these risks. It uses predefined ways of calculating risk and incorporates a static quota on the required amount of capital to be held for different risk types. Correlations between asset types and in between liabilities etc. are also given. When considered appropriate, the standard model of quantifying risk may very well be used in the ORSA and have consequently been so. However, it is of great importance throughout the entire ORSA process that the use of all assumptions, models and assigned ratios are carefully motivated. Hence, it is up to the insurer whether the use of standard formulas is appropriate in the context of the ORSA or not.

On behalf of the European Commission, EIOPA have defined the SCR standard formulas in the Quantitative Impact Studies (QIS) reports with the most recent being the Technical Specifications on the Long Term Guarantee Assessment (LTGA). The standard formulas are
based on a number of risk modules each including several sub-modules for various risk types. The risk modules are divided into three underwriting risks (Health, Life and Non-life), two financial risks (Market and Credit Default), and finally Operational risk. The aggregate risk measure is adjusted with respect to intangible assets, loss-absorbing capacity and diversification. The standard SCR calculations as described in the LTGA are calibrated to represent a 99.5% Value-at-risk with 1-year time horizon, and the majority of the calculations are intended to be calculated at a transaction level. Given the focus of this thesis, not all risk-modules and their respective calculations will be considered here. The main areas of concern are the market risk, non-life underwriting risk, default risk and operational risk modules as well as the adjustment module. The following calculations and descriptions are conclusions and summaries from the LTGA – Technical Specifications Part 1 (EIOPA, 2013.1).

The figure illustrates the overall structure of the Solvency Capital Requirement, SCR, for all types of insurance and reinsurance. The figure originates from the Technical Specifications on the LTGA (Part 1), (EIOPA, 2013.1).
6.3.1. Module 1 - Market Risk
The SCR for the whole market risk module is calculated by adding the seven sub-modules together with predefined correlations. The calculations are divided in two, one interest rate up and one interest rate down scenario. In each scenario the SCR for interest rate risk is recalculated and different correlation matrices are assumed in the scenarios. The following formula is given:

\[
SCR_{mkt} = \max \left( \sqrt{(SCR_{up})^T CorrMktUp(SCR_{up})}, \sqrt{(SCR_{down})^T CorrMktDown(SCR_{down})} \right)
\]

where

\[
SCR_{up/down} = (SCR_{Int}, SCR_{Eq}, SCR_{Prop}, SCR_{Spr}, SCR_{Curr}, SCR_{Cncl}, SCR_{ll})^T
\]

is the vector of SCR for the respective sub-modules. The SCR_{Int} is the only SCR value changing between the scenarios.

CorrMktUp/Down = The correlation matrix for the respective sub-modules in an up/down market scenario. The correlation matrices as defined in the LTGA are presented in Appendix I.

The calculations for each sub-module are presented below.

6.3.1.1. Interest Rate Risk
The interest rate sub-module is calculated by stressing the interest rates. This will affect the company’s assets and liabilities that are sensitive to changes in interest rates. Two stress-scenarios are applied; one increase, SCR_{Int}^{up}, and one decrease, SCR_{Int}^{down}, in interest rates. Each capital requirement is then equal to the relative change in net value of asset minus liabilities, \( \Delta NAV \), given the change in interest rates. The stresses are derived by multiplying the assets current interest rate curve by \((1 + s^{up}(t))\) and \((1 + s^{down}(t))\) where \(s^{up}(t)\) and \(s^{down}(t)\) are defined as the relative change in interest rate for an asset with maturity t. The table of relative interest rate changes is presented in its entirety in Appendix I.

6.3.1.2. Equity Risk
Equity risk is divided into two categories, Type 1 and Type 2. Type 1 is defined as all equities and shares listed in regulated markets in the countries which are members of the European Economic Area (EEA) or the Organization for Economic Co-operation and Development
The category Type 2 include non-listed equities, emerging markets, hedge funds and other investments not included elsewhere in the market risk module. The SCR for the sub-module is calculated by simulating a fall in these two categories. The shock is defined as the following:

<table>
<thead>
<tr>
<th>Equity Shock</th>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>39%</td>
<td>49%</td>
</tr>
</tbody>
</table>

The table presents the predefined severity of the equity shock used in the SCR calculations of equity risk.

The capital requirements for the two categories are defined as the effect the equity shock has on the net value of asset minus liabilities. The two shocks are then added by using the correlation matrix given in the LTGA.

The regulations also include a risk mitigating effect, the equity dampener, on the shocks depending on the current market situation. The purpose of the equity dampener is to avoid pro-cyclical effects in the markets. More information about the equity dampener can be found in the Level 2 Implementing Measures on the equity risk sub-module (CEIOPS, 2010).

6.3.1.3. Property Risk
The investments which should be considered within the property risk sub-module are:

- land, buildings and immovable-property rights;
- direct or indirect participations in real estate companies that generate periodic income or which are otherwise intended for investment purposes;
- property investment for the own use of the insurance undertaking.

An investment in companies which are engaged in real estate management, project development or similar activities are included in the equity sub-module and shall therefore not be included here.

The property shock is defined by a 25% decrease in value and the capital requirements is the effect the shock has on the total exposure:

\[
SCR_{prop} = \max(\Delta NAV | \text{property shock}; 0)
\]
6.3.1.4. Currency Risk
The currency risk shall cover changes in foreign currencies. The shocks applied are an instantaneous 25% increase or decrease in value of the foreign currencies against the local currency. The capital requirement for each currency is defined as the maximum change in value before and after the two shocks. Then the total SCR for currency risk is obtained by adding the capital requirements for every currency. The following formula is to illustrate the calculations:

\[ SCR_{curr} = \sum_i \max(\Delta NAV_i | f x \ up \ shock; \Delta NAV_i | f x \ down \ shock; 0) \]  

(6.19)

6.3.1.5. Spread Risk
The spread risk module applies to different types of bonds, asset-backed securities and structured credit products. The spread risk shock is defined as the decrease in value due to the widening of the asset’s credit spreads. The capital requirement is calculated with the following formula:

\[ SCR_{sp} = \sum MV_i \cdot Duration_i \cdot F^{Up}(rating_i) \]  

(6.20)

Where \( F^{Up} \) is a function of the rating class of the credit risk exposure which is calibrated to deliver a shock consistent with VaR 99.5% following a widening of credit spreads. The \( F^{Up} \) value depends on the composition of assets. For example government bonds in general generates lower values and for all government bonds issued by an EEA-state the \( F^{Up} \)-value equals zero. For structured products and derivatives the \( F^{Up} \)-value is increased. The complete tables of prescribed values for \( F^{Up} \) are found in LTGA section 5.9.

6.3.1.6. Concentration Risk
The exposure at default for a single counterparty also needs to be taken into account. The capital requirement calculations are performed in three steps:

1. **Excess Exposure:**

\[ XS_i = \max \left( 0, -\frac{E_i}{Assets} - CT \right), \]  

(6.21)

where Assets is the total amount of assets considered in the concentration risk, \( E_i \) the exposure at default of counterparty \( i \), and CT the threshold depending on rating:
Table 6.2 – Concentration Threshold for Excess Exposure Calculations

<table>
<thead>
<tr>
<th>Rating</th>
<th>Concentration Threshold (CT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA-AAA</td>
<td>3%</td>
</tr>
<tr>
<td>A</td>
<td>3%</td>
</tr>
<tr>
<td>BBB</td>
<td>1.50%</td>
</tr>
<tr>
<td>BB or lower</td>
<td>1.50%</td>
</tr>
</tbody>
</table>

The table presents the predefined concentration thresholds for different ratings. The thresholds are used to calculate the excess exposure in the SRC calculations of concentration risk.

2. Risk Concentration Capital Requirement per ‘name’

The capital requirement per counterparty is calculated by an instantaneous decrease of value:

\[
Conci = XS_i * g_i
\]  \hspace{1cm} (6.22)

where the parameter \( g_i \) is depending on the counterparty’s credit rating or for non-rated counterparties, solvency ratio:

Table 6.3 – The \( g_i \) Parameter

<table>
<thead>
<tr>
<th>Rating</th>
<th>Credit Quality Step</th>
<th>Solvency Ratio</th>
<th>( g_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>1A</td>
<td>&gt;175%</td>
<td>0.12</td>
</tr>
<tr>
<td>AA</td>
<td>1B</td>
<td>&gt;175%</td>
<td>0.12</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>&gt;150%</td>
<td>0.21</td>
</tr>
<tr>
<td>BBB</td>
<td>3</td>
<td>&gt;125%</td>
<td>0.27</td>
</tr>
<tr>
<td>BB or lower</td>
<td>4-6</td>
<td>&lt;125%</td>
<td>0.73</td>
</tr>
</tbody>
</table>

The table presents the predefined parameter \( g_i \) for different credit ratings and solvency ratios used as an instantaneous decrease in value. The parameter is used to calculate the capital requirements for concentration risk per counterparty.

3. Aggregation

At last the total capital requirement is determined by:

\[
SCR_{conc} = \sqrt{\sum_i (Conci)^2}
\]  \hspace{1cm} (6.23)

where the defaults of different counterparties are assumed to be uncorrelated (in accordance with the LTGA).
6.3.1.7. **Counter Cyclical Premium**
As the equity dampener the purpose of the counter cyclical premium is to avoid pro-cyclicality and thereby stabilize the insurer’s long term products. It manages this by adding the premium on to the risk free rate used to value long term liabilities. Due to the long term properties of this adjustment measure it is rarely applied in a non-life insurance company. More information about this measure can be found in the second part of the LTGA Technical Specifications Part II (EIOPA, 2013.2).

6.3.2. **Module 2 – Counterparty Credit Default Risk**
The counterparty credit default risk module is designed to reflect possible losses due to unexpected defaults or deterioration in credit rating. The risk is divided into two types of exposure with respect to liability types. Type 1 exposure covers risk mitigating, cash at bank and legally binding commitments which may create payment obligations. This also includes reinsurance. Type 2 exposures include all credit contract not included in the spread risk module or in the Type 1 exposure within counterparty credit default risk. In particular it contains receivables from intermediaries, policy holder debtors and mortgage loans.

The capital requirement for Type 1 exposure depends on the quality and quantity of the exposure, as a result the calculations are quite comprehensive. On the other hand the requirement for Type 2 exposure depends solely on the quantity of the exposure and the calculations are quite straightforward. The details of the calculations are presented in Appendix I.

6.3.3. **Module 3 - Non-Life Underwriting Risk**
Non-life underwriting risk contains three types of sub-modules, namely premium and reserve risk, lapse risk and catastrophe risk. The capital requirement is determined by combining the requirements from the sub-modules as

\[
SCR_{nl} = \sqrt{NL^T \cdot CorrNL \cdot NL}
\]  

(6.24)

where

\[
NL = \begin{pmatrix}
NL_{pr} \\
NL_{lapse} \\
NL_{CAT}
\end{pmatrix}
\]

and CorrNL is the corresponding correlation matrix.
6.3.3.1. Non-Life Premium and Reserve Risk
In order to calculate the premium and reserve risk capital requirement, the insurer needs to estimate claims, written and earned premiums for each line of business over the forthcoming year. Volume measure and standard deviation is derived for every line of business and thereafter added together to determine the combined volume measure and standard deviation. Finally the capital requirement calculations for the premium and reserve risk is determined by:

\[ NL_{pr} = \rho(\sigma) \cdot V \]  

(6.25)

where

- \( V \) is the Volume measure, a function of future estimations and historical data of earned and written premiums
- \( \sigma \) is the combined standard deviation
- \( \rho(\sigma) \) is a function of the combined standard deviation

For a detailed description of the definitions and calculations, see Appendix I.

6.3.3.2. Lapse Risk
Lapse risk is the risk that policyholders options turn out to be faulty or needs to be changed. Examples of policyholder options are options to terminate contracts in advance or renew contracts according to previous agreements. The SCR is determined by taking the maximum change in net value assets minus liabilities when applying three different lapse scenarios, a permanent decrease, a permanent increase of the rates of lapsation and a mass lapse event. More detailed calculations and descriptions are found in the LTGA section 9.3.

6.3.3.3. Catastrophe Risk
The standard calculations for catastrophe risk are based around 1-in-200-years scenarios, and to what extent these affect the insurer. The scenarios are divided into two main types, natural catastrophes and man-made. Natural catastrophes include Windstorm, Flood, Earthquake, Hail and Subsidence. Man-made catastrophes are defined as extreme events arising from Motor, Fire, Marine, Aviation, Liability, Credit & Suretyship and Terrorism. Correlation matrices are predefined for every scenario-type and for different countries. These calculations are extensive and to describe them all here would be somewhat overwhelming. The interested reader is instead referred to the Non-life CAT risk sub-module chapter, section 9.4, in the LTGA.
6.3.4. Operational Risk

The operational risk SCR calculations under Solvency II are quite straightforward. The calculations are based on a max/min function of the aggregated SCR for the other sub-modules, premium earnings and technical provisions.

\[
SCR_{op} = \min \left( 0.3 \times BSCR, \max \left( Op_{premiums}, Op_{provisions} \right) \right)
\] (6.26)

For more information about the complete calculations used, see Appendix I.

6.3.5. Adjustment

The final step in completing the SCR-calculations is to determine the loss-absorbing capacity for the insurer. These adjustments are divided into two categories, one based on future discretionary benefits and the other one on the deferred taxes. Future discretionary benefits commonly only appear in life insurance and are not an issue for non-life insurers. The deferred taxes are based on the tax shield, where a maximum of 50 % of the company’s deferred taxes can be used as loss-absorbing effects.

6.4. Proportionality and Simplifications

To handle some of the problems that arise when applying a common extensive regulation to many markets and companies of different size, EIOPA have designed a proportionality principle. This to some extent copes with the problem that there are very big differences between not only the markets but also the companies within. For example in Sweden, where five of the largest non-life insurance companies have 83 per cent of the market share, there are big differences between a large and a small insurance company. This issue is addressed via the proportionality principle which states that a small insurer does not have to make as extensive modeling as a large corporation.
7. Methodology
The methodology chapter provides a detailed description of the methods used in order to fulfill the aim of this thesis. An outline of the steps that will be covered in the process of constructing the suggested model is described, along with a discussion on the practical application of the theoretical concepts.

7.1. Choice of Methodology
Due to the purpose of the ORSA, we have decided to focus primarily on those parts where an external advisor can contribute to the insurer’s own process. The aim is to provide an assessable model for the intended user, namely the small, Swedish non-life insurer. With transparency and interpretability in mind, the models developed are designed to pose an appropriate fit for the intended target market.

7.2. Overview
Given the prerequisite that the “solvency requirements should be based on an economic valuation of the whole balance sheet” (CEIOPS, 2009) and the central part the BSP has in the ORSA, we have chosen to proceed from the balance sheet in the construction of the approach proposed here. By combining methods used in general econometrics, corporate valuation and using the fundamental approach behind DFA we strive to design a dynamic model used for linking the BSP, stress tests and an extensive sensitivity analysis that constitutes the core of the quantitative modeling in the context of the ORSA. We tie these parts together with a number of overlying risk factors. By defining dependencies and linking these to market data and the insurer’s balance sheet, the result is a flexible framework responsive to further, future expansions and development. The approach is evaluated in form of a case study on a small, Swedish non-life insurer.

The concept of DFA uses advanced stochastic modeling to produce large numbers of future possible scenarios. These models are in general extremely complex and sophisticated and consequently require heavy calculations. A too sophisticated model is however partially deemed unfit in the context of this thesis as manageability and transparency of this model are most important aspects when creating a solution suitable to the target market. The basic approach on the other hand, as outlined by Eling and Pamitzke (2007) offers many valuable constituents for a simpler and more tangible approach like the one suggested here.
Figure 7.1 – Overview of the Implemented Model

To create and evaluate this model we plan to take the following steps (in a chronological order):

1. Identification of risk factors
2. Establishing dependencies
3. Projecting the balance sheet
4. Transforming the balance sheet
5. Defining and linking stress tests
6. Calculating capital requirements
7. Analyzing and evaluating results

7.3. Identifying Risk Factors
When identifying relevant risk factors for our model, a couple of aspects had to be taken into certain consideration. As the model suggested here should target a group of insurer’s (small, Swedish non-life) rather than a single company, the chosen risk factors should be representative for this particular group. Furthermore, they must be able to explain a significant extent of the variations in the insurer’s balance sheet.
The identified risk factors can be divided into two categories; asset classes and insurance-related. The review of previous literature within the area identifies a number of key risk factors for non-life insurers (Schmeiser, 2004). Aggregate data over the Swedish non-life insurance industry displays an asset allocation that is highly concentrated on the domestic markets, with a large proportion of domestic stocks and bonds. A closer look at various insurers’ balance sheets combined with the notion of common practice within corporate valuation and discounted cash flow (DCF) methods where revenues play a central part, additional potential insurance-related key risk factors were identified. The latter were then further supported via consultation with several representatives from the Swedish insurance industry. All with relevant experience from risk management. The key risk factors identified and later used in the model suggested here are presented in Figure 7.2.

Figure 7.2 – Identified Key Risk Factors

The figure presents the identified key risk factors that on which the factor model is based on.

The figure is our own compilation.

The above-identified risk factors were then assigned underlying historical data that appropriately represent them. The factors stocks and bonds were assigned relevant indices to capture the dynamics of these. Stocks are represented by the OMXS30 index that captures the overall fluctuations on the Swedish stock market. Bonds are modeled with an index comprised of several types of bonds, reflecting the general movement on the Swedish bond market. Real estate was modeled with empirical data of real estate pricing on the Swedish market provided by IPD (Investment Property Databank, 2013). The insurance-related risk
factors were all represented by historical industry data comprised of aggregate numbers for Swedish non-life insurers. This empirical data was supplied by Svensk Försäkring\(^2\).

7.4. Projecting the Balance Sheet and P&L Account  
To create one particular scenario that the model proceeds from, a so-called “base case”, we use a combination of the insurer’s and professional analyst’s economic expectations, linear regression methods, corporate valuation methods and historical averages. These are subject to a clear hierarchy and are applied by preference accordingly. The base case is projected over a time span of 3 years ahead.

![Figure 7.3 – The Hierarchy for the Projection Method](image-url)

7.4.1. Integrating the Business Plan  
Due to the fact that the risk is to be assessed over the relevant strategic planning period (three years) the demands on projections, sensitivity analyses and stress tests are high. To model the future is obviously quite complex and difficult. A major problematic issue is to take the company’s strategic plan into consideration when trying to predict the future. Since the model suggested here is of the generic kind, a standardized set of information is required as input. This includes premium revenue forecast at an insurance type level, stock market projections and an interest rate forecast.

The base case scenario should reflect the, in the insurer’s own opinion, most probable projection of their statement of financial position and comprehensive income and it is probable to believe most insurers would have an opinion regarding the above. However, in case an insurer would not have formed an opinion of the development on the stock market or the term structure of interest rates, an alternative is then to use alternative projections. In our model, forecasts made by the equity research and fixed income research groups at

\(^2\) [http://www.svenskforsakring.se/](http://www.svenskforsakring.se/)
Handelsbanken are used\(^3\). The development on the real estate market is estimated based on a historical weighted average of the liquid Swedish real estate market over the past twelve years, provided by IPD (Investment Property Databank, 2013).

### 7.4.2. Definition of Hierarchical Criteria

A number of conditions have to be imposed in order for the model to appropriately evaluate and select among the given information. The selection algorithm follows the internal data ranking as described above. The insurer’s view always has top priority as it reflects the most probable scenario and hence constitutes a cornerstone of the base case scenario. In case the insurer does not have a pre-defined view, the risk factor model deploying linear regression is used, where the overlying risk factors are estimated by external professional analysts. In case of weak or inconclusive results, the particular row is instead projected based on the insurer’s expected premium revenue. The regression coefficient criterion is based on the test statistics and manual intervention. Since these kind of statistical tests require a certain amount of qualitative type of analysis, we have chosen not to try to automate this process completely. Instead a “red flag” system is put in place with the intention of considerably facilitating the manual selection.

A number of items in the balance sheet has however been taken into special consideration, excluding them from the selection process described. Not all items on the balance sheet and P&L account are relevant to model with a number of risk factors like the ones used here or even set to relate with premium revenues. Some items are functions of others and are hence treated accordingly. One such item is the “Tax on profit” which instead is set at the Swedish corporate tax rate multiplied by the current year’s net profit before tax. A few items are also considered to be modeled most accurately by historical averages due to e.g. developments that are close to static, and have been treated as exceptions.

### 7.4.3. Linear Regression Model

To identify and assess the relation between the identified risk factors and the insurer’s P&L and balance sheet we deploy the following linear regression model

\[ \Delta l = \beta_0 + \beta_1 x_1 + \cdots + \beta_5 x_5 + e \]  

(7.1)

Or, with matrix notation

\[ Y = \beta X + e \]  

(7.2)

\(^3\) Fixed income forecasts available at [http://research.handelsbanken.se/fi-fx-credits-commodities/](http://research.handelsbanken.se/fi-fx-credits-commodities/). The equity forecast data is however not made public by the equity research team.
Where $X$ represents the vector of risk factors

$$X = \begin{pmatrix}
    x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5
\end{pmatrix} = \begin{pmatrix}
    \text{Stocks} \\ \text{Bonds} \\ \text{Real Estate} \\ \text{Premium Revenue} \\ \text{Insurance Claims}
\end{pmatrix} \quad (7.3)$$

and

$$Y = \begin{pmatrix}
    y_1 \\ y_2 \\ \vdots \\ y_n
\end{pmatrix} \quad (7.4)$$

$$y_i = \Delta t = \text{Relative change of row } i \text{ from previous point of measurement} \quad (7.5)$$

Using the “red flag” system as described previously, every regression is evaluated based primarily on two criterions; the $R^2$ statistic and the p-value. The $R^2$ statistic is considered acceptable if a minimum value of $R^2_{\text{min}} = 0.5$ is attained. A statistic lower than the $R^2_{\text{min}}$ boundary will result in a red flag. As discussed in the texts by Lang (2011) and Kennedy (2011), a $R^2$ close to 1 should also raise question marks. Unmotivated high $R^2$ values could be the result of spurious regression caused e.g. by non-stationary time series’. As a result, an $R^2 > 0.9$ will raise a “yellow flag”, telling the user to use extra caution. In the same way, a p-value > 0.5 will cause the covariate to be red-flagged. If one or more covariates are indeed red-flagged due to high p-values, a restricted regression will be run with the red-flagged covariates excluded from the model. This leaves the user with two options based on linear regression.

<table>
<thead>
<tr>
<th>$R^2$</th>
<th>$R^2&lt;0.5$</th>
<th>0.5$&lt;R^2&lt;0.9$</th>
<th>$R^2&lt;0.9$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P$-value</td>
<td>P&lt;0.5</td>
<td>p&gt;0.5</td>
<td></td>
</tr>
</tbody>
</table>

The table illustrates the criteria on $R^2$ and $p$-values which we impose in order to facilitate the evaluation process for the insurer.

Rather obviously, the risk factors will be correlated to some extent. This would imply that multicollinearity is present in the data set and could potentially render the regression estimations useless. We apply Kennedy’s (2011) first rule of thumb and regress the risk factors on each other and evaluate the $R^2$ values in comparison with the values from the regressions.
7.5. Transforming the Balance Sheet
In order to transform the balance sheet from current IFRS standards to an economic valuation compliant with the QIS5 and in accordance with the Solvency II regulation framework, a number of considerations have to be made. First and foremost, as it is stated that the assets and liabilities should be valued at the amount for which they could be exchanged, transferred or settled between knowledgeable willing parties (EIOPA, 2013.1), certain items have to be removed. Goodwill is one such item. Other items have to be transformed from book value to market value.

An important item in this regard is the provisions for claims outstanding and provisions for unearned premiums. The PV’s of these reserves are highly dependent on the associated discount factor. Accounting standards allow for quite rough estimates and the deviation from the value at which willing parties may exchange or settle in an arm’s length transaction can therefore become relatively large.

7.6. Stress Tests
Under Solvency II, EIOPA requires the insurer to regularly carry out stress tests on a regular basis. The scope and frequency of these tests should be in line with the nature, scale and complexity of the insurer’s business, taking use of the principle of proportionality (EIOPA, 2011.3).

After constructing a base case scenario, the insurer is to stress the balance sheet in order to assess their resilience in case of an unfortunate event. We have chosen to do this in three ways – through sensitivity analysis, with deterministic stress scenarios and using reversed stress tests. Our method provides the insurer with comprehensive information on how their financial situation will persist in extreme situations. In all types of stress testing used here, we use a “top-down” approach where we measure the relative sudden changes in the specified risk factors and uses the same hierarchical set-up and linkage as described above (excluding the insurer’s own view). The European Commission (2013.1) highlights that if the considered stress is assumed to be instantaneous, no management actions may be assumed. All deterministic stresses applied in this model are considered to be instantaneous.

7.6.1. Sensitivity Analysis
By isolating risk factors one at a time and re-evaluating these under the base case scenario, the implications on the insurer’s solvency quota as a result of a sudden change in one of these factors is made visible. The sensitivity analyses are primarily used for isolating stresses on
assets in the insurer’s portfolio. As a second step these isolated stress tests are combined and made visible in a matrix form, illustrating the implications of simultaneous movements in more than one factor.

### 7.6.2. Deterministic Stressed Scenarios

Even though history is unlikely to repeat itself, historical extreme events act as a relevant proxy for modeling future catastrophic situations. In particular they reveal a broader picture as large sudden changes in certain markets are likely to have an effect on many more. The chain of events and domino effects in large extreme events are highly complex and difficult to properly trace. By using deterministic historical events, we can empirically incorporate these types of effects and linkages. The historical events used here are

- Housing bubble (August 7 1990)
- Russian default (August 17 1998)
- Burst of the IT-bubble (May 18 2000)
- 9/11 (September 11 2001)
- The Lehman Crash (September 15 2008)

To measure the effects of these historic events, a time period of one year following the defined “event-date” is examined. In accordance with the guidelines expressed in the Solvency II directives, a conservative approach is used. Every risk factor is treated separately and the worst case development under the examined period is identified independently of the other risk factors. I.e.

\[
\Delta_{j,\text{stress}} = \min \left( \frac{S_{j,1} - S_{j,0}}{S_{j,0}}, \ldots, \frac{S_{j,30} - S_{j,0}}{S_{j,0}} \right)
\]

(7.6)

where \(\Delta_{j,\text{stress}}\) is the worst case development of risk factor \(j\). Under this definition, the aggregated worst case stress can be based on data from different dates. The scenarios are determined using the same data sets as in the regression. An exception is the event Housing bubble where the bond prices are estimated from Swedish 5 year yields on mortgage bonds retrieved from Bloomberg.

One major limitation to the stress tests carried out here is that we have not isolated the effects on the insurance-specific risk factors from the historical events. To find and link these effects is anything but straightforward and due to limited access to data we have chosen not to try to include this in the example carried out in this thesis.
7.6.3. Reversed Stress Tests
The stress tests used above can be utilized in another way, namely in a “reversed order”. A reversed stress test aim to find exactly those scenarios that causes an insurer in this context to precisely cross the line of becoming insolvent. Reversed stress tests are not a substitute for regular stress tests, but rather a complement (Grundke, 2011).

When implementing the reversed stress tests, a primary motive was to design these to be as tangible as possible. Our reversed stress tests proceed from the deterministic stress tests described above. A deterministic scenario is solved for a multiple corresponding to a target value of a solvency capital ratio of 1.0. This resulting linear optimization problem is solved using the Simplex method. In other words, the reversed stress tests yield a maximum endurance level before the insurer’s business turns insolvent expressed as a multiple of a historical extreme event.

7.7. Connecting the Capital Base and Capital Requirements
After a P&L and BS have been constructed under a certain scenario, the overall solvency of the insurer is evaluated. The capital base is calculated from the projected numbers. The capital requirements have to be calculated with the SCR-models or similar. These require more detailed input data than what is shown on the balance sheet. The insurer’s own projection in terms of e.g. premium revenue is used to calculate the SCR under the base case scenario. However under alternative scenarios, these figures may very well have changed on an aggregate level. Given that no further information is available, a simplification is made where the relative composition of revenues and liabilities is kept static and scaled before used as input in the SCR calculations.

7.8. Data
The articles covered in the literature review conducted in this study are mainly derived from the scientific databases Social Science Research Network (SSRN), JSTOR Business and Business Source Elite (EBSCO). The primary source of regulatory related information stems from official material published by the European Commission, EIOPA, CEIOPS as well as publications from the Swedish, British and American financial services authorities.

To implement the actual model, relatively large sets of data were required. Internal data required from the insurer include
- Historical P&L and BS
- Current portfolio data
- Premium revenues divided by insurance type
- Reserves data divided by insurance type

Market data required include
- Historical stock market returns
- Historical bond market data
- Historical real estate and housing price data
- Historical premium earnings for the Swedish non-life insurance industry
- Historical insurance claims for the Swedish non-life insurance industry

The market data was acquired primarily from the financial database provided by Bloomberg. Bond index data was provided by Handelsbanken and historical real estate and housing price data from IPD (Investment Property Databank, 2013). The premium earnings and insurance claims are acquired from the Swedish Insurance Association, SFF. The historical time period used for the input data is 2000-2012.

7.9. Capital Requirement
We have chosen to proceed from the capital requirements that are imposed by Pillar I in our ORSA calculations. The guidelines presented in Technical Specifications on the LTGA (EIOPA, 2013.1) have been used. The methods are in most cases rather straightforward and the concept is well known within the industry. Following is the assumptions and simplifications that have been made to the calculations. The underlying reasons for these simplifications are to a large extent dependent on the restrictions in our dataset and how the input data is assembled as well as the limited scope of this thesis. One important simplification that has been made is that the calculations have not been carried out on individual assets but rather have they been bucketed in what we consider to be an appropriate way.

For the intended target group of insurers, certain SCR risk modules have been removed since they are likely not to apply or have a negligible impact on their business. Instead, this has resulted in the following SCR structure:
The figure illustrates our identified structure for the Solvency Capital Requirement, SCR, for our case study object and similar insurance and reinsurance businesses. The figure is our own composition based on the illustration in the Technical Specifications on the LTGA (Part 1). (EIOPA, 2013.1).

7.9.1. Market Risk

7.9.1.1. Interest Rate Risk

When calculating interest rate risk with the SCR standard model, a predefined table of relative change-ratios divided by maturity buckets is prescribed in the LTGA. We have chosen to use a slightly less detailed bucketing due to the accuracy of the data available to us. We have tried to use a conservative approach when we bucket the input data for the interest-rate shocks. The following stresses have been used as input in our model:

<table>
<thead>
<tr>
<th>Maturity t (years)</th>
<th>Relative Change $s^{UP}(t)$</th>
<th>Relative Change $s^{Down}(t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 year</td>
<td>70%</td>
<td>-75%</td>
</tr>
<tr>
<td>&lt; 3 years</td>
<td>70%</td>
<td>-65%</td>
</tr>
<tr>
<td>&lt; 5 years</td>
<td>59%</td>
<td>-50%</td>
</tr>
<tr>
<td>&lt; 10 years</td>
<td>49%</td>
<td>-39%</td>
</tr>
<tr>
<td>≥ 10 years</td>
<td>31%</td>
<td>-28%</td>
</tr>
</tbody>
</table>

The table presents the predefined changes in interest rate as the percentage of the current interest rate for the different time buckets used. $s^{UP}(t)$ is the market up scenario, where the interest rates increase, and $s^{Down}(t)$ is the market down scenario, where interest rates consequently decrease.
Another simplification that has been made is that only the interest-bearing assets have been stressed while the liabilities have been left out. The interest rate has a large effect on an insurance company’s liabilities and should therefore also be exposed to an interest rate shock. In this case, our data restricts us from reevaluating the liabilities after a shock. This is however not considered a major issue since the liabilities of a non-life insurer is characterized by short durations and hence is not affected by interest-rate risk in the same way as life-insurers.

7.9.1.2. Equity Risk
The equity risk calculations as defined in the LTGA and described in section 6.3.1.2 Equity risk are straightforward. The capital requirements are derived after first dividing the case study objects exposure into the predefined buckets divided by markets and asset types. In these calculations we also chose to ignore the risk mitigating effect presented in the Solvency II framework. We do this to make our model more generic and to ensure that it is conservative.

7.9.1.3. Property Risk
Our case study object does not have any direct exposure to real estate. They do however have some real estate exposure through stocks in a real estate company. This exposure is included in the capital requirements for property risk. This is done in accordance with the predefined definitions from the LTGA, as described in section 6.3.1.3 Property risk.

7.9.1.4. Currency Risk
Given that our study object is a local Swedish insurer the foreign exposure is low and consequently, so is the currency exposure. The company does also minimize this risk by hedging the different currencies. The capital requirement for the not fully hedged currencies is done by a decrease in all currencies simultaneously by 25 %.

7.9.1.5. Spread Risk
When we derive the capital requirements for spread risk we create rating-buckets for the bonds instead of treating all assets individually. The F-weights used for the buckets are chosen conservatively as follows:
Table 7.3 – F-Weights for our SCR Calculations for Spread Risk

<table>
<thead>
<tr>
<th>Rating</th>
<th>$f^{up}$</th>
<th>Duration Floor</th>
<th>Duration Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>0.9%</td>
<td>1</td>
<td>36</td>
</tr>
<tr>
<td>AA</td>
<td>1.1%</td>
<td>1</td>
<td>29</td>
</tr>
<tr>
<td>A</td>
<td>1.4%</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>BBB</td>
<td>2.5%</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>BB</td>
<td>4.5%</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>B or lower</td>
<td>7.5%</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Unrated</td>
<td>3.0%</td>
<td>1</td>
<td>12</td>
</tr>
</tbody>
</table>

The table presents the weights for counterparty credit ratings. The weights are used as a risk measure when determining the insurer’s spread risk.

7.9.1.6. Concentration Risk
Due to the fact that our case study object has large exposure to a few unrated companies, which is a problem for many local insurance companies, this post is therefore of great importance in these cases. We start of by determining the excess exposure of the company’s investments given the predefined thresholds. The aggregated concentration risk is then acquired by summarizing the risks for the different exposures which exceeds the thresholds. These calculations can be found in Appendix I.

7.9.1.7. Counter Cyclical Premium
We chose not to include the counter cyclical premium into our SCR calculations due to the fact that our case study object is a non-life insurer and therefore this sub-module will have very little effect.

7.9.1.8. Total Market Risk
The total market risk is finally added up by using the predefined correlation matrices from the LTGA. The correlation matrix used can be found in Appendix I.

7.9.2. Underwriting Risk, Non-Life and Health
Within underwriting risk, the calculations are made in several steps and the health insurance parts are separated from the non-life insurance. The standard calculations are followed, including the predefined input variables.

The calculations for the health insurance related risk are the same as for non-life insurance related risk. The difference lies in the input value of the standard deviations. We assume no correlation between health and non-life undertakings. For more details on how the calculations are made, see Appendix I.
Due to restraints in our input data lapse risk is excluded from our calculations. The effects from lapse risk is however quite limited for a non-life insurer with a liability-portfolio comprised of contracts with short durations in general.

To determine the catastrophe risk many different assumptions has to be made and a lot of data is needed to base these assumptions on, and due to our time constraints we chosen to use our study objects own calculations as our SCR for non-life catastrophe risk.

7.9.3. Counterparty Credit Default Risk
The standard calculations for counterparty credit default risk are straightforward but due to the aggregations in our dataset we need to make some assumptions when calculating the SCR for credit default risk. Due to this fact we have no information about the Type 2 exposure and therefore we only calculate the SCR for the Type 1 exposure. Because of this we chose to ignore the SCR lowering effect on type 1 exposures and use the multiple 5. Defined as $i f \sqrt{V} \leq 7.05\% \sum LGD_i$ then use a lower multiple, 3, when making the final calculation. This is in order to make sure we are as conservative as possible.

7.9.4. Operational Risk
The SCR for operational risk is calculated in accordance with the LTGA and as presented in section 6.3.4 Operational risk. No deviations from the standard calculations were made.

7.9.5. Adjustments
We only use the deferred taxes as a loss-absorbing capacity effect as future discretionary benefits do not apply to our case study object. For the deferred taxes, we utilize the full amount allowed, i.e. 50%.
8. Results, Analysis and Discussion
The results presented here is the outcome of the BSP, statistics from the linear regression model as well as the results from the sensitivity analysis and stressed scenarios. All numerical results were derived from implementing the model on the case study object used in this thesis. This implicates that all in-data in terms of portfolio structure, future estimates and so on are actual figures provided from this particular insurer. The results from the implemented model are continuously analyzed and discussed. We provide our interpretation of the results and highlight those parts that we find especially noteworthy.

8.1. BSP under the Base Case Scenario
The projection of the P&L and balance sheet shows an overall consistency with the estimated development in the identified risk factors. Occasional discrepancies can be contributed to the flexibility in the model as items are projected using different models. Since we have not received a complete set of future estimates from the case study object, several risk factors were projected using alternative estimations. The projections of the two first risk factors are based on data from Handelsbanken’s research departments. The third factor has been estimated based on historical data and the insurance-related risk factors represent the case study objects own view.

<table>
<thead>
<tr>
<th>Risk Factor 1 Stock Market</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Factor 2 Bond Market</td>
<td>1.3%</td>
<td>1.3%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Risk Factor 3 Real Estate Market</td>
<td>4.0%</td>
<td>4.0%</td>
<td>4.0%</td>
</tr>
<tr>
<td>Risk Factor 4 Premium Revenue</td>
<td>3.2%</td>
<td>2.8%</td>
<td>2.6%</td>
</tr>
<tr>
<td>Risk Factor 5 Insurance Claims</td>
<td>3.2%</td>
<td>2.8%</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

The table presents the expected development in each factor. These expectations create our base case prognosis and are used as a starting point for our simulations.

The result of the balance sheet projection based on the base case is presented below. The original data from the annual report is presented along with the transformed market valuation. Alongside is the resulting three-year prognosis which proceeds from the market valued data. The model have used the following estimation methods in the projection.
The table display the number of items projected in the base case scenario using the approaches presented above.

Table 8.3 – Our Case Study Objects Profit and Loss Account for 2012-2015

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical account of non-life insurance</td>
<td>Premiums from insurance contracts</td>
<td>1</td>
<td>4,837</td>
<td>4,837</td>
<td>4,992</td>
<td>5,132</td>
</tr>
<tr>
<td></td>
<td>Premiums ceded to reinsurers (-)</td>
<td>5</td>
<td>-306</td>
<td>-306</td>
<td>-316</td>
<td>-325</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>4,531</td>
<td>4,531</td>
<td>4,676</td>
<td>4,807</td>
<td>4,932</td>
</tr>
<tr>
<td></td>
<td>Investment income transferred from financial operations</td>
<td>2</td>
<td>177</td>
<td>177</td>
<td>187</td>
<td>199</td>
</tr>
<tr>
<td>Claims incurred (net of reinsurance)</td>
<td>4,708</td>
<td>4,708</td>
<td>4,863</td>
<td>5,006</td>
<td>5,144</td>
<td></td>
</tr>
<tr>
<td>Claims paid</td>
<td>Gross</td>
<td>1</td>
<td>-3,770</td>
<td>-3,770</td>
<td>-3,890</td>
<td>-3,999</td>
</tr>
<tr>
<td></td>
<td>Reinsurers’ share (+)</td>
<td>3</td>
<td>294</td>
<td>294</td>
<td>229</td>
<td>235</td>
</tr>
<tr>
<td>Change in provision for claims outstanding</td>
<td>Gross</td>
<td>5</td>
<td>45</td>
<td>144</td>
<td>-515</td>
<td>-553</td>
</tr>
<tr>
<td></td>
<td>Reinsurers’ share (+)</td>
<td>5</td>
<td>159</td>
<td>141</td>
<td>-1</td>
<td>47</td>
</tr>
<tr>
<td>Total</td>
<td>-3,271</td>
<td>-3,191</td>
<td>-4,177</td>
<td>-4,270</td>
<td>-4,410</td>
<td></td>
</tr>
<tr>
<td>Operational costs</td>
<td>4</td>
<td>-971</td>
<td>-971</td>
<td>-996</td>
<td>-1,021</td>
<td>-1,048</td>
</tr>
<tr>
<td>Insurance earnings before bonuses and rebates</td>
<td>465</td>
<td>546</td>
<td>-310</td>
<td>-285</td>
<td>-314</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bonuses and rebates</td>
<td>5</td>
<td>-9</td>
<td>-9</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technical result</td>
<td>456</td>
<td>537</td>
<td>-310</td>
<td>-285</td>
<td>-314</td>
<td></td>
</tr>
<tr>
<td>Non-technical account of non-life insurance</td>
<td>Investment income</td>
<td>3</td>
<td>338</td>
<td>338</td>
<td>548</td>
<td>563</td>
</tr>
<tr>
<td></td>
<td>Unrealised gains on investments</td>
<td>3</td>
<td>888</td>
<td>888</td>
<td>688</td>
<td>708</td>
</tr>
<tr>
<td></td>
<td>Investment charges</td>
<td>3</td>
<td>-464</td>
<td>-464</td>
<td>-282</td>
<td>-290</td>
</tr>
<tr>
<td></td>
<td>Unrealised losses on investments</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>-128</td>
<td>-132</td>
</tr>
<tr>
<td>Investment result</td>
<td>762</td>
<td>762</td>
<td>826</td>
<td>849</td>
<td>871</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allocated investment return transferred to technical acc.</td>
<td>2</td>
<td>-177</td>
<td>-177</td>
<td>-187</td>
<td>-199</td>
</tr>
<tr>
<td>Remaining capital</td>
<td>586</td>
<td>586</td>
<td>639</td>
<td>650</td>
<td>659</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other income</td>
<td>3</td>
<td>656</td>
<td>656</td>
<td>510</td>
<td>525</td>
</tr>
<tr>
<td></td>
<td>Other expenses</td>
<td>3</td>
<td>-733</td>
<td>-733</td>
<td>-601</td>
<td>-617</td>
</tr>
<tr>
<td></td>
<td>Results of subsidiaries</td>
<td>3</td>
<td>-5</td>
<td>-5</td>
<td>-6</td>
<td>-6</td>
</tr>
<tr>
<td>Profit before appropriations and taxes</td>
<td>960</td>
<td>1,041</td>
<td>232</td>
<td>266</td>
<td>244</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Allocations</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>-51</td>
<td>-58</td>
</tr>
<tr>
<td>Profit before tax</td>
<td>960</td>
<td>1,041</td>
<td>181</td>
<td>207</td>
<td>190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tax on profit</td>
<td>5</td>
<td>40</td>
<td>40</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Profit for the year</td>
<td>1,000</td>
<td>1,081</td>
<td>181</td>
<td>207</td>
<td>190</td>
<td></td>
</tr>
</tbody>
</table>

The table presents the profit and loss account for our case study object for 2012 including our three-year prognosis. The 2012 MV is a revaluation from accounting standards into a market valuation on which the prognosis is based.
Table 8.4 – Our Case Study Objects Balance Sheet, Part I – Assets for 2012-2015

<table>
<thead>
<tr>
<th>Balance sheet Part I - Assets</th>
<th>1 January - 31 December</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 2012</td>
</tr>
<tr>
<td>Kkr</td>
<td></td>
</tr>
<tr>
<td>Intangible assets</td>
<td></td>
</tr>
<tr>
<td>Goodwill</td>
<td>-</td>
</tr>
<tr>
<td>Other Intangible assets</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
</tr>
<tr>
<td>Land and buildings</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>-</td>
</tr>
<tr>
<td>Financial assets</td>
<td></td>
</tr>
<tr>
<td>Equity and shares</td>
<td>1</td>
</tr>
<tr>
<td>Bonds and other interest-bearing contracts</td>
<td>1</td>
</tr>
<tr>
<td>Other loans</td>
<td>3</td>
</tr>
<tr>
<td>Derivatives</td>
<td>3</td>
</tr>
<tr>
<td>Securities from reinsurance</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>14 611</td>
</tr>
<tr>
<td>Reinsurers share of technical provisions</td>
<td></td>
</tr>
<tr>
<td>Reinsurers share of claims outstanding</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>2 032</td>
</tr>
<tr>
<td>Receivables</td>
<td></td>
</tr>
<tr>
<td>Receivables arising out of direct insurance operations</td>
<td>2</td>
</tr>
<tr>
<td>Receivables arising out of reinsurance operations</td>
<td>2</td>
</tr>
<tr>
<td>Tax receivables</td>
<td>5</td>
</tr>
<tr>
<td>Other receivables</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>1 957</td>
</tr>
<tr>
<td>Tangible assets</td>
<td>3</td>
</tr>
<tr>
<td>Cash and cash equivalents</td>
<td>3</td>
</tr>
<tr>
<td>Other assets</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>449</td>
</tr>
<tr>
<td>Prepaid expenses and accrued income</td>
<td>4</td>
</tr>
<tr>
<td>Deferred acquisition costs</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>181</td>
</tr>
<tr>
<td>Total assets</td>
<td>19 278</td>
</tr>
</tbody>
</table>

The table presents the first part of the balance sheet for our case study object for 2012 including our three-year prognosis.

The 2012 MV is a revaluation from accounting standards into a market valuation on which the prognosis is based.
Table 8.5 – Our Case Study Objects Balance Sheet, Part II – Equity & Liabilities for 2012-2015

Balance sheet Part II – Equity & Liabilities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other funds</td>
<td>3</td>
<td>3 453</td>
<td>3 453</td>
<td>3 651</td>
<td>3 753</td>
<td>3 851</td>
</tr>
<tr>
<td>Profit carried forward including net profit for the year</td>
<td>5</td>
<td>3 784</td>
<td>4 834</td>
<td>5 326</td>
<td>6 013</td>
<td>6 803</td>
</tr>
<tr>
<td>Total equity:</td>
<td></td>
<td>7 237</td>
<td>8 287</td>
<td>8 977</td>
<td>9 766</td>
<td>10 654</td>
</tr>
<tr>
<td>Provisions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical provisions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provisions for unearned premiums and unexpired risks</td>
<td>2</td>
<td>2 110</td>
<td>1 993</td>
<td>2 131</td>
<td>2 269</td>
<td>2 410</td>
</tr>
<tr>
<td>Provisions for claims outstanding</td>
<td>2</td>
<td>6 991</td>
<td>5 674</td>
<td>6 189</td>
<td>6 742</td>
<td>7 336</td>
</tr>
<tr>
<td>Bonuses and discounts</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>105</td>
<td>108</td>
<td>111</td>
</tr>
<tr>
<td>Total</td>
<td>9 101</td>
<td>7 667</td>
<td>8 425</td>
<td>9 119</td>
<td>9 857</td>
<td></td>
</tr>
<tr>
<td>Provisions for other risks and charges</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pensions and similar obligations</td>
<td>3</td>
<td>86</td>
<td>86</td>
<td>112</td>
<td>115</td>
<td>118</td>
</tr>
<tr>
<td>Deferred tax liability</td>
<td>5</td>
<td>1 599</td>
<td>1 599</td>
<td>1 599</td>
<td>1 599</td>
<td>1 599</td>
</tr>
<tr>
<td>Other provisions</td>
<td>2</td>
<td>49</td>
<td>49</td>
<td>55</td>
<td>62</td>
<td>70</td>
</tr>
<tr>
<td>Total</td>
<td>1 734</td>
<td>1 734</td>
<td>1 765</td>
<td>1 775</td>
<td>1 786</td>
<td></td>
</tr>
<tr>
<td>Total provisions</td>
<td>10 835</td>
<td>9 401</td>
<td>10 191</td>
<td>10 895</td>
<td>11 643</td>
<td></td>
</tr>
<tr>
<td>Creditors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creditors arising out of direct insurance operations</td>
<td>3</td>
<td>134</td>
<td>134</td>
<td>105</td>
<td>108</td>
<td>110</td>
</tr>
<tr>
<td>Creditors arising out of reinsurance operations</td>
<td>3</td>
<td>64</td>
<td>64</td>
<td>116</td>
<td>119</td>
<td>122</td>
</tr>
<tr>
<td>Derivatives</td>
<td>3</td>
<td>13</td>
<td>13</td>
<td>17</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>Tax liabilities</td>
<td>3</td>
<td>24</td>
<td>24</td>
<td>42</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>Other creditors</td>
<td>3</td>
<td>285</td>
<td>285</td>
<td>286</td>
<td>294</td>
<td>302</td>
</tr>
<tr>
<td>Total</td>
<td>519</td>
<td>519</td>
<td>566</td>
<td>582</td>
<td>597</td>
<td></td>
</tr>
<tr>
<td>Accruals and deferred income</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other accruals and deferred income</td>
<td>3</td>
<td>687</td>
<td>687</td>
<td>623</td>
<td>641</td>
<td>657</td>
</tr>
<tr>
<td>Total</td>
<td>687</td>
<td>687</td>
<td>623</td>
<td>641</td>
<td>657</td>
<td></td>
</tr>
<tr>
<td>Total current liabilities and provisions</td>
<td>1 206</td>
<td>1 206</td>
<td>1 189</td>
<td>1 223</td>
<td>1 254</td>
<td></td>
</tr>
<tr>
<td>Total equity and liabilities</td>
<td>19 278</td>
<td>18 894</td>
<td>20 358</td>
<td>21 883</td>
<td>23 552</td>
<td></td>
</tr>
</tbody>
</table>

The table presents the second part of the balance sheet for our case study object for 2012, including our three-year prognosis. The 2012 MV is a revaluation from accounting standards into a market valuation on which the prognosis is based.

8.1.1. Analysis and Discussion

The BSP under the base case scenario yielded an overall good consistency in the projections. Some discrepancies can however be found if we compare the estimates with the actual result from 2012. For instance, profit for the year has taken a big leap. This is due to the technical result, and more specifically the “change in provision for claims outstanding”. 2012 was an exceptional year and was not consistent compared to older historical data and ratios. This will cause the estimates for the next time-period to deviate significantly. Comparing the projected numbers to the years pre-2012 indicates that the projections were consistent with these results. The actual accuracy of the projections is of course difficult to validate.
8.2. Risk Factor Model

In the case study, the risk factor model was used on a total number of seven items in the P&L and the BS. This equals close to 20 % of the potential total number of items that could have been modeled with linear regression. Out of these seven, six were re-regressed using a restricted model.

To assess the potential issue of multicollinearity, the following correlation matrix between the risk factors were produced:

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Bonds</th>
<th>Real Estate</th>
<th>Premium Revenue</th>
<th>Insurance Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stocks</td>
<td>1</td>
<td>0.612</td>
<td>0.305</td>
<td>-0.203</td>
<td>-0.004</td>
</tr>
<tr>
<td>Bonds</td>
<td>1</td>
<td>-0.221</td>
<td>-0.110</td>
<td>0.221</td>
<td></td>
</tr>
<tr>
<td>Real Estate</td>
<td>1</td>
<td></td>
<td>-0.059</td>
<td>-0.335</td>
<td></td>
</tr>
<tr>
<td>Premium Revenue</td>
<td></td>
<td></td>
<td>1</td>
<td>0.606</td>
<td></td>
</tr>
<tr>
<td>Insurance Claims</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the empirical correlations between the different factors.

In accordance with the multicollinearity “rule of thumb”, the $R^2$ values from the regression on one risk factor, using the others were produced. The largest $R^2$ value has been highlighted in Table 8.7.

<table>
<thead>
<tr>
<th></th>
<th>Stocks</th>
<th>Bonds</th>
<th>Real Estate</th>
<th>Premium Revenue</th>
<th>Insurance Claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R^2$ value</td>
<td>0.594</td>
<td>0.567</td>
<td>0.430</td>
<td>0.463</td>
<td>0.515</td>
</tr>
</tbody>
</table>

8.2.1. Analysis and Discussion

From the output of the regression, we consider the automated part of the constructed model to be successful. The algorithm manages to produce valid estimations in terms of the test statistics. To a great extent, the accuracy of the estimations is also considered to be improved when a restricted regression is run. To conclude whether a regression is to be viewed as successful or not can be problematic since there are no distinct lines to be drawn. A single statistic like the $R^2$ is not sufficient ground to base that decision on. When we have analyzed the results from the regressions, a number of aspects have been taken into account. Besides the $R^2$ we have focused on standard errors, the F-test statistic and the p-values of the coefficients.
In line with what we anticipated, the results in Table 8.6 show that the risk factors are indeed correlated. The maximum $R^2$-value between the risk factors was however lower than any $R^2$-value from any regression used. This led us to proceed according to Peter Kennedy’s (2011) first suggestion – we did nothing. Additionally, virtually all of the t-statistics of the coefficients in the regressions used had a value higher than two. This further suggests that multicollinearity will not endanger the accuracy of the regression results produced.

The identified risk factors were used in approximately one in five in our model given the constraints that were imposed. This result is considered successful since the projection is significantly enhanced by the risk factor model. Furthermore, several items on the P&L and Balance Sheet are not even considered for the risk factor model. The reason being that they include many detailed and specific items on a level that is difficult to link to general factors like the ones proposed. It is also extremely important to be aware of the fact that correlation does not necessarily imply causality. This is perhaps particularly essential in the context of the balance sheet since several items are interlinked. Our approach of at forehand selecting a group of potential items on which we tried to apply the risk factor model did however limit the risk of making such false conclusions.

The selection of the five risk factors is an important aspect of the relevance of the resulting risk factor model. Since the composition of a typical Swedish, non-life insurer is comprised mainly by stocks and bonds as well as some exposure toward the real estate market, the corresponding risk factors can be included quite naturally in a risk factor model like the one suggested here. Premium revenues and insurance claims are at the core of the insurer’s liabilities and is an important part of the development of their financial situation. The aspect of expandability has also been taken into consideration from our side in the set-up of the risk factor model.

Potentially, several other factors could have been chosen as part of our risk factor model although the majority of factors identified in previous research by Schmeiser (2004) were included. Particularly liability and insurance specific factors could be strong candidates to include in the model we have constructed. Provisions are one such potential candidate. In this study however, we had limited access to data and have been unable to experiment with additional risk factors.
8.3. Sensitivity Analysis

It is important to note that the sensitivity analysis and the stress tests proceed from the P&L and balance sheet projections under the base case, i.e. the changes in the risk factors proceeds from the current level as projected in the base case scenario. If any factors are not affected by a particular stress of the projection, these will remain as in the base case prognosis. In the sensitivity analyses, this method effectively illustrates how the insurer’s financial situation will be altered if their own beliefs in part turn out to be too optimistic.

The following matrices display the resulting solvency capital ratio under various hypothetical scenarios. The matrices illustrate simultaneous movements in two of the identified risk factors and its effect on the case study object. All scenarios are calculated under the base case projection at 31-12-2013.

<table>
<thead>
<tr>
<th>Stocks</th>
<th>1.3%</th>
<th>-0.7%</th>
<th>-2.7%</th>
<th>-4.7%</th>
<th>-6.7%</th>
<th>-8.7%</th>
<th>-10.7%</th>
<th>-12.7%</th>
<th>-14.7%</th>
<th>-16.7%</th>
<th>-18.7%</th>
<th>-20.7%</th>
</tr>
</thead>
<tbody>
<tr>
<td>-9%</td>
<td>2.16</td>
<td>2.14</td>
<td>2.12</td>
<td>2.09</td>
<td>2.07</td>
<td>2.05</td>
<td>2.02</td>
<td>2.00</td>
<td>1.98</td>
<td>1.95</td>
<td>1.92</td>
<td>1.90</td>
</tr>
<tr>
<td>4%</td>
<td>2.14</td>
<td>2.12</td>
<td>2.10</td>
<td>2.07</td>
<td>2.05</td>
<td>2.03</td>
<td>2.00</td>
<td>1.98</td>
<td>1.95</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
</tr>
<tr>
<td>-1%</td>
<td>2.12</td>
<td>2.10</td>
<td>2.08</td>
<td>2.05</td>
<td>2.03</td>
<td>2.00</td>
<td>1.98</td>
<td>1.95</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
</tr>
<tr>
<td>-6%</td>
<td>2.10</td>
<td>2.08</td>
<td>2.05</td>
<td>2.03</td>
<td>2.00</td>
<td>1.98</td>
<td>1.95</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.82</td>
</tr>
<tr>
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<td>2.08</td>
<td>2.06</td>
<td>2.03</td>
<td>2.01</td>
<td>1.98</td>
<td>1.95</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.78</td>
</tr>
<tr>
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<td>2.03</td>
<td>2.01</td>
<td>1.98</td>
<td>1.95</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.78</td>
<td>1.75</td>
</tr>
<tr>
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<td>1.98</td>
<td>1.96</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.78</td>
<td>1.75</td>
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<tr>
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<td>1.96</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
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<td>1.81</td>
<td>1.78</td>
<td>1.75</td>
<td>1.72</td>
<td>1.68</td>
</tr>
<tr>
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<td>1.96</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.78</td>
<td>1.75</td>
<td>1.71</td>
<td>1.68</td>
<td>1.65</td>
</tr>
<tr>
<td>-36%</td>
<td>1.96</td>
<td>1.93</td>
<td>1.90</td>
<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.78</td>
<td>1.74</td>
<td>1.71</td>
<td>1.68</td>
<td>1.64</td>
<td>1.61</td>
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<tr>
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<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.77</td>
<td>1.74</td>
<td>1.71</td>
<td>1.67</td>
<td>1.64</td>
<td>1.60</td>
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</tr>
<tr>
<td>-46%</td>
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<td>1.87</td>
<td>1.84</td>
<td>1.81</td>
<td>1.77</td>
<td>1.74</td>
<td>1.71</td>
<td>1.67</td>
<td>1.63</td>
<td>1.60</td>
<td>1.56</td>
<td>1.52</td>
</tr>
</tbody>
</table>

The table presents the results of the sensitivity analysis performed on stocks and bonds. The base case prognosis is tuned down by 5 per cent per row for stocks and 2 per cent per column for bonds. All remaining risk factors remain untouched. The solvency capital ratio is calculated per 31-12-2013 and the shadings indicate the margin to the critical SCR value of 1.0.
Table 8.9 – Sensitivity Analysis of Stress in Stocks and Real Estate

<table>
<thead>
<tr>
<th>Stocks</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>2.16</td>
</tr>
<tr>
<td>4%</td>
<td>2.16</td>
</tr>
<tr>
<td>-1%</td>
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<td>-6%</td>
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<tr>
<td>-11%</td>
<td>2.08</td>
</tr>
<tr>
<td>-16%</td>
<td>2.06</td>
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<tr>
<td>-21%</td>
<td>2.03</td>
</tr>
<tr>
<td>-26%</td>
<td>2.01</td>
</tr>
<tr>
<td>-31%</td>
<td>1.98</td>
</tr>
<tr>
<td>-36%</td>
<td>1.96</td>
</tr>
<tr>
<td>-41%</td>
<td>1.93</td>
</tr>
<tr>
<td>-46%</td>
<td>1.90</td>
</tr>
</tbody>
</table>

The table presents the results of the sensitivity analysis performed on stocks and real estate. The base case prognosis is tuned down by 5 per cent per row for stocks and 3 per cent per column for real estate. All remaining risk factors remain untouched. The solvency capital ratio is calculated per 31-12-2013 and the shadings indicate the margin to the critical SCR value of 1.0.

Table 8.10 – Sensitivity Analysis of Stress in Stocks and Premium Revenue

<table>
<thead>
<tr>
<th>Stocks</th>
<th>Premium Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>2.16 2.15 2.15 2.14 2.12 2.11 2.10 2.10 2.09 2.08 2.07 2.06 2.05 2.03 2.01 2.00</td>
</tr>
<tr>
<td>4%</td>
<td>2.14 2.13 2.13 2.12 2.11 2.10 2.09 2.08 2.07 2.06 2.05 2.04 2.03 2.01 2.00</td>
</tr>
<tr>
<td>-1%</td>
<td>2.12 2.11 2.11 2.10 2.09 2.08 2.07 2.06 2.05 2.04 2.03 2.02 2.01 2.00</td>
</tr>
<tr>
<td>-6%</td>
<td>2.10 2.09 2.08 2.07 2.06 2.05 2.04 2.03 2.02 2.01 2.00</td>
</tr>
<tr>
<td>-11%</td>
<td>2.08 2.07 2.06 2.05 2.04 2.03 2.02 2.01 2.00</td>
</tr>
<tr>
<td>-16%</td>
<td>2.06 2.05 2.04 2.03 2.02 2.01 2.00</td>
</tr>
<tr>
<td>-21%</td>
<td>2.03 2.02 2.01 2.00</td>
</tr>
<tr>
<td>-26%</td>
<td>2.01 2.00 1.99 1.98 1.97 1.96 1.95 1.94 1.93 1.92 1.91 1.90</td>
</tr>
<tr>
<td>-31%</td>
<td>1.98 1.97 1.96 1.95 1.94 1.93 1.92 1.91 1.90</td>
</tr>
<tr>
<td>-36%</td>
<td>1.96 1.95 1.94 1.93 1.92 1.91 1.90 1.89 1.88 1.87 1.86 1.85 1.84</td>
</tr>
<tr>
<td>-41%</td>
<td>1.93 1.92 1.91 1.90 1.89 1.88 1.87 1.86 1.85</td>
</tr>
<tr>
<td>-46%</td>
<td>1.90 1.89 1.88 1.87 1.86 1.85 1.84 1.83 1.82 1.81 1.80 1.78 1.77 1.75</td>
</tr>
</tbody>
</table>

The table presents the results of the sensitivity analysis performed on stocks and premium revenue. The base case prognosis is tuned down by 5 per cent per row for stocks and 2 per cent per column for premium revenue. All remaining risk factors remain untouched. The solvency capital ratio is calculated per 31-12-2013 and the shadings indicate the margin to the critical SCR value of 1.0.
Table 8.11 – Sensitivity Analysis of Stress in Stocks and Insurance Claims

<table>
<thead>
<tr>
<th>Insurace Claims</th>
<th>3.2%</th>
<th>5.2%</th>
<th>7.2%</th>
<th>9.2%</th>
<th>11.2%</th>
<th>13.2%</th>
<th>15.2%</th>
<th>17.2%</th>
<th>19.2%</th>
<th>21.2%</th>
<th>23.2%</th>
<th>25.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>2.16</td>
<td>2.15</td>
<td>2.14</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.09</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
</tr>
<tr>
<td>4%</td>
<td>2.14</td>
<td>2.13</td>
<td>2.12</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.07</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
<td>2.01</td>
<td>2.00</td>
</tr>
<tr>
<td>-1%</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.08</td>
<td>2.07</td>
<td>2.06</td>
<td>2.04</td>
<td>2.03</td>
<td>2.02</td>
<td>2.00</td>
<td>1.99</td>
<td>1.98</td>
</tr>
<tr>
<td>-6%</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
<td>2.01</td>
<td>1.99</td>
<td>1.98</td>
<td>1.97</td>
<td>1.95</td>
</tr>
<tr>
<td>-11%</td>
<td>2.08</td>
<td>2.07</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
<td>2.01</td>
<td>2.00</td>
<td>1.98</td>
<td>1.97</td>
<td>1.96</td>
<td>1.94</td>
<td>1.93</td>
</tr>
<tr>
<td>-16%</td>
<td>2.06</td>
<td>2.04</td>
<td>2.03</td>
<td>2.02</td>
<td>2.00</td>
<td>1.99</td>
<td>1.97</td>
<td>1.95</td>
<td>1.93</td>
<td>1.91</td>
<td>1.90</td>
<td>1.89</td>
</tr>
<tr>
<td>-21%</td>
<td>2.03</td>
<td>2.02</td>
<td>2.01</td>
<td>1.99</td>
<td>1.98</td>
<td>1.96</td>
<td>1.95</td>
<td>1.93</td>
<td>1.92</td>
<td>1.90</td>
<td>1.89</td>
<td>1.87</td>
</tr>
<tr>
<td>-26%</td>
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<td>2.00</td>
<td>1.98</td>
<td>1.97</td>
<td>1.95</td>
<td>1.94</td>
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<td>1.90</td>
<td>1.89</td>
<td>1.87</td>
<td>1.86</td>
<td>1.84</td>
</tr>
<tr>
<td>-31%</td>
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<td>1.97</td>
<td>1.95</td>
<td>1.94</td>
<td>1.92</td>
<td>1.91</td>
<td>1.89</td>
<td>1.88</td>
<td>1.85</td>
<td>1.83</td>
<td>1.81</td>
<td>1.80</td>
</tr>
<tr>
<td>-36%</td>
<td>1.96</td>
<td>1.94</td>
<td>1.93</td>
<td>1.91</td>
<td>1.89</td>
<td>1.88</td>
<td>1.86</td>
<td>1.85</td>
<td>1.84</td>
<td>1.83</td>
<td>1.81</td>
<td>1.80</td>
</tr>
<tr>
<td>-41%</td>
<td>1.93</td>
<td>1.91</td>
<td>1.90</td>
<td>1.88</td>
<td>1.86</td>
<td>1.85</td>
<td>1.83</td>
<td>1.81</td>
<td>1.80</td>
<td>1.78</td>
<td>1.76</td>
<td>1.75</td>
</tr>
<tr>
<td>-46%</td>
<td>1.90</td>
<td>1.88</td>
<td>1.87</td>
<td>1.85</td>
<td>1.83</td>
<td>1.82</td>
<td>1.80</td>
<td>1.78</td>
<td>1.76</td>
<td>1.75</td>
<td>1.73</td>
<td>1.71</td>
</tr>
</tbody>
</table>

The table presents the results of the sensitivity analysis performed on stocks and insurance claims. The base case prognosis is tuned down by 5 per cent per row for stocks and 2 per cent per column for insurance claims. All remaining risk factors remain untouched. The solvency capital ratio is calculated per 31-12-2013 and the shadings indicate the margin to the critical SCR value of 1.0.

Table 8.12 – Sensitivity Analysis of Stress in Stocks and Insurance Claims

<table>
<thead>
<tr>
<th>Insurance Claims</th>
<th>3.2%</th>
<th>5.2%</th>
<th>7.2%</th>
<th>9.2%</th>
<th>11.2%</th>
<th>13.2%</th>
<th>15.2%</th>
<th>17.2%</th>
<th>19.2%</th>
<th>21.2%</th>
<th>23.2%</th>
<th>25.2%</th>
</tr>
</thead>
<tbody>
<tr>
<td>3%</td>
<td>2.16</td>
<td>2.15</td>
<td>2.14</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.09</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
</tr>
<tr>
<td>1%</td>
<td>2.15</td>
<td>2.14</td>
<td>2.13</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.07</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
</tr>
<tr>
<td>-1%</td>
<td>2.15</td>
<td>2.13</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
</tr>
<tr>
<td>-3%</td>
<td>2.14</td>
<td>2.13</td>
<td>2.11</td>
<td>2.10</td>
<td>2.09</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
<td>2.02</td>
<td>2.01</td>
</tr>
<tr>
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<td>2.12</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.07</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
<td>2.01</td>
<td>2.00</td>
<td>1.99</td>
</tr>
<tr>
<td>-7%</td>
<td>2.12</td>
<td>2.11</td>
<td>2.10</td>
<td>2.08</td>
<td>2.07</td>
<td>2.06</td>
<td>2.04</td>
<td>2.03</td>
<td>2.02</td>
<td>2.00</td>
<td>1.99</td>
<td>1.98</td>
</tr>
<tr>
<td>-9%</td>
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<td>2.10</td>
<td>2.09</td>
<td>2.07</td>
<td>2.06</td>
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<td>2.03</td>
<td>2.02</td>
<td>2.01</td>
<td>1.99</td>
<td>1.98</td>
<td>1.97</td>
</tr>
<tr>
<td>-11%</td>
<td>2.10</td>
<td>2.09</td>
<td>2.08</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
<td>2.01</td>
<td>2.00</td>
<td>1.99</td>
<td>1.98</td>
<td>1.97</td>
</tr>
<tr>
<td>-13%</td>
<td>2.10</td>
<td>2.08</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
<td>2.00</td>
<td>1.99</td>
<td>1.98</td>
<td>1.97</td>
<td>1.96</td>
</tr>
<tr>
<td>-15%</td>
<td>2.09</td>
<td>2.07</td>
<td>2.06</td>
<td>2.05</td>
<td>2.03</td>
<td>2.02</td>
<td>2.00</td>
<td>1.99</td>
<td>1.98</td>
<td>1.96</td>
<td>1.95</td>
<td>1.93</td>
</tr>
<tr>
<td>-17%</td>
<td>2.08</td>
<td>2.06</td>
<td>2.05</td>
<td>2.04</td>
<td>2.02</td>
<td>2.01</td>
<td>1.99</td>
<td>1.98</td>
<td>1.97</td>
<td>1.95</td>
<td>1.94</td>
<td>1.92</td>
</tr>
<tr>
<td>-19%</td>
<td>2.07</td>
<td>2.05</td>
<td>2.04</td>
<td>2.03</td>
<td>2.01</td>
<td>2.00</td>
<td>1.98</td>
<td>1.97</td>
<td>1.96</td>
<td>1.94</td>
<td>1.93</td>
<td>1.91</td>
</tr>
</tbody>
</table>

The table presents the results of the sensitivity analysis performed on premium revenue and insurance claims. The base case prognosis is tuned down by 2 per cent per row for premium revenue and 2 per cent per column for insurance claims. All remaining risk factors remain untouched. The solvency capital ratio is calculated per 31-12-2013 and the shadings indicate the margin to the critical SCR value of 1.0.
8.3.1. Analysis and Discussion
The sensitivity analysis provides a broad overview of implications from the identified and implemented risk factors. We can see that the implications of simultaneous movements in more than one risk factor vary between pairs. Real estate seems to be the only factor that has very little correlation with the insurer’s capital adequacy.

Even though the sensitivity analysis covers rather extreme changes in the risk factors, the insurer still never finds itself in such financial distress that the company’s solvency capital ratio falls below 1.0. This could at least in part be explained by the company’s corporate structure. As a mutual insurer, the possibilities of raising external capital in times of need are substantially limited since there are no equity holders to turn to. As a result, this type of organization is often well capitalized as they are in greater need of a financial “cushion” to cover unexpected losses than their publicly traded counterparts.

In the first row and column respectively of the sensitivity analysis matrix, the resulting capital solvency capital ratio when one of the risk factors, ceteris paribus, are stressed. We found that the factors for stocks and bonds have the largest effect on the solvency capital ratio. When combined, results show that if stocks and bonds fall simultaneously the insurer’s solvency capital ratio will decrease significantly. However, a decrease in the overall bond value of the extent that is shown in the matrix does not represent a particularly probable outcome for our case study insurer as they have a quite diversified bond portfolio. Furthermore, such a decrease in bond and stock prices is not probable without the insurer being able to react and reallocate their positions. Nevertheless, these kinds of events should not be ruled out merely because they are affiliated with low probabilities. For instance during the 1929 stock market crash, prices on the New York stock exchange plummeted with approximately 24 % in merely two days.

We also find that the other factors do not have as large effect on the solvency capital ratio compared to stock and bond prices. The case study object is on the other hand quite heavily invested in stocks and bonds and the relatively high implications from a shift in these asset types are to some extent expected.

Finally, the results indicate that a combination of negative changes in both premium revenue and stocks will have a quite severe impact on the insurer’s financial situation. This suggests
that insurers with similar exposure should pay close attention to investigating possible scenarios that could lead to this kind of developments.

8.4. Deterministic Stress Tests and Reversed Stress Tests

Proceeding from the date when the event took place, we isolate the most extreme outcome over the following year, individually for each asset-based risk factor and independent of each other. The following risk factor changes were identified.

Table 8.13 – The Effect of Historical Stressed Events on the Identified Risk Factors

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Stocks</th>
<th>Bonds</th>
<th>Real Estate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Housing Bubble (August 7 1990)</td>
<td>-40.00%</td>
<td>-6.00%</td>
<td>-25.00%</td>
</tr>
<tr>
<td>Russian Default (August 17 1998)</td>
<td>-39.50%</td>
<td>-2.00%</td>
<td>2.80%</td>
</tr>
<tr>
<td>Burst of IT-bubble (May 18 2000)</td>
<td>-44.70%</td>
<td>-14.70%</td>
<td>-4.00%</td>
</tr>
<tr>
<td>The Lehman Crash (September 15 2008)</td>
<td>-35.00%</td>
<td>-12.50%</td>
<td>-1.39%</td>
</tr>
<tr>
<td>9/11 (September 11 2001)</td>
<td>-33.00%</td>
<td>-2.00%</td>
<td>-3.60%</td>
</tr>
</tbody>
</table>

The table presents the effect from the stressed scenarios on our risk factors. The numbers are derived from the actual historical event, taking the worst outcome over the next year following the event.

The stresses were implemented under the projection for year 2013. The results presented in Table 8.15 – Reversed Stress Test Results below are expressed as the impact on the solvency capital ratio relative to the base case scenario. None of the deterministic stresses led to the company’s solvency capital ratio falling below 1.0.
The table presents the results of the five stress tests we defined above. In the right column the effect of the given scenario on the insurer’s solvency capital ratio is presented. Due to the assumptions made when creating the stress tests, the effect is presented on a one year time horizon.

The results of the reversed stress tests are presented as a multiple of the historical asset-shocks corresponding to a capital solvency capital ratio of 1.

The table presents the results of the reversed stress tests. The multiple in the right column corresponds to the intensity of the given scenario required before the insurer falls below the critical SCR value of 1.0. Due to the assumptions made when creating the stress tests, the effect is presented on a one year time horizon.
8.4.1. Analysis of the Deterministic Stress Tests and Reversed Stress Tests
The stress tests are based on four historical extreme events which have occurred between 1990 and 2008. Even though the exact same event will not happen twice, deterministic stresses are an effective method for relating otherwise rather abstract results from e.g. sensitivity analyses to reality. The reversed stress tests are a highly illustrative way of indicating an insurer’s level of resilience under financial distress. As the results show, even the most severe event such as the Burst of the IT-bubble or 9/11, if occurred today, needs to be multiplied by a factor close to two before the minimum SCR level is breached.

This indicates that the case study insurer is well capitalized and resilient to financial distress. Again, this is partly expected due to the fact that our case study object is a mutually owned insurer.

Since the stresses have not taken any insurance-specific factors into consideration, the results attained here will overestimate the insurer’s resilience to a certain degree. Given the data we had access to, including insurance-specific factors into the stress tests was virtually impossible to do. The shocks created instead acts as isolated asset-shocks, thus only telling part of the truth.

8.5. SCR
The results of the SCR calculations are presented below. The results are based on the calculations made per 31-12-2013 unless otherwise stated. The relative change of the total SCR over the projection period is also presented.

8.5.1. Market Risk
The composition of the total amount of market risk is presented below.
The figure presents the composition of the market risk module capital requirements using the SCR standard calculations for market risk. From the left the sub-modules are added up to the market risk SCR module adjusted with a diversification effect.

Within equity risk (SCReq), roughly 83% of the risk stems from type 2 exposures, i.e. non-listed equities, emerging markets etc. Within concentration risk (SCRconc) a total of five investments exceeded the concentration risk thresholds and thus contributing to the total SCR.

8.5.2. SCR for Underwriting Risk
The underwriting risk was calculated in two parts; non-life and health. Non-life risk comprised 80.6% of the total underwriting risk exposure.

8.5.3. SCR for Counterparty Credit Default Risk
The SCR for counterparty credit default risk stem from financial derivatives, cash at bank and reinsurance. However, since the case study object does not have any exposure in derivatives, this is not a factor in this case. The resulting total amount of credit risk exposure was in part due to this found to be relatively low. The largest contribution to the counterparty credit default risk was reinsurance, contributing with 75% of the total SCR within the module.
8.5.4. BSCR
The composition of the BSCR over the projected time period stays, as expected, relatively stable. The prognoses for equity, bond and real estate are quite aggressive over the projected time period. This together with more modest growth projections for premium revenues that mainly affects the underwriting risk capital requirement, the relative size of the market risk capital requirement increases slightly over time in the base case scenario.

Table 8.16 – BSCR Composition for 2012-2015 before Diversification

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market Risk</strong></td>
<td>70 %</td>
<td>70 %</td>
<td>71 %</td>
<td>72 %</td>
</tr>
<tr>
<td><strong>Underwriting Risk</strong></td>
<td>27 %</td>
<td>26 %</td>
<td>26 %</td>
<td>25 %</td>
</tr>
<tr>
<td><strong>Counterparty Default Risk</strong></td>
<td>4 %</td>
<td>3 %</td>
<td>3 %</td>
<td>3 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
<td>100 %</td>
</tr>
</tbody>
</table>

The table display how the BSCR changes over time given our base case prognosis. The modules of the BSCR are presented as a percentage of the total each year to illustrate the relative change in each module.

8.5.5. SCR for Operational Risk
The capital requirements from operational risk was derived from

$$SCR_{Op} = \min \left( 0.3 \times BSCR, \max (Op_{premiums}, Op_{provisions}) \right)$$

where the result yielded

$$0.3 \times BSCR > Op_{premiums} > Op_{provisions}$$

Hence, for our case study object

$$SCR_{Op} = Op_{premiums}$$

In the SCR calculations above the operational risk amount based on premiums ($Op_{premiums}$) were higher than the corresponding amount based on technical provisions ($Op_{provisions}$). The quota of 30 % of the BSCR was however substantially higher than any of these.

The SCR for operational risk added 2.6 % which is quite low compared to the 15% that the banking industry is forced to set aside under the Basel regulations.
8.5.6. Loss-Absorbing Effect
The only loss absorbing effect the company can take advantage of is the deferred taxes, which lowered the capital requirement by 10%.

8.5.7. Total SCR
The composition of the total SCR is presented below in Figure 8.2. We see that the major contributing factor is market risk, which could be expected due to company’s assets allocation. The other large contributor is the underwriting risk module. As in the market risk module we obtain a large diversification effect largely due to the use of the predefined correlation matrices found in the LTGA. The correlation between the market risk and the underwriting risk modules are set to 0.25.

The figure presents the composition of the total capital requirement using the SCR standard calculations. From the left the sub-modules are first added up to the BSCR module adjusted with a diversification effect. Subsequently the capital requirement for operational risk is added and the loss absorbing effect subtracted to yield the total SCR.
The solvency capital ratio increase over the projected period. The results in the table below have been normalized as a percentage of the ratio at 31-12-2012.

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvency Capital Ratio (Normalized)</td>
<td>100%</td>
<td>100%</td>
<td>101%</td>
<td>102%</td>
</tr>
</tbody>
</table>

The table presents the development of the solvency capital ratio as a percentage of the value per 31-12-2013.

8.6. Analysis of the SCR
Because our data is aggregated on different levels we have chosen to be conservative in the simplifications we have done throughout the SCR calculations. We see that the SCR we obtain is reasonable for an insurer of this size and in line with the insurer’s own preliminary estimates.

Given that the case study object and the target insurer is a small, non-life insurer, the amount of long-time liabilities should be quite restricted. This suggests that an interest-rate stress like the one described in the methodology chapter and subsequently was carried out here, should have a limited effect on the total value of the liabilities.

The SCR for market risk is quite dominated by a high capital requirement for equity risk and concentration risk. Our case study object has over 40% of their total investments concentrated in stocks and shares in a few unrated companies. The fact that they are unrated leads to increased capital requirements and hence a higher total SCR for the market risk module. The large exposure to these few companies also result in a large concentration risk exposure, which constrain even more capital as the thresholds in the concentration risk sub-module is breached a number of times.

One of these large exposures consists of equity in a real estate management company. This exposure accounts for the insurer’s complete exposure towards real estate. The real estate management business is, within Solvency II, not treated as exposure to real estate but rather as equity risk. Given that this particular real estate management company also is unrated, this exposure is classified in the high-risk category within equity risk. Treating this exposure as unrated equity in the SCR standard calculations, results in a stress twice as intense as if it would have been treated as property risk. Since we believe it can be argued that property risk accurately reflects the actual risk in this company, we have chosen to treat this exposure as property. This example highlights the opportunities for an insurer to adjust current models or
develop own risk calculations under Pillar II and the ORSA since this would in similar cases have a large effect on the resulting total capital requirement.

Despite the case study object’s fairly concentrated exposure we do still obtain a high level of diversification for our total SCR. This is to some extent due to the fact that in the predefined correlation matrices from the LTGA that we apply, the correlation between equity and concentration risk is set to zero. To set this correlation coefficient to zero is not obvious since a general decline in e.g. the stock market could very well affect the financial situation of the counterpart that we are heavily exposed to. Regardless of whether this counterparty is a stock company or not.

That the majority of the SCR for underwriting risk is derived from non-life insurance is expected due to the fact that our study object is a non-life insurer. There are some health insurance characteristics in some of the non-life insurance products, and these parts can contribute to a lot of risk due to their longer obligation periods. We believe it is quite reasonable that the health insurance parts have a relatively high contribution to the SCR. The company themselves value the health insurance liabilities within the company to 20% of the total technical provisions, which is in line with its calculated SCR contribution of 19.4%.

8.7. Concluding Analysis
Overall, the constructed model succeeds in interlinking all parts in a consistent way. The factor model enhances the projections by making use of the identified risk factors. The case study object on which this model is implemented, shows great resilience against financial distress and are well capitalized.

Our results showed that the correlations between the real estate factor and the other risk factors as displayed in Table 8.6 were quite low in general. Furthermore, an isolated fall in real estate prices did not have any substantial effect on the solvency capital ratio of the studied insurer. An important point to make here is though that this (non-existent) correlation between real estate and the other factors have been derived under “normal” market conditions. The burst of the Swedish housing bubble in 1990 differs quite substantially from these findings. During this extreme event, a steep fall in real estate prices was accompanied by an even more extreme fall in the stock market as well as a downward change in the bond market. In other words, a collapse in the real estate market will most likely have effects on other
financial markets as well, and during these times of distress previous correlation assumptions prove to be inaccurate to say the least.

The implementations of the standard SCR calculations show that the case study objects’ solvency capital requirement is heavily concentrated to the market risk module. In this particular case the concentration risk constitutes an important part, something we believe to be common for this type of mutual insurers.

An advantage of using the standard SCR calculations to calculate the capital requirements is of course that it is predefined and hence the insurer is not forced to develop any calculations or measurements on their own. This is a relief in particular for the target insurer where resources often are constrained. The use of predefined measurements does however imply that the insurer allows and accepts the many assumptions on which these models are based. The predefined correlation matrices are one example, and it can be argued that these are not always very accurate in describing the dependencies of an individual insurer’s exposure.

Another disputable assumption is that government bonds issued by countries within the European Union derive zero spread risk. We know for a fact (the depreciation of Greek sovereign bonds during the fall of 2011) that these types of bonds can carry a lot of risk and should therefore carry a capital requirement. This is a clear example of how politics influence regulations in a somewhat inconsistent and illogical way.

Examples like the ones above suggests that even though many insurers may benefit from using predefined calculation models, the underlying assumptions and simplifications that these entail should perhaps first be thoroughly reviewed and in some cases adjusted before being used in the context of the ORSA.
9. Conclusion

In this section our conclusion of the study is communicated. The chapter ends with a number of suggestions on future research topics and suggested expansions of the implemented model.

9.1. Final Conclusion

We have managed to construct a model combining several methodologies and approaches that successfully interlinks all parts to produce transparent and comprehensible results. The risk factor-based set-up constitutes a valuable addition to traditional balance sheet projection methods and had a significant influence in the case study projection. An important advantage with the set-up is also that it incorporates considerable flexibility and opens up possibilities to expand the model in a desired fashion. Overlying risk factors are a very useful and powerful tool when analyzing changes on a global market, or socioeconomic level. By choosing the risk factors with respect to this fact, our model is enabled for future extensions where an overlooking macroeconomic scenario can be added and linked to the identified risk factors. This also increases the model’s interpretability as a scenario expressed as a real development can easily be related to. Hence is the structure of the model framework suggested here considered particularly well-suited for assessing risk in the context of small, non-life insurers.

When carrying out the capital requirement calculations in this study, we chose to use the pre-defined standard model as expressed under Pillar I of Solvency II. With some exceptions, the underlying assumptions of the SCR are considered to be adequate for our target insurer. The major issues we encountered were related to the concentration risk sub-module and the treatment of unrated exposures. In these cases in particular, the insurer may very well benefit from making own assumptions and motivating alternative considerations. With support from the study, it could be argued that the individual insurer could have a lot to gain from developing entirely own, internal risk measure models. However, it is likely that for the small, non-life insurer, this potential gain is not large enough in order to make up for the immense cost in terms of money and resources that this would require.

The result of the sensitivity analysis is easy to interpret and provides a good perspective on how the insurer will be affected under unfortunate market developments. The stress tests constructed here are considered to be somewhat of a disappointment since we did not achieve to incorporate the effects on the insurance-related risk factors. As a result, the deterministic stresses could not be used to draw any major conclusions regarding insurer-specific resilience from.
9.2. Suggestions for Further Research

The implemented model has shown to be a good starting point for a small non-life insurer to proceed from when implementing the quantitative parts of the ORSA process. We have however identified a few most relevant suggestions for further expansion of the model.

The ORSA is a potentially great tool for strategic planning if utilized to its full potential. With this in mind, a relevant development of the model would be to expand the sensitivity analysis construct to incorporate an analysis of asset and liability composition. What would for example be the implications in terms of capital requirements if our insurer decided to focus all attention on home insurance while at the same time dismantling other lines of businesses?

Another beneficial addition to the model would be to estimate and assign probabilities to various outcomes. This is in particular true for the deterministic stress tests, where assigned probabilities would be a valuable complement.

Global marketplaces and geographically unbound dependencies are part of today’s reality. This implicates that local economies, almost regardless of where they might be situated, are highly affected by global politics and global economy. Macroeconomic scenarios is thus of great importance, even for the small, local insurer. The model can with few complications be expanded with an additional layer, tying the identified risk factors together under a more general macro scenario such as a recession or escalating unemployment.

Figure 9.1 – Extensions to Our Model

![Diagram showing the extended model](image-url)

The figure presents our suggested further developed model, incorporating macro scenarios and a module to make strategic implications visible. The figure is our own compilation based on ideas received from previous research.
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Appendix I - SCR Calculations

A. Market Risk Module

a) Total Market Risk Correlation Matrix

Table A.1 – The Predefined Correlation Matrix for the Interest Rate Up Scenario

<table>
<thead>
<tr>
<th>CorrMktUp</th>
<th>Interest</th>
<th>Equity</th>
<th>Property</th>
<th>Spread</th>
<th>Currency</th>
<th>Concentration</th>
<th>Illiquidity premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property</td>
<td>0</td>
<td>0.75</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread</td>
<td>0</td>
<td>0.75</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currency</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Illiquidity premium</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the predefined correlation matrix for the interest rate up scenario. The correlations are used when calculating the market risk module using the SCR standard calculations.

Table A.2 – The Predefined Correlation Matrix for the Interest Rate Down Scenario

<table>
<thead>
<tr>
<th>CorrMktDown</th>
<th>Interest</th>
<th>Equity</th>
<th>Property</th>
<th>Spread</th>
<th>Currency</th>
<th>Concentration</th>
<th>Illiquidity premium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interest</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Property</td>
<td>0.5</td>
<td>0.75</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spread</td>
<td>0.5</td>
<td>0.75</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Currency</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concentration</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Illiquidity premium</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-0.5</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the predefined correlation matrix for the interest rate down scenario. The correlations are used when calculating the market risk module using the SCR standard calculations.

b) Interest Rate Relative Changes

Table A.3 – The Predefined Changes in Interest Rate

<table>
<thead>
<tr>
<th>Maturity t (years)</th>
<th>Relative change $s^{UP}(t)$</th>
<th>Relative change $s^{DOWN}(t)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.25</td>
<td>70%</td>
<td>-75%</td>
</tr>
<tr>
<td>0.5</td>
<td>70%</td>
<td>-75%</td>
</tr>
<tr>
<td>1</td>
<td>70%</td>
<td>-75%</td>
</tr>
</tbody>
</table>
The table presents the predefined interest rate changes given the both scenarios. The change for a scenario is given per year to maturity. Assets with longer than 30 years to maturity are stressed with the same interest rate change as the ones with 30 years to maturity.

c) **Equity Risk Correlation Matrix**

Table A.4 – The Predefined Correlation Matrix within the Equity Shock

<table>
<thead>
<tr>
<th>CorrEquity</th>
<th>Type 1</th>
<th>Type 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type 1</strong></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Type 2</strong></td>
<td>0.75</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents predefined correlation for the shock used in the equity risk SRC calculations.

d) **Non-Life Underwriting Risk Correlation Matrix**

Table A.5 – The Predefined Correlation Matrix for the SCR Calculations for Non-Life Underwriting Risk

<table>
<thead>
<tr>
<th></th>
<th>NLpr</th>
<th>NLLapse</th>
<th>NLCAT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NLpr</strong></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NLLapse</strong></td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>NLCAT</strong></td>
<td>0.25</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the predefined correlations between the different capital requirements within non-life underwriting risk. The correlations are used when calculating the total SCR for non-life underwriting risk.
B. Counterparty Default Risk Module

The total SCR for default risk is

\[
SCR_{def} = \sqrt{SCR_{def,1}^2 + 1.5 \times SCR_{def,1} \times SCR_{def,2} + SCR_{def,2}^2}
\]  

(0.1)

The SCR for Type 1 exposure, \(SCR_{def,1}\), is determined by the following calculations:

\[
SCR_{def,1} = \begin{cases} 
3 \times \sqrt{V}, & if \quad \sqrt{V} \leq 7.05\% \times \sum_i LGD_i \\
5 \times \sqrt{V}, & if \quad 7.05\% \times \sum_i LGD_i \leq \sqrt{V} \leq 20\% \times \sum_i LGD_i \\
\sum_i LGD_i, & if \quad 20\% \times \sum_i LGD_i \leq \sqrt{V}
\end{cases}
\]  

(0.2)

where

\(LGD_i\) is the Loss-given-default for type 1 exposure of counterparty \(i\)

\(V\) is the variance of the loss distribution of the type 1 exposures.

The variance is calculated in the following way

\[
V = \sum_j \sum_k u_{j,k} \times y_j \times y_k + \sum_j v_j \times z_j
\]  

(0.3)

\[
y_j = \sum_i LGD_i, \quad z_j = \sum_i (LGD_i)^2
\]  

(0.4)

\[
u_{j,k} = \frac{p_i (1 - p_i) p_j (1 - p_j)}{(1 + \gamma)(p_i - p_j) - p_i p_j}
\]  

(0.5)
where $p$ denotes the probability of default. Using the standard approach from QIS5 we have:

\[
  v_j = \frac{(1 + 2\gamma)p_i(1 - p_j)}{2 + 2\gamma - p_i}
\]

(0.6)

Table B.1 – The Predefined Probability of Default for Different Rating Classes

<table>
<thead>
<tr>
<th>Rating $i$</th>
<th>Credit Quality Step</th>
<th>$p_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAA</td>
<td>0</td>
<td>0.002%</td>
</tr>
<tr>
<td>AA</td>
<td>1</td>
<td>0.01%</td>
</tr>
<tr>
<td>A</td>
<td>2</td>
<td>0.05%</td>
</tr>
<tr>
<td>BBB</td>
<td>3</td>
<td>0.24%</td>
</tr>
<tr>
<td>BB</td>
<td>4</td>
<td>1.20%</td>
</tr>
<tr>
<td>B</td>
<td>5</td>
<td>6.04%</td>
</tr>
<tr>
<td>CCC or lower</td>
<td>6</td>
<td>30.41%</td>
</tr>
</tbody>
</table>

The table presents the predefined probability of default, $p$, for different rating classes. The $p$-values are used in the standard calculations for the SCR module for credit default risk.

And for unrated counterparties we use the solvency ratio to determine the probability of default as follows:

Table B.2 – The Predefined Probability of Default for Different Solvency Ratios

<table>
<thead>
<tr>
<th>Solvency ratio</th>
<th>$p_i$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&gt;200%$</td>
<td>0.025%</td>
</tr>
<tr>
<td>$&gt;175%$</td>
<td>0.050%</td>
</tr>
<tr>
<td>$&gt;150%$</td>
<td>0.1%</td>
</tr>
<tr>
<td>$&gt;125%$</td>
<td>0.2%</td>
</tr>
<tr>
<td>$&gt;100%$</td>
<td>0.5%</td>
</tr>
<tr>
<td>$&gt;90%$</td>
<td>1.0%</td>
</tr>
<tr>
<td>$&gt;80%$</td>
<td>2.0%</td>
</tr>
<tr>
<td>$\leq 80%$</td>
<td>10.0%</td>
</tr>
</tbody>
</table>

The table presents the predefined probability of default, $p$, for unrated companies with different solvency ratios. The $p$-values are used in the standard calculations for the SCR module for credit default risk.

\[
  LGD_i = \max(50\% \times (Recoverables_i + RM_{re,j} - Collateral_i), 0)
\]

(0.7)

where
- **Recoverables** \(_i\) is the best estimate of the recoverables from reinsurance contracts \(i\) and any other debtors arising out of the reinsurance arrangement or SPV securitization \(i\).
- **Collateral** \(_i\) is the risk adjusted value of the collateral in relation to the reinsurance arrangement or SPV securitisation \(i\).
- **RM_{re,j}\) it the risk mitigating effect on underwriting risk of the reinsurance arrangement or SPV securitization \(i\).

The SCR for the type 2 exposure is calculated by taking the change in net asset value when applying a stress to the type 2 exposure.

\[
SCR_{def,2} = \Delta NAV| \text{type 2 counterparty default shock} \tag{0.8}
\]

The shock is defined as a 15 % fall in all type 2 exposures except receivables from intermediaries which are due for more than 3 months. These shall endure a fall of 90 %.

### C. Underwriting Risk Module

e) **Non-Life Underwriting Risk**

The function \(\rho(\sigma)\) is specified as:

\[
\rho(\sigma) = \frac{\exp(N_{0.995} \cdot \sqrt{\log(\sigma^2 + 1)})}{\sqrt{\sigma^2 + 1}} - 1 \tag{0.9}
\]

where

\(N_{0.995}\) is the 99.5% quintile of the standard normal distribution

The following lines of businesses are applies for the calculations:

<table>
<thead>
<tr>
<th>Number</th>
<th>Line of Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Motor vehicle liability</td>
</tr>
<tr>
<td>2</td>
<td>Motor, other classes</td>
</tr>
<tr>
<td>3</td>
<td>Marine, aviation, transport (MAT)</td>
</tr>
<tr>
<td>4</td>
<td>Fire and other property damage</td>
</tr>
<tr>
<td>5</td>
<td>Third-party liability</td>
</tr>
<tr>
<td>6</td>
<td>Credit and suretyship</td>
</tr>
<tr>
<td>7</td>
<td>Legal expenses</td>
</tr>
<tr>
<td>8</td>
<td>Assistance</td>
</tr>
<tr>
<td>9</td>
<td>Miscellaneous</td>
</tr>
</tbody>
</table>
The table presents the predefined lines of business used within the standard SCR calculations for non-life underwriting risk.

The volume measures for premium risk in the individual lines of businesses (lob) are determined as:

\[ V_{\text{premium,lob}} = \max\left( p_{lob}^{\text{written}}, p_{lob}^{\text{earned}}, p_{lob}^{-1,\text{written}} \right) + p_{lob}^{pp} \]  

(0.10)

<table>
<thead>
<tr>
<th>LoB</th>
<th>Standard deviation for premium risk (net of reinsurance)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor vehicle liability</td>
<td>10%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Other motor</td>
<td>7%* ( N P_{lob} )</td>
</tr>
<tr>
<td>MAT</td>
<td>17%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Fire</td>
<td>10%* ( N P_{lob} )</td>
</tr>
<tr>
<td>3rd-party liability</td>
<td>15%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Credit</td>
<td>21.50%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Legal expenses</td>
<td>6.50%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Assistance</td>
<td>5%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>13%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Np reins (prop)</td>
<td>17.50%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Np reins (cas)</td>
<td>17%* ( N P_{lob} )</td>
</tr>
<tr>
<td>Np reins (MAT)</td>
<td>16%* ( N P_{lob} )</td>
</tr>
</tbody>
</table>

The table presents the standard deviation for premium risk for each line of business used in the SCR calculations within non-life underwriting risk. The standard deviations are given as a predefined standard deviation times a adjustment factor for non-proportional reinsurance, \( N P_{lob} \).

The volume measures for reserve risk in the individual lines of businesses (lob) are determined as:

\[ V_{\text{res,lob}} = PCO_{lob} \]  

(0.11)
The standard deviation for reserve risk for each line of business used in the SCR calculations within non-life underwriting risk.

\[
\sigma_{(lob)} = \sqrt{\left(\sigma_{(prem,lob)} V_{(prem,lob)}\right)^2 + 2 \alpha \sigma_{(prem,lob)} \sigma_{(res,lob)} V_{(prem,lob)} V_{(res,lob)} + \sigma_{(res,lob)} V_{(re:)} V_{(prem,lob)} + V_{(res,lob)}}
\]

Then the overall standard deviation \(\sigma\) is determined by:

\[
\sigma = \sqrt{\frac{1}{V^2} \sum_{r,c} \Sigma_{r,c} \sigma_r \sigma_c V_r V_c}
\]

where

\(r,c\) are all indices of the form (lob)

\(\Sigma_{r,c}\) is the correlation matrix of all lob

\(V_r, V_c\) is the column measures for the individual lines of business, as defined above

The overall volume measure for each LoB, \(V_{lob}\) is determined by:

\[
V_{lob} = (V_{(prem,lob)} + V_{(res,lob)}) \times (0.75 + 0.25 \times DIV_{lob})
\]

where
\[ DIV_{lob} = \frac{\sum_j (V_{(\text{prem},j,lob)} + V_{(\text{res},j,lob)})^2}{(\sum_j (V_{(\text{prem},j,lob)} + V_{(\text{res},j,lob)}))^2} \]  

(0.15)

### Table C.4 – The Predefined Correlation Matrix for the Non-Life Underwriting Risks

<table>
<thead>
<tr>
<th>Correlation matrix, lob</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Motor vehicle liability</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Other motor</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. MAT</td>
<td>0.5</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Fire</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. 3rd-party liability</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Credit</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Legal expenses</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Assistance</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Miscellaneous</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Np reins (prop)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Np reins (cas)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12. Np reins (MAT)</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the correlations matrix for the twelve different lines of businesses within the non-life underwriting risk module. The correlations are used within the standard SCR calculations for the module.

### D. BSCR

Table D.1 – The Predefined Correlation Matrix for the Composition of the BSCR.

<table>
<thead>
<tr>
<th>Correlation matrix</th>
<th>Non-life undertaking risk</th>
<th>Health undertaking risk</th>
<th>Market risk</th>
<th>Counterparty default risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-life undertaking risk</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health undertaking risk</td>
<td>0</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market risk</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Counterparty default risk</td>
<td>0.5</td>
<td>0.25</td>
<td>0.25</td>
<td>1</td>
</tr>
</tbody>
</table>

The table presents the correlations matrix for the BSCR components. The correlations are used within the standard SCR calculations for the module.

### E. Operational Risk

The following formula is used:

\[ SCR_{Op} = \min \left( 0.3 \times BSCR, \max \left( Op_{premums}, Op_{provisions} \right) \right) \]  

(0.16)
where the BSCR (Basic SCR) is the aggregated number corresponding to the sum of the SCR calculations from the other sub-modules. $Op_{premiums}$ and $Op_{provisions}$ are calculated in the following manner

\begin{align*}
Op_{premiums} &= 0.04 * Earn_{life} + 0.03 * Earn_{non\text{-}life} \\
&\quad + \max \left( 0, 0.04 * (Earn_{life} - 1.1 * pEarn_{life}) \right) \\
&\quad + \max \left( 0, 0.03 * (Earn_{non\text{-}life} - 1.1 * pEarn_{non\text{-}life}) \right) \\
\end{align*} 

(0.17)

$$Op_{provisions} = 0.0045 * \max (0, TP_{life}) + 0.03 * \max (0, TP_{non\text{-}life})$$ 

(0.18)

where

$Earn_{life}$ is the earned premium from life and health insurance obligations during the last 12 months.

$Earn_{non\text{-}life}$ is the earning from non-life insurance obligations during the last 12 months.

$pEarn_{life}$ is the earning from life and health insurance obligations during the 12 months leading up to the last 12 months.

$pEarn_{non\text{-}life}$ is the earning from non-life insurance obligations during the 12 months leading up to the last 12 months.

$TP_{life}$ is the technical provisions for life and health insurance obligations.

$TP_{non\text{-}life}$ is the technical provisions for non-life insurance obligations.