Asset Allocation under Solvency II

The impact of Solvency II on the asset allocation of Swedish life insurance companies

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KTH Industrial Engineering and Management

Master of Science Thesis
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Tillgångsallokering och Solvens II

Regelverkets effekt på svenska livbolags placeringar

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Abstract

This thesis investigates the impact of Solvency II on the asset side of Swedish mutual life insurers. With the help of a quantitative analysis and a qualitative examination of our results we find that there will be a significant change in demand for certain products. A substantial increase in demand for government bonds and interest rate swaps with long maturities should be expected. Furthermore, both corporate and covered bonds will be more attractive investments under the new regulatory framework. Another big impact is the lower risk-adjusted return for equity, which over time will lead to a reduction in Swedish life insurers' relatively high exposure to equity and equity based products. Furthermore, we conclude that there are large gains to be made by incorporating an optimization with regard to the solvency capital requirements dictated by the legislative texts.

Key-words

Solvency II, Life insurance, Asset Allocation, SCR, Portfolio Theory, Regulations

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Sammanfattning

Denna uppsats har undersökt vilken inverkan Solvens II kommer ha på svenska ömsesidiga livbolags tillgångssidor. Med hjälp av en kvantitativ analys och en kvalitativ undersökning av våra resultat har vi funnit att det kommer ske en betydande förändring i efterfrågan av vissa instrument. En stor ökning på efterfrågan av statsobligationer och ränteswappar med långa löptider är att vänta. Dessutom kommer både företags- och säkerställda obligationer vara betydligt mer attraktiva investeringsalternativ under det nya regelverket. En annan stor inverkan är den lägre riskjusterade avkastningen för aktier och aktierelaterade produkter. Över tid kommer detta sannolikt leda till en reduktion av svenska livbolags relativt höga exponering har gentemot aktier. Därutöver finner vi att bolagen har mycket att vinna på att införliva en optimering med avseende på de av regelverket angivna kapitalkraven.

Nyckelord

Solvens II, Livbolag, Tillgångsallokering, SCR, Portföljteori, Regleringar

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1. Introduction

1.1 Background

Insurance companies constitute some of the largest institutional investors in the capital markets. Swedish life insurers have aggregated investments of close to 2.5 trillion SEK (SCB, 2012). These assets should be enough to cover not only the present value of all future net payouts to the policy holders, but also the legislated solvency buffer, intended to minimize the risk of insolvency.

The solvency of insurance companies has long been considered an important enough issue to justify specific regulations of this area. In Sweden, laws regulating the solvency of insurance companies have been in place since the beginning of the 20th century[1]. Klein (1995) identified the primary objective of insurance regulations as protecting the policy holders and society against insurer insolvencies. This is vital since, unlike the situation for bank depositors, there is no government backed guarantee to protect insurance policy holders from losses if an insurance company should not be able to meet its commitments.

On an EU level the foundations of a coordinated regulatory framework were laid in the 1970s. The EU solvency regime was then updated in 2002 through the Solvency I directives, which, although they provided some updates to the almost 30 year old regulations, were not intended to fundamentally change the EU solvency regime. This was criticized since the solvency requirements are volume based and therefore punish companies with large reserves instead of taking into account the real risks that insurance companies face. Such non-risk based capital requirements were applied in many countries before the 1990s but since the end of the last decade most have switched to risk-based models (Eling, Schmeiser, & Schmit, 2007). Many member states have also concluded that the requirements in the directives were set too low. At the same time the directives leave considerable room for member states to implement national legislations (Steffen, 2008). This has lead to a situation where the regulations and solvency requirements for insurance companies vary remarkably across the EU member states. Since the main purpose of the EU level legislation is to facilitate the progression towards a single European insurance market, as well as guaranteeing a certain level of policy holder protection across the union (European Commission, 1998), the need for a complete reformation of the EU solvency regime became apparent. This reformation has come to be called Solvency II and is to be implemented by all EU member countries by 2014.

1.2 Problem Formulation and Objective

Unlike Solvency I, Solvency II has a risk-based solvency requirement where insurance companies are to hold enough capital, called Solvency Capital Requirement (SCR), to remain solvent for one more year with a 99.5 percent probability. In most cases this will

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[1] SFS 1903:94 Lag om försäkringsrörelse

mean a significant increase in the amount of capital the companies need to hold compared to the current requirement. In the calculation of this amount, risks associated with the asset side of the balance sheet are incorporated, meaning that the asset allocation will impact the amount of capital an insurance company needs to hold. Since holding large amounts of capital is expensive, most insurance companies will seek to minimize the SCR and therefore optimize the asset allocation accordingly. This means that there is a discrepancy between how insurance companies optimize their asset allocation pre-Solvency II and how they will optimize after the implementation of Solvency II. Since the aggregated investments of Swedish life insurance companies are close to 2.5 trillion SEK, even a small reallocation of the assets would have a large impact on the financial markets and could mean a considerable change in demand for certain instruments. The impact of Solvency II on the insurance market is therefore an important question not only for insurance companies but also for other participants in the capital markets. This leads to the objective of this thesis; to analyze and assess what effect Solvency II will have on the asset allocation of Swedish mutual life insurers. This will be done mainly by focusing on the following question:

- What type of assets are Swedish mutual life insurance companies likely to increase and/or decrease their investments in after the implementation of Solvency II?

In order to answer this, many implicit areas need to be considered. Firstly the current asset allocation of life insurance companies needs to be examined. Secondly the ways in which Solvency II differs from the current regulations need to be established. As a third point, the possible investments for Swedish life insurance companies need to be discussed. This will be done primarily in terms of liquidity.

1.3 Delimitations

As the research question suggest the focus in this thesis will be on life insurance companies that operate according to mutual principles. This includes mutual insurance companies as well as what is usually called hybrid companies. These insurance companies represent a majority of the assets invested by Swedish insurers. In terms of asset allocation under Solvency II they are therefore regarded as the most interesting participants in the Swedish financial market.

1.4 Prior Research

The impacts of insurance regulations have been discussed in several studies and articles. Munch and Smallwood (1980) present empirical evidence on the impact of solvency regulations in the US and concluded that regulations on capital requirements seem to reduce the number of insolvencies by reducing the number of small firms. Cummings (1989) identifies two positive consequences of regulations. Firstly, regulations reduce monitoring and information costs for policy holders. Secondly, regulations provide some protection when the beneficiary of the insurance policy is not the buyer thereof, and has thus not chosen the insurance company.

Finsinger and Pauly (1992) constructs models for predicting the optimal level of reserves for unregulated firms. They find that if firms are left unregulated they will hold levels of reserves that are generally lower than the social optimum. Willenborg (2000) studies the decision by state regulators in the U.S. to take actions against certain insurance companies with solvency issues but not others. He finds that the likelihood of solvency-related regulatory action is positively correlated to the number of states in which the insurance company operates but that the likelihood does not decrease with the size of the insurance company.

Høyland and Wallace (2001) apply an asset-liability management model to analyze the implications of the regulations on the Norwegian life insurance market. They conclude that the regulations do not benefit the interest of the policy holders.

Research concerning Solvency II has been focusing on a wide range of issues. A large part of the early research focused on the calibration of the SCR calculation. Sandström (2007) proposes how to adjust for skewness in any of the modules' underlying distributions and shows examples of the effect of not calibrating for skewness. Ronkainen, Koskinen and Berglund (2007) discuss some topical aspects of internal SCR models. Pfeifer and Strassburger (2008) show the existence of stability problems in the SCR aggregation formula when there is skewness in some of the individual risk distributions.

Steffen (2008) describes the main features of the Solvency II project and the work by CEIOPS[2]. Holzmüller (2009) analyzes and compares Solvency II to the United States RBS standards and the Swiss Solvency test using the framework for analysing risk-based capital systems provided by Cummings et al. (1994). She concludes that the requirements in Solvency II and the Swiss solvency test perform superior to those in the RBS standards but that it is hard to evaluate which of the two European standards will be most successful.

Much of the research that has been conducted with reference to the market impact of Solvency II has so far been made by stakeholders within the industry. For instance, Fitch Ratings (Poizot, Hughes, Prowse, & Insoll, 2011) discuss the attractiveness of different asset classes in view of the implementation of the Solvency II regime. A couple of their main findings are an expected shift to shorter-term debt and an increasing demand for government bonds and higher-rated corporate debt. They also expect better derivative duration-matching and a general increase in financial engineering as to the creation of Solvency II-specific assets, such as reverse repos and structured notes.

[2] Committee of European Insurance and Occupational Pensions Supervisors

The research that has been produced by academia on this topic is somewhat limited. Eling, Gatzert, Schmeiser (2008), examines the market implications of the Swiss Solvency Test, which in many ways resembles the Solvency II regime. Their findings indicate a shift toward long-term bonds (as opposed to Piozot et. al.) and a flat term structure over *"the next few years"*. Furthermore, they infer that a similar shift might occur in the real estate market and that stock market activity is not likely to change. They also suggest that these results are likely to be of interest when estimating the impacts of Solvency II, due to the similarities between the two regulatory frameworks. Sundén-Cullberg and Wenneberg (2011) discuss the impact of the Solvency II regime on private equity investments. One main finding is that the differences between overcapitalized insurers and undercapitalized insurers will increase due to Solvency II. This comes from the notion that undercapitalized insurance undertakings need to raise their exposures to low risk assets and hence decreasing future expectations on returns, while overcapitalized undertakings will be able to hold a more diversified portfolio when looking at risk and expected return. Another interesting observation was made by Gatzert and Martin (2012) who concludes that the standard model appears to underestimate the risk of low-rated bonds, while it overestimates the risk of high-rated bonds. Findings like this are relevant given that none of the quantitative requirements are irrevocably established as of yet.

This thesis focuses on the Swedish life insurance market and the particular circumstances under which the companies operate. Characteristics such as comparably rigorous regulations, a product mix with a high degree of occupational pension and an asset allocation which very much differs from that of the average European life insurer have led the Swedish life insurance companies to in many ways be unlike their European counterparts. It is therefore of great interest to study how the Solvency II framework, developed in a European context, will impact Swedish life insurers. This is an area where very little research has been made which can be seen as surprising given the volume of life insurance companies' investments. Furthermore, this thesis will provide an overview and analysis of the Solvency II framework, focusing on market risk and the calculation of the SCR, which should be of interest for anyone wanting to learn about this new, extensive regulatory framework.

1.5 Outline

- Section 2, *Method*, describes the methodology to be used and the motives for choosing it. The main method is a quantitative model which optimizes the asset allocation in terms of minimizing the SCR given constraints on minimum required expected return. The model is complemented by a qualitative analysis of aspects which cannot be quantified in the optimization, such as more qualitative aspects of the legislations and the characteristics of the markets for different assets. Further, the data used is presented and discussed as well as the limitations in the methodology.

- Section 3, *Theoretical framework,* briefly presents the Swedish life insurance industry after which the topic of portfolio choice and Modern Portfolio Theory is treated. A review of the theory of portfolio selection for life insurance companies follows and the section ends with an overview of the current asset allocation for Swedish life insurance companies.

- Section 4, *Regulatory framework,* describes the Solvency II framework as well as the current legislations regulating Swedish life insurance companies. The section begins with outlining the different legal forms of life insurance companies followed by an overview of Solvency I and the Traffic Light Model, the frameworks which are currently regulating the solvency of Swedish insurance companies. Solvency II is then more thoroughly presented, beginning with the plan for the implementation process followed by the Quantitative Impact Studies that has been carried out to test the implications of the framework. The different parts of the framework are then presented more in-depth with focus on the quantitative requirements under Pillar 1 and especially the requirements covering market risk.

- Section 5, *Results,* presents the results of the quantitative model and certain aspects of the framework which are important for the future attractiveness of different assets.

- Section 6, *Analysis,* provides analyses of the results as well as combing the results with aspects not covered in the quantitative model. The findings are also compared to those of previous research. Examples of possible implications of some specific parts of the new legislations are given and discussed and some significant factors for how the framework will impact Swedish life insurance companies are pointed out.

- Section 7, *Conclusion,* provides a summary of the purpose and main findings of the thesis. It further gives suggestions for future research topics that would be of interest.

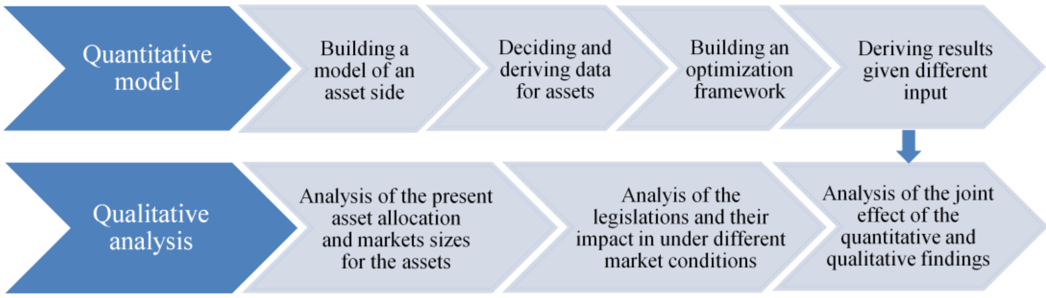
2. Method and Data

2.1 Choice of Methodology

The main objective in this thesis, to show how a life insurance company which operates according to mutual principles should optimize its asset portfolio under Solvency II, implies a quantitative methodology built on mathematical models. A quantitative approach is suitable as the research questions suggest quantification of variables such as expected return, risk and capital constraints. However, the full impact of Solvency II is hard to capture using only a quantitative model since there is some uncertainty as to how Solvency II will be implemented for different kinds of insurance companies, and how the qualitative constraints in Pillar 2 will be applied. Furthermore, the quantitative requirements in Pillar 1 are not irrevocable and the pace of implementation is at this stage an open question. For this reason, the main methodology of this thesis is a quantitative study complemented by a qualitative analysis and research of the legislation and its probable effects of the insurance and financial markets.

Figure 1 - Summary of the timeline of the methodology

This thesis has had both a quantitative and qualitative approach due to the complexity of the issue at hand. The figure below gives a summary of the methodology used, both in terms of chronology and approach.



2.2 Quantitative Model

A mathematical model is used to derive primary data on the impact of the quantitative constraints (specified in Pillar 1 of the Solvency II framework) on the optimal asset allocation of insurance companies. Since the impact of the asset allocation on the capital requirement is captured under the market risk module in the SCR calculation, the model focus only on this module and the SCR for market risk. Of the sub-modules, only the interest-rate, equity, property and spread risk modules are considered (see figure 10, p. 28, for an illustration of all risk modules). The reason for the exclusion of the illiquidity premium and concentration risk modules is their very limited impact on the total SCR as have been shown in the Quantitative Impacts Studies that have been carried out[3]. The exclusion of the currency risk module is a consequence of the fact that only Swedish assets have been considered in the model. This delimitation to Swedish assets in the

[3] The Qualitative Impacts Studies will be further discussed in section 4.4.2 Quantitative Impact Studies

model is done for simplicity reasons. However, foreign assets and currency risk will be discussed in the qualitative analysis.

The model comprises a representation of a mutual insurance company which is produced in order to reflect a typical Swedish mutual insurance company. The representation is used for determining the size of the technical provisions as well as determining the impact of an interest rate stress on the present value of the liabilities side of the balance sheet. Furthermore, it is used as a benchmark of the asset allocation of Swedish life insurers.

The basis of the representation of the liability side is historical data on a portfolio of insurance contracts from a Swedish life insurance company. The data set, containing only traditional life insurance, has been sorted by type and time to maturity after which 27 data points has been created. The aggregated liabilities representation has then been constructed from the data points. The benchmark asset side composition is the aggregated holdings of Swedish life insurers, which is deemed appropriate since the holdings of the major life insurers do not differ significantly.

The model finds the optimal asset allocation in terms of minimizing the Solvency Requirement Capital given a minimum expected return. This can be illustrated by the following optimization problem:

$$\begin{aligned} &\mathbf{min}\ SCR \\ &\text{s.t.}\ \ \boldsymbol{w}^T\boldsymbol{\mu} \geq \mu_0 \\ &\qquad \boldsymbol{w}^T\mathbf{1} = 1 \\ &\qquad \boldsymbol{w} \geq \mathbf{0} \end{aligned} \tag{1}$$

In this expression $\boldsymbol{w}$ are the weights of the different assets, SCR is the Solvency Requirement Capital which is a function of $\boldsymbol{w}$, $\boldsymbol{\mu}$ is the expected returns of the assets and μ_0 is the minimum expected return.

Since the SCR for market risk is calculated as the square root of the sub-modules'[4] SCRs times the market SCR correlation matrix[5] times the sub-modules' SCRs, the term SCR in the optimization (1) above can be expressed as:

$$SCR = \sqrt{(\boldsymbol{SCR_{sub}})^T\, \boldsymbol{C}\, (\boldsymbol{SCR_{sub}})} \tag{2}$$

where $\boldsymbol{SCR_{sub}}$ is a vector with the SCR of the market sub-modules (and $\boldsymbol{SCR_{sub}}^{\boldsymbol{T}}$ is the transposed vector) and $\boldsymbol{C}$ is the SCR market correlation matrix. The SCR of the sub-modules (SCR for interest rate risk, equity risk, spread risk, property risk, etc.) are linear functions of the weights $\boldsymbol{w}$**.** This means that $\boldsymbol{SCR_{sub}}$ can be expressed as $\boldsymbol{Gw}$, where $\boldsymbol{G}$ is a matrix containing the linear functions for computing the SCR of the sub-modules

[4] The SCR for market risk has seven sub-modules; interest rate risk, equity risk, property risk, spread risk, currency risk, concentration risk and illiquidity premium risk. This calculation of SCR will be further treated in section 4.4.3.

[5] The complete market SCR correlation matrix is shown in Table 5.

according to the SCR calculations defined under Pillar 1 (presented under the Theory section). The term SCR in the optimization expression (1) can then be rewritten as:

$$SCR = \sqrt{\boldsymbol{w}^T\, \boldsymbol{G}^T \boldsymbol{C}\, \boldsymbol{G}\boldsymbol{w}} \tag{3}$$

Since minimizing $\sqrt{\boldsymbol{w}^T\, \boldsymbol{G}^T \boldsymbol{C}\, \boldsymbol{G}\boldsymbol{w}}$ is analogous with minimizing $\boldsymbol{w}^T\, \boldsymbol{G}^T \boldsymbol{C}\, \boldsymbol{G}\boldsymbol{w}$ the square root can be left out of the optimization, leaving the problem as:

$$\min_{\boldsymbol{w}}\ \boldsymbol{w}^T(\boldsymbol{G}^T \boldsymbol{C}\, \boldsymbol{G})\boldsymbol{w} \tag{4}$$

$$\text{s.t.}\quad \begin{aligned} &\boldsymbol{w}^T\boldsymbol{\mu} \geq \mu_0 \\ &\boldsymbol{w}^T\boldsymbol{1} = 1 \\ &\boldsymbol{w} \geq \boldsymbol{0} \end{aligned}$$

As seen, what is left is very similar to the traditional convex Mean-Variance optimization described by Markowitz (1952), with the difference that this optimization is done over SCR instead of variance. This optimization problem is then solved using MATLAB. Different values for μ_0 are used as well as different interest levels, effecting the function matrix $\boldsymbol{G}$.The main levels used for μ_0 in the comparison of instruments are 2, 4 and 6%, which should reflect the room for manoeuvre offered at different degrees of solvency.

The assets used in the model are government bonds, covered bonds, corporate bonds, listed shares, private equity and property. These assets represent an absolute majority of the assets held by mutual life insurance companies in Sweden. In the case of bonds the assets have been further divided by rating and maturity (see Table 10 in the appendix for the complete list of assets used in the optimization.)

Alongside the SCR optimization an ordinary Mean-Variance optimization is done in order to compare the results of the SCR optimization and evaluate whether the optimal asset allocation in terms of minimizing the SCR deviates from the asset allocation when minimizing the variance which is traditionally used as a main measurement of risk.

2.3 Qualitative Analysis

The quantitative model is complemented by a more qualitative analysis of the legislations and of the Swedish markets for the relevant assets and asset classes. The qualitative analysis comprises both the impact of the qualitative requirements found under Pillar 2 as well as an analysis of the relative attractiveness of the available assets under different market conditions given both the way the SCR is calculated and the size and liquidity of the Swedish market.

2.4 Collection of Data

Secondary data

The quantitative model requires data on expected return of the different assets. This is derived from historical data using two different assumptions. Under the first assumption the expected return is equal to the average return of the historical data set. Under the second assumption the expected return is calculated using a constant Sharpe ratio using the following formula:

$$\mu_i = S\sigma_i + \mu_f \tag{5}$$

where μ_i and σ_i are the expected return and standard deviation of asset i, S is the Sharpe ratio (which is held constant at the historical average for all assets) and μ_f is the risk free rate. In this case the expected excess return is hence assumed to be proportional to the volatility.

In both cases the data used is time series of monthly index data from August 2004 to March 2012 collected from Reuters. The complete list of the indexes used for the different assets is shown in Table 11 in the appendix. Where possible Swedish indexes have been used but when no suitable Swedish index has been available the data series has been converted to SEK using the corresponding time series of exchange rates. For corporate bonds where the same index has been used the expected return has been linearly interpolated for different ratings and adjusted to have an increase in expected return with increased maturity corresponding to the increase seen for government bonds.

For both the quantitative model and the qualitative analysis, data on balance sheet items and in particular the asset allocation of Swedish mutual insurance companies is used as well as data found in the income statement of these companies. Statistics Sweden (SCB) puts together statistics on the aggregated assets of life insurance companies in Sweden four times per year.

Since there for each asset are several possible indices to use as benchmarks the choice of index will have an impact on the results of the optimization. As always when using historical data, there are no guarantees that the chosen data will be a good predictor of future behavior of the assets. For this reason two distinctly different ways of deriving the expected return has been used, allowing for conclusions to be drawn that are not specific to particular assumptions on future returns.

Another matter is the fact that there are no suitable indices for Swedish corporate bonds. Instead indices denominated in USD have been used and then converted to SEK using the corresponding time series of exchange rates. There are, however, fundamental differences between the Swedish and the US markets and the values in SEK are also impacted by exchange rate volatility. But this is a problem that is very much shared with Swedish life insurers and due to the limited Swedish corporate bond market we argue that the use of an American index converted into SEK is actually closer to the realistic investment scenario of Swedish life insurance companies.

3. Theoretical Framework

3.1 The Swedish Life Insurance Industry

The insurance industry can be divided into non-life and life insurance. Non-life insurance products covers a wide range of risk, such as property insurance, travel insurance and third-party liability insurance while life insurance products can both cover risks associated with the life and health of the policy holder and act as saving product. Examples of these products are occupational pension insurance[6] and endowment insurance[7] (Svensk Försäkring, 2010).

In 2010 there were 44 life insurance companies active in the Swedish market (Försäkringsförbundet, 2010). This number includes both insurance companies dealing exclusively with occupational pension as well as companies offering a wider range of products. Distinguishing for the Swedish market is the limited foreign participation and the large presence of mutual insurance companies (Lindmark, Andersson, & Adams, 2006).

The aggregated investments of Swedish insurance companies are approximately SEK 2,943 billion. Life insurance companies make up a clear majority of these assets, about SEK 2,447 billion, making life insurance companies some of the largest institutional investors in the Swedish financial markets (SCB, 2012).

3.2 Portfolio Choice

Portfolio optimization is very much linked to Markowitz' Modern portfolio theory (Markowitz, 1952). The theory tries to minimize the risk of a portfolio for a given expected return. From this theory the Mean-Variance optimization can be derived;

$$\min_{\boldsymbol{w}} \boldsymbol{w}^{\boldsymbol{T}} \Sigma \boldsymbol{w} \tag{6}$$

$$\text{s.t.} \quad \boldsymbol{w}^{\boldsymbol{T}} \boldsymbol{\mu} = \mu_0$$
$$\boldsymbol{w}^{\boldsymbol{T}} \mathbf{1} = 1$$
$$\boldsymbol{w} \geq \mathbf{0}$$

where $\boldsymbol{w}$ represents the weights of the assets, Σ is the covariance matrix of the assets, $\boldsymbol{\mu}$ is the expected returns of the assets, and μ_0 is the required expected return.

Markowitz describes portfolios which are optimal in the sense that they have the lowest possible risk given a minimum expected return to be efficient. The entire set of efficient portfolios for different expected returns make up the efficient frontier. The risk measurement in the efficient frontier is usually standard deviation but other risk measurements are also possible.

[6] Sw: *tjänstepensionsförsäkring*

[7] Sw: *kapitalförsäkring*

While the impact of Modern portfolio theory cannot be overestimated, there has been some strong critique against some of the theory's underlying assumptions. One of the most common critiques is that the theory requires quadratic utility functions or that the returns are jointly elliptically distributed while returns in practice tend to be asymmetrically distributed (Grottveld & Hallerbach, 1999). The fact that returns are not symmetrically distributed also implies that variance is not an optimal risk measure, since variance is impacted as much by upside movements, which are normally desired, as by downside movements.

As a result of the limitations of Modern portfolio theory a new paradigm called Post Modern portfolio theory developed in the early 1990's. The theory can be seen as a more generalized extension of Modern portfolio theory, applicable also when returns are asymmetrical. Instead of variance, a risk measure called downside risk is used. Unlike volatility, downside risk is tied to an investor's target return, referred to as minimum acceptable return. Only volatility below the investor's target return incurs risk, whereas volatility above the target return does not impact the downside risk (Rom & Ferguson, 1993).

Another model, building on Modern portfolio theory, which was developed in the early 1990's, is the Black-Litterman model (Black & Litterman, 1992). Black and Litterman identified two main problems with quantitative asset allocation models. The first being that expected returns are very difficult to estimate and the second being that the optimal asset allocation suggested by the models is very sensitive to the return assumptions used. The proposed solution to these problems is to combine the mean-variance optimization framework with the capital asset pricing model (CAPM)[8]. In a second stage the investor's own views about the outlook for different assets is incorporated. The model will hence in the base case render a market capitalization weighted portfolio, with deviations from that equilibrium only when the investor has specific views on different assets.

3.3 Portfolio Selection for Life Insurance Companies

According to (Jones, 1968) the portfolio selection of life insurance companies is made on the basis of two ultimate objectives; to maintain its solvency and to be competitive. These two goals are in some ways conflicting as aiming to maintain a high solvency means limiting the risk exposure while the goal of being competitive requires an insurance company to strive towards offering a high return to its policy holders.

A characteristic of life insurance products, which is of large importance for the solvency objective, is their long duration which makes life insurance companies sensitive to interest rate risk. The classic portfolio strategy for dealing with this risk is interest rate immunization (Hörngren & Viotti, 1994) which is a concept within the framework of dedicated portfolio theory initially presented by insurance actuaries. The theory basically

[8] CAPM was first described by W. F. Sharp in *"Capital Assets Prices: A Theory of Market Equilibrium Under Conditions of Risk"*, Journal of Finance, 1964

shows how it is possible to minimize the sensitivity to interest rate movement by matching the assets with the liabilities through the purchase of fixed income securities. One of the earliest contributions to this theory was made by Koopmans (1942) who showed that a portfolio can be practically immunized against interest rate changes by matching the duration of the bonds held in the portfolio with the duration of the liabilities.

In practice, a high level of immunization using only bonds is in most cases not uncomplicated, or even feasible, as there is a limited range of bonds available (Hörngren & Viotti, 1994). Such an immunization strategy would also require a level of activity in the management of the bond portfolio which would generate large costs (Benkato, Haddad, Al-Loughani, & Baur, 2003). Instead, interest rate derivatives are often used alongside bonds to minimize sensitivity to interest rate movements. Since the emergence of interest rate swaps in the financial markets these derivatives have become very popular for managing interest rate risk. Bierwag & Kaufman (1991) showed how interest rate swaps can be efficiently used to reduce the duration gap, i.e. the difference in duration, between assets and liabilities and how swap agreements can be tailored to satisfy interest rate risk requirements.

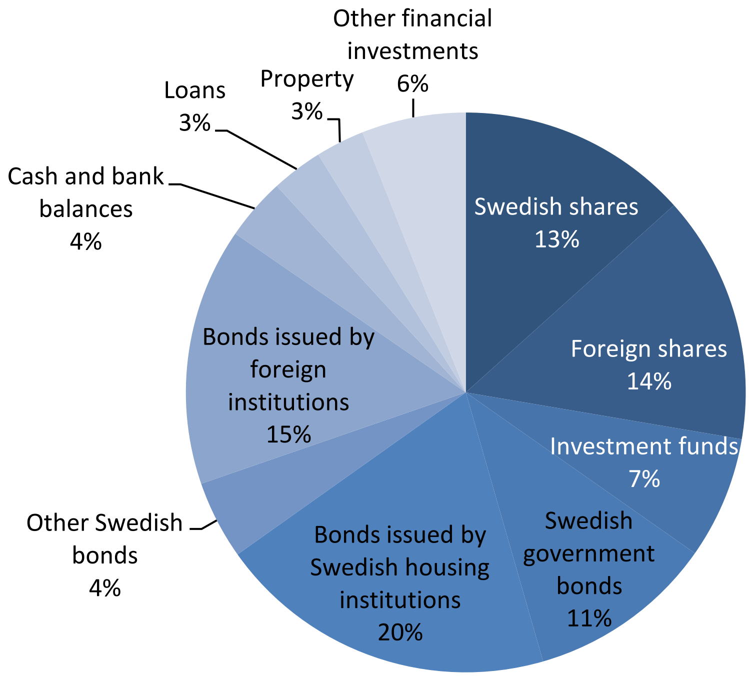
3.4 Present Asset Allocation of Life Insurance Companies

Of the SEK 2,447 billion invested by Swedish life insurance companies, shares and participations[9] stand for half of the investments while interest bearing securities represent 40 percent. The high percentage for shares and participations is in part due to unit-linked insurance[10] where investment funds stand for close to all of the assets. Excluding unit-linked insurance (SEK 548 billion) the composition of the aggregated investments of Swedish life insurance companies is shown in Figure 2.

[9] Participations in, for instance, private equity funds

[10] Sw: *fondförsäkringar*

Figure 2 - The asset side structure of Swedish life insurance companies (excluding unit-linked)
The chart shows the aggregated investments of Swedish life insurance companies as of 2011-12-31. The total amount is SEK 1.9 trillion.



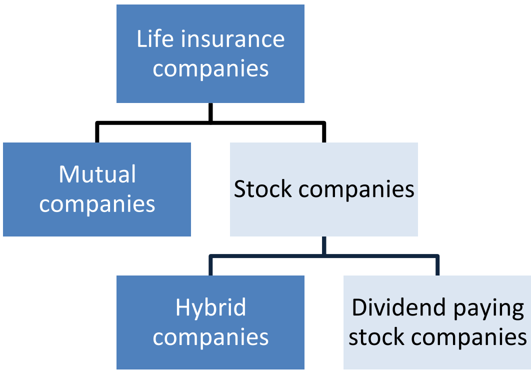
Source: SCB, 2012

4. Regulatory Framework

4.1 The Different Legal Forms of Life Insurance Companies

The ownership structure of life insurance companies is in many ways different from that in other industries. In Sweden there are two legal forms of insurance companies: mutual companies, which are owned collectively by the policyholders, and stock companies, which are owned by the shareholders. The stock companies can be further divided into regular dividend paying stock companies[11] and hybrid companies[12], which are stock companies operating according to mutual principles.

Figure 3 - The legal forms of insurance companies in Sweden
Life insurance companies in Sweden can either be stock companies or based on mutual principles. In turn, stock companies can either be a normal dividend paying business or so called hybrids, which operate under mutual principles. The focus on this thesis will be on mutual and hybrid companies.



Historically, the most common legal form by far has been the mutual company. The concept of mutual insurance is that the policyholders do not only serve as the clients but also as the owners of the company. This is a way to alleviate potential conflicts about the distribution of surpluses between owners and policy holders (O'Sullivan, 1998).

The policyholders can also be said to act as the financiers of the business. Since mutual insurance companies have no shareholder equity they are obliged to set up a surplus fund[13]. The surplus fund consists of the accumulated surplus of the business and has the same function as equity in a stock company. It serves as risk capital and can be used to cover any loss that the company may sustain. The individual policyholders have no legal claim to the surplus fund. However, funds in excess of an appropriate surplus level should be distributed back to the policyholders (SOU 2006:55).

[11] Sw: *vinstutdelande aktiebolag*
[12] Sw: *hybridbolag* i. e. a life insurance company that, although limited by shares, does not have the right to distribute profits to its shareholders
[13] Sw: *konsolideringsfond*

The deregulation of the Swedish insurance market, primarily in the 1980s and 1990s, allowed the emergence of stock companies in the life insurance market. However, the Insurance Business Act[14] from 1982 did not allow the distribution of profit to shareholders. This led to the development of a new legal form, the so called hybrid company which is a stock company operating according to mutual principles. This means that it may not pay dividends to shareholders. Just like for mutual insurance companies a surplus should instead be distributed to the policyholders and a surplus fund should be maintained (Finansdepartementet, 2010).

The restriction on profit distribution to shareholders was lifted in 1999, which has led to a demutualization of many insurance companies. However, a demutualization still has to be approved by *Finansinspektionen* (FI), which shall deny the demutualization if it is found to be disadvantageous for the policyholders.

Since lifting the restriction on profit distribution to shareholders, doubts have been raised about the legal form of hybrid companies. It has been suggested that hybrid companies should have to either demutualize or turn into fully mutual companies. The currently running governmental study on how life insurance should be conducted, *Livförsäkringsutredningen*, is supposed to come with a recommendation in the matter (Finansdepartementet, 2010).

One of the major differences between the mutual and the non-mutual companies is the way the return is distributed in traditional (with profit) life insurance. Traditional life insurance comes with a guaranteed return. Basically, the policyholder pays a premium which is then invested by the insurance company. The policyholder then receives the maximum of the investment return and the guaranteed return. This works in slightly different ways for mutual and dividend paying stock companies. For mutual insurance companies, if the return of the investment of the premiums paid by all policyholders is higher than the guaranteed return, the excess return from the investment is allocated to all policyholders. However, this excess return can then be reallocated if the investment return should later drop below the guaranteed return.

[14] Försäkringsrörelselagen (1982:713)

Figure 4 - The major life insurance companies in Sweden listed by legal form
Listed below is a selection of the largest life insurance companies currently active in the Swedish market.
*At the time of the writing of this thesis Skandia Liv is in the process of converting to a mutual company.

Mutual	Hybrid	Dividend paying
• Folksam Liv • Alecta	• Skandia liv* • AMF • AFA • LF Liv • SEB Trygg Liv Gamla • KPA Liv • KPA Pension	• SPP Liv • Nordea Liv • Handelsbanken Liv • Fondförsäkrings AB SEB Trygg Liv

For dividend paying stock companies the investment return is calculated for each individual policyholder. If this is higher than the guaranteed return the policyholder is attributed the majority of the excess return while the company keeps a part as profit. However, if the investment return should not reach the guaranteed return level the company is obliged to make up for the difference. This means that the owners of the company, the shareholders, take on a portion of risk that in mutual companies lies with the policyholders. This risk has become very apparent in recent times with the historically low interest rates pushing down investment returns and making guarantees hard to meet. Consequently, many of the dividend paying insurance companies have closed their traditional insurance portfolios for the writing of new policies[15].

4.2 Solvency I

The foundation of the current EU level regulatory framework, Solvency I, was laid in 1973 with the First Non-life Directive and in 1979 with the First Life Directive[16]. Another step towards a single insurance market within the EU was taken in 1992 with the third generation of the Life and Non-life Insurance Directives[17]. These directives allow insurers authorized in any one EU member state to sell insurance products throughout the EU (Nyström, 1994). Ten years later, after a revision of the EU solvency regime, the directives were again updated when the Solvency I framework[18] was accepted.

Solvency I was not a fundamental change to the earlier solvency regime but rather provided amendments to it. The solvency requirement, called solvency margin, is relatively easily calculated and straightforward; it is basically a function of the technical

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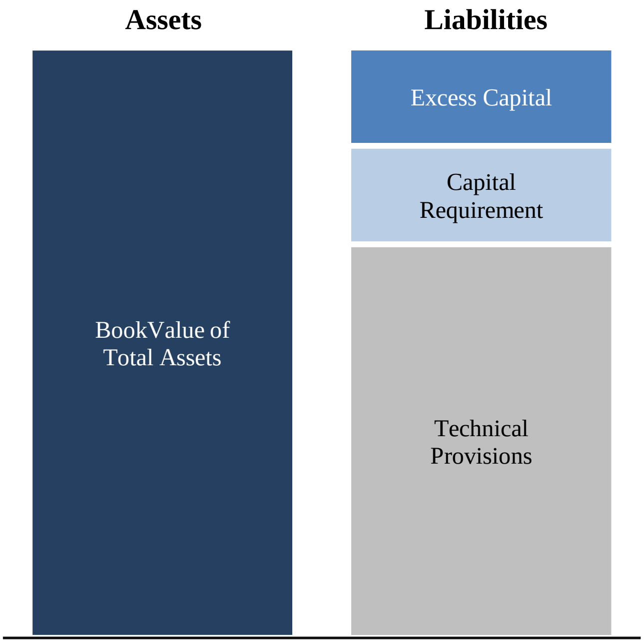
[15] Companies that have closed their traditional insurance portfolio are for example: Länsförsäkringar Liv, Swedbank Försäkring, SEB Trygg Liv, Handelsbanken Liv and Nordea Liv.
[16] Directive 73/239/EEC and Directive 79/267/EEC
[17] Directive 92/96/EEC and 92/49/EEC
[18] Directive 2002/12/EC and 2002/13/EC

provisions[19]. In simple terms, for traditional (with profit) life insurance[20] the solvency requirement is approximately 4 percent of the technical provisions minus reinsurance cessions, while for unit linked insurance[21] the corresponding share is 1 percent (European Parliament, Council, 2002).

Figure 5 - Balance sheet of insurance companies according to Solvency I
In the base case the assets are valued at book value. However there is still a possibility to value assets at market value. The capital requirement is volume based and generally substantially lower than the SCR under Solvency II.



Source: CEA (2006)

The critique against Solvency I have mainly focused around two issues. The first is that the solvency requirements are set too low and hence do not provide satisfactory protection for policyholders if the economic conditions should deteriorate. The second issue, which is often regarded as the most important one, is the fact that the solvency requirement does not encompass all risks that the insurance companies face (Steffen, 2008). Risks such as market, counterparty and operative risk are not taken into account in the solvency requirement. This means that the requirements constitute no incentive to minimize risk taking. Instead, by calculating the solvency requirement as solely a function of the technical provisions, prudence is effectively punished since higher provisions result in higher solvency margins.

4.3 Traffic Light Model

Partly as a result of the limitations of Solvency I, many EU member states have adopted their own regulations and models for the supervision of insurance companies. Since 2006

[19] Sw: *försäkringstekniska avsättningar*. Provisions to cover the future obligations due to insurance undertaking

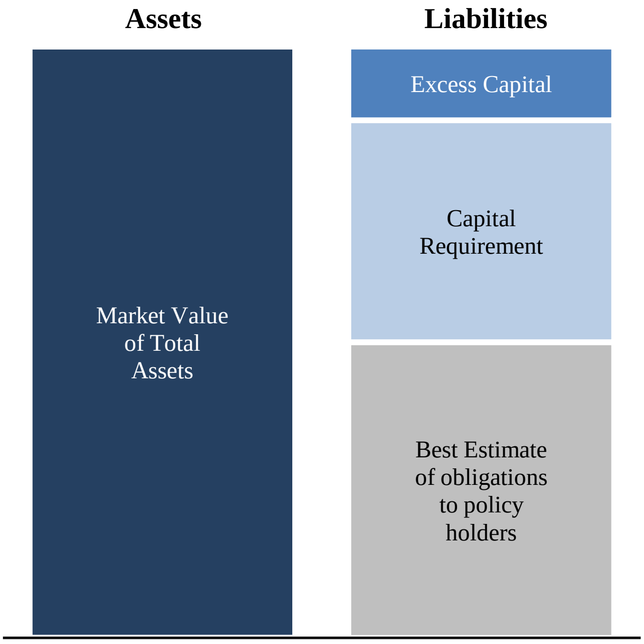
[20] Sw: *traditionell livförsäkring*

[21] Sw: *fondförsäkring*

Swedish life insurance companies have been evaluated by Finansinspektionen according to a methodology called the Traffic Light Model[22]. The model was developed to identify insurance companies that take on too much risk with regard to their capital base.

Unlike the Solvency I framework the Traffic Light Model encompasses market risks associated with the asset side of the balance sheet. The first model used in 2006 focused only on financial risk. The model was then updated in 2007 to also include insurance risks (Homenius & Söderström, 2007). The structure is in many ways similar to Solvency II, although simpler. Just as Solvency II, the model is based on fair values of assets and liabilities and a scenario approach is used to calculate the capital requirement. The drivers of the capital requirement are market risks and life risks which are stressed at a level which is supposed to approximately represent a 99.5% one-year Value at Risk.

Figure 6 - Balance sheet of insurance companies according to the Traffic Light Model
The balance sheet according to the Traffic Light Model resembles the equivalent under Solvency II in many ways. The capital requirement calculation is however simpler and does not capture as many risks as the SCR calculation under Solvency II.



Source: von Bahr (2007)

Each insurance company is obliged to report their result of the model quarterly. The outcome is then summarized with either a green light if the capital buffer is sufficient or a red light if the capital buffer is less than required. In the case of a red light Finansinspektionen conducts more in depth monitoring measures of both quantitative and qualitative aspects.

In a juridical sense the Traffic Light Model is just a methodology used for supervision; there is technically no regulatory demand to fulfill the capital requirement. However, in

[22] Sw: *Trafikljusmodellen*

practice the Traffic Light Model has come to serve as the main framework dictating the capital requirement for Swedish insurance companies (Barr, 2011).

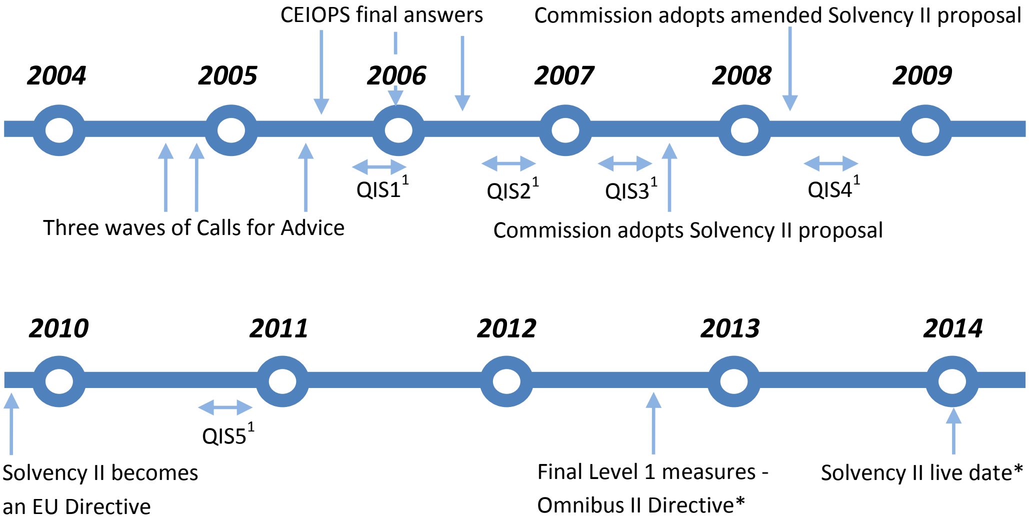
4.4 Solvency II

The shortcomings of the Solvency I framework led to a discussion about improving the regulation by taking a wider approach when looking at the financial position of insurance undertakings. The discussions were shaped by current developments in risk management, financial reporting and prudential standards, finance techniques etc., and the project was named Solvency II (Eling, Schmeiser, & Schmit, 2007).

In 2004 and 2005, the European Commission issued three Calls for Advice (CfAs) to the Committee of European Insurance and Occupational Pensions Supervisors (CEIOPS)[23], concerning various features of the new solvency framework. The Commission's main policy guidelines and principles was published in July 2004 in the *Framework for Consultation* document, and served as a guide to CEIOPS. Following extensive dialogue with main stakeholders, internal discussions and public consultations, CEIOPS returned the three CfAs between June 2005 and May 2006 (European Commission, 2011).

In July 2007, the Commission adopted the Solvency II Proposal, after the completion of the consultation process, and in November 2009, the Solvency II Directive was voted through the European Parliament (European Commission, 2009).

Figure 7 – Timetable for the Solvency II process
The timetable for Solvency II has been updated on multiple occasions. Shown below are the main historical events as well as the planed dates for Omnibus II Directive and the Solvency II implementation as of April 2012.



*Preliminary date
[1] Quantitative Impact Study
Source: European Commission (2010 & 2012); CEIOPS (2006 & 2008); Financial Services Authority, (2005 & 2007)

[23] CEIOPS was replaced by the European Insurance and Occupational Pensions Authority (EIOPA) in January 2011.

4.4.1 Implementation

The adaption of Solvency II is done according to the Lamfalussy process. The process was developed in 2001 and is named after Alexandre Lamfalussy, the chair of the EU advisory committee that formed it. It is composed of four levels designed to ensure that EU legislation in complex areas of financial services law is relevant for changing circumstances (Alford, 2006).

Level 1, the Framework directive, is the "Directive on the taking up and pursuit of the business of insurance and reinsurance"[24] which was accepted by the European Council and Parliament in 2009. The directive provides the general framework for the legislation and its implementation (Patel, 2009). However, parts of the Level 1 directive are to be modified with the Omnibus II Directive (Level 1 Framework Directive - Solvency II, 2012), scheduled for plenary vote September 10, 2012 (Whittaker, 2012).

Level 2, the Implementing measures, are more detailed instructions on how the new legislations should be implemented. The Level 2 legislation is prepared by the European Commission following advice from European Insurance and Occupational Pensions Authority (EIOPA). The exact legal form of the implementing measures is not yet determined as it is one of the issues that will be clarified by the Omnibus II Directive.

Level 3, the Guidance, covers recommendations and guidelines with the purpose of enhancing convergent and efficient applications of the regulations in the member states. These should be regarded as supervisory standards, not binding documents. Responsible for the issuance of these standards, recommendations and guidelines is EIOPA which issues a number of consultation papers on certain aspects of the Solvency II framework.

Lastly, Level 4, the Enforcement, is the final step in the process which focuses on evaluating and ensuring that the member states are complying with the legislation. This is done by the European Commission which can also take enforcing actions against a member state if it should find it necessary (Alford, 2006).

In all levels there is supposed to be a high level of input from the member states as well as the market participants.

[24] Directive 2009/138/EC

Table 1 - Lamfalussy process overview for Solvency II

Solvency II is adapted according to four levels, following the Lamfalussy process. Each level marks a new stage in the work with the framework, from the first level which focuses mainly on the development, through the second and third levels, which are more directed towards the implementation, to the fourth and final level, where the compliance to the frameworks is treated.

	Scope	Content	Responsible body	Approving body
Level 1	Framework directive (Solvency II directive)	Overall framework principles	European commission	European Parliament and European council (co-decision process)
Level 2	Implementing measures	Detailed implementing measures	European commission (advised by EIOPA)	European Commission (consented by the European parliament)
Level 3	Guidance	Supervisory standards, recommendations and guidelines	EIOPA	EIOPA
Level 4	Enforcement	Evaluation, monitoring of compliance and enforcement	European commission	European Commission

Source: International Centre for Financial Regulations (ICFR), (Patel, 2009)

4.4.2 Quantitative Impact Studies

Given that Solvency II constitutes many major changes from the previous standard there has been a need to evaluate the capability of insurance companies to adjust and comply with the new regulations. For this reason CEIOPS and later EIOPA[25] has conducted five studies on the quantitative impact of Solvency II. The studies have provided crucial input for the design of the Solvency II framework in trying to ensure that the new regulations are efficient but not overly complex for the insurance companies (EIOPA, 2011). The latest of these studies is Quantitative Impact Study 5 (QIS5) which was conducted in August to November 2010. The results of the study were published in March 2011.

Even though the participation in QIS5 was not compulsory, many insurance companies chose to take part since the study provided an opportunity to test the Solvency II framework and also to express opinions on specific issues to the supervisory authorities. In Sweden, 29 life insurance companies, with a combined market share of approximately 90 percent of the Swedish market participated in the study (Finansinspektionen, Resultat av QIS5 - Utfallet av den femte kvantitativa studien (QIS5) för svenska försäkringsbolag och försäkringsgrupper, 2011). The results were good in general for the insurance companies in the sense that a majority already kept enough capital to fulfill the Solvency Capital

[25] EIOPA replaced CEIOPS in January 2011

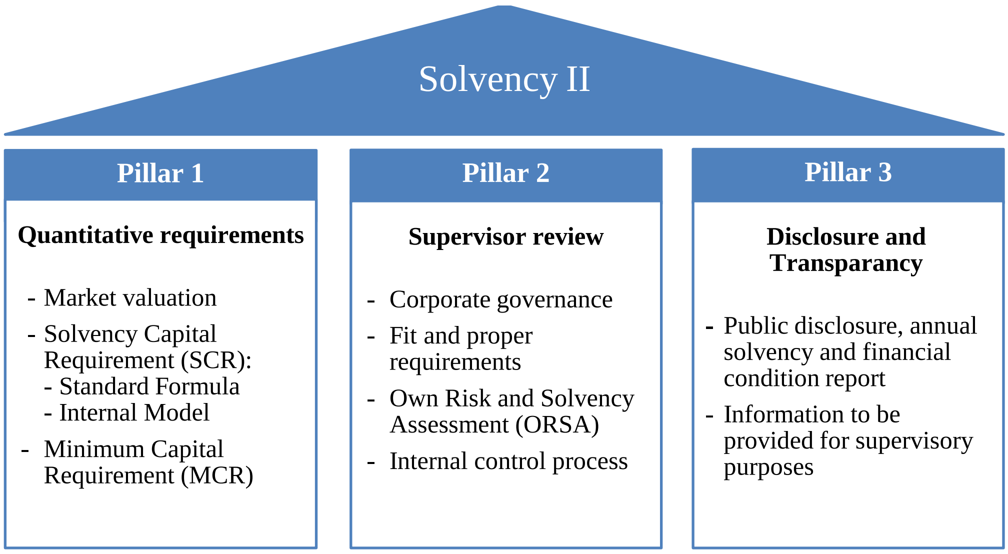
Requirement. This despite the fact that the results also showed that capital requirements will be higher than in the Traffic Light Model and considerably higher than in Solvency I. Furthermore, the results showed that for life insurance companies, market risk will be the main driver of SCR and that among market risks, equity risk will be the most significant contributor to SCR (Finansinspektionen, Resultat av QIS5 - Utfallet av den femte kvantitativa studien (QIS5) för svenska försäkringsbolag och försäkringsgrupper, 2011).

4.4.3 Framework

The Solvency II framework can be divided into three pillars, where Pillar 1 represents the quantitative requirement, Pillar 2 the supervisory review, and Pillar 3 the transparency and disclosure of the insurance undertaking.

Figure 8 - Illustration of the Solvency II framework

Following the model of Basel III, the Solvency II framework is commonly divided into three pillars where the quantitative requirements are found under Pillar 1.



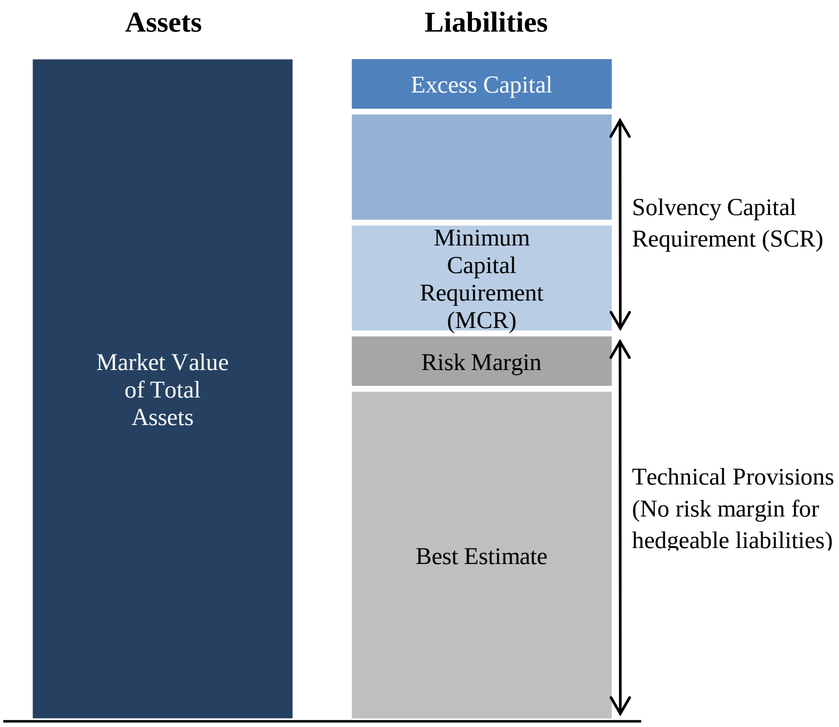
Source: CEIOPS (2009 & 2011)

Pillar 1

The quantitative requirements in Pillar 1 are based on market values of both assets and liabilities. This means that the balance sheet according to Solvency II is very different from that under Solvency I which is based on book value. Basically, the liability side consists of a best estimate of the obligations due to insurance undertaking, a risk margin, the SCR and excess capital if the company should hold more capital than the regulations require. The calculations of all these components are regulated under Pillar 1 (Steffen, 2008).

Figure 9 - Balance sheet of insurance companies according to Solvency II

The balance sheet under Solvency II is based on a market-consistent approach. On the liabilities side the technical provisions is made up of a best estimate of the present value of future cash flows and a risk margin. On top of the technical provisions the liabilities side also consists of the SCR and excess capital if the company meets the solvency requirements. A part of the SCR is the MCR which should not be breached at any point.



Source: CEA (2006)

Technical Provisions

The main item of the liabilities side of the balance sheet for life insurance companies is the technical provisions. The technical provisions under the Solvency II framework are made up of a Best Estimate of future cash flows and a Risk Margin.

Best Estimate

The Best Estimate should equal the present value of probability weighted future cash flows. For the present value calculation a relevant and risk-free interest rate term structure should be used. Furthermore, intrinsic options in the insurance contracts must be identified together with various guarantees. The data used must be relevant and up-to-date, assumptions must be realistic, and prudential actuarial and statistical methods must be employed (CEIOPS-DOC-33/09, 2009). In addition, future management actions must be taken under consideration (CEIOPS-DOC-27/09, 2009).

Calculation of the Best Estimate

Segmentation

Insurance undertakings must be segmented and classified. Within the life insurance category, there are 16 lines of business with a few main risk categories (with profit participation, where the policyholder bears the investment risk, without profit participation, and reinsurance.) The sub categories are: death as a risk driver, longevity as a risk driver, and sickness as a risk driver. Insurance risks are on the other hand negligible, i.e. could be considered as savings (CEIOPS-DOC-22/09, 2009).

Risk-free Interest Rate Term Structure

The single most important parameter in the Best Estimate calculation is the risk-free interest rate term structure. It is primarily used in the present value calculation of future obligations for the insurance undertaking. In other words: on the liability side, future in- and outflows are discounted using the relevant risk free interest rate. Since life insurance undertakings normally have a long time horizon, small changes in the term structure can have a great impact on the size of the Best Estimate.

At present, the mean of government and covered bonds yield rates is used as the risk-free rate in the Best Estimate calculation in Sweden. After the last liquid data point (10 years maturity for Sweden in QIS5) the remaining term structure is extrapolated as a straight line up to 80 years maturity. However, in the Solvency II directive, the term structure is suggested to be based on the current swap rates, with a 10 basis point reduction due to the higher counterparty risk for swaps. The main reason why swap rates are used as base rate for the liquid part of the curve is that swaps are more liquid than government bonds (CEIOPS, 2010).

Interpolation and Extrapolation

For the matter of interpolation and extrapolation of the term structure, the Smith-Wilson method (Smith & Wilson, 2011) was applied in QIS5. The swap yields, together with an Ultimate Forward Rate (UFR) are the main input parameters, and a curve is fitted to form a continuous term structure (CEIOPS, 2010).

Ultimate Forward Rate (UFR)

In practice, the UFR works as a convergence level where the curve always ends up. The UFR is set for each currency and should be stable over time and only modified to correspond with fundamental changes in a long-term macro-economic outlook.

The two most crucial explanatory economic factors of long-term forward rates are expected real interest rates and long-term inflation. It can also be argued that the expected long-term nominal convexity effect and long-term nominal term premium are components explaining the long-term forward rate. However, these factors are disregarded in the UFR estimation because of a lack of credible and robust data. Hence, the UFR assessment is based solely upon the estimates of long-term inflation and short-term real rate.

A high degree of convergence between forward rates for different currencies can be expected when extrapolating over long time horizons. It also "*seems consistent*" (CEIOPS, 2010, p. 3), in a macro economical point of view, to expect roughly the same value for the UFR for practically all countries around the world in 100 years. However, where the real interest rate and/or inflation expectations deviate significantly, the UFR should be modified to better fit these disparities. In QIS5 three UFR categories was used. For the main category the UFR was set to 4.2 per cent, which was the sum of an expected inflation rate of 2 per cent and short-term yearly yield on risk free bonds of 2.2 per cent. For the other two categories one percentage point was added and removed respectively, which was solely based on different expectations of future inflation rates (CEIOPS, 2010).

Table 2 - Ultimate Forward Rates for different currencies

The Ultimate Forward Rate defines the rate to which the Risk-free Interest Rate defined in the Solvency II framework will converge towards. This rate is set to 4.2% for most European countries, including Sweden, while for example the Swiss rate has been set lower at 3.2% due to Switzerland's lower inflation target. For a number of growth economies the rate has been set at 5.2% to reflect a higher expected inflation rate in those countries.

Category	Currency
3.2%	CHF, JPY
4.2%	AUD, BGN, CAD, CNY, CZK, DKK, EEK, EUR, GBP, HKD, HUF, ISK, KRW, LTL, LVL, MYR, NOK, PLN, RON, SEK, SGD, THB, TWD, USD
5.2%	BRL, INR, MXN, TRY, ZAR

Source: *Risk-free interest rates – Extrapolation method* (CEIOPS, 2010)

Risk Margin

For hedgeable cash flows, the Best Estimate calculation is sufficient in the Technical Provision calculation. This is only the case when the following three conditions are fulfilled:

1. The future cash flow coupled with the insurance obligation can be replicated reliably.
2. The replication can be made by financial instruments.
3. The financial instruments in condition (2) have reliable and observable market values.

However, if a cash flow is considered non-hedgeable, a risk margin should be added to the Best Estimate. The cash flows regarding future expenses, for instance, cannot be considered hedgeable, and a risk margin should therefore be added to the Best Estimate calculation (CEIOPS-DOC-35/09, 2009).

The risk margin should correspond to the cost of immediately moving the commitments to another company. In other words, the risk margin should reflect the difference between the Best Estimate and the price the insurance company would have to pay to transfer all of its insurance obligations to another insurer. It is calculated by looking at the cost of maintaining the SCR during the life time of the portfolio, i.e. a cost-of-capital approach is used (CEIOPS-DOC-36/09, 2009).

Valuation of Assets and Liabilities beyond Technical Provisions

Market valuation should, if possible, be used in the valuation of assets. The market price should be observable and reliable, which should be interpreted as the existence of a deep, liquid, and transparent market on a permanent basis (CEIOPS-DOC-35/09, 2009). The definition of such a market is that large-volume deals can be easily executed with only a small impact of the price of an instrument, and that current trade and quote information is available to the public. Furthermore, these conditions should be satisfied on a permanent basis. Altogether, the same valuation principles as in the International Financial Reporting Standards (IFRS) should be applied (CEIOPS-DOC-31/09, 2009).

In absence of a market value (defined as above) an alternative approach that is consistent with market information should be applied. For tradable assets that lack market value, an estimation of the sale price should be used. If the asset is illiquid and/or non-tradable, it should be valued prudently with counterparty and liquidity risk included in the calculations. Furthermore, the estimated value of an asset cannot exceed the purchase price minus the estimated profit margin by the seller and depreciations. Moreover, immaterial assets, office furniture, computer equipment and similar assets with a significant risk for value depreciation are valued at zero.

The requirements for documentation surrounding the valuation process are greater compared to prior frameworks in order to secure the appropriateness and reliability of estimations. Well documented guidelines and procedures regarding the valuation approach should be used together with a description of the roles and responsibilities involved and the relevant models and sources of information and data. The assets which are valued using an alternative approach should be identified and the used approach must be motivated. Also, independent and reliable expert opinions can be included in the valuations. Furthermore, the level of uncertainty in the valuation must be documented and reported to top management in order to make them well aware of the situation.

There should be a procedure in place for internal audit that assures that guidelines and routines are followed in the valuation process. Every company must be able to show that personnel in charge of valuating the assets have the right knowledge and skills in order to calibrate and develop the model. Finally, there should be appropriate review of the valuation methodology and it should also be validated on a periodical basis (CEIOPS-DOC-31/09, 2009).

Solvency Capital Requirement (SCR)

The most important quantitative regulation in the Solvency II framework is the Solvency Capital Requirement (SCR). The SCR states the amount of capital an insurance company need to hold in excess of the technical provision and the risk margin in order to reduce the risk of insolvency.

Minimum Capital Requirement (MCR)

A portion of the total SCR is the Minimum Capital Requirement (MCR). This is an obligatory for the authorisation of insurance undertakings. If the amount of eligible basic own funds drops below the MCR and the concerned insurer is not quickly able to restore the funds at the required level, the authorisation for a company to conduct insurance business should be withdrawn.

The MCR should lie somewhere in the interval 25%-45% of the total SCR and should be calculated on at least a quarterly basis (CEIOPS-DOC-47/09, 2009).

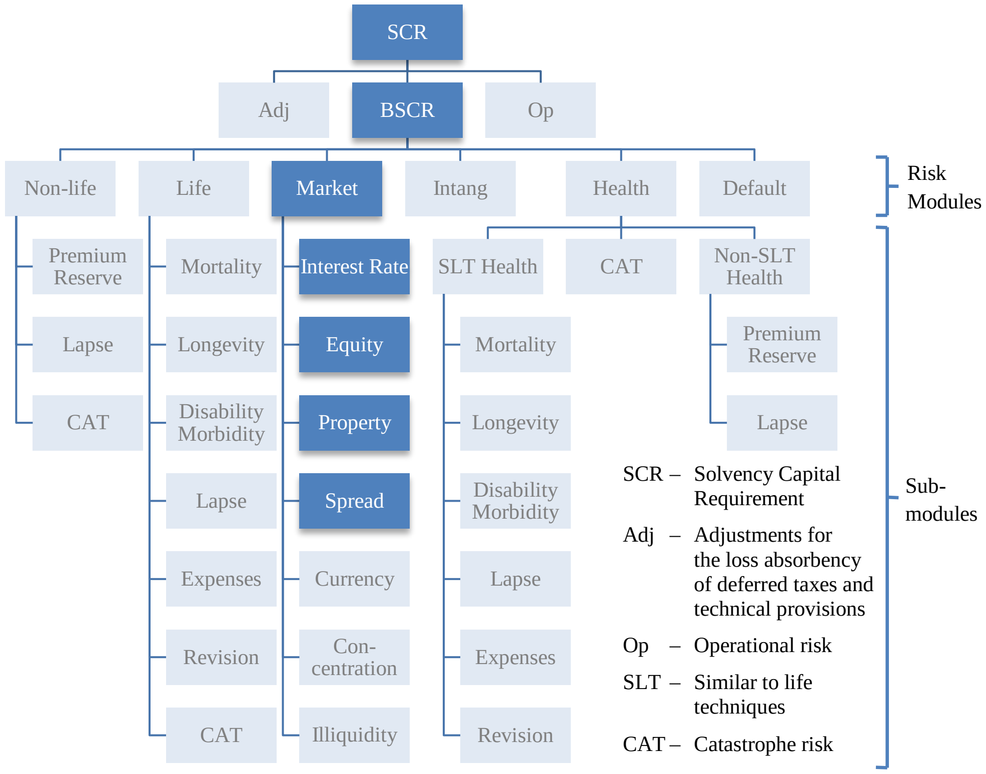
Standard Model

The SCR is calibrated to a 99.5% Value-at-Risk with a 1-year time horizon.

There are a large number of risks divided in risk and sub-modules. These are aggregated at different levels in order to produce an overall SCR figure. First, the capital requirement for each individual sub-module is calculated. In a second step, the capital requirements within each risk module are aggregated. Here, correlation matrices are used to account for the relationship between certain risks in order to avoid it being exaggerated in the overall risk calculation. When aggregated, these risks form the Basic Solvency Capital Requirement, which is then added to the operative risk (Op) and the adjustments for the loss absorbency of deferred taxes and technical provisions (Adj) to form the SCR (CEIOPS, QIS5 Technical Specifications, 2010).

Figure 10 - Solvency Capital Requirement components

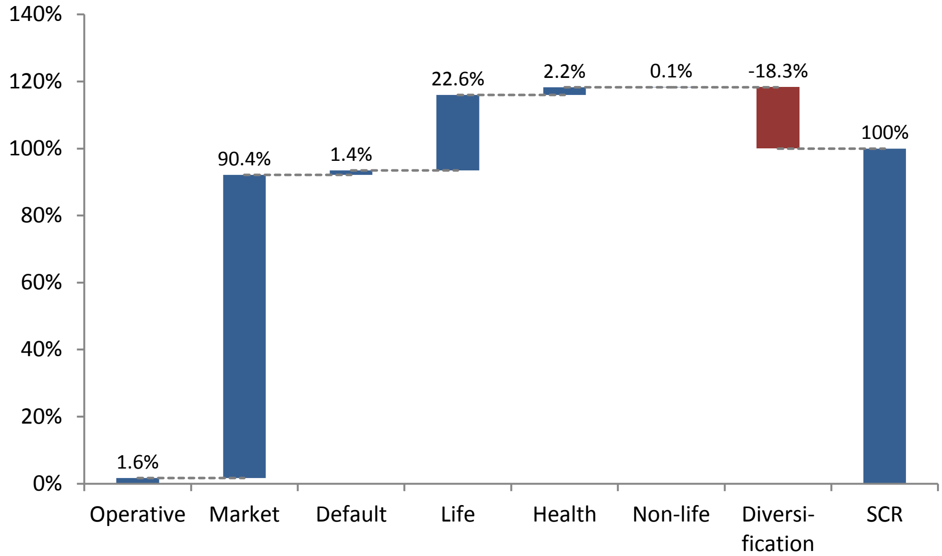
The calculation of the SCR is done in tree levels. On the highest level, the total SCR is received by adding an adjustment for the loss absorbency of deferred taxes and technical provisions and a SCR for operational risk to the Basic SCR (BSCR). The BSCR is calculated through an aggregation of capital requirements for seven different risk modules. The capital requirement for each risk module is in turn calculated from sub-modules for the specific risk included in risk module. While the total number of modules and sub-modules is rather large, the importance, in terms of contribution to the total SCR, is highly concentrated to the market risk and life risk modules for life insurance companies. The highlighted modules and sub-modules are the ones primarily treated in this thesis which is motivated by their large contribution to the total SCR in QIS5 (see figures 11 and 12).



Source: (CEIOPS, QIS5 Technical Specifications, 2010)

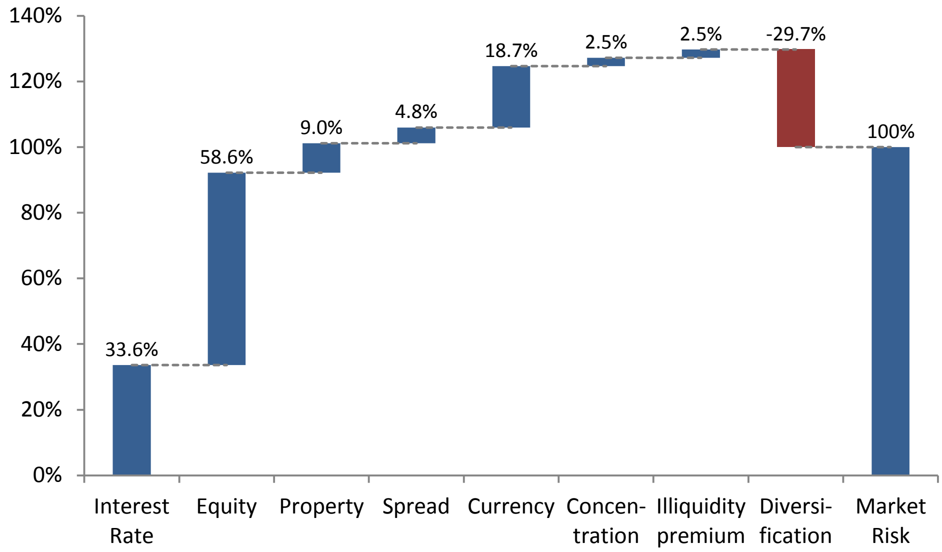
The results of QIS5 in general (EIOPA, 2011, pp. 65-67) and for Swedish life insurance companies (see Figure 11 and Figure 12) show that a few risk and sub-modules contribute to the greater part of the total SCR. In Sweden, the Market Risk Module accounted for 90.4% and among its sub-modules interest rate and equity risk contributed by 33.6% and 58.6% respectively. The most important sub-modules in the SCR-calculation are described in more detail in the following sections.

Figure 11 - SCR Structure for Swedish Life Insurers (QIS5 results)
The figure shows the average contribution to the total SCR of the risk modules and the diversification effect in the latest Qualitative Impact Study, QIS5.



Source: Finansinspektionen

Figure 12 – Breakdown of Market Risk Module for Swedish life insurers (QIS5 results)
The figure shows the average contribution of each sub-module under the Market Risk Module together with the diversification effect.



Source: Finansinspektionen

The market risk module has seven sub-modules as shown in Figure 10. The SCR for the market risk module is calculated from the SCRs of each of the sub-modules using the following formula**:**

$$SCR_{mkt} = \sqrt{(\boldsymbol{SCR_{sub}})^{\boldsymbol{T}}\ \boldsymbol{C}\ (\boldsymbol{SCR_{sub}})} \qquad (7)$$

where $\boldsymbol{SCR_{sub}}$ is a vector with the SCRs of the sub-modules (and $\boldsymbol{SCR_{sub}}^{\boldsymbol{T}}$ is the transposed vector) and $\boldsymbol{C}$ is the SCR Market correlation matrix shown in Table 3.

Table 3 - SCR Market correlation matrix
The SCR for the market risk module is calculated by aggregating the SCR for the seven sub-modules; interest rate, equity, property, spread, currency, concentration and illiquidity premium, using the correlation matrix shown below. For the Interest rate's correlation with Equity, Property and Spread, 0 is chosen if the highest SCR is given by an increase in the interest rate. Otherwise, 0.5 is used.

	Interest rate	Equity	Property	Spread	Currency	Concen-tration	Illiquidity Premium
Interest rate	1						
Equity	0.5/0	1					
Property	0.5/0	0.75	1				
Spread	0.5/0	0.75	0.5	1			
Currency	0.25	0.25	0.25	0.25	1		
Concentration	0	0	0	0	0	1	
Illiquidity Premium	0	0	0	-0.5	0	0	1

Source: European Commission, Errata to the QIS5 Technical Specifications (2010)

Interest Rate Risk

All assets and liabilities for which the net asset value will be affected by changes in the interest rate term structure or the volatility of interest rates should be included in the interest rate risk calculation. Examples of instruments concerned are fixed-income investments, financing instruments (e.g. loan capital), insurance assets, policy loans, and interest rate derivatives.

The change in net asset value caused by an instantaneous stress of the term structure determines the capital requirements for the concerned instruments. The stress levels are predefined (see Table 4 for stress levels in QIS5) and the type of shock that instigates the highest capital requirement is used to derive the interest rate capital requirement. The downward stress should be at least one percentage point (irrespective of the predefined stress levels), and where the unstressed interest rate is below 1% the downward stress scenario should equal a 0% interest rate level.[26] (CEIOPS, QIS5 Technical Specifications, 2010)

[26] This constraint is not applicable for index linked bonds.

Table 4 - Interest rate stress levels in QIS5

The stress levels for different kinds of maturities used in the calculation of interest rate capital requirement in QIS5. For longer maturities (>30 years) a +25%/-30% stress level should be maintained.

Maturity t (years)	Relative change in up-stress	Relative change in down-stress
0,25	70%	-75%
0,5	70%	-75%
1	70%	-75%
2	70%	-65%
3	64%	-56%
4	59%	-50%
5	55%	-46%
6	52%	-42%
7	49%	-39%
8	47%	-36%
9	44%	-33%
10	42%	-31%
11	39%	-30%
12	37%	-29%
13	35%	-28%
14	34%	-28%
15	33%	-27%
16	31%	-28%
17	30%	-28%
18	29%	-28%
19	27%	-29%
20	26%	-29%
21	26%	-29%
22	26%	-30%
23	26%	-30%
24	26%	-30%
25	26%	-30%
30	25%	-30%

Source: QIS5 Technical Specifications

Equity Risk

All assets and liabilities for which the value will be affected by changes in equity prices should be included in the equity risk calculation. Hedging and other risk transfer mechanisms should also be accounted for in the risk capital requirement calculation.

Equities are divided in two categories: “Global” and “Other”, where the former incorporates companies listed in the EEA[27] and/or OECD member countries. Non-listed equity, equity listed in emerging markets, hedge funds and investments not included elsewhere in the market risk module constitute the “Other” category. (CEIOPS, QIS5 Technical Specifications, 2010)

[27] European Economic Area

The change in net asset value caused by an instantaneous decrease in value of equities (see Table 5 for size of equity shock) determines the equity risk capital requirement.

Table 5 - Equity shock levels for the individual equity categories
Base stress levels for the equity sub-module. The change in net asset value caused by an instantaneous decrease in value of the relevant holdings gives rise to the SCR for equity risk.

	Global	Other
Equity shock	39%	49%

Source: QIS5 Technical Specifications

However, these levels are just the base case since a symmetric adjustment mechanism is applied; the equity dampener. The objective of the dampener is to prevent pro-cyclical effects of solvency capital requirement, i.e. restrain the incentive to sell equity in case of a general decline in the value of equities. With the above stated level as a benchmark, the equity shock will vary in line with the moving average of a major index[28] chosen for this purpose. The shock level is subject to a band of ±10% on either side of the base level, i.e. the equity shock will be somewhere between 29% and 49% for the *Global* category and 39% to 59% for the *Other* category (CEIOPS-DOC-65/10, 2010).

For equity owned in undertakings part of the same group shock levels differ as specific rules regarding participations is applied:

- For participation in financial and credit institutions: 0% shock.
- Strategic participations (in all markets): 22% shock.
- Other participations are subject to the shock levels corresponding to either the “Global” or “Other” categories, depending on the definitions stated above.

The capital requirement for equity risk is then calculated by merging the capital requirements for the two categories using a correlation matrix (see Table 6)

Table 6 - Correlation matrix for individual equity categories
The correlation matrix used in QIS5 for the combining of the two equity categories “Global” and “Other”

Correlation Index	Global	Other
Global	1	
Other	0.75	1

Source: QIS5 Technical Specifications

Property Risk

The following list of investments should be included in the property risk sub-module:

- Buildings, land and immovable property rights;
- Participations (direct or indirect) in real estate companies which generate periodic income or that are made as an investment.
- Property owned and used by the undertaking itself.

[28] A 1-year moving average for MSCI Developed Index was proposed by CEIOPS (CEIOPS-DOC-65/10, 2010). A 3-year moving average was proposed by the Commission Service (Finansinspektionen F. S., 2011)

It is important to note that investments in companies engaged in real estate development and/or management as well as companies that have leveraged its property investments from an outside source should be treated as equity investments under the equity risk sub-module.

The capital requirement for property risk is calculated as the change in net asset value caused by a property shock of 25%, i.e. an instantaneous 25% decrease of in the value of real estate investments. The shock should take hedging arrangements, gearing and other specific investment policy in account. (CEIOPS, QIS5 Technical Specifications, 2010)

Spread Risk

The spread risk sub-module should capture the risk arising from the sensitivity of the value of assets to changes in the level or the volatility of credit spreads over the risk free interest rate. In particular, the sub-module applies to the following classes of bonds:

- Investment grade corporate bonds
- High yield corporate bonds
- Covered bonds
- Subordinated debt
- Hybrid debt

Besides the assets mentioned the spread risk sub-module also applies to all types of asset-backed securities and tranches of structured credit products such as collateralised debt obligations (CDOs). The sub-module does however not apply to government bonds issued by a national government of an EEA state or bonds issued by non-EEA government if the bond have a rating of AA or higher (CEIOPS, QIS5 Technical Specifications, 2010). This means that bonds issued by a national government of an EEA state do not generate any SCR for spread risk even if the rating should be as low as CCC.

In the case of bonds the SCR for spread risk is calculated as the market value of the bond times the duration of the bond multiplied by a factor $\boldsymbol{F}$ which is decided by the type and rating of the bond. For the duration there is, however, a floor and a cap depending on bond type and rating. The factor $\boldsymbol{F}$ and the duration floors and caps are shown in Table 7.

Table 7 - Spread risk factors for bonds

The SCR for spread risk for bonds depends on the type, market value, rating and duration of the bond. The market value of a bond is multiplied with its duration and the factor ***F*** which is decided by the type and rating of the bond. EEA government bonds do not generate any SCR for spread risk while covered bonds with rating AAA generate less than corporate bonds with the same rating.

Type	Rating	*F*	Duration floor	Duration cap
Covered bonds	AAA	0.6%	1	53
Corporate bonds	AAA	0.9%	1	36
	AA	1.1%	1	29
	A	1.4%	1	23
	BBB	2.5%	1	13
	BB	4.5%	1	10
	B	7.5%	1	8
	Unrated	3.0%	1	12

Source: QIS5 Technical Specifications

Diversification

For the overall SCR-calculation, a correlation matrix (see appendix) is used for the different Risk Modules in order to recognize the fact that all individual risks are not expected to occur simultaneously. As seen in Figure 11, this reduced the overall SCR for Swedish life insurers by 18.3%, while the reduction for all European participants in QIS5 were 32% (EIOPA, 2011, p. 63).

Internal Model

Every insurance undertaking is allowed to develop and use an internal model instead of the standard model for the SCR calculation. It can be either a full internal model, i.e. the standard formula is totally excluded from the calculation, or a partial internal model when using a combination of an internally developed model and the standard formula. The model must be scrutinized and approved by the authorities before being taken into practice.

In QIS5, undertakings that used a full or partial internal model were also asked to calculate the SCR with the standard formula in order to provide input for the development of the framework. However, because of the small sample provided and the fact that the internal models had not been finalized, no exact conclusions could be drawn in the comparison between internal models and the standard formula (EIOPA, 2011, p. 14).

Some of the main reasons why internal models are developed are that they better reflect the risk profile of the undertaking, that additional risks can be covered, and that the risk aggregation can be made more granular (CEIOPS-DOC-61/10). However, Poizot et al. (2011) finds that internal models in the Market Risk Module only offer relief (in terms of SCR) in a few areas; for example continental European property and certain structured products.

Pillar 2

Unlike Solvency I a significant part of Solvency II is composed of qualitative requirements. These are mainly found under Pillar 2 and are in many ways just as important as the quantitative requirements found under Pillar 1.

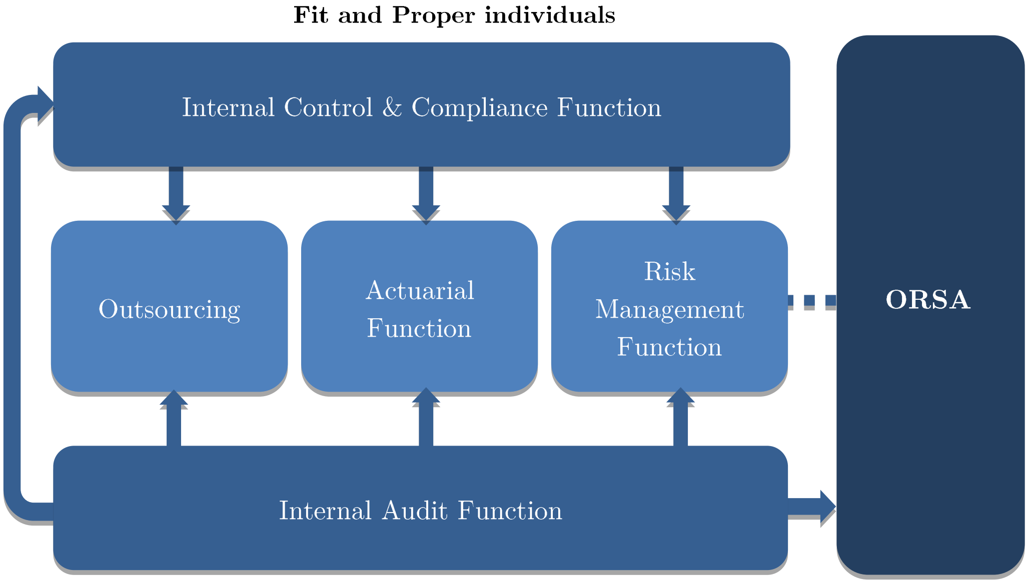
Pillar 2 focuses on the corporate governance of insurance companies, referred to as the "System of Governance". It basically dictates the minimum requirements for the risk management, the internal control and compliance, the internal audit and the Own Risk and Solvency Assessment (ORSA) for a firm (Financial Services Authority, 2012). The requirements are designed to represent a "best practice", meaning that they should already be observed within successful insurance companies.

The risk management requirements dictates that a company should keep detailed descriptions of their risk-management strategy including main principles, overall risk appetite and the assignment of risk managing responsibilities. Risk limits should be defined for different types of risk and the implementation of the risk policies in the everyday operations should be demonstrated. Further, there should be processes within a firm which allows it to sufficiently identify, manage, monitor and report risks that the company is exposed to or is probable to be exposed to in the future. Reporting procedures should be adequate to guarantee that the information on risks is actively processed (Directive 2009/138/EC, 2009).

To ensure the risk management competency insurance companies are to have a Risk management function monitoring, reporting and advising on risk management matters.

Figure 13 - Illustration of the qualitative requirements under Pillar 2

The figure shows the relationship between the different requirements and obligatory functions found under Pillar 2. Of these the Own Risk and Solvency Assessment (ORSA) is arguably the largest change from the current requirements.



Source: Financial Services Authority, 2012; CEIOPS, 2009

The internal control and compliance requirements dictate that a company should have an internal control system that ensures the compliance with applicable laws and regulations, the efficiency of the business' operations and the availability and reliability of information on all parts of the business. This requires, at a minimum, administrative and accounting processes which are aligned to an internal control framework and appropriate reporting procedures at all company levels. Companies are also obliged to have a specific compliance function that should identify, assess, monitor and report on risks and events that could compromise the compliance of the company (Barr, 2011).

Under Solvency II insurance companies are also required to have an internal audit function. The main purpose of the function is to evaluate the internal control as well as the other management functions and elements of governance within the company. For this reason the internal audit function should be independent from the operative functions and be free to assess and disclose findings on processes in all parts of the company.

The requirements also state that companies should have an actuarial function which should be responsible for coordinating the technical provisions calculation. Furthermore, the framework has set requirements for ensuring that the technical provisions are calculated in a way suitable for the business, ensuring that the IT system is adequate for the calculations, assessing whether the premiums are enough to cover future payments and assessing the underwriting policy as well as the reinsurance arrangements.

In addition to the functions and structures there are also requirements of the suitability of individuals at key positions and functions. These requirements focus on both fitness, such as professional qualifications, knowledge and experience, and the propriety of the individual such as repute and integrity, honesty and financial soundness.

Beside the requirements of the internal governance there are also requirements on the procedures of outsourcing. If an insurance company should choose to outsource any function or activity to an external service provider it should first ensure that outsourcing will not have a significant negative impact on the "System of Governance" or the operational risk and that it will not affect the ability of supervisors to monitor the company's compliance with regulations (CEIOPS, 2009).

Own Risk and Solvency Assessment

As a part of the risk management an insurance company is obliged to regularly conduct an Own Risk and Solvency Assessment (ORSA); "*the heart of Solvency*" (Bernardino, 2011). This is one of the most important new requirements in the Solvency II regulatory framework (Barr, 2011). The purpose of the ORSA is to ensure that an insurance company is actively assessing its entire exposure to risks and calculates its capital needs accordingly.

Within the ORSA an insurance company should implement suitable processes for identifying, assessing, monitoring and quantifying both its risks and solvency needs. It should also implement measures to ensure that the results of these assessments are incorporated into its decision making processes. The solvency needs in this sense should be the company's own evaluation incorporating its risk exposure, approved risk tolerance limits and business strategy. It is subsequently not the same as the company's SCR, the calculation of the solvency needs in the ORSA should be adapted for the specific company and not done using a general model. However, there are also requirements for the ORSA stating that a company should assess the adequacy of its regulatory capital position. Within the ORSA it should evaluate its continuous fulfillment of the MCR and SCR as well as the technical provisions requirements. It should also consider whether the SCR is appropriate given the company's risk profile. It should assess the importance of the deviation between the company's risk profile and the assumptions underlying the SCR calculation. This is independent of whether the company has just an internal model or the standard model to calculate SCR (EIOPA-CP-11/008, 2011).

5. Results

5.1 Optimization Results

Government Bonds

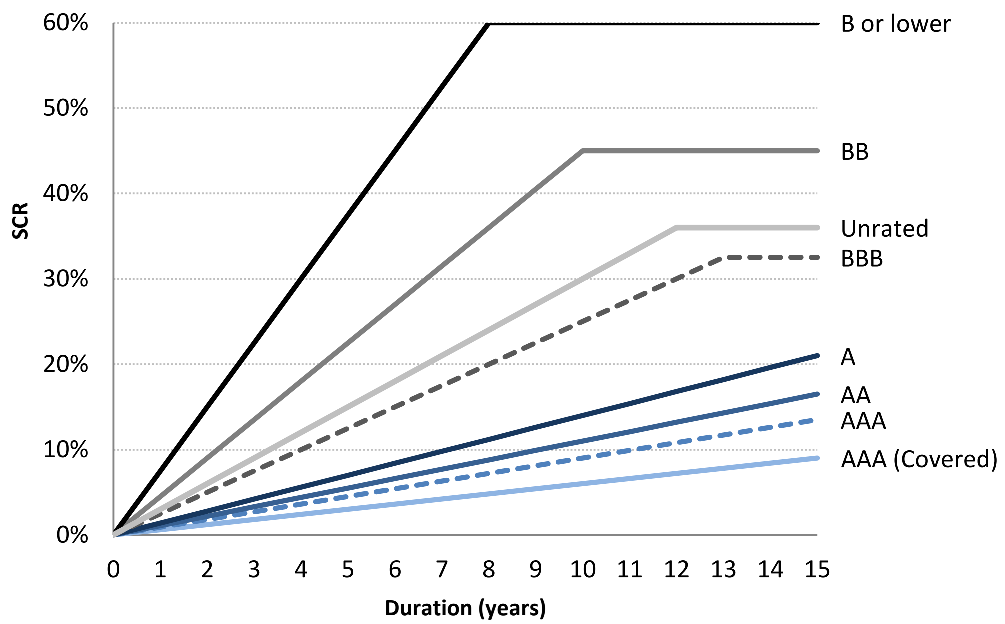
The optimization clearly shows that government bonds, based on the low SCR that comes with them (0% in this and most other cases), will become a more attractive investment in all types of scenarios. Especially in a scenario with low solvency, the optimal asset allocation is much skewed towards government bonds. Shorter duration government bonds will not be as attractive as those with a longer duration due to their historically lower yield.

Corporate Bonds

Highly rated corporate bonds will also look more attractive because of their low contribution to the SCR combined with their expected return, which is slightly higher than for government and covered bonds. Corporate bonds rated BBB and below do, however, generate significantly higher SCR (especially those with longer duration) which makes them unfavourable for companies with low solvency (see Figure 14). For companies with higher solvency high yielding corporate bonds are, however, an alternative to equity or property.

Figure 14 - Spread Risk SCR per rating

Here, the SCR produced by the Spread Risk Module is displayed. Covered bonds rated AAA receives an SCR discount compared to other relevant bonds (mainly corporate). N.B: the spread risk SCR for bonds rated AAA-BBB are all capped at approximately 32% (after varying lengths of time). A clear trend shift can be noticed between the spread risk for A and BBB rated bonds. For instance, an A rated bond with a 4-year duration has a spread risk SCR of 5.6% whereas a BBB rated bond with the same duration has a 10% SCR. The SCR then increases even more rapidly in the next step down the rating ladder (80% compared to 78.6% between A and BBB). This causes lower rated corporate bonds to be neglected in most optimizations where SCR is the target function.



Covered Bonds

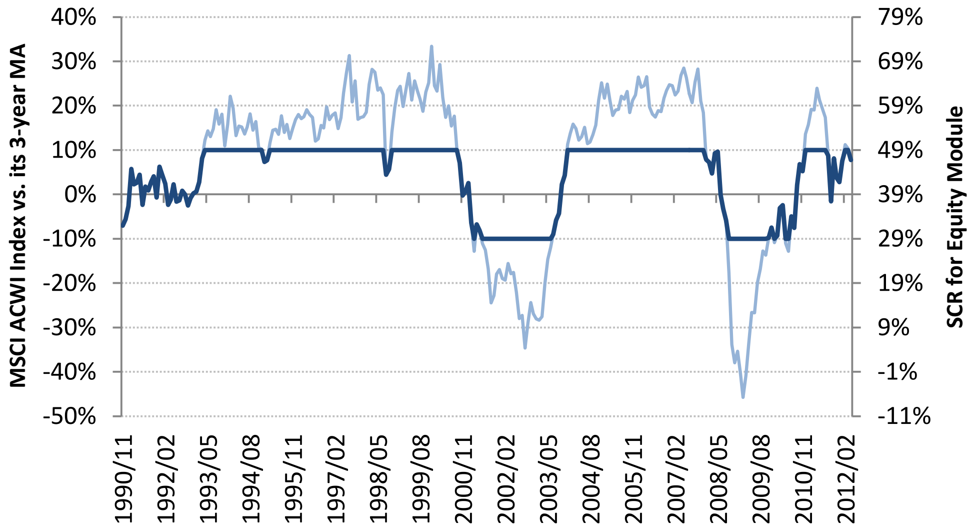
Covered bonds are very attractive in all scenarios as they generate very little SCR. Swedish life insurance companies already have a large portion of their investments in covered bonds and the model suggests no reason to change that.

Equity

The optimization clearly suggests a decrease in the holdings of equity. This is due to equity's high impact on SCR and the fact that both property and high yield corporate bonds seem to be more attractive investments under most scenarios. What is not included in the model is that the SCR produced by the Equity Module has been significantly higher (base level plus 4.62%) from a historical perspective (see Figure 15). If this had been taken under consideration, the suggested allocation to equity would have been even lower.

Figure 15 - The symmetric adjustment mechanism; the equity dampener

The brighter line illustrates the movements of the MSCI All Country World Index compared to its 3-year moving average on the left axis. The darker line illustrates the movements (with thresholds at +-10%) of the SCR for the Equity Global category on the right axis, where 39% is the base level. SCR changes in the same fashion for the Equity Other category. Since April 1993, the SCR level has hit the floor or bottom 188 out of 229 months (82%). Because of the upward trend of the index, the average level on which the SCR should have been based has been 4.62 percentage points above the base levels.



Property

In an optimization, property is only an alternative when the solvency is not too low and hence a limiting factor. However, due to the relatively lower SCR of property compared to equity it becomes an attractive asset when the solvency and constraints on expected return are high.

Table 8 - Optimization implications on different asset classes with various solvency constraints

The table illustrates the effect on the attractiveness of different asset classes, ranging from --- to +++, in the SCR-optimization, where today's average holdings of Swedish life insurers is the neutral stage. One plus sign indicates a slightly higher attractiveness compared to today; three plus signs a strong increase (based on an optimization where SCR is minimised with a minimum return constraint). Minus signs indicate a decreasing attractiveness. The ratings are a subjective compilation of the optimization results, which were produced over three solvency scenarios; each with a different constraint for expected return (2, 4, and 6%, respectively.)

Optimization Scenarios	Low Solvency	Medium Solvency	High Solvency
Government Bonds	Long durations: +++ Medium: +++ Short: ++	Long durations: +++ Medium: ++ Short: +	Long durations: +++ Medium: + Short: +
Corporate Bonds	High rated (AAA-A): ++ Low rated: -	High rated (AAA-A): +++ Low rated: +	High rated (AAA-A): + Low rated: +
Covered Bonds	AAA: ++	AAA: +++	AAA:+
Equity	Global: -- Other: -	Global: - Other: -	Global: - Other: +
Property	Compared to Equity: ++ Overall:-	Compared to Equity: + Overall: -	Compared to Equity: + Overall: +

Efficient Frontier – SCR and Standard Deviation

The optimization shows that by optimizing the asset allocation an insurance company can substantially reduce the SCR without reducing the expected return. This means that there will be a strong incentive for insurance companies to consider SCR in investment decisions, even when solvency ratios are relatively high. As shown in figure 16 and 17, the portfolios optimized according to traditional mean-variance have significantly higher SCR than the corresponding portfolios optimized after SCR both when historical returns are used and when constant Sharpe ratio is used to calculate the expected return.

Figure 16 - Efficient frontier when historic average returns are used as expected return
The figure shows the relationship between SCR and expected return as well as standard deviation and expected return in efficient portfolios. As seen portfolios which are efficient in terms of standard deviation generates significantly higher SCR than when efficient in terms of SCR. The SCR is displayed as a percentage of the total asset value.

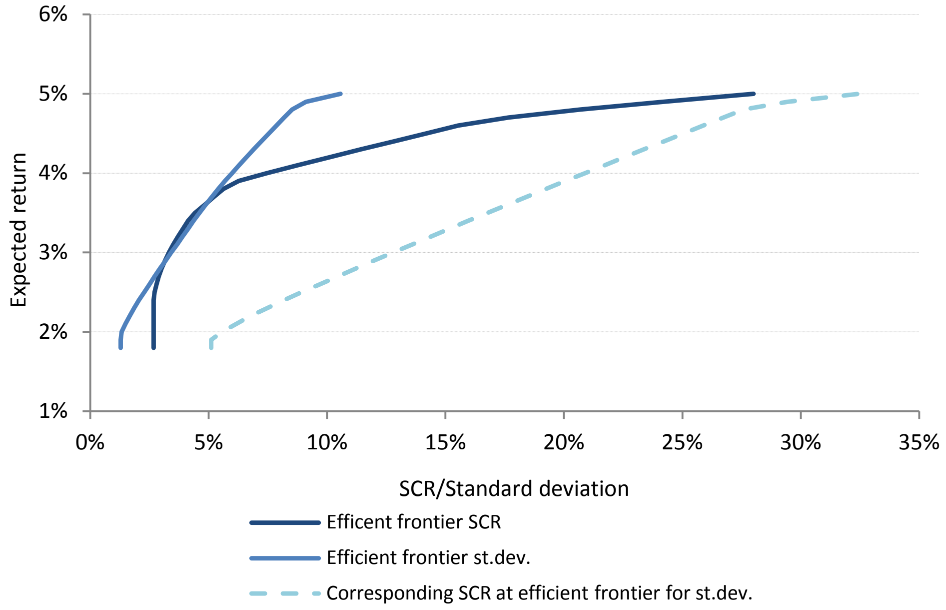
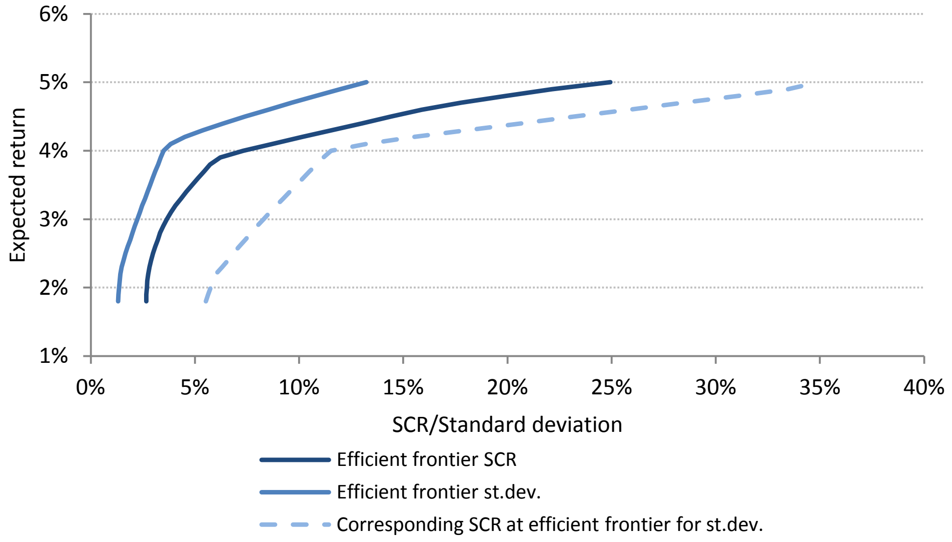


Figure 17 - Efficient frontier when a Sharpe ratio is used to calculate expected return
The figure shows the relationship between SCR and expected return as well as standard deviation and expected return in efficient portfolios. As seen portfolios which are efficient in terms of standard deviation again generates considerably higher SCR than when efficient in terms of SCR. The SCR is displayed as a percentage of the total asset value.



6. Analysis

The purpose of this thesis was to evaluate the effect Solvency II will have on the demand for different asset classes for Swedish life insurance companies. We have shown the impact, asset by asset, where the starting point is a typical Swedish life insurer under today's regulatory framework. However, these results must also be brought into a larger context, where the layout of the financial markets plays an important role, mainly because of the large holdings of life insurance undertakings. Furthermore, we have shown that a life insurer can substantially reduce its SCR while still receiving the same expected return by merely optimizing with regard to SCR instead of standard deviation. For example, a modelled 3.7% expected return generates an SCR of 18.4% if optimized with regard to standard deviation. On the other hand, if the optimization is made with SCR as the target function, a 3.7% return generates a SCR of 5.1%, which clearly shows the need for taking both parameters into account in the asset and liability management for life insurers under Solvency II.

Government Bonds

For insurance companies that seek to minimize their SCR one of the most attractive assets are long-term government bonds. Long-term government bonds have two major advantages. Firstly they do not, unlike other types of bonds, give rise to any SCR for spread risk. Secondly, they increase the duration of the asset side of the balance sheet. This feature has generally a positive impact on the SCR by lowering the SCR for interest rate since the liabilities normally have a longer average duration than the assets. By decreasing the duration gap between the assets and liabilities the impact of the interest rate stress have less significance. However, volumes and liquidity of long-term government bonds in the Swedish market are far from sufficient to make them a realistic investment for Swedish life insurance companies in any larger scale. Instead, it is more likely that life insurance companies will seek to increase their investments in medium term (2-10 years) government bonds. The potential for these bonds are however also somewhat limited since life insurance companies already own more than a fourth of the Swedish government bonds outstanding (as seen in figure 18). In this discussion an important factor is the guidelines that control how the Swedish government debt is managed. These guidelines state that debt should not be issued with the purpose of meeting the need for government debt unless it is required on account of threat to the functioning of the financial markets. Further, the Swedish government predicts a decline in the outstanding government debt and a somewhat shortened maturity thereof in the next few years (Regeringskansliet, Ministry of Finance Sweden, 2011).

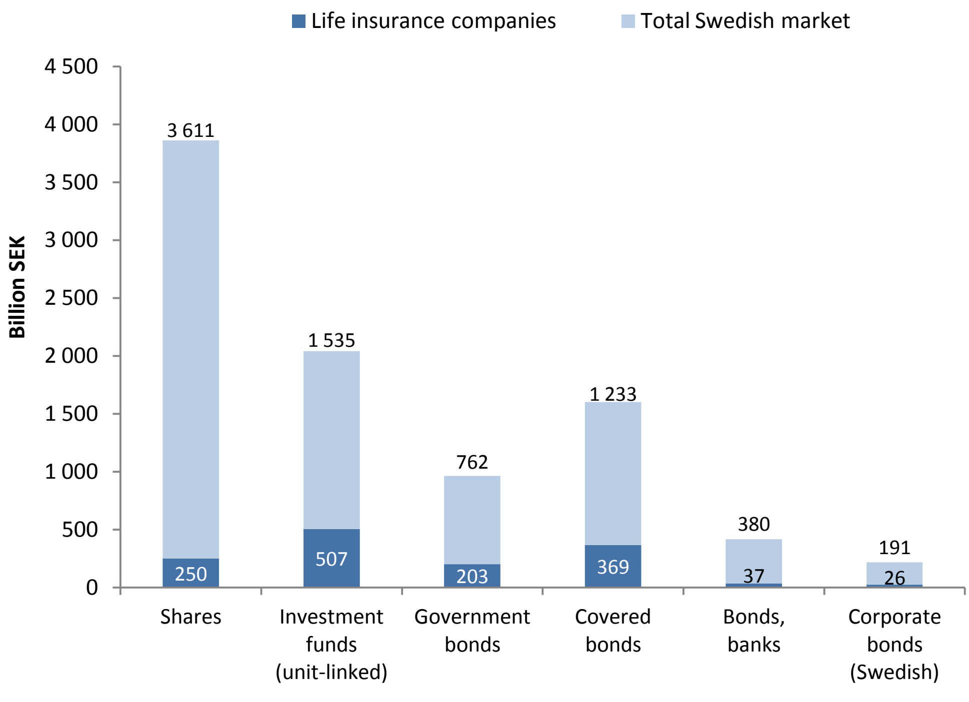
The limited liquidity of Swedish long term government bonds indicates a possible increase of investments in foreign government bonds. This increase can also be promoted by the comparatively higher yield on many government bonds compared to the Swedish equivalents.

Given the way the SCR is calculated, if no regard is taken to real risk, lower rated EEA government bonds are to be preferred in the optimization since they combine a relatively high yield with no spread SCR. In reality, however, assets which are clearly riskier than the SCR would imply, like lower rated government bonds, are not a given option. The main issue is the Own Risk and Solvency Assessment (ORSA), which is made to act as a safety net; capturing all real risks and making sure that management are aware of them. This makes it hard to hold large positions in, for instance, Greek and Spanish government bonds while complying with the ORSA-requirement of sound and prudent management of the undertaking. Another factor to be taken under consideration is the high indebtedness of many European governments and, hence, a possible deleveraging over the next decade. This would bring about a reduction in bond issuing, thus causing less liquid bond markets. The same reasoning can be used for other bond markets, where, for instance, a high indebtedness of households might reduce the liquidity in the European covered bond market over the next decade (Fiorante, 2012).

Our findings with regard to long-term government debt is in line with the findings of Eling et al. (2008) who predicts an increase in demand of long-term government debt as a result of the Swiss Solvency Test, much due to the same reasons as mentioned above for Solvency II.

Figure 18 - Holdings of life insurance companies as part of the total Swedish market

The figure illustrates the aggregated investments of Swedish life insurance companies in the Swedish markets compared to the outstanding volumes of the markets for some of the securities in which life insurance companies have large holdings as of 2011-12-31. A majority of the investments in investment funds by life insurance companies is held by non-mutual stock companies offering unit-linked insurance.



Source: (SCB, 2012)

Covered Bonds

Covered bonds presently represent the single largest holding of Swedish life insurance companies. Since covered bonds with rating AAA are given a SCR "discount" compared to the corresponding corporate bonds they are also very attractive under the Solvency II framework. Theoretically, covered bonds should be preferred over a combination of government and corporate bonds as long as they yield more than 0.43 times the yield of A-rated corporate bonds plus 0.57 times the yield for government bonds[29]. In practise, unlike the case for long-term government bonds and corporate bonds, there is a liquid and sizable Swedish market for covered bonds. This indicates that covered bonds will be an even more attractive asset class after the implementation of Solvency II. Yet concerns about the high level of indebtedness of Swedish households have already brought about regulation from FI, the Swedish Financial Supervisory Authority. Since October 1 2010 mortgage loans are only allowed to cover 85% of the market value of a property (Finansinspektionen, 2010), and more regulatory intervention could be expected, particularly in the form of mandatory amortization. This has been suggested by the Swedish Bankers' Association (Ingves, 2011) and considered by Stefan Ingves, Chairman of the Executive Board and Governor of the Riksbank (Goksör/TT, 2012). If mortgage lending were to decrease, a reduction in the issuing of covered bonds would follow, thus leading to a lower liquidity in the Swedish covered bond market. A consequence of this would probably be falling yields, which would lower the attractiveness of SEK-denominated covered bonds as an investment option and could therefore force Swedish life insurers to allocate more capital in foreign markets.

Corporate Bonds

Just as for long-term government bonds, corporate bonds with rating A or higher would be a more attractive investment for many insurance companies if the size of the corporate bond market would be larger. Moreover, short-term corporate bonds with lower ratings are still less expensive in terms of SCR than equity and property and could provide an alternative to those assets. This type of bonds could subsequently be used to fill the gap between government and covered bonds, which generate very little SCR but offers relatively low yields, and equity and property, which historically has had a higher rate of return but generates substantially more SCR. However, the Swedish corporate bond market would need to grow substantially (from the current outstanding amount of less than SEK 200 billion for non-financials) to become a serious investment possibility for life insurance companies. An obstacle for this to happen is the, in many respects, unique Swedish market structure, mainly caused by the close relationships between banks and the corporate lenders (Straume & Wetter, 2012). Due to these obstacles it is likely that Swedish life insurers will continue to mainly invest in foreign markets when it comes to corporate bonds.

[29] Covered bond spread risk is approximately 43% of A-rated bond spread risk, whereas the spread risk for most government bonds is 0%.

Swaps

Because of the SCR for interest rate risk there will be an apparent incentive for insurance companies to minimize the effect of an interest rate stress. With the historically low interest rates, especially a downwards stress of the interest rate term structure can be expensive in terms of SCR since that means an increase in the present value of the liabilities. As mentioned, this impact can be reduced by matching the cash flows of the assets with those of the liabilities, in other words by matching the size and duration of the assets with those of the liabilities. Theoretically, this can be done using bonds only. However, in practice this is not realistic, in part due to the limited market and liquidity for long-term bonds. Therefore, an increase in demand for interest rate instruments such as swaps and swaptions, used for matching the asset portfolio with the liabilities, is likely to be seen. These instruments will be particularly attractive for companies with low solvency and companies with large parts of their portfolios in non-interest bearing assets, who subsequently have a large duration-mismatch between assets and liabilities. These findings corresponds to those made by Poizot et al. (2011), who in addition predicts that the increased use of swaps and interest rate derivatives could lead to a general increase in the cost of hedging. However, the availability of interest rate swaps is linked to the covered bond and government bond markets, since the housing institutions and the Swedish national debt office (Riksgälden) are important counterparties in interest rate swap agreements.

Equity

As the results of the optimization show, Solvency II will be an incentive for Swedish life insurance companies to reduce their investments in equity. Swedish life insurance companies have a relatively high percentage of their investments in equity which resulted in 59 percent of the SCR for market risk being due to equity risk for Swedish life insurance companies, while the European average was only 42 percent in QIS5 (EIOPA, 2011, p. 72).

The SCR for equity in the base case is 39% for shares listed on an OECD stock exchange and 49% for private equity and shares listed in an emerging markets stock exchange. This means that equity is relatively expensive in terms of SCR. However, due to the Equity dampener, equity can generate both more and less SCR than in the base case, depending on whether the benchmark index is above or below its moving average. If the index is above the average the SCR rates can increase up to as much as 49% and 59% respectively. Conversely, if the index is below the average the SCR rates can decrease down to 29% and 39%. This movement in SCR rates can have a significant impact on the attractiveness of equity compared to other assets and can very fast cause a large increase in SCR for an insurance company with relatively large holdings in equity if stock markets should go up. In fact, two times during the past decade the SCR level for equities has gone from the bottom to the top level within a period of six months which can have a substantial impact on the total SCR (see example in Table 9). For life insurers with large equity holdings that are uncorrelated with the benchmark index, this might lead to a demand for hedging instruments, linked to the underlying index fluctuations, that compensates for the risk of a steep increase in SCR.

Basic financial theory and empirical evidence stipulates that bond returns are lower than equity returns because of the higher risk associated with equity holdings[30]. This is true because bond holders have a priority claim in case of default. However, a peculiar situation for corporate debt could occur in periods of weak economic climate. Due to the equity dampener, the SCR for *Global* equity can drop to 29% in the event of a stock market decline (see Figure 15). At the same time, corporate bonds rated BBB with duration of 12 years and more will then have a higher SCR than the corresponding equity. For bonds rated BB and B, the same situation applies to 7- and 4-year durations respectively. In other words, for the bonds mentioned, the regulatory risk measurement is higher than for equity, which in itself is counterintuitive and shows the large impact of the Equity dampener in certain cases.

Table 9 – Illustrative SCR variation for model life insurer
At the time of the base scenario the portfolio consists of 30 percent equities (50% Global and 50% Other) and 70 percent bonds. By the second time step, equities have increased in value by 25% and the SCR level has gone from the bottom (29%/39%) to the top level (49%/59%), which happened two times during the past decade. Everything else alike, this will cause an increase in the total SCR of 54% an increase of equity-related SCR of almost 100%.

	Scenario 1	**Scenario 2**
Equities	30	37.5
Equity SCR	10.2	20.25
Bonds	70	70
Bond SCR	8.4	8.4
Total SCR	**18.6**	**28.65** (+54%)
Assets over SCR	**5.38**	**3.75**

In the category classified as Equity Other there is a wide range of different assets that are all punished with the same SCR. Examples of these are hedge funds that, although very diverse as a group, generate the same level of SCR. This could very much reduce the attractiveness of relatively low yielding hedge funds that also have low volatility compared to listed equity.

Even though large holdings in equity are not optimal from a SCR perspective there are few liquid alternatives with comparable expected return in the Swedish market, which suggest that life insurance companies will continue to allocate a large part of their assets to equity even after Solvency II is implemented. Furthermore, the matter of solvency level will have a large impact on the size of equity investments. While a low solvency will force

[30] See for instance Mehra and Prescott (1985) and Fama and French (2001)

a company to focus on lowering SCR and hence reduce exposure to equity, a high solvency will create room for manoeuvre in terms of SCR and therefore equity holdings. The very tradition of large equity holdings might also play a role in maintaining a considerable investment in the asset class. Over time, however, most companies will most likely be forced to reduce their holdings due to the low risk-adjusted return.

Internal Models

The impact of internal models is yet to be seen. In Sweden the internal models are currently being reviewed by FI, but formal approvals are expected to be a year ahead.

Internal models could be of importance for the future asset allocation of life insurance companies given that they will impact the way the capital requirements for different assets are calculated. It is likely that this will primarily be of importance for assets that generates high SCR. For Swedish insurance companies the largest potential for reduction of SCR by the use of internal models is for equity, since it is the largest contributor to SCR. One possible strategy would require a plan for future management actions that would justify a lower capital requirement than in the standard SCR calculation. Such management actions could very well have a big impact on the activity of life insurance companies in the stock markets during periods of decline.

Internal models could also be interesting for some assets in the Equity Other category that have low historical volatility. However, for assets such as hedge funds there is a problem with the demand for transparency. For this reason this could very well be an area where new types of products are developed to suit the Solvency II requirements.

Another important issue for the authorities that has not been treated much in the literature is the coordination between the different national financial supervisors in the approval process of internal models. One of the main objectives with the Solvency II framework was to standardize regulation among EU members. To meet these expectations much cooperation between national supervisors is required, and it remains to be seen if they have the resources at hand to tackle the issue over the coming years.

7. Conclusions

The new solvency regulations for insurance companies within the EU, Solvency II, means a shift from volume based to risk based solvency requirements. One of the greatest impacts of this is that the amount of solvency buffer capital a life insurance company will need to hold, the Solvency Capital Requirement (SCR), will to a large extent depend on market risk. This thesis has illustrated that mutual life insurance companies can significantly reduce this capital requirement by optimizing their asset allocation after SCR. Moreover, the results indicate that certain assets will be increasingly attractive under the Solvency II framework as compared to today. These assets include long-term government bonds, covered bonds, interest rate derivatives such as swaps and swaptions and high grade corporate bonds. On the other end, equity will be very costly in terms of SCR and also be less attractive compared to other risky assets such as property and short-term high yield bonds if there is not a substantial difference in expected return. However, these results must be seen in light of the size and liquidity of the markets for the different assets in Sweden. The investment opportunities in long-term government bonds and corporate bonds are very limited compared to the volumes of the holdings of life insurance companies. This suggests that covered and medium term government bonds as well as interest rate derivatives will be the assets life insurance companies will increase their holdings in the most. Furthermore, there are still questions about some aspects of the new regulatory framework which could very much impact the relative attractiveness of certain assets. The impact of internal models for equity in particular is an important issue for Swedish life insurance companies. These results are of great relevance to life insurance companies evaluating the impact of Solvency II on their balance sheet as well as other market participants trying to assess the overall impact of the regulatory framework.

While much of the previous research has focused on specific aspects of the framework, we have taken a wider view while producing a country-specific analysis. Further research of this sort ought to be carried out in order to highlight the skewness of the impact of this relatively rigid framework. Additional research of interest includes optimal hedging strategies for reducing the impact of an interest rate stress. Because of the dynamics of the liabilities of life insurance companies, a hedging strategy must offer great flexibility while at the same time matching the long duration. A comparative study of the impact of Solvency II in different countries would also be of interest. Some countries, such as the United Kingdom, have higher liquidity in long-term and corporate bonds than for example Sweden. Also for countries within the Euro zone there are much greater investment opportunities without having to hedge against FX risk as compared to Sweden where unhedged holdings in other currencies than SEK results in an SCR for currency risk of 25%. Research that would also be of great interest relating to the topic of this thesis would be an ex ante study of the movements in asset allocation of Swedish mutual life insurance companies after the implementation of Solvency II.

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Appendix

Table 10 - The assets used in the optimization model
In total, 30 different assets were used in the optimization. Equity is divided by type into Listed shares, which represent shares listed in an OECD stock market, and Private equity, hedge funds which should represent what is referred to as Equity Other in the Solvency II framework. Bonds are divided by type, rating and maturity.

Asset class	Type	Rating	Maturity
Bonds	Swedish Government bonds	AAA	1-3 years
		AAA	3-5 years
		AAA	>5 years
	Covered bonds	AAA	1-3 years
		AAA	3-5 years
		AAA	>5 years
	Corporate bonds	AAA	1-3 years
		AAA	3-5 years
		AAA	>5 years
		AA	1-3 years
		AA	3-5 years
		AA	>5 years
		A	1-3 years
		A	3-5 years
		A	>5 years
		BBB	1-3 years
		BBB	3-5 years
		BBB	>5 years
		BB	1-3 years
		BB	3-5 years
		BB	>5 years
		B	1-3 years
		B	3-5 years
		B	>5 years
		CCC and lower	1-3 years
		CCC and lower	3-5 years
		CCC and lower	>5 years
Equity	Listed shares	-	-
	Private equity, hedge funds	-	-
Property		-	-

Table 11 - Indices used for historical prices of assets

14 different indices were used for the collection of historical prices for the different asset types. Monthly index data from August 2004 to March 2012 was collected from Reuters.

Asset	Index	Currency
Swedish Government bonds, 1-3 years	OMRX Treasury Bond1-3 y Index	SEK
Swedish Government bonds, 3-5 years	OMRX Treasury Bond 3-5 y Index	SEK
Swedish Government bonds, >5 years	OMRX Treasury Bond 5- y Index	SEK
Covered bonds , 1-3 years	OMRX Mortgage Bond 1-3 y Index	SEK
Covered bonds , 3-5 years	OMRX Mortgage Bond 3-5 y Index	SEK
Covered bonds , >5 years	OMRX Mortgage Bond 5- y Index	SEK
Corporate bonds, AAA, 1-3 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, AAA, 3-5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, AAA, >5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, AA, 1-3 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, AA, 3-5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, AA, >5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, A, 1-3 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, A, 3-5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, A, >5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, BBB, 1-3 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, BBB, 3-5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, BBB, >5 years	Dow Jones Corporate Bond Index	USD
Corporate bonds, BB, 1-3 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, BB, 3-5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, BB, >5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, B, 1-3 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, B, 3-5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, B, >5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, CCC, 1-3 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, CCC, 3-5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Corporate bonds, CCC, >5 years	Credit Suisse High Yield Bond Fund, Vanguard High-Yield Corporate Inv	USD
Listed shares	OMXS 30	SEK
Private equity	Dow Jones Credit Suisse Core Hedge Fund Index , MSCI EM (EMERGING MARKETS) Standard (Large+Mid Cap)	USD
Property	GPR 250 Index	EUR
Risk free rate	OMRX, T-Bill index	SEK

Table 12 – SCR Risk Module Correlation Matrix

The overall SCR is calculated by aggregating the SCR for the five risk modules; Market, Default, Life, Health, and Non-life risk, using the correlation matrix shown below. This is done in order to recognize the fact that all individual risks are not expected to occur simultaneously.

	Market	Default	Life	Health	Non-life
Market	1				
Default	0.25	1			
Life	0.25	0.25	1		
Health	0.25	0.25	0.25	1	
Non-life	0.25	0.5	0	0	1

Source: QIS5 Technical Specifications