LISBON SCHOOL OF ECONOMICS & MANAGEMENT
UNIVERSIDADE DE LISBOA

MSc ACTUARIAL SCIENCE

**MASTERS FINAL WORK**

PROJECT

# TRILEMMA ANALYSIS IN A P&C INSURANCE COMPANY

(ASSETS & LIABILITIES, EQUITY AND RISK)

SABANI DAHAMANI

OCTOBER, 2016

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# ABSTRACT

This project forms part of a wider and vibrant conversation pertaining to the analysis of a *Property and Casualty* (P&C) insurance company´s finances, assets & liabilities, and the possible risks in the company in relation to the legislative parameters of the Solvency II Regime, and the wider implication of this for the core stakeholders of interest. To the best of my knowledge, it is the first project that deploys the use of a *Dynamic Financial Analysis* (DFA) model for the calculations of *the Solvency Capital Requirement* (SCR) based on the SCR standard given by *European Insurance and Occupational Pensions Authority* (EIOPA)

The fundamental idea here is to provide perspectives into how the use of DFA models could be integrated into the valuation of Assets & Liabilities, Equity and Risk into providing empirical actuarial credence to companies whose business concerns spins around property and casualty, under the legal framework Solvency II Regime, under *European Union* (EU) and EIOPA guidelines.

The main purpose of this thesis is to find an equilibrium for managing a P&C insurance company's finances (for example, earnings, returns, dividends, etc.) under a regime very demanding of capital, management of the company's assets and liabilities (ensuring that the company's liabilities are properly funded by a portfolio of assets), and the impact of these managements on the SCR of the company in line with Solvency II directives. In order to properly manage and make financial projections of the company, a DFA model was thus proposed.

## *KEYWORDS*

Assets & Liability Management, Capital Management, DFA, Profitability, Property & Casualty Insurance, SCR, Solvency II, Solvency Ratio, Standard Formula.

# RESUMO

Este projeto constitui uma componente de uma análise mais vasta e muito relevante no âmbito do estudo de uma companhia de seguros Não Vida, relativamente à situação financeira, gestão de ativos e passivos, bem como aos possíveis riscos no âmbito do regime prudencial Solvência II. Para além destes pontos, são ainda relevantes as implicações deste novo regime nos interesses dos principais *stakeholders*.

Tendo em conta as informações disponíveis, trata-se do primeiro projeto que faz uso de um modelo Dynamic Financial Analysis (DFA) para o cálculo do Requisito de Capital de Solvência (SCR) baseado na fórmula padrão, definida pela European Insurance and Occupational Pensions Authority (EIOPA).

A ideia fundamental neste trabalho é estabelecer para companhias do setor Não Vida as indicações sobre a utilização de modelos DFA numa análise integrada, tendo em conta a avaliação de Ativos e Passivos, Capital Próprio, Risco, assim como as estimativas atuariais, segundo o regime Solvência II.

O propósito fundamental deste projeto, através da utilização de uma ferramenta como o DFA, centra-se em estabelecer uma metodologia que permita um compromisso entre a gestão financeira de uma companhia de seguros Não Vida (por exemplo, rendimentos, resultados, dividendos, etc), a gestão dos ativos e passivos da companhia (assegurando que os passivos da companhia estão devidamente financiados por um portfolio de ativos), e o impacto desta gestão no SCR da companhia, em linha com as orientações de Solvência II.

Para responder à necessidade de elaborar projeções financeiras e integrar as diferentes perspetivas, foi proposto um modelo DFA.

## ACKNOWLEDGEMENT

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ALM – Asset and Liability Management

BSCR - Basic Solvency Capital Requirement

CAPM - Capital Asset Pricing Model

CAS – Casualty Actuarial Society

CIR – Cox, Ingersoll and Ross

DFA – Dynamic Financial Analysis

DRMC – Dynamic Risk Management Committee

DST – Dynamic Solvency Testing

EC – European Commission

EEA - European Economic Area

EIOPA - European Insurance and Occupational Pensions Authority

LOB – Line of Business

P&C – Property and Casualty

SCR – Solvency Capital Requirement

# Chapter 1: Introduction

The human race is all about security and protection, humans have strived for security since the beginning of their existence. The need for security continues to increase as a result of the increasing population growth among the human race, and individuals within the economic framework (Society) becomes more specialized as time passes. Property and Casualty insurance company have recently been identified by the World Bank as a critical element for the development of emerging economies ( see Brown et al., 2007) , hence the need to protect, preserve and monitor their performance and sustainability for the betterment of the economy and the World as a whole.

Solvency II, introduced new requirements to be fulfilled by insurance companies in the member states of the *European Union* (EU). Solvency II is an EU Directive designed to regulate the capital of insurance companies and reduce the risk of insolvency. The regulation affects capital calculations, governance and reporting, thereby creating serious burden for insurers and their asset managers and custodians.

The main aim of Solvency II is to provide greater protection for policyholders against failure of insurance and reinsurance undertakings, reduce the risk of insolvency and to ensure greater consistency in supervisory requirements across the *European Economic Area* (EEA).

The above mentioned cannot be achieved without proper financial management and regulations. One key objective in financial management is to maximize profits while minimizing risks as much as possible. There are many factors influencing the profitability of an insurance company, and by properly regulating these factors, companies can put good measures in place in order to maximize profits at a given risk level. This project attempts to justify the contributions and the use of *Dynamic Financial Analysis* (DFA) as a powerful business tool that allows insurers to assess the different business strategies and select the plan that provides the best returns for the risks that are undertaken in compliance with the calculations of solvency capital requirements. By deployment of DFA system, insurance companies can recognize the conditions that generate unfavorable outcomes, so that decision makers can deal with these effects appropriately through proper calibrations to replace rough intuition.

Financial crisis in individual insurers are generally not just as a result of holding inadequate capital but also stems from ineffective or misaligned strategies and activities in the undertaking, for example with regards to risk management, investments, pricing, reserving or business growth. Holding adequate capital can be seen as a cushion against contingent losses that may arise from poor management of business.

The purpose of this work is to find an equilibrium for managing a *Property & Casualty* (P&C) insurance company's finances (earnings, returns, dividends, etc.) under a regime very demanding of capital, management of the company's assets and liabilities (ensuring that the company's liabilities are properly funded by a portfolio of assets), and the impact of these managements on the *Solvency Capital Requirement* (SCR) of the company in line with Solvency II directives. In order to properly manage and make financial projections of the company, a DFA model is proposed.

The main contributions and motivations of the work are as follows:

- ✓ To the best of my knowledge, it is the first project that deploys the use of a DFA model for the calculations of the SCR based on the SCR standard given by *European Insurance and Occupational Pensions Authority* (EIOPA);
- ✓ The analysis and the calculation is based on real data and also in with collaboration and under the supervision of insurance risk managers of a prominent insurance company in Portugal;
- ✓ Last but not the last, I will attempt to justify the contribution and the use of a DFA as a powerful business tool that will allow insurers to assess the different business strategies and select the plan that provides the best returns for the risk that are undertaken in compliance with the SCR of insurance companies.

There has been a lot of research with regards to DFA models, SCR calculation, Assets and liability management, etc., which are component of this work. The main interesting part of this work is not just about looking into DFA models, calculating SCR, controlling the flow of funds in a P&C Insurance company but integrating the above mentioned components and establishing an equilibrium between these three key areas in the insurance industry.

A DFA model is a class of structural simulation risk model of an insurance company's operations, focusing on underwriting and financial risks, designed to generate financial pro forma projections.

This text is organized in 6 chapters. Chapter 1 gives a general overview of the project, outlining the studies and its objectives and a brief discussion of the methodology involved. Chapter 2 talks about the literature review, Chapter 3 gives an overview of the company and the data used for this work. Chapter 4 deals with the methodology used in this studies, Chapter 5 presents the results of the studies with the final Chapter 6 discussing the results and conclusions. The next chapter presents the literature review.

# Chapter 2: Literature Review

With the new Solvency II directives and regulations, there is a high concern for financial management in insurance sectors in Europe in order to fulfil the new requirements. There are many factors influencing the profitability of an insurance company and by properly regulating these factors, companies can put good measures in place to maximize profit whilst conforming to the capital requirement set by Solvency II regulation. The concern for controlling the flow of funds, management of assets and liabilities as well as calculating the SCR and their implications motivated several literatures both from academics and practitioners. This project contributes to the literature by studying the question of whether a DFA model can be used not just for making projections of financial statements but also in the calculations of the SCR based on the SCR standard formula. The work closest to this project is DFA Model as a tool for solvency assessment by Hugo Miguel Moreira Borginho (2005). However, the solvency assessment was not based on the current (Solvency II) SCR standard formula given by EIOPA.

## 2.1: DFA Models Literature Review

One way of controlling a company's financial flow and management of its assets and liabilities is to be able to predict and forecast the future solvency of the company.

DFA Committee of the Casualty Actuarial Society (2008), provides an overview of DFA and its usage in a property casualty context. The DFA research committee of the Casualty Actuarial Society developed a DFA model under the supervision of the *Dynamic Risk Management*

*Committee* (DRMC). Their main results are reported in a DFA handbook, which is used as a guide in the development of company specific risk based DFA models for P&C insurance companies.

In another overview, Blum et al. (2004) presented the value proposition, the elements, and examples of DFA use. Wiesner et al., (2000) incorporated DFA into the strategic decision process of workers' compensation carrier. D'Arcy et al., (1998) describe an application of the publicly available "Dynamo" DFA model to a property-liability insurer.

Lowe et al., (1997) and Kaufmann et al., (2001) both provide an introduction to this field by presenting a model framework, as well as an application of their models. Lowe et al., (1997) present a DFA model that is used by a property catastrophe reinsurer to handle the underwriting, investment, and capital management process. Kaufmann et al., (2001) give a model framework comprising the components most DFA models have in common and integrate these components in an up-and-running model. Blum et al., (2001) use DFA for modeling the impact of foreign exchange risks on reinsurance decisions, while D'Arcy et al., (2004) use DFA to determine whether there is an optimal growth rate in the property-liability insurance business. Using data from a German nonlife insurance company, Schmeiser (2004) develops an internal risk management approach for property-liability insurers based on DFA, an approach that might be used to calculate the new risk-based capital standards in the European Union.

Also, Hugo M.M.B (2005) used the DFA model as a tool for solvency assessments in general insurance companies in Portugal. Martin et al., (2005) use a DFA to model insurance company's cash flows in order to forecast assets, liabilities, and ruin probabilities, as well as full balance sheets for different scenarios.

However, implementing a DFA for a P&C involves several key factors and variables that must be taken into account. Some of the key variables are; interest rate models, equity returns models, the business underwriting cycle and the loss development. These variables have also attracted several writers. For example, there are many different interest rate models used by financial economist. An overview of some common ones and their application is given by Ahlgrim et al., (2001). See also Kjersti et al., (2015) for comparison of different interest rate models. Kristin et al., (2014) describe how to calibrate the parameters for different interest rate models. Laura et al., (2008) provide an application of the equity and interest rate models in the long term insurance simulations. Hakan et al., (2013) also gave a description of the relation between the Smith-Wilson method and the integrated Ornstein-Uhlenbeck processes. Rocco et al., (2009) describe the dynamic analysis of the business underwriting cycle in non-life insurance companies. Shaun S. et al., vol.5 analysis the historical business underwriting cycle of US insurance companies and developed a regime-switching model for simulating future cycles.

## 2.2: SCR Standard Formula Literature Review

One of the key role of solvency II is to secure policyholders and investors. Solvency II requires that every insurance company in the EU must hold an initial capital amount sufficient to offer protection against adverse contingent events.

There are several literature on capital adequacy and its relationship to risk measure. One of the most popular and known risk measure, *Value at Risk* (VaR), which is widely used in financial risk management constitute the basis for the Solvency II regulatory standards ( see Sandstorm, 2005).

In spite of the highly venerable goals of Solvency II, there are some major theoretical and practical limitations in its applications (see Gaurang, 2010).

VaR, which forms the basis for the risk measure in solvency II regulatory standard has some pitfalls. For instance, VaR is not sub-addictive and hence there exist situations where it behaves poorly under aggregation (see Artzner et al., 1999). The pitfalls of the VaR is not discussed in this project. For details on how to overcome these pitfalls, see Artzner et al., (1997) introduced the notion of coherent risk measures. See also Dhaene et al., (2006) for the overview of theoretical properties of various well-known risk measures used in SCR.

A master's thesis by Gaurang (2010) outlined the potential advantages and possible challenges posed by Solvency II for insurance companies in the EU. Gaurang (2010) attempted to weigh the marginal benefits of the regulation along with its marginal costs and wrapped up with some recommendations on possible solutions or approaches that can be adopted by the EU regulators to resolve such challenges of the directive in insurance regulations.

The general framework of Solvency II, in particular the SCR standard formula have had intense analysis and discussions by both academicians (see Linder & Ronkainen, 2004; Doff, 2008) and practitioners (see Fitch Ratings, 2011; Ernst & Young, 2011). On the contrary, no article to the best of my research has focused on the use of a DFA model in connection with Solvency II SCR calculations.

The market risk module of the SCR standard formula which accounts for almost 70% of the overall SCR (see Fitch Rating, 2011) for insurance companies in the EU has attracted several empirical literature that focus on the impact of this risk on the different investments strategies of an insurance company.

Fisher and Schluetter (2014) provide an in-depth analysis of one of the sub risk module (equity risk) of the market risk and its impact on the investment strategies of a shareholder-value maximizing insurer within the options framework. Their results showed that, the standard formula has a strong influence on both the capital and investment strategies.

Also, a research by Braun et al., (2015) highlights that the market risk standard formula suffers from several shortcomings, which has the potential to create an opportunity to invest in less-diversified portfolios associated with an increased default risk from a proper asset-liability perspective.

In this regard, it is assumed in this work that, the insurer underwriting portfolio is given and cannot be changed within a one-year time horizon. By this the capital requirement under the SCR standard formula as well as the insurer's profit are calculated. The next chapter presents the data and company overview

# Chapter 3: Company and Data Statistics

This chapter presents the statistics of the company and the data used in the work. In contributing to this discussion, primary source of data interwoven with other secondary sources has been the bedrock on which a wide spectrum of different investments structures and test are based on. The data used includes only the accessible economic and statistical information that non-life insurance companies in Portugal are obliged to present annually to their regulators.

## 3.1: Company Overview

The selected company is a significant non-life insurer in the Portuguese insurance market, with exposure to almost all *Lines of Businesses* (LOBs) as outlined by Solvency II regulations (Art. 80 of Directive 2009/138/EC).

Property and Casualty insurance companies under Solvency II are required to present the profit and loss account disaggregated per line of business in accordance with list of insurance groups given by the directive. See *Appendix A* for lists*. (Art. 80 of Directive 2009/138/EC).*

The selection of list of LOBs used for this work is aimed at obtaining a relative stable history of loss ratios without forgoing intuition. Concerning the inputs (premiums, expenses, losses, exposures, etc.), each line of business was considered separately. The selection of our lists is based on the list provided by Solvency II Directive with some adjustments (aggregating lines of business with unstable loss ratios) aimed to increase the stability of the results. Below is the final selected list for this study:

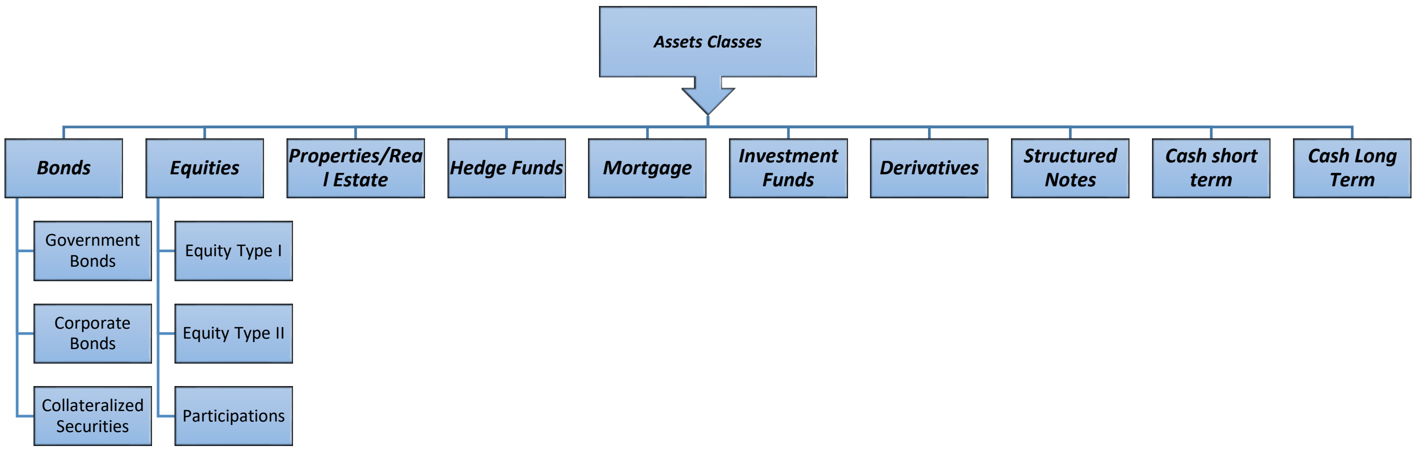
1. Worker´s Compensation Insurance
2. Medical Expenses Insurance
3. Motor Insurance
4. Marine, Aviation, and Transport
5. General Insurance (Third-Party Liability)
6. Fire and other property damage
7. Income Protection Insurance
8. Others

See *Appendix A* for the adjustments made over the original list.

Insurance companies are faced with variety on investments options, there is no rule governing what type of assets an insurance company should or should not invest in.

The objective here is to project the expected asset returns for the future years. It is thus necessary to break down the portfolios into individual asset categories. The major categories considered were equities, bonds, cash, property etc. See Figure 1 for detailed classification of the assets classes considered in this work.

**Figure 1: Portfolio of Asset Classes**




## 3.2: Data Statistics

The major source of data for this work is real life data collected from a non-life insurance company in Portugal. It can be seen from the balance sheet on Table 1 that more than half of the company's funds are invested. The company invests in different classes of assets with bonds and equities being the majority. Figure 2 shows the details of the proportion invested in the various assets as at the end of 2015. We consider the company´s asset classes as fixed and the proportion invested in each class is allowed to vary each year.

**Table 1: Detailed Balance Sheet Proportions**

| Assets | Amount in Percentage | | Liabilities |
|---|---|---|---|
| Goodwill | 3.76% | 2.52% | Ordinary share capital |
| Intangible assets | 3.31% | -12.46% | Retained earnings |
| Deferred tax assets | 3.37% | 0.65% | Other reserves from accounting balance sheet |
| Pension benefit surplus | 0.00% | 25.13% | Other paid in capital instruments |
| Property, plant & equipment held for own use | 9.02% | *21.40%* | *Preference shares* |
| Investments | 55.51% | *3.73%* | *Subordinated liabilities* |
| Loan on Policies | 0.00% | 0.47% | Pension benefit obligations |
| Loans & mortgages (except loans on policies) | 0.87% | 66.99% | Technical provisions |
| Deposits to cedants | 0.03% | 1.57% | Provisions other than technical provisions |

| | | | |
|---|---|---|---|
| Reinsurance recoverable | 6.75% | 1.82% | Insurance & intermediaries payables |
| Deferred acquisition costs | 1.98% | 1.00% | Reinsurance payables |
| Cash and cash equivalents | 2.32% | 1.50% | Deposits from reinsurers |
| Insurance & intermediaries receivables | 9.17% | 1.42% | Payables (trade, not insurance) |
| Reinsurance receivables | 0.94% | 0.00% | Debts owed to credit institutions |
| Receivables (trade, not insurance) | 2.11% | 0.00% | Financial liabilities |
| Any other assets, not elsewhere shown | 0.85% | 9.38% | Any other liabilities, not elsewhere shown |
| Total assets | 100.00% | 100.00% | Total liabilities |

Historical earned premiums (see Figure 4) for the past ten years are used for projection purposes. Property-Liability insurers have the opportunity to change the premium level prior to writing new or renewal business. Thus, as expenses or expected losses changes, insurers can reflect changes in the new rate levels. For this purpose, two years historical new and renewal ratios is considered and used as the basis for future years. Table 2 shows the renewal ratios for both new, 1st renewal and 2nd & subsequent renewal business premiums for 2014 and 2015. Figure 3 presents the amount in proportion of the company's exposure per LOB. Observations from the historical data shows almost 50% of the company's income is from Motor Liability insurance. For this reason, the loss development triangle (see in Appendix) for Motor Liability insurance is presented here. The same format goes for the other LOB. The next chapter presents the methodology for this work.

**Table 2: New and Renewal Ratios for Premiums**

| 2014 | | | | |
|---|---|---|---|---|
| LOB | New Written Premium (%) | 1st Renewal Written Premiums (%) | 2nd Renewal Written Premiums (%) | Total (%) |
| Motor | 27.67 | 4.50 | 67.83 | 100.00 |
| Worker's Compensation Insurance | 28.50 | 5.00 | 66.50 | 100.00 |
| Marine, Aviation & Transport | 29.86 | 2.00 | 68.14 | 100.00 |
| Fire and Other property damage | 11.64 | 2.30 | 86.06 | 100.00 |
| General Insurance(Third-party liability) | 29.28 | 2.90 | 67.82 | 100.00 |
| Medical Expenses Insurance | 20.47 | 2.00 | 77.53 | 100.00 |
| Income Protection Insurance | 35.37 | 3.50 | 61.13 | 100.00 |
| All Purpose Insurance | 8.62 | 1.50 | 89.88 | 100.00 |

| 2015 | | | | |
|---|---|---|---|---|
| LOB | New Written Premium (%) | 1st Renewal Written Premiums (%) | 2nd Renewal Written Premiums (%) | Total (%) |
| Motor | 29.66 | 5.40 | 64.94 | 100.00 |
| Worker's Compensation Insurance | 27.40 | 6.20 | 66.40 | 100.00 |
| Marine, Aviation & Transport | 29.80 | 3.01 | 67.19 | 100.00 |
| Fire and Other property damage | 10.60 | 3.30 | 86.10 | 100.00 |

| | | | | |
|---|---|---|---|---|
| General Insurance(Third-party liability) | 29.01 | 4.50 | 66.49 | 100.00 |
| Medical Expenses Insurance | 21.40 | 3.90 | 74.70 | 100.00 |
| Income Protection Insurance | 34.30 | 4.60 | 61.10 | 100.00 |
| All Purpose Insurance | 8.92 | 3.02 | 88.06 | 100.00 |

**Figure 2: Proportion Invested in Each Asset**

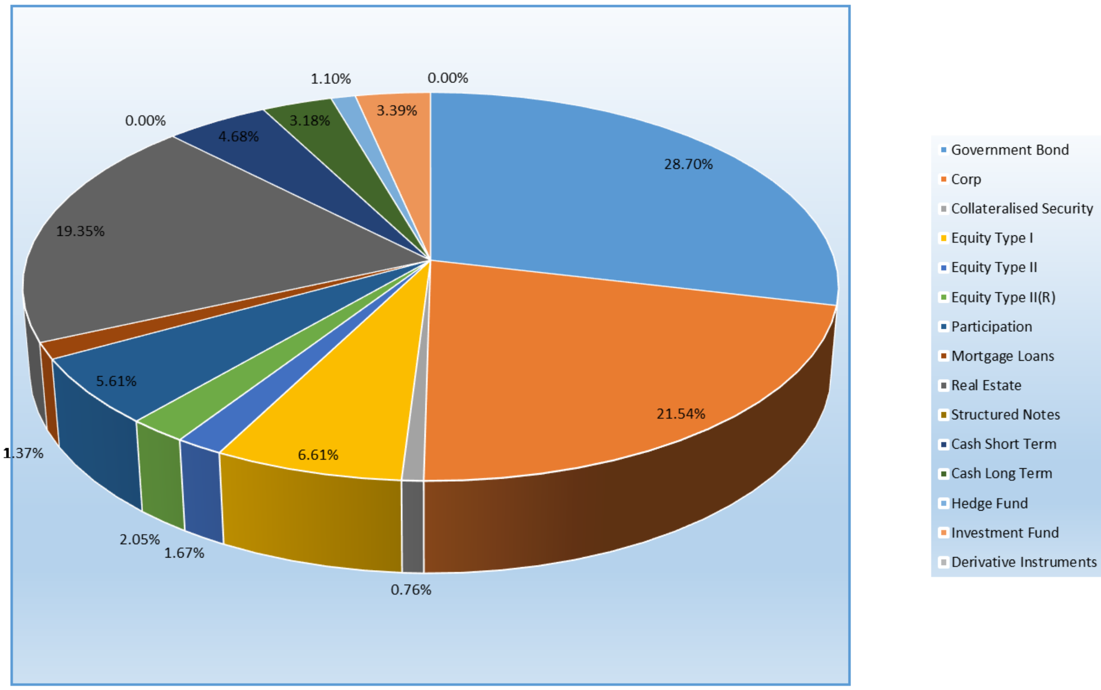


**Figure 3: Written Exposure Proportion per LOB**

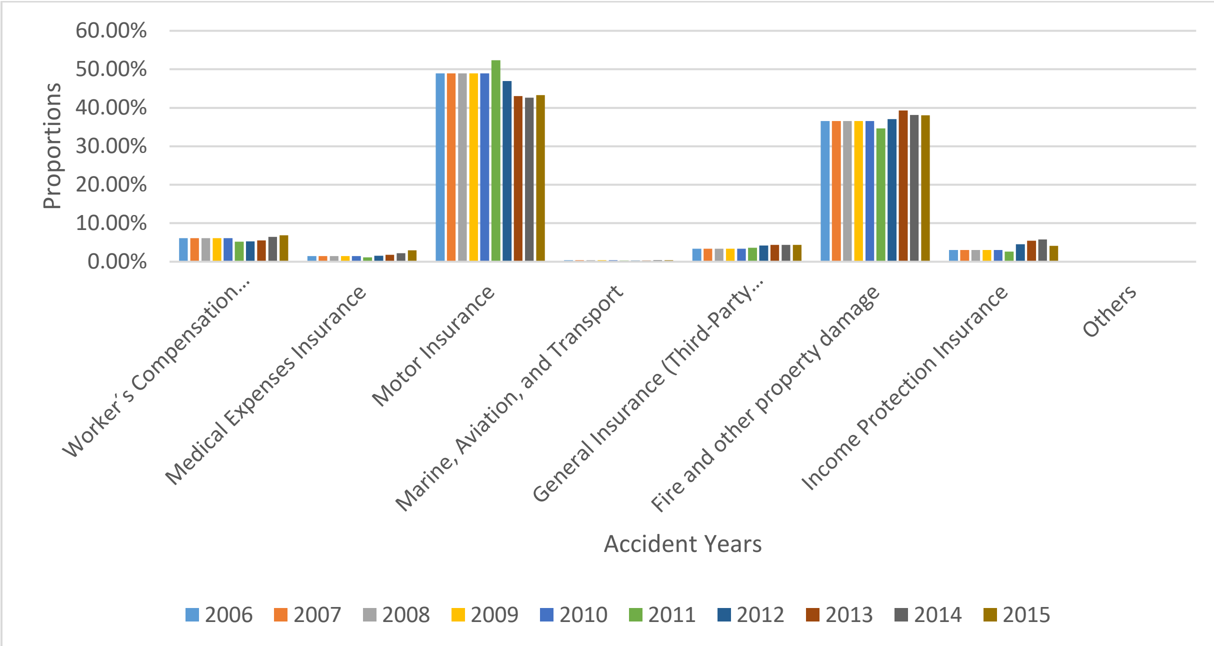
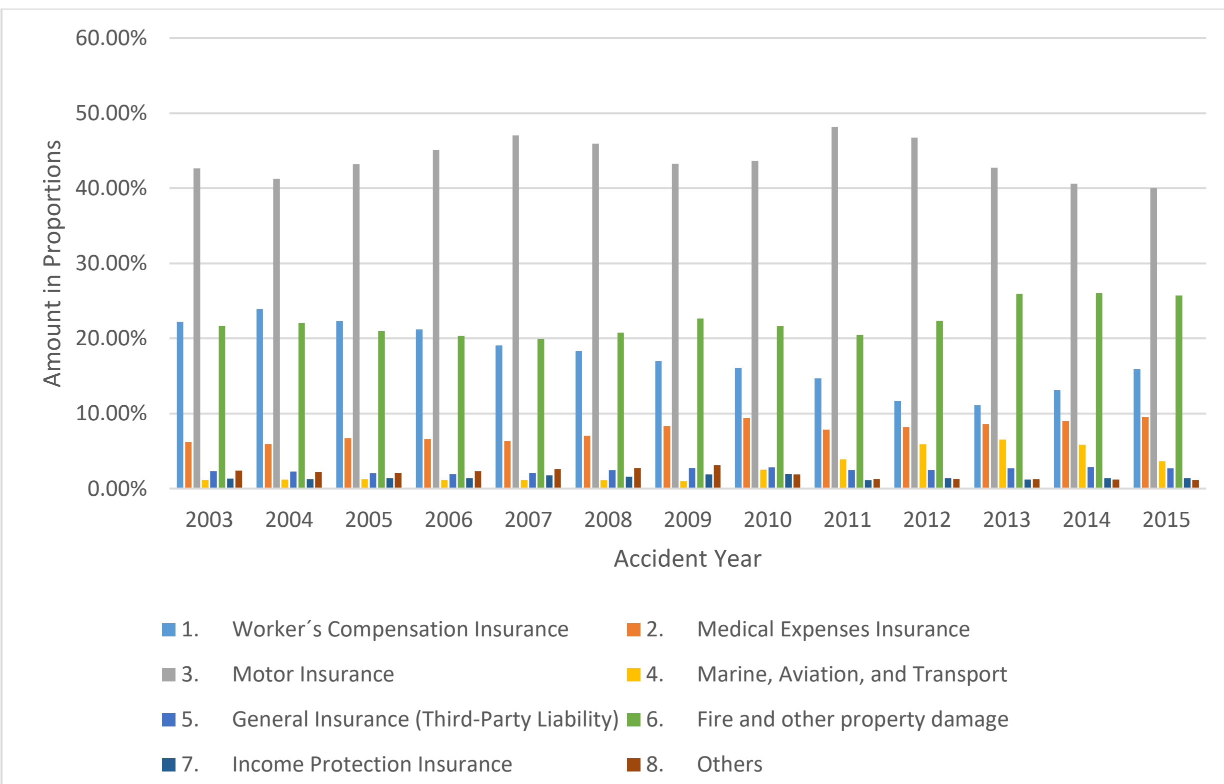



**Figure 4: Historical Earned Premiums in Proportions**



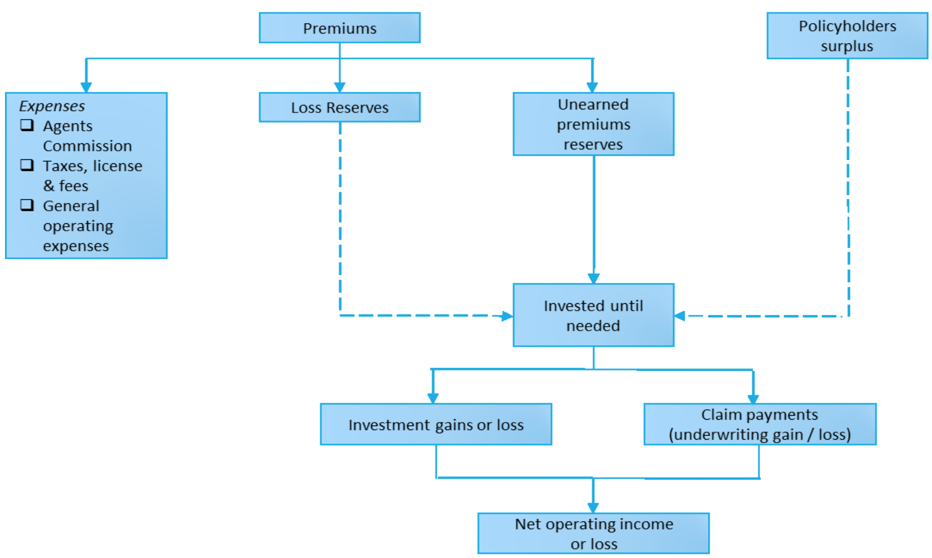
# Chapter 4: Methodology

As mentioned in the introduction, two models are used in this project to help achieve the aim of this study. Figure 9 in the appendix gives a brief summary of the main aim of this work. The risk measure used in this work is the SCR which is calculated based on the standard formula provided by solvency II regulators and a DFA model developed by CAS is used for the management of the assets and liabilities, flow of funds and to make financial projection of the company. Sections 4.1 and 4.2 below gives detailed presentations of the methodology behind DFA model and the SCR standard formula respectively.

## 4.1: Flow of Funds through a P&C Insurance Company

Insurance enables individuals and entities to share the burden of unexpected losses associated with damage or destruction to properties or incurred liabilities. A P&C insurance company is faced with various types of cash flows on a daily basis, and these cash flows needs to be properly managed in order to remain solvent. Figure 5 below shows the flow of funds through a P&C insurance firm.

**Figure 5: Flow of funds through a P&C Insurance Firm**




A P&C company collects premiums (payments) from policyholders that face similar risks including for example automobile accidents and house fires. Such premiums are pooled together by the company with payment made from the pool to individual and entities that experience loss.

From Figure 5, following the underwriting and policy issuance, the premiums received are placed in an unearned premium reserve. Such funds are then “earned” or recognized as revenue over the term of the policy, typically on a monthly basis. The revenue is then used to pay wide variety of expenses with the single largest expense being losses otherwise known as claims made by policyholders. Other expenses includes agents/brokers commission, workforce salaries, and claim-related expenses such as direct and overhead expenses. Insurers are also expected to set aside funds to cover contingent claims referred to as loss reserves.

Overall the underwriting portion of the company’s profit/loss is determined by subtracting such expenses from the total premiums received. Premiums have to be set at a level that closely match premium revenue with expected loss payout. Due to the complexity of estimating loss payout, underwriting operations of many insurers often experience losses.

The total profitability of a P&C company comprises not only the performance of the underwriting segment but also gains/losses on invested loss reserves, unearned premiums reserves, and policyholder’s surplus, hence the need for proper management of the company’s assets and liabilities. For example, during periods of high investments returns, management of insurers may choose to reduce premium prices in order to gain market shares thereby relying on investments income for overall profitability. Conversely, in periods of declining investments returns, insurers may be unable to lower premiums and may even have to increase premiums to avoid the possibility of net losses. P&C insurance markets are also subjected to cycles that fluctuates between different market conditions.

## 4.2: Proposed DFA Model

Actuaries look at the future as part of their everyday work, with a new approach called Dynamic Financial Analysis that sets traditional forecasting methods on their ear. Rather than looking only at certain aspects of a balance sheet, this new methodology considers the broad spectrum of a company's financial condition, and analyzes its health in an uncertain and changing world.

A DFA model was proposed to manage and make financial projections, and to check the impact of these projections on the company’s SCR. The DFA model used in this work was developed by CAS see Kaufmann R. et al., (2001), a public access DFA model with some adjustments made to reflect the structure of a P&C insurance company in Portugal. In this project, the adjusted DFA is used to manage and make financial projections and to check its financial impact on the company.

### *4.2.1: Structure of DFA Model*

DFA is the process of examining the entire financial position of an insurance company over time, considering both the interrelations among the various parts and the stochastic nature of the factors that can affect the results. Insurance companies have various areas with potential applications for DFA such as solvency testing, asset allocation, capital allocation, etc. In this work, our attention is on DFA and its variants such as *dynamic solvency testing* (DST) and *dynamic capital adequacy testing* (DCAT).

DFA can be performed using two approaches; scenario testing and stochastic simulation.

Under the scenario testing, the financial position of the company is determined based on a number of preselected potential scenarios (factors), that's factors that influence the company´s finances. The scenarios of interest to every actuary is the infrequent factors that can put the company into serious jeopardy, for example, sharp variations in interest rates, inflation rates, mortality, loss frequencies & severity, investment returns and other underwriting factors such as underwriting cycle of the company, catastrophe variables and payment pattern.

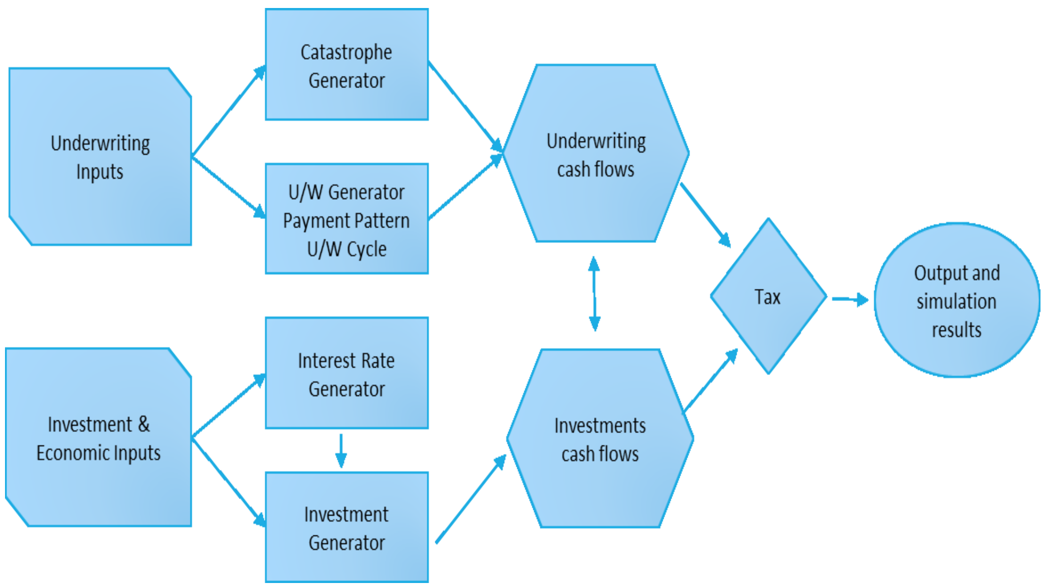
This approach addresses such questions as, "What happens if interest rates increases by say "$\alpha$%"?" or "What effect would a "$\alpha$%" decrease in investment returns have on an insurer?" One benefit of this approach for actuaries is that it avoids criticism associated with incorrect point estimates, as long as the actual outcome is somewhere in the range provided.

Nonetheless, this approach is not very useful for policy makers, since it provides no indication of the likelihood of the different outcomes. Although the uncertainty of the future is reflected, the range is so wide that making decisions based on these data is fruitless.

On the other hand, stochastic simulation is grounded on a theoretical framework (mathematical models) where all the main variables affecting the financial status of the company are treated as random variables with suitable probability distributions. Estimations of parameters are done through the analysis of relevant past data. Stochastic simulation also takes into account the correlations between the variables, since an independence assumption between these variables could lead to unbiasedness of the results and consequently underestimation or overestimation of potential losses in the company.

One common use of this approach is to determine the proportion of outcomes that are unacceptable (e.g., surplus less than zero). If this proportion is considered too high, then changes in operations or current financial position can be made to reduce this value to an acceptable level. The model for this study follows the structure of the public access DFA model as displayed in Figure 6 below.

**Figure 6: Structure of DFA Model**




*Source: http://www.casact.org/research/dfa/index.html*.

**Table 2: Selected Key Variables used in the DFA**

| Underwriting Variables | Investments and Economic Variables |
|---|---|
| Business Underwriting cycle | Assets Income |
| Expenses | Dividend Yield |
| Exposure | Equity Risk Premium |
| Loss Frequency | Inflation |
| Loss Severity | Interest Rate Term Structure |
| Payment Patterns | Taxes |
| Reinsurance Variables | |

An important aspect of developing a DFA model is to identify the variables that should be included as well as suitable probability distributions that describe them and the relationships between all variables. But, before this task, it is important to understand the risks that general insurance companies face throughout their business. *See appendix B* for details of the risks faced by insurance company as specified by solvency.

Models are always approximations to reality, hence not all minor factors are incorporated into it. It is kept simple by considering only the most relevant factors. In this thesis the factors in Table 2 above will be considered.

The next step is to identify which variables should be stochastic and which ones should be deterministic. Again, it is important that only the most relevant variable are represented by random variables for easy understanding and implementation of the model. Below is list of some of the variables that are treated stochastically:

### *4.2.2: Interest Rate Generator*

A key aspect of solvency II is to compute the best estimator of the liabilities, this should be the probability of weighted average of future cash flows discounted to its present value. Movements in economic variables are often the driving forces of changes in liabilities present values hence insurers need stochastic models for producing future path, for example interest rates as well as equity and bond returns.

On the assets side, an interest rate generator is needed in order to estimate interest rate risk, which is probably the most important asset risk since non-life insurance companies are strongly exposed to it due to generally large investments in fixed income assets classes.

Interest rates are strongly correlated with inflation (see Roger K. et al*.*, 2001) which itself influences the changes in claim size and claim frequency.

One single generator that simulates short term, long term interest rate, general inflation and inflation by line of business was constructed. There are different interest rates models used by economist (*see* D'Arcy and Gorvett, 1998), to simulate the annualized for every year "t", a discretization of the mean reversion model proposed by Cox, Ingersoll and Ross (CIR model) was used in this thesis.

The CIR model in continuous time is characterized by the equation (See J.C. Cox et al., (1985)):

$$(1.1)\quad dr(t) = \alpha(\mu - r(t))dt + \sigma\sqrt{r(t)}dz(t)$$

$r(t)$ is the instantaneous short term interest rate

$\alpha$ is the constant that determines the speed of reversion

$\mu$ is the long term mean of interest rate

σ is the volatility of the interest rate process

Z(t) is a standard Brownian motion

The parameters above were calibrated using historic interest rates of Portugal by applying least mean square method in excel. See J.C. Cox et al., (1985). Lamberton et al., (1996) proof the following results which were used to estimate the long term interest rate:

$$(1.2)\quad E\left[e^{-\int_0^T r_{t+s}\partial s}\right] = e^{\ln A_T - r_t B_T} \quad \text{where}$$

$$A_T = \left(\frac{2\theta e^{(\alpha+\theta)\frac{T}{2}}}{(\alpha+\theta)(e^{\theta T}-1)}\right)^{\frac{2\alpha\mu}{\sigma^2}} \quad \text{And} \quad B_T = \frac{2(e^{\theta T}-1)}{(\alpha+\theta)(e^{\theta T}-1)+2\theta}$$

defining $R_{t,T}$ as the yield of a zero coupon with term to maturity of T, we can write the

Discounting factor $E\left[e^{-\int_0^T r_{t+s}\partial s}\right]$ as $e^{-TR_{t,T}}$ which implies

$$(1.3)\quad R_{t,T} = \frac{r_t B_T - \ln A_T}{T}$$

### *4.2.3: General Inflation and Stock Returns*

Inflation is simulated using the short term interest rate by using a linear regression model

(1.4) $i_t = a + br_t + c\varepsilon_t$,

Where a, b and c are constants estimated by regression using historical data (see R. Kaufmann, 2001). General inflation is necessary for modeling loss payments.

Another necessary generator on the asset side is stock returns which also depends on interest rates. In order to model assets suitably, stock returns were simulated using the Sharpe-Lintner CAPM pricing equation (see for example Ingersoll, 1987):

(1.5) $r_t^s = r_t^f + \beta_t (r_t^m - r_t^f)$ where

$r_t^s$ is the expected stock return at time t,

$r_t^f$ is the risk free rate of return at time t, (see equation (1.3) )

$r_t^m$ is the expected market returns at time t,

$\beta_t$ is the stock beta at time t.

Note, the expected market returns ( $r_t^m$ ) and the stock betas ($\beta_t$) are input variables based on the company's specifics.

### *4.2.4: Underwriting Variables*

Another major portion of an insurer's income is generated by the underwriting business (cycle). In particular, the underwriting cycle is not quantified in the standard formula under the EIOPA, but probably it could be included as it provides additional volatility to liability distribution and could increase the capital requirement. EIOPA does not define any additional capital requirement for the underwriting cycle. It is worth mentioning that the underwriting cycle contribute an artificial volatility to the underwriting results that lies outside the statistical realm of insurance risk (see, Meyers, 2007), hence the additional volatility could lead to high capital requirement. In this project, it is assumed the underwriting cycle follows a Markov process (in discrete time) and therefore the so-called transition probability indicating the probability of the underwriting cycle switching from one state to another is assumed based on the company´s historic premiums evolution, (see Appendix C for the assumed transition probability matrix). The estimation of the transition probability matrix is outside the scope of this project, (see Kaufmann, Gadmer and Klett 2001; D'Arcy 1997, for the estimations of the so-called transition probability matrix for a non-life insurance company).

A business cycle comprising of three possible states was considered in this project:

- State 1: a very sound market phase which leads to a high premium income( Hard market phase)
- State 2: a state where premium levels are medium
- State 3: a soft market phase with low premium level

Denoted by the variable $P_{ij}$ is the probability of switching from one state (say i) to another state (say j) which led to the following transition matrix:

$$P_{ij}=\begin{pmatrix} p_{11} & p_{12} & p_{13} \\ p_{21} & p_{22} & p_{23} \\ p_{31} & p_{32} & p_{33} \end{pmatrix}$$

### *4.2.5: Payment Pattern and Loss Reserves*

Payment pattern is modeling when and how losses are paid. Figure 10 shows the paid losses in the triangle on the left side of the thick line which are known whereas the ones on the other side represent outstanding and future loss payments which are unknown. For every accident year say $t_1$, the pattern gives us the information which part of the total loss is paid in which development year say $t_2$. Each line of business was modeled separately and it was assumed that for every line of business, there is an ultimate development year $t_2$ until which all claims will be paid. In order to estimate adequately the loss reserves, the ultimate loss $Z_{t1}^{ult}=\sum_{t=0}^{T} Z_{t1,t}$ which varies by accident year $t_1$ was calculated since all claim payment $Z_{t1}$, $Z_{t2}$ for the previous year $t_1+t_2 \leq t_0$ is known. This was done by applying the Chain Ladder method

(See Mack, 1994). Ratios were applied to cumulative payments per accident year to estimate the Loss development Factors (LDF) defined as $d_{t1,t2}$ :

$$d_{t1,t2} = \frac{Z_{t1,t2}}{\sum_{t=0}^{t2-1} Z_{t1,t}}$$

Loss development factors describe how losses change from one development year to the next. A Beta distribution is used to simulate future payment percentages with the Beta parameters derived using the historical payment averages.

## 4.3: Risk Measure Used

The SCR, whether calculated from the Standard Formula or otherwise, is the capital level correspond[ing] to the Value-at-Risk (VaR) of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period. This is sometimes referred to as the 99.5% one year VaR standard. This is a level intended to be sufficient such that the insurer could withstand a 1 in 200 year shock within one year with sufficient assets remaining to allow for the sale or transfer of its remaining liabilities to another insurer. See EIOPA (2014a). In addition to the SCR, each insurer also calculates a Minimum Capital Requirement (MCR). The MCR represents a threshold below which the national supervisor would intervene. The MCR is intended to reflect an 85% probability of adequacy over a one-year period and is bounded between 25% and 45% of the insurer's SCR.

In order to calculate the SCR, the regulator provides insurance companies with the standard formula for different risk types that are said to be calibrated on the basis of historical data to reflect a VaR with 99.5% and a time horizon of one year. (See, EIOPA, 2014a). Three risk modules are considered for the purpose of this analysis. The market risk module, which accounts for almost 70% of the overall SCR, counterparty default risk and the non-life risk.

### *4.3.1: Market Risk Module*

Market risk is the possibility of experiencing losses due to factors that affect the overall performance of the financial markets. The market risk module is as a result of the aggregation of six sub risk modules, that is, interest rate risk, equity risk, property risk, credit spread risk, currency and concentration risk. Equation (1.6) below shows the market risk formula.

$$(1.6)\quad SCR_{market} = \sqrt{\sum CorrMkt_{i,j} . SCR_{mkt\_i} . SCR_{mkt\_j}}$$

Solvency II regulators defined the difference between an insurer's assets and liability as Basic Own Funds (BOF). Within each sub module, the determination of the SCR is based on a specific scenario that has an impact on the level of the BOF (see EIOPA, 2014a). Therefore, each scenario is used to measure the influence of shocks from the capital market as reflected by the stress factor on the BOF denoted as ΔBOF.

The first sub risk module is the interest rate. This is the risk due to the impact of changes in the interest rate term structure in the values of assets and liabilities (see EIOPA, 2014a). The SCR for interest rate risk comprises two states due to the upward and downward shifts of the interest rate term structure, thus the SCR for interest risk is calculated as follows (see EIOPA, 2014a):

$$Mkt_{\text{int}}^{up} = \Delta BOF \,|_{up}$$

$$Mkt_{\text{int}}^{down} = \Delta BOF \,|_{down}$$

$Mkt_{\text{int}}^{up}$ and $Mkt_{\text{int}}^{down}$ represents $\Delta BOF$ caused by a rise and a fall in interest rates respectively. In both cases interest rate stress is applied to the yield curve as follows (see EIOPA, 2014a):

$$\Delta r_t^{up} = r_t . (1 + s_t^{up}) - r_t \quad \forall \text{t, in the upward shock}$$

$$\Delta r_t^{down} = r_t . (1 + s_t^{down}) - r_t \quad \forall \text{t, in the upward shock,}$$

With $s_t^{up}$ and $s_t^{down}$ being the interest rate shock for the two scenarios, and $r_t$ is the spot interest rate for maturity t.

The second sub-module is the equity risk that is the risk of loss due to changes in the market price of equities (see EIOPA, 2014a). The capital charge for equity risk is split into two categories to account for specific characteristics of different equity investments. Equities listed in the stock exchange of EEA member states termed Type 1 equities and Type 2 equities which refers equities listed in stock exchange of countries that are not members of EEA. The capital requirement is then calculated based on given stress for each category as follows:

$$Mkt_{eq.,i} = \max(\Delta BOF \mid shock\_equity_i ; 0)$$

Where $shock\_equity_i$ denotes the stress factor for equity category *i*. Equation below is then used to calculate the SCR for the market equity risk.

$$SCR_{mkt\_equity} = \sqrt{(SCR^2_{mkt\_type1equities} + SCR^2_{mkt\_type2equities} + 2.75\%.SCR_{mkt\_type1equities}.SCR_{mkt\_type2equities})}$$

Analogous to equity risk, the capital requirement for property risk reflects assets, liabilities, and financial investments that react sensitive to real estate prices. The SCR is calculated as follows:

$$SCR_{mkt\_property} = \max(\Delta BOF \mid shock\_property_i ; 0),$$

where $shock\_property_i$ denotes the stress factor for property.

The next sub-risk module, Spread risk is as a results of $\Delta BOF$ due to changes in the creditworthiness of the issuers of security held in insurance investments portfolio. For the purpose of simplicity and reliability of data, the SCR for spread is restricted to only bonds. Firstly, the spread risk shock on bonds is calculated as follows (see EIOPA, 2014a):

$$Spread\_shock\_on\_bonds = \sqrt{MV_i.duration_i.F^{up}(rating)}$$

Based on the shock, SCR for spread is defined as (see, EIOPA, 2014a):

$$SCR_{mkt\_spread} = \max(\Delta BOF \mid spread\_shock\_on\_bonds ; 0)$$

The fifth but not the last, is the concentration risk due to reduced level of diversification of the asset portfolio. It is calculated as follows (see EIOPA, 2014a):

$$SCR_{mkt\_conc} = \sqrt{\sum Conc_i^2}\text{, where} \quad Conc_i = XS_i \cdot g_i$$

$$XS_i = \max(0,\ E_i - CT_i \cdot Assets)$$

$XS_i$ is the excess exposure to $i$, $E_i$ is the net exposure at default to $i$ and $CT_i$ is the relative excess exposure threshold to $i$. $Conc_i$ is the capital requirement for market risk concentration to $i$. The market risk is then calculated using Equation (1.6).

### *4.3.2: Non-Life Underwriting Risk*

Underwriting risk is the risk of loss, or of adverse changes in the value of insurance liabilities, due to inadequate pricing and provisioning assumptions.The non-life underwriting risk is composed of 3 different sub-risk modules (premium and reserve, lapse and CAT). The non-life risk applies only to non-life insurance obligations other than health insurance. For simplicity and reliability of this studies, the focus is only on the premium and reserve risk sub-module.

The non-life premium and reserve risk as the name implies is composed of the premium and reserve risk. The premium risk is due to uncertainty on the timing, frequency, and severity of insured events in relation to future claims stemming from new policies, renewals of existing policies and the unexpired periods of existing policies, while, reserve risk is the uncertainty associated with timing and amount with regards to claim settlement. The SCR for the non-life premium & reserve risk is calculated as follows (see EIOPA, 2014a):

$SCR_{nl\_prem\_res} = 3 \cdot \sigma_{nl} \cdot \mathrm{V}_{nl}$, where $\mathrm{V}_{nl}$ and $\sigma_{nl}$ denotes volume and standard deviation respectively and calculated as showed below:

$$\mathrm{V}_{nl} = \sum_s \mathrm{V}_s \text{ and } \mathrm{V}_s = (\mathrm{V}_{prem,s} + \mathrm{V}_{res,s}) \cdot (75\% + 25\% \cdot \mathrm{DIV}_s) \text{ where}$$

$$\mathrm{V}_{prem,s} = \max(P_s;\ \mathrm{P}_{last,s}) + \mathrm{FP}_{exiting,s} + \mathrm{FP}_{future,s}$$

Where $P_s$ is the estimate of net premium to be earned in the following 12months for segment s, $\mathrm{P}_{last,s}$ is the net premium earned in the last 12months for segment s, $\mathrm{FP}_{exiting,s}$ is the expected present value of net premiums be earned after the following 12months for exiting contracts for segment s, $FP_{future,s}$ is the expected present value of net premium to be earned for the contracts where the initial recognition date falls in the following 12months but excludes net premiums to be earned during the 12months after the date for segment s, $PCO_s$ is the net best estimate of claims provision for segment s, and $DIV_s$ is the reduction factor reflecting the effect of geographical diversification for insurers and is 1 by default.

$$\sigma_{nl} = \frac{1}{V_{nl}} \cdot \sqrt{\sum_{s,t} CorrS_{s,t} \cdot \sigma_s \cdot V_s \cdot \sigma_t \cdot V_t}$$

$$\sigma_s = \frac{\sqrt{(\sigma_{prem,s} \cdot V_{prem,s})^2 + 2.50\% \cdot \sigma_{prem,s} \cdot \sigma_{res,s} \cdot V_{prem,s} \cdot V_{res,s} + (\sigma_{res,s} \cdot V_{res,s})^2}}{V_{prem,s} + V_{res,s}}$$

$$V_{res,s} = PCO_s$$

$PCO_s$, $\sigma_{res,s}$, $\sigma_{prem,s}$ and $CorrS_{s,t}$ denotes the net best estimate of claims provision, standard deviation of the reserve probability distribution, standard deviation of the premium probability distribution and the correlation matrix for the pair of segments (i,j) respectively.

### *4.3.3: Counterparty Default Risk*

The counterparty default risk is the risk due to default or deterioration of the creditworthiness of the debtors and counterparties of the insurer. (See EIOPA, 2014a). The SCR for the counterparty default risk differentiate between:

- Type 1 exposures which consist of small number of counterparties which are likely to be rated. The risk charge for type 1 exposure are based on a loss distribution derived from loss given default and default probabilities.

$$SCR_{def,1} = \begin{cases} 3 \cdot \sqrt{V}, & \text{if } \sqrt{V} \leq 7\% \cdot \sum_i LGD_i \\ 5 \cdot \sqrt{V}, & \text{if } 7\% \cdot \sum_i LGD_i \leq \sqrt{V} \leq 20\% \cdot \sum_i LGD_i \\ \sum_i LGD_i, & \text{if } 20\% \cdot \sum_i LGD_i < \sqrt{V} \end{cases}$$

Where $V = V_{inter} + V_{intra}$

$$V_{inter} = \sum_{(j,k)} \left[ \frac{PD_k \cdot (1 - PD_k) \cdot PD_j \cdot (1 - PD_j)}{1.25 \cdot (PD_k + PD_j) - PD_k \cdot PD_j} \cdot \sum_{i:PD_j} LGD_i \cdot \sum_{i:PD_k} LGD_i \right]$$

And,

$$V_{intra} = \sum \frac{1.5 \cdot PD_j \cdot (1 - PD_j)}{2.5 - PD_j} \cdot \sum_{i:PD_j} LGD_i^2$$

Where;

$V$ is the variance of the loss distribution, $LGD_i$ denotes the loss-given default of counterparty $i$ and $PD_i$ denotes the probability of default for credit quality step $i$.

Type 2 exposure where there is likely to be a diversified mix of counterparties which are not rated. The risk charge for Type 2 exposures are based on an immediate shock, assuming losses of 90% receivables which have been due for more than 3months and 15% on other receivables. Though for the purpose of this analysis, SCR for Type 2 exposure is not considered.

That is: $SCR_{def,2} = 90\% \cdot LGD_{receivables > 3months} + \sum_{receivables \leq 3months} 15\% \cdot LGD_i$

The SCR for the counterparty default risk is then calculated using the formula below:

$$SCR_{def} = \sqrt{SCR_{def,1}^2 + 2.75\% SCR_{def,1} \cdot SCR_{def,2} \cdot SCR_{def,1}^2}$$

The next chapter presents the results of this work.

# Chapter 5: Results

This chapter presents the results of this project. It is broken into two subsections to ease analysis and understanding. Subsection 5.1 outlines the outputs and results from the DFA model which is the main bases for the calculations in Subsection 5.2. Subsection 5.2 presents a detail outline of the SCR calculations based on the SCR standard formula using the DFA outputs.

## 5.1: DFA Model Output and Results

In this section will be discussed the outputs and results from the DFA model. As stated earlier, a DFA model is used to analyze the flow of funds in the company and also make projections about the financial status of the company based on the risk profile of the company for a time horizon of five years.

A common aphorism in statistics by Statistician George Box said “all models are wrong”. Before proceeding to the output and results, it is necessary to state emphatically that models are caricatures to reality. The most that can be expected from a model is how illuminating and useful it is for what it was meant to represent. Among other things estimated and projected for the purpose of this project are: Balance sheets, Income statements and some key variable that influence the financial status of a P&C insurance company.

### *5.1.1: Projected Balance Sheet*

Table 3 shows an extract of the projected balance sheet over a five-year time horizon. The balance sheet is a snapshot at a single point in time of the company’s accounts covering its assets, liabilities and shareholders’ equity. The purpose of the balance sheet is to give users (risk managers) an idea of the company’s financial status along with displaying what the company owns and owes. The state of liquidity to service claims of policyholders can also be ascertained from the balance sheet figures that will indicate the efficiency of the company to meet its liability as and when called for.

**Table 3: Balance Sheet (Projected)**

| Summarized Statutory Financial Balance Sheet (€000’s) | | | | | | |
|---|---|---|---|---|---|---|
| ***Assets*** | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
| | | | | | | |
| Bonds (Amort. Cost) | 166,760 | 182,233 | 193,052 | 199,257 | 201,414 | 205,169 |
| Stocks | 52,137 | 65,539 | 80,976 | 97,696 | 114,250 | 131,548 |
| Cash & Short Terms | 25,718 | 32,028 | 39,261 | 47,033 | 54,622 | 62,475 |
| Real Estate | 63,266 | 69,136 | 73,241 | 75,595 | 76,413 | 77,838 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Other Investments | 19,153 | 4,699 | 5,387 | 5,788 | 5,651 | 5,849 |
| Total Investments | 327,034 | 353,636 | 391,917 | 425,369 | 452,351 | 482,880 |
| Other Assets | 134,880 | 120,263 | 110,113 | 105,416 | 102,950 | 107,380 |
| Total | 461,913 | 473,899 | 502,030 | 530,786 | 555,301 | 590,259 |
| | | | | | | |
| ***Liabilities*** | | | | | | |
| | | | | | | |
| Loss Reserve | 117,664 | 119,965 | 126,347 | 133,228 | 131,704 | 141,221 |
| Unearned Premium Reserve | 8,393 | 9,263 | 9,801 | 10,215 | 10,807 | 11,755 |
| Other Liabilities | 269,403 | 274,583 | 277,971 | 280,959 | 290,682 | 299,536 |
| | | | | | | |
| Total | 395,460 | 403,810 | 414,119 | 424,038 | 433,194 | 452,512 |
| | | | | | | |
| Own Funds | 66,453 | 70,089 | 87,910 | 106,747 | 122,107 | 137,748 |
| Growth in Own Fund | | 7% | 32% | 26% | 17% | 15% |
| Total | 461,913 | 473,899 | 502,030 | 530,786 | 555,301 | 590,259 |

From the balance sheet, the total assets equates the total liability for each year. Own funds (Excess of assets over liability) for 2015 is €66,453,000 with a marginal increase along the five-year period. The figures shows on average an increase of 18% in own funds over the five-year period. It also shows a 6% average growth on the assets side (especially on bonds and stocks).

### *5.1.2: Projected Income Statement*

Contrary to the balance sheet, the income statement shows the record of the company´s operating results and as well serve as a guide in anticipating how the company may perform in the future. It also shows how much the company earned or lost during the evaluation year. From Table 3, the gross for 2016 is €46,167,000 with a marginal increase in 2017 of about 8%. On average there was a 5% increase in gross income along the five-year time horizon. This is a result of the corresponding increase on both the earned premiums and claims along the years.

**Table 4: Income Statement (Projected)**

| Summarized Statutory Financial Income Statement (€000's) | | | | | |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 |
| | | | | | |
| Net Earned Premium | 182,714 | 193,633 | 201,929 | 213,512 | 231,990 |

| | | | | | |
|---|---|---|---|---|---|
| Reserve Development | (12,733) | (2,455) | 2,438 | (3,041) | 2,881 |
| Calendar Year Loss Ratio | 70.73% | 70.31% | 71.04% | 66.75% | 65.94% |
| Expenses as a % of Earned Premium | 7.49% | 7.47% | 7.47% | 12.05% | 13.58% |
| Underwriting gains/losses | 39,802 | 43,012 | 43,393 | 45,268 | 47,515 |
| Underwriting gains/losses (%) | 21.78% | 22.21% | 21.49% | 21.20% | 20.48% |
| Interest | 6,365 | 6,833 | 8,471 | 8,855 | 9,330 |
| Unrealized Capital Gains | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total | 6,365 | 6,833 | 8,471 | 8,855 | 9,330 |
| Return/Assets | 1.40% | 1.44% | 1.69% | 1.68% | 1.67% |
| Gross Income | 46,167 | 49,844 | 51,864 | 54,123 | 56,844 |
| Federal Income Tax | 35,617 | 34,750 | 34,312 | 34,598 | 35,984 |
| Net Income | 10,550 | 15,094 | 17,552 | 19,525 | 20,861 |
| Return on Equity | 20.31% | 27.15% | 23.91% | 21.17% | 19.39% |
| 5 Year Return | | | | | 21.00% |
| Unrealized Capital Gains | 610 | 774 | 964 | 1,170 | 1,378 |
| Change in Equity | 11,160 | 15,868 | 18,516 | 20,695 | 22,238 |

### *5.1.3: Projected Key Financial variables*

This section outlines some key variables from both the balance sheet and the income statements which have a great influence on the solvency level of a P&C insurance company. From Table 5, the cost of direct insurance claims projected amounted to €101,870,000 in 2016, with an average increase of 6% over the five-year period. This increase is justified by the corresponding increase in both the written & earned premiums and technical provisions which goes a long way to have a positive increase on the own funds value (Excess of assets over liability).

**Table 5: Selected Key Variables (Projected)**

| **Selected Key Financial Variables (€000's)** | **Projections** | | | | | |
|---|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 | 2020 |
| Written Premium | 186,748 | 197,512 | 205,830 | 217,795 | 236,950 | 1,044,835 |
| Earned Premium | 186,245 | 196,974 | 205,415 | 217,197 | 235,992 | 1,041,823 |
| Prior Ultimate Losses | 101,870 | 102,221 | 114,173 | 115,950 | 128,020 | 562,235 |
| Technical Provisions | 123,682 | 128,712 | 135,748 | 133,808 | 142,901 | 664,851 |

The above projected variables form the basis for the calculations of the SCR in the next section.

## 5.2: Solvency Capital Requirement (SCR) Output and Results

This section presents the results and outputs of the SCR of the company together with the evolution of the company´s own funds over the five-year time horizon. With the projected SCR and own funds, management can determine possible measures to either improve or maintain the company´s future solvency.

### *5.2.1: Projections of Risk and Capital*

It should be noted that all calculations of SCR in this project are based on the Solvency II SCR standard formula given by EIOPA. The overall SCR is determined by summing up the *Basic Solvency Capital Requirement* (BSCR), SCR for operational risk and adjustments (in our case is assumed to be zero).

The risk modules consisted in the project are; the market risk, counterparty default risk, non-life underwriting risk and health similar to life risk. Under the market risk, all sub risks modules were considered except currency risk which is not included since it is assumed all transactions and investments are in euros.

$$SCR_{market} = \sqrt{\sum CorrMkt_{i,j} . SCR_{mkt\_i} . SCR_{mkt\_j}}$$

The overall market risk is calculated based on the above formula. It combines interest rate risk, equity risk, currency risk (in our case zero), property risk, spread, and concentration risk using the correlation matrix in Table 6.

**Table 6 : Market Risk Correlation Matrix**

| i \ j | Interest | Equity | Property | Spread | Currency | Concentration |
|---|---|---|---|---|---|---|
| Interest | 1.00 | 0.00 | 0.00 | 0.00 | 0.25 | 0.00 |
| Equity | 0.00 | 1.00 | 0.75 | 0.75 | 0.25 | 0.00 |
| Property | 0.00 | 0.75 | 1.00 | 0.50 | 0.25 | 0.00 |
| Spread | 0.00 | 0.75 | 0.50 | 1.00 | 0.25 | 0.00 |
| Currency | 0.25 | 0.25 | 0.25 | 0.25 | 1.00 | 0.00 |
| Concentration | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 |

Table 7 presents the individual market sub risks modules with the overall market risks projected for five years. There is a 10% increase on average in the overall market risk along the five years projected.

**Table 7: SCR Market Risks Projected**

| **Financial Risk (€000's)** | **Projections** | | | | |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 |
| **SCR Market Risk** | 34,010 | 37,971 | 41,975 | 45,556 | 49,349 |
| Interest rate risk | 6,595 | 7,202 | 8,652 | 9,702 | 10,350 |

| | | | | | |
|---|---|---|---|---|---|
| Equity risk | 13,518 | 16,705 | 20,157 | 23,576 | 27,150 |
| Property risk | 17,284 | 18,310 | 18,899 | 19,103 | 19,459 |
| Spread risk | 6,123 | 6,123 | 6,123 | 6,123 | 6,123 |
| Concentration risk | 3,679 | 3,679 | 3,679 | 3,679 | 3,679 |

This increase is justified by the corresponding increase in the individual sub risks modules with the exception of spread and concentration risks which is stable along the projected years. It is assumed in this project that creditworthiness of the issuers of securities held in the insurer's investment portfolio and the level of diversification of the asset portfolio are constant over the five-year period which explains the stable spread, and concentration risks along the years.

In the counterparty default risk, only Type I default sub risk module is considered in this project, likewise the premium and reserve risk sub module is the only risk considered in both the non-life underwriting risk and the health similar to life risk. Table 8 below presents the projected values for all risks and sub risks modules considered in this analysis.

**Table 8: Projected Financial Risks**

| **Financial Risk (€000's)** | **Projections** | | | | |
|---|---|---|---|---|---|
| | 2016 | 2017 | 2018 | 2019 | 2020 |
| **SCR Market Risk** | 34,010 | 37,971 | 41,975 | 45,556 | 49,349 |
| *Interest rate risk* | 6,595 | 7,202 | 8,652 | 9,702 | 10,350 |
| *Equity risk* | 13,518 | 16,705 | 20,157 | 23,576 | 27,150 |
| *Property risk* | 17,284 | 18,310 | 18,899 | 19,103 | 19,459 |
| *Spread risk* | 6,123 | 6,123 | 6,123 | 6,123 | 6,123 |
| *Concentration risk* | 3,679 | 3,679 | 3,679 | 3,679 | 3,679 |
| **SCR Counterparty Default Risk** | 1,345 | 1,467 | 1,454 | 1,440 | 2,589 |
| *Type I* | 1,345 | 1,467 | 1,454 | 1,440 | 2,589 |
| **SCR Non-Life Underwriting Risk** | 41,609 | 42,963 | 43,932 | 45,310 | 47,595 |
| *Premium & Reserve risk* | 41,609 | 42,963 | 43,932 | 45,310 | 47,595 |
| **SCR NSLT Health Risk** | 15,524 | 16,022 | 16,370 | 16,869 | 17,705 |
| *Premium & Reserve risk* | 15,524 | 16,022 | 16,370 | 16,869 | 17,705 |

The BSCR is then computed by combing the individual risks (market risk, counterparty default risk, non-life underwriting risk and Health similar to life risk) using the correction matrix in Table 9. The equation below is used in calculating the BSCR;

$$BSCR = \sqrt{\sum Corr_{i,j} . SCR_i . SCR_j + SCR_{\text{int}\,angibles}}$$

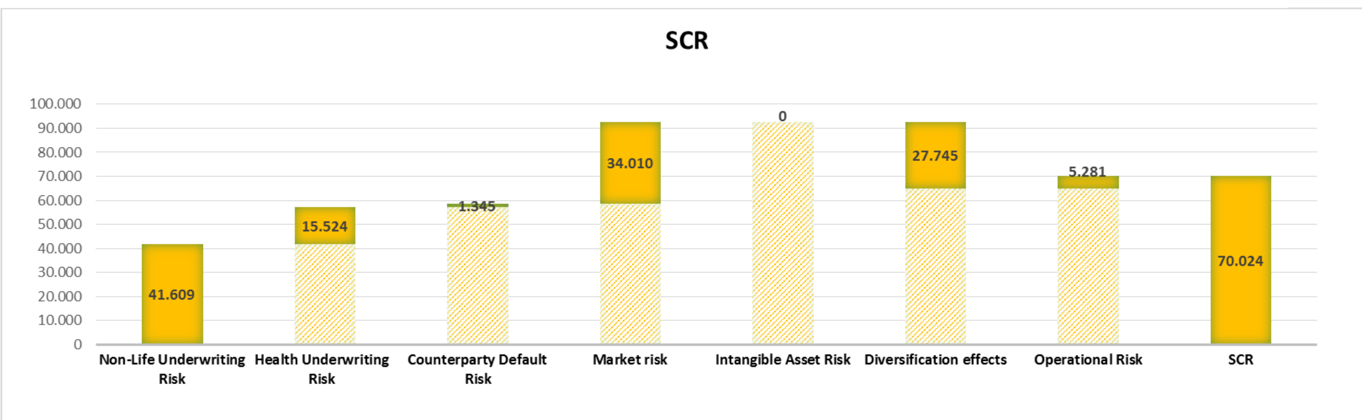
**Table 9: BSCR Correlation Matrix**

| j / i | Market | Default | Life | Health | Non-life |
| --- | --- | --- | --- | --- | --- |
| Market | 100% | 25% | 25% | 25% | 25% |
| Default | 25% | 100% | 25% | 25% | 50% |
| Life | 25% | 25% | 100% | 25% | 0% |
| Health | 25% | 25% | 25% | 100% | 0% |
| Non-life | 25% | 50% | 0% | 0% | 100% |

Figure 7, shows the exposure per each risk modules in the BSCR for 2016, with strong exposure to non-life underwriting risk and market the second largest exposure.

The SCR for operational is then calculated as 30% of BSCR, calculated as described above. The overall SCR is then calculated by summing up the BSCR, SCR for operational risk and adjustments (zero in our case).

**Figure 7: Decomposition of BSCR for 2016 (€000's)**




## *5.2.2: Evolution of Solvency and Capital Position*

Given the above assumptions and considering the projections for each financial year together with the business plan, I analyzed the capital and solvency evolution over the five-year period.

It is assumed in this project that dividends are not distributed but rather retained, a fact which primary reason is to strengthen the balance sheet hence increasing the own funds significantly over the years. Table 10 shows the projected values for BSCR, SCR, solvency ratio, and SCR for operational risk over the five years period. It can be observed that, there is a consistent growth of the company over the five-year period which is reflected in the amount of own funds and the SCR values. An increase in both SCR and own funds is seen along the projected years with own funds and SCR values of €70,089,000 and €70,024,000 respectively in 2016 to €137,748,000 and

€89,796,000 respectively in 2020 resulting in a growing trend in the solvency ratio from a value of 100% in 2016 to 153% in 2020 as in Figure 8.

Each insurance company is required to maintain its solvency ratio at 100% over time. Should the insurance company fall below this level, it needs to inform the regulator (EIOPA) and present a realistic recovery plan that shows how it aims to bring its Solvency Ratio to 100% over the following six months. Many insurance companies may use a certain level of solvency to demonstrate financial health to their customers. For the purpose of this analysis, the strategic goal for the company is 125% solvency ratio.

Also, Solvency Ratio is seen by some as a buffer against adverse developments. Maintaining a 125% solvency level might not only increase the chances of securing the ability to meet obligations but also the capacity to continue operating after an adverse event. The solvency ratio in the first year of projection is 100% as required by EIOPA, with the business plan put in place, the company is expected to attain the 125% level by 2018 as per the business plan.

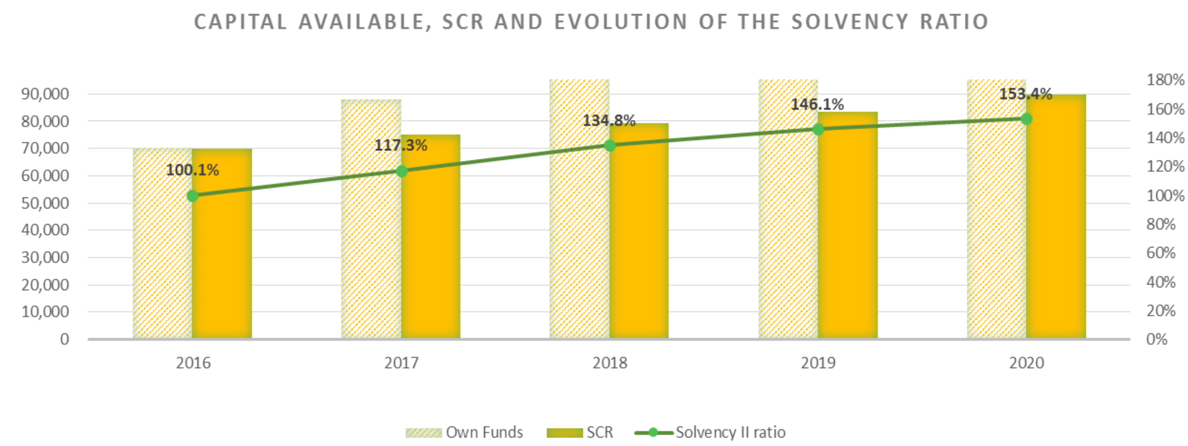
The solvency ratio is higher than the target ratio for the company in the last three years of projections, that is, 134.5%, 146.1% and 137.3% for 2018, 2019 and 2020 respectively. In order to establish an equilibrium, part of the excess of assets over liability could be distributed to shareholders in years where the solvency ratio is above the target ratio for the company.

Operational risk also evolved positively and gradually over the projection years in line with the growth of earned premiums.

**Table 10: 2016-2020 SCR Projections**

| **Capital Requirement** | **Projections** | | | | |
|---|---|---|---|---|---|
| Solvency Ratio | 2016 | 2017 | 2018 | 2019 | 2020 |
| Own Funds | 100% | 117% | 135% | 146% | 153% |
| SCR (€000) | 70,089 | 87,910 | 106,747 | 122,107 | 137,748 |
| BSCR (€000) | 64,743 | 69,057 | 73,034 | 77,081 | 82,716 |
| Operational Risk(€000) | 5,281 | 5,909 | 6,162 | 6,516 | 7,080 |
| Adjustments(€000) | 0,000 | 0,000 | 0,000 | 0,000 | 0,000 |

**Figure 8: SCR and Evolution of Solvency Ratio**




The next chapter presents the discussions and conclusion.

# Chapter 6: Discussion and Conclusion

It has been demonstrated in this project that DFA model is a useful tool in the management of a P&C insurance company's finances as well as making projections about the future solvency of the company. The approach P&C insurers take to address the prudential regime of Solvency II when using the standard formula has low degrees of freedom. Additionally, management is oriented towards profitability to remunerate shareholders and add value to remaining stakeholders. The way companies are facing these challenges is very similar to a trilemma. In fact, profitability, prudential capital requirements and business sustainability, especially between assets and liabilities, are all coming together to the decision making process of management.

In this project the trilemma is managed through a DFA, a powerful tool to address the links between the Profit & Loss and Balance Sheet accounting regime, the stability between assets and liabilities and the prudential regime, where own funds must be adequate to capital requirements. The capability of the DFA model to represent the reality and produce scenarios to analyse conflicting objectives is very relevant in the risk budgeting process that P&C insurers execute on a regular basis.

As in the ORSA (Own Risk and Solvency Assessment), and the risk budgeting, these actions contribute to enhance strategic planning, which can be a very complex process. The degree of complexity can be managed with tools such as the DFA, where components are built according with the level of knowledge from the P&C insurers and the specificities of the business.

In the project it was built a simplification of reality, but some of the risk factors and assumptions on the market were developed to bridge between the accounting and prudential regimes. The more complex and detailed a DFA is, the more level of information is provided into the decision making process.

There are several limitations inherent to the design of this project. Although the balance sheet and the investment portfolio used in this project is based upon the annual reports and investor presentation of a sample of European Insurance companies, the result is specific to the chosen company, which limits the general applicability of the conclusion. For example, only the non-life aspect of the chosen company is considered in this studies.

Furthermore, the DFA model used is based upon implicit assumptions taking into consideration the future business plan of the chosen insurance company.

Moreover, the SCR calculation is based on the SCR standard formula provided by EIOPA. Some insurance companies will potentially adapt partial or full internal models instead of the standard formula to calculate the regulatory capital requirement. The impact of the use of an internal model on the SCR is not considered in this studies. It is also assumed in this studies that credit ratings is constant over time. The importance of ratings differs for individual insurers. For example, companies with strong commercial business lines depends on good credit ratings (see Stanley et al., 2011). The analysis also limits the calculation of the SCR to market risk (excluding currency risk), premium and reserve risk (for both non-life underwriting and health similar to life), and counterparty default risk. Notwithstanding these limitations, the major concern in the decision making process and the equilibrium between conflicting objectives relies on the methodology used by management and the frequency of the analysis in order to control and mitigate deviations and potential pitfalls on the scenario construction process. Hence, interesting avenues for future research includes the extension of the SCR calculation to all risk modules as specified by EIOPA as well as extending the DFA model to other lines such as life insurance and reinsurance companies.

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# APPENDIX

## Appendix A: Lines of Business selected for the study

A non-life insurance companies in Portugal under Solvency II are required to present the profit and loss account disaggregated per line of business in accordance with list of insurance groups given by the directive as below:

**Non-life insurance obligations**

(1) Medical expense insurance

Medical expense insurance obligations where the underlying business is not pursued on a similar technical basis to that of life insurance, other than obligations included in the line of business 3.

(2) Income protection insurance

Income protection insurance obligations where the underlying business is not pursued on a similar technical basis to that of life insurance, other than obligations included in the line of business 3.

(3) Workers' compensation insurance

Health insurance obligations which relate to accidents at work, industrial injury and occupational diseases and where the underlying business is not pursued on a similar technical basis to that of life insurance.

(4) Motor vehicle liability insurance

Insurance obligations which cover all liabilities arising out of the use of motor vehicles operating on land (including carrier's liability).

(5) Other motor insurance

Insurance obligations which cover all damage to or loss of land vehicles (including railway rolling stock).

(6) Marine, aviation and transport insurance

Insurance obligations which cover all damage or loss to sea, lake, river and canal vessels, aircraft, and damage to or loss of goods in transit or baggage irrespective of the form of transport. Insurance obligations which cover liabilities arising out of the use of aircraft, ships, vessels or boats on the sea, lakes, rivers or canals (including carrier's liability).

(7) Fire and other damage to property insurance

Insurance obligations which cover all damage to or loss of property other than those included in the lines of business 5 and 6 due to fire, explosion, natural forces including storm, hail or frost, nuclear energy, land subsidence and any event such as theft.

(8) General liability insurance

Insurance obligations which cover all liabilities other than those in the lines of business 4 and 6.

(9) Credit and suretyship insurance

Insurance obligations which cover insolvency, export credit, instalment credit, mortgages, agricultural credit and direct and indirect suretyship.

(10) Legal expenses insurance

Insurance obligations which cover legal expenses and cost of litigation.

(11) Assistance

Insurance obligations which cover assistance for persons who get into difficulties while travelling, while away from home or while away from their habitual residence.

(12) Miscellaneous financial loss

Insurance obligations which cover employment risk, insufficiency of income, bad weather, loss of benefit, continuing general expenses, unforeseen trading expenses, loss of market value, loss of rent or revenue, indirect trading losses other than those mentioned above, other financial loss (non-trading) as well as any other risk of non-life insurance not covered by the lines of business 1 to 11.

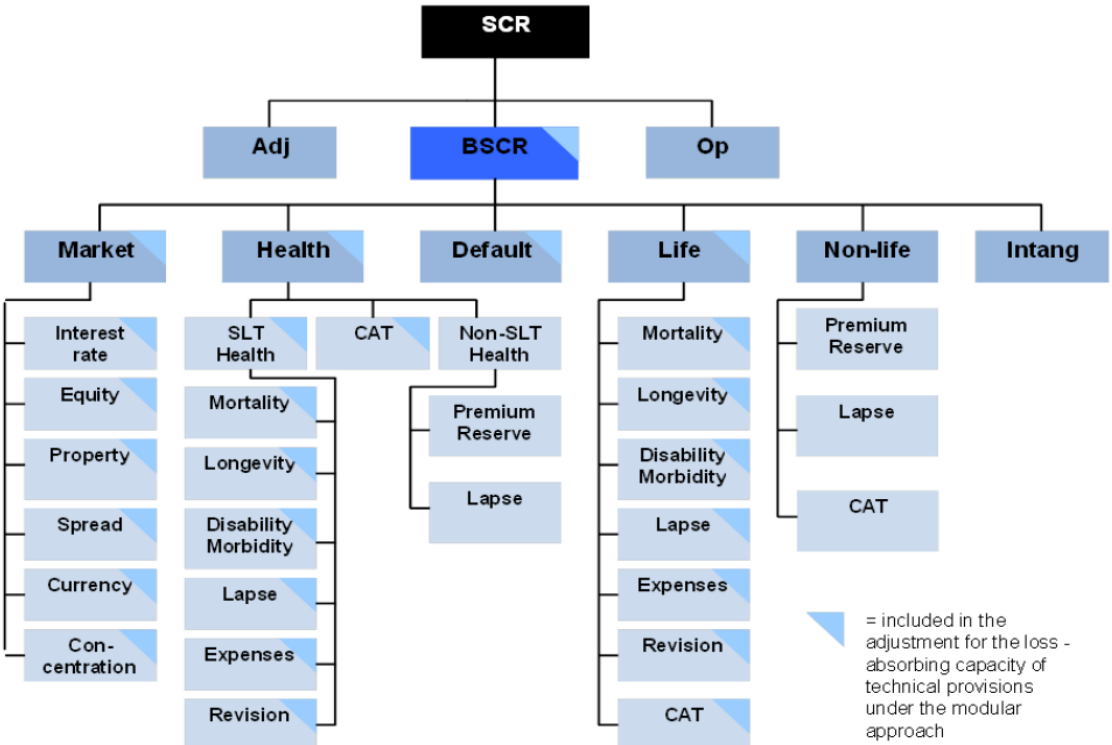
*Source: Official Journal of the European Union, pp227-Annex I*

Below is a presentation of the correspondence between the final selection and the original grouping indicated above:

Worker´s Compensation Insurance – (3)
Medical Expenses Insurance - (1)
Motor Insurance – (4) & (5)
Marine, Aviation, and Transport – (6)
General Insurance (Third-Party Liability) – (8)
Fire and other property damage – (7)
Income Protection Insurance – (2)
Others – (10), (11) & (12)

# Appendix B: Risk Classifications

Source: *The underlying assumptions in the standard formula for the Solvency Capital Requirement calculation(EIOPA)*



# Appendix C: Structural Overview of Project & Future Business Plan

**Figure 9: Structural Overview of Project**

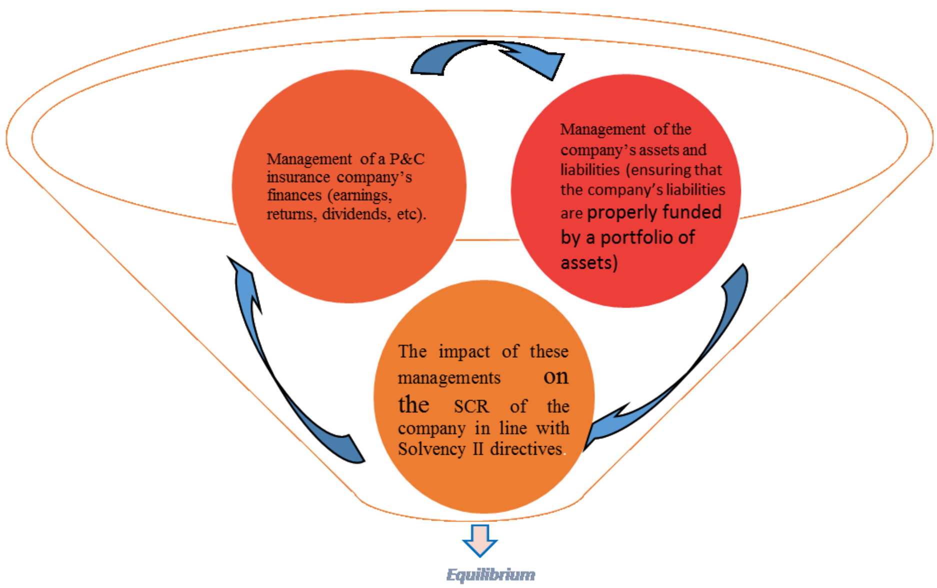
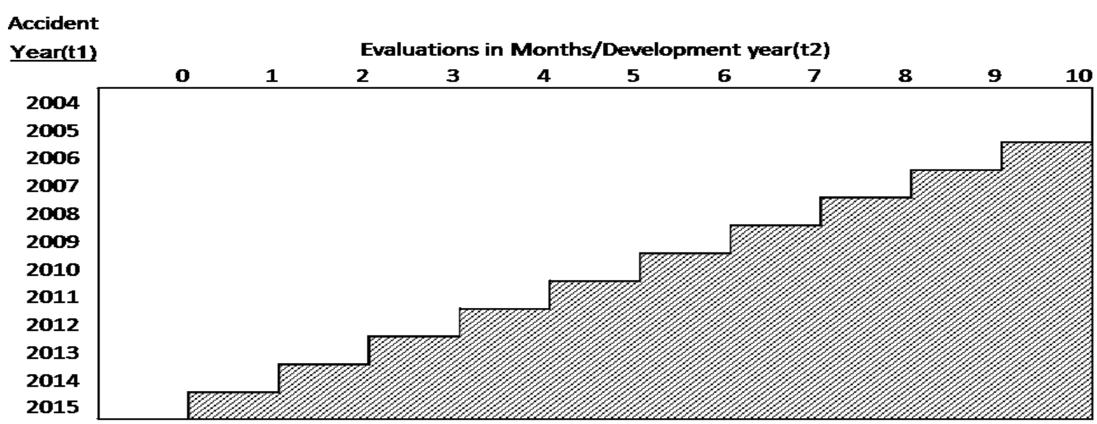



**Figure 10: Paid Loss (upper left triangle), outstanding loss and future loss payments**



## Figure 11: Strategic Business Plan

| Year | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| State 1 | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% |
| State 2 | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% |
| State 3 | 1.5% | 1.5% | 1.5% | 1.5% | 1.5% |

| Business Renewal Ratio | | | | | |
|---|---|---|---|---|---|
| Year | 2016 | 2017 | 2018 | 2019 | 2020 |
| New Business | 23% | 23% | 23% | 23% | 23% |
| 1st Renewal | 5% | 5% | 5% | 5% | 5% |
| 2nd and Subsequent Renewals | 72% | 72% | 72% | 72% | 72% |

**Interest Rate Parameters Estimated**

**Cox Ingersoll Ross Parameters**

$$dr(t) = \alpha(\mu - r(t))dt + \sigma\sqrt{r(t)}dz(t)$$

| | |
|---|---|
| Reversion parameter (α) | 12.0% |
| Long-term mean (μ) | 4.2% |
| Market risk premium | 0.0% |
| Current short-term rate ($r_o$) | 0.9% |
| Standard error (σ) | 4.5% |

| Transition Probability Matrix | | | |
|---|---|---|---|
| Phase | State 1 | State 2 | State 3 |
| State 1 | 50% | 40% | 10% |
| State 2 | 10% | 50% | 40% |
| State 3 | 40% | 10% | 50% |