Optimisation of Insurance Capital and Reserve Using Catastrophe Bonds

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Abstract The study proposed a model to optimise the size of catastrophe bonds within firms' capital structure and minimize the cost of capital within the scope of Insurative Model proposed by Shimpi (2001, 2002). To do so, a linear optimisation model has been developed, considering the Solvency 2 ratio as a constraint. The linear optimisation model suggests two mixes of the capital structures, one with a size of CAT-BOND 1.24% and the other 55.34% of the capital. In addition, the study concluded to the optimum allocation of CAT-BOND adds value to insurance companies.

Keywords: • catastrophe bonds • insurative model • linear optimisation • capital structure • solvency 2 • cost of capital • firm value

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1 Introduction

As Weston *et, al.* (1996:583) defines the target (optimal) capital structure as 'The percentages of debt, preferred stock, and common equity that will maximise the price of the firm`s stock`. Apart from these sources of capital mentioned in the definition, there are other sources of capital. For example, the contingent convertible bonds (CoCo-bond), which used by the financial firms such as the banks to transfer the speculative risks. Another source of capital can be the insurance-linked securities (ILSs) such as the CAT-BOND used by the insurance companies.

This research primarily focuses on how to optimise the capital structure of the insurance companies using the CAT-BOND. Obviously, the decision of hedging the risk that associated with the catastrophe events is a risk management decision. Shimpi (2001) describes two models for capital structure; the standard model, which addresses only the paid-up capital. The other model is the insurance model that focuses only on the risk being transferred and the associated cost. Contrasting these two models, the standard model does not specifically accommodate the elements of risk and the insurance is not directly specified. Thus, Shimpi Insurative model, which combine both the standard and the insurance model is considered as a primary model for this study. Essentially, The Insurative model integrates the capital management with the risk management in the concept of the integrated corporate risk management (Shimpi, 2001).

1.1 Significance and Motivation of the Study

Until recently, few studies e.g., Cummins and Phillips (2005); Smith and Exley (2006) have highlighted factors that are associated with the capital structure and the cost of capital. Particularly, these studies focused on the capital structure of the banking systems. On one hand, minimising the cost of capital and optimising the structure has been investigated intensively (Philosophov and Philosophov, 1999). The cost of capital according to Weston *et al.* (1996) is the combination of the interest rate and required return on equity. The cost of capital can be minimised by mixing the sources of capital. Mixing the sources of capital depend on the industry and the business lines. For example, the insurance companies mixing their capital so that both the cost of the capital the risk are minimum. Insurers traditionally minimise the risk by transferring the risk through reinsurance. Consequently, re(insurance), in general, is a source of capital (Shimpi, 2004).

Scholars e.g., Philosophov and Philosophov (2005) focused on the optimisation of capital in financial firms and developed a model to estimate the optimum capital taking the probability of bankruptcy as a factor that the affect the mix of capital sources. They studied and developed models to estimate the optimum capital. However, the missing point in the literature is that to what extent the insurance firms can use ILSs to hedge its capital or to be used as a contingent capital. Traditionally, hedging capital is used as a risk management technique or strategy to eliminate the probability of loss or fluctuation in profit because of investing in the uncertain environment or risky investment (Hull, 2012). However, the contingent capital is an asset reserved and can be used when a pre-defined event or events happen. To differentiate between the ILS and the Contingent Convertible bonds, the latter is the general term form of any bonds that converts to equity when a pre-defined event occurs. However, the ILS is an insurance contract in the form of a bond, although it converts to equity, the risk that these Bond covers is the systematic risk in the form of catastrophe. Essentially, the Contingent convertible bonds cover the speculative risks, arises from the fluctuation of the market in term of opportunity and loss he speculative risk as defined by (Diacon and Carter, 1992), characterizing it as an insurance-capital market financial product.

If the insurance companies are defined as the external entity that the firms and individuals are transferring their risk to, then insurance companies need to hedge their capital. As Philosophov and Philosophov (1999), state that the optimum capital structure must maximise the corporate share value, and as Shimpi (2001) claimed that insurance is part of the capital, then optimising the insurance capital using insurance add value to the firm. This study focuses on to answer the question, what is the optimum amount of CAT-BOND the insurer can use in their capital. To clarify this issue, we need to define the CAT-BOND and its properties first then specify the importance of the optimal capital structure and the significance of this study.

Vaugirard (2003) Defines the properties of the CAT-BOND for the purpose of developing a pricing model. According to Vaugirard (2003) the probability of the occurrence of the catastrophe such as hurricanes, very low if we consider the occurrence from an objective and statistics point of view. However, the severity might be high in term of loss. The properties of this CAT-BOND as Vaugirard describe them; it price is greater than the risk-free rate, and the principal plus the premium converts to equity if the pre-specified natural hazard happened. This definition of the CAT-BOND derives the decision of using risk management involvement. For the meantime, the risk management decision of using the insurance-linked securities (ILSs) as a source of capital, as Shmipi (2001) explained in his Insurative model require analysis of its impact on the capital structure.

1.2 Impact of this Study

The global warming and the dramatically change of the weather and nature; make the catastrophe that rare in one place more probable to happen (Houghton, 2009). The principle of insurance is guided by the law of large numbers, and not all individuals will suffer losses at the same time. Systematic risk is defined as the risk that cannot be diversified (Weston, 1996), and also the risk that affects the overall market, not just a particular industry (Diacon and Carter, 1992). Taking the risk of natural events as a systematic one, and specifically the catastrophe, which might make a severe loss to the insurance company, to the extent that the firm may not be able to meet its obligations.

Thus, the insurer needs to hedge their business risks from that unexpected systematic losses. The investors, who buy this bond, on the other hand, they take the risk as this Cat-Bond acts as an insurance contract. According to Shimpi (2001), by providing a premium above the interest of the bond (the price of the cat-bond). Thus, the investor will be subject to uncertainty (e.g., Act of God) since the catastrophe can happen without warning, although the probability might be low.

Insurance companies should ensure that using cat-bond as a source of capital, it should optimise the capital and reserve of the firm. From the definition of the optimum capital structure mentioned previously and for the insurance capital to be optimised, cat-bond must help minimise the cost of capital. According to Meyricke and Sherris (2014), the cost of capital is a major factor in determining the premiums charged by the insurers. In insurance business the cost of the service or the product is related to the cost of capital. In other words, the firm, as the first condition of optimisation, needs to understanding the cost of capital of the CAT-BOND on the capital structure. The second condition for the optimisation, considering CAT-BOND as a source of capital, it has to minimise the risk as well, which might be dependent on the risk attitude and appetite of the firm.

1.3 Aim and Objectives of this Study

The aim of this study is to optimise insurer's capital structure with the use of CAT-BOND. The optimum amount of cat-bond that can be used to optimise the capital structure of the firm can be a benchmark, considering the insurer is a risk neutral entity. However, the amount of cat-bond can vary according to the risk appetite of the insurer, the risk appetite according to Ward (2005) is the willingness of taking the risk. As they can exceed this amount, but the optimum should be addressed first.

To achieve the aim of this study, we need first to choose the suitable framework that considers, debts, equity, contingent capital, and the insurance as sources of capital. The framework will be used to develop the general equation, and the constraints of the equation need to be derived from the regulation bodies. Then will develop the optimisation model that will give the optimum amount of cat-bond that minimises the cost of capital.

The aim will be achieved by addressing the following objectives.

- First to analyse the Insurative model. The Insurative model as a holistic framework that lists all the sources of capital and also integrating the risk management and the capital management is the suitable framework that can help estimate the optimum capital structure using the cat-bond (Shimpi, 2004).
- Second, to analyse the ORSA (Own Risk and Solvency Assessment). Solvency II can contribute to developing the constraints for the optimisation model. ORSA establishes a direct relationship between risk management and capital management,

that out the OSRA in line with the insurative model Ozdemir (2015). According to Fairall and Murphy (2013) ORSA helps insurers to understand the risk related to the insurance business and allow them to plan their strategy and capital planning. Thus, the minimum required capital under Solvency II is vital important when deciding to mix the capital in term of debts and equities to minimise the cost of capital. The insurative model, on the other hand, is a combination of the standard model and the insurance model. By combining standard and insurance models together in the insurative model, the insurer has more capital sources than before, thus make the Solvency 2 more important to reduce the potential risk of adequate capital.

- Third, to develop the optimisation model.
- Fourth, to empirically test the optimisation model empirically using the data obtained from the Bloomberg and DataStream. This testing can be used for the purpose of developing the model.

1.4 Structure of the paper

This paper is structured into five sections including this introduction Section 1. The second section, literature review, where we discuss and develop the understanding of the topic, developing the hypothesis, and pointing the gap in the research in this subject. Pointing the gap in the research, in turn, help to confirm the aim and the objectives of the study. In this second section we will also discuss the problem and the issues in estimating and calculating the optimum capital structure. In section three, we discuss the methodology and the method of the research, which it is based on the comparison of the literature review held previously and the aim and objective been confirmed. In section four, we discuss the data analysis technique and the Insurative model as well as developing the model of optimising the capital and reserve in insurance companies in details. Moreover, we will use secondary data obtained from the Bloomberg and DataStream to test the model. The results will be furnished in this section. In section five, we analysis the results from section four and draw out findings. Finally, in Section 6 we draw conclusion of the study, where we put the recommendation, limitation, and the outcome of the study in general.

2 Section 2: Literature Review

The literature of insurers' risk and capital is limited to three interrelated topics i.e., capital structure, cost of capital and the contingent capital.

The capital structure of the insurance companies, those underwrite long tail natural catastrophe risks, is complex. This is mainly because of the high level of uncertainty in both the frequency and the severity associated with the catastrophe risks during the currency of policies. Catastrophe risks are usually financed by insurance linked securities (ILS). Catastrophe bonds is a security that comes from the contingent convertibles capital (CoCo), as an ILSs the cat-bond has its properties that distinguish it from other mezzanine debts. The mezzanine finance as defined by (Investopedia, 2003), is a hybrid debt that might transform into equity. The CAT-BOND covers the risk of catastrophes. The severity and the frequency of the catastrophe can be considered as the properties of the event. Thus, the pricing of the bonds that covers this kind of event depends heavily on the predefinitions of the event, the probability, and the severity of the catastrophe (Čižek et al., 2011).

The cost of capital as defined is the interest associated with the debts and the required return on the equity (Weston, 1999). In other words, the cost of capital means the expenses of having a capital whatever the source of that capital. The capital, in general, is a mix of equity and debts, as the cost of each one is deferent; that derive the decision maker from thinking of mixing these sources to minimise the cost, that optimises the capital. Hence, the optimisation of capital requires an understanding of what sources are available. Contingent capital, for example, is an off-balance sheet capital (Shimpi, 2001). Taking the Contingent Convertible Bond as an example of contingent capital, it has a general two forms; one meant to cover the speculative Risk, which used in the banking system as a tool to raise and optimise the capital. Goes et al. (2016) investigated the effect of this source of capital to prove its suitability as a source of capital. The other form of contingent capital is the CAT-BOND. Insurers for example using CAT-BOND to transfer, a systematic risk, and specifically the catastrophes. Shimpi (2001) claims that insurance, in general, is a source of capital. This assertion gives the inspiration to think how to optimise the capital structure and minimise the risk using the CAT-Bond.

The valuation of a firm is closely linked to its cost of capital. The Value of the firm is a combination of the market value of common stock, preferred equity, and market value of debt. From this definition, the cost of capital affects the values of this component because of all these expenses of capital as defined previously is also the combination of the cost of Equity and the cost of the debts. Michalak (2014) elaborated more on the capital structure and the value of the firm and argued that the value of the enterprise can be calculated as the proportion of the earnings before interest and tax (EBIT) to the WACC.

$$VU = VL = \frac{EBIT}{WACC} = \frac{EBIT}{CeU}$$

[Equation 1: Firm Value]

Where, VU is the value of company not using foreign capital (unlevered firm), VL the value of the company using foreign capital (levered firm), CeU the cost of equity capital of company not using foreign capital (unlevered firm), $EBIT$ is the net operational income (earnings before income tax) and $WACC$ is the weighted average cost of capital.

Therefore, the firm value depends on the cost of capital (Eskandari & Zadeh, 2012). We used this assumption to calculate the firm value within the scope of the Insurative model while estimating the cost of capital of an insurance company.

Furthermore, the optimisation of capital structure can be studied from two perspectives. The first perspective is the cost of capital. Weston et al., (1996) define the capital components as the types of capital used by firms to raise money. This definition raises the arguments about what is the types of capital, which in turn can be a key factor when deciding to mix and structure the capital of the firm. Since sources of capital vary in term of cost, such as the interest rate of the bonds issued, the cost of preferred shares. The mix that minimises this cost considered to be the optimum. The second perspective is what the effect of the capital component of the optimum capital structure. This point of view, investigate the deferent sources of capital to verify its impact on the structure of the capital.

2.1 The Cost of Capital

The capital structure of insurance companies is distinct from other financial services firms. Smith and Exley (2006) investigated the influence of some factors on the capital structure of banking system and insurance. They state that the increase in the cost of capital affect the structure of the capital as the firm tend to use 'less capital'. The term less capital is very controversial; less capital can mean decreasing the amount of capital, while less capital also can mean revising the sources of capital. Revising capital structure is an issue need to be studied because the question of what is the optimum capital structure is very subjective although many attempts to quantify this problem (Philosophov & Philosophov, 1999).

The classical theories of the cost of capital proposed by Smith and Exley (2006) helps to understand the deferent factors that have implications for product pricing, performance measurement and capital structure optimisation. In essence, they hypothesised that required return on the assets that have been financed through debts are the factor of setting the target profit. Breaking this hypothesis into two parts, the first part is the required rate of return and the second part is the debts, we can confirm this assumption as a very similar to the fact that, the cost of capital is negatively related to the firm value. They used WACC (Weighted Average Cost of Capital)in determining the capital structure and the sources of the capital while estimating the cost of capital. Nonetheless, the effect of ILSs on the capital structure and specifically the CAT-BOND was not studied in the literature.

Shimpi (2004) presents the insurative model that deals with the estimation of the cost of capital and the capital structure in the insurance companies. Also, it tackles the problem of overestimation of the cost of capital, as reinsurance or insuring part of the capital; decreasing the cost of capital, since it releases capital. Doherty (2005) critically examined the cost of capital and to test whether the insurative model underestimates the cost of capital. They concluded to that, the concepts of Shimpi's approach accurately estimate the cost of capital when there is part of the capital hedged using insurance contract. The noticeable thing in Shimpi`s` model is that it divides the capital into three sections, paid up, contingent capital, and ILSs, while Smith and Exley (2006) in their study they define the capital as components, as every component has its cost. In Shimpi's opinion, Insurance is a form of capital; he argues that insurance release an amount of capital, and without integrating the capital management and the risk management, the cost of capital may not be estimated or calculated accurately.

Comparing the cost of capital using the weighted average cost of capital, with the average total cost of capital:

$$TACC = WD * Cost\ of\ Debts + WE * Cost\ of\ Equities + WI * Cost\ of\ Insurance$$

[Equation 2: Total Cost of Capital]

W represent the weight of capital source, and can be calculated as:

$$W = Cost\ of\ Capital\ Source * \left[\frac{Cource\ of\ Capital}{Total\ Capital}\right]$$

[Equation 3: Total Average Cost of Capital]

From this equation (3) it is clear that insurance is a part of the capital structure where insurance takes the form of contingent Capital (contingent convertible securities) that itself has two forms. The first is the CoCo bonds, which hedge the speculative risk. The second form is the ILSs (the insurance-linked securities) in term of Catastrophe bonds, which can be a reinsurance against systematic risk, specifically the natural disasters as an example. The probability of this systematic risk is very low with a severe impact. Thus, the part that this Insurative model does not cover is to what extend the cat-bond can help maximise the capital of insurance companies.

2.2 Optimisation of Capital

Yeh (2011) attempted to test whether the low agency cost can increase the firm performance through optimisation of capital, while Smith and Exley (2006) demonstrate that the equity capital is in positive correlation with the agency cost. However, Yeh (2011) concluded to the key result is that the optimal capital is something subjective, and stating that, the optimal structure can be decided by the manager to combat the agency cost.

The capital structure in perspective of Shimpi (2001) consists of three parts, off-balance sheet capital, paid-up capital, and the insurance-linked securities (ILSs). Goes *et al.* (2016) found the impact of contingent convertible bonds (CoCo) on the capital structure

of the regulations of BASEL III. They found that CoCos could optimise the capital structure. Contrasting this conclusion with the insurative model (Shimpi, 2004), we can notice that CoCo, is part of the capital, which considered in the model as an off-balance sheet capital. They based their results on three key conditions:
The first condition is the value of bank with CoCo need to be higher than the value of Bank with subordinated debt. The second condition is the maximisation of the value of the bank, where the subordinated debt optimal coupon must be lower than the CoCo optimal coupon. The probability of insolvency of contingent convertible (CoCo) has to be lower than the subordinated one; this last condition put the argument of this study in line with the risk management decision as proposed by Shimpi (2001) i.e.,

$$Required\ Capital = Capital\ Requires\ to\ Cover\ Firm's\ Risk$$

This equation justifies the condition of optimum capital when using CoCo that Goes *et al.* (2016) put to verify the effect of CoCo Bond on the capital structure of the banks in Brazil. The hedging tools and the insurance of the capital can maximise the capital structure, but the issue is what is the right amount and the weight of this source of capital in the structure.

On the other hand, Philosophov and Philosophov (2005) were interested in the optimal capital structure and they consider the capital structure a central problem of corporate finance. They agreed with Shimpi on that optimum capital structure is an application of decision making in the organisation. In essence, risk management and capital management are two faces of the same coin (Shimpi, 2001). A similar research about the optimum capital structure by Philosophov and Philosophove (1999) using Bayesian approach, demonstrates that the ratio of Debt to Equity as a prognosis to estimate the optimum capital structure. This model is taking into account only the debts and equity as two main sources of capital. The argument of this model is that the optimum ratio of the debt to equity maximise the firm value. Comparing this model with the insurative model, one can notice that Philosophov and philosophov model are considering a small part of the capital that the insurative model introduce as the paid-up capital.

Considering Philosophov and Philosophov's (2005) hypothesis i.e., the probability of bankruptcy restricts the amount of borrowed capital (debt), we can assume that the amount of debt defines the capital structure while the probability of bankruptcy defines the firm's value. In this respect, there is essentially no difference between this assumption and Goes et al., (2016) hypotheses. However, both of them are based on the standard WAthe CC model with limitation that they did not consider the release of capital from insurance that Shimpi's (2001) model exceptionally considered.

In the insurance field Karabey (2012) investigated risk capital allocation methods for both life and non-life insurance. Comparing this aim with the aim of this study, it is observed that the allocation of the risk capital is similar to the allocation of ILSs to optimise the capital. The risk capital as it defined by the ORSA (Own Risk and Solvency Assessment) is the equity capital of a firm that used for the recovery from losses, and impact of taking risks and uncertainty (Ozdemir, 2015). Furthermore, Karabey (2012) found that the analysis of solvency capital and risk factor contributions provide powerful signals for long-term risk management of the insurance companies. In the literature, hedging as mentioned is a part of the capital Karabey (2012) with an impact on the risk capital, which in turn affects the structure of the capital. Taking the cost of capital from the different perspective scholars e.g., Upreti (2013) found deferent factors that have implications for product pricing, performance measurement, capital structure optimisation and the cost of the equity capital of non-life insurance companies. they concluded to that reinsurance in the UK non-life insurance markets have a comparatively lower cost of equity than their counterparts without any reinsurance cover, and also leverage and liquidity are found to be positively related to the cost of equity. These findings appreciate the importance to corporate risk management and its effect on firm value.

2.3 The Contingent Convertible (CoCo) Bonds

The Contingent Convertible Capital is defined as “bonds that convert to equity, or are written off, after some triggering event such as a decline in a bank’s capital below a threshold" (Pennacchi et al., 2014). Shimpi (2001) defines the contingent convertible bonds as a source of capital; he justifies that as CoCo can release part of the capital. Doherty, (2005) confirm Shimpi`s claim about the contingent capital as a source of capital. Doherty (2005) assumed that the Insurative model and specifically the Total Cost of Capital (TACC) underestimates the cost of capital. However, he concluded to that the Total Cost of Capital takes into account the insurance and contingent capital as a source of capital. That why it releases part of the capital, which in turn reduce the cost of capital, whereas the WACC or the standard model takes into account the equity and the debts as the sources of the capital.

2.4 The ORSA Insurative Model and Cost of Capital

As discussed earlier, the insurative model is combining two classical cost of capital models. The fist model is the standard model which considering the capital as debts and equities, while the insurance model focuses on the insurance, this combination links the risk management and the capital management together (Shimpi, 2004). The insurative model not only releases capital and propose new sources of capital (Doherty, 2005), the risk of the insurer not be able to meet its obligations that an issue need to be managed.
The ORSA (Own Risk & Solvency Assessment) it an internal self-assessing framework for the firm’s risk profile as outlined in Figure 1 (Ozdemir, 2015). The ultimate aim of the ORSA framework is to ensure that the insurer has an adequate capital as a buffer of risk. Solvency 2 minimum capital required can be estimated as the ratio of the profit to the debts as follows:

$$Solvency\ II = \left[\frac{Net\ Profit + Depreciation}{Short_{Term}Debts + Long_{Term}Debts}\right]$$

[Equation 4: Solvency Ratio]

Key elements (or steps) of ORSA framework for capital and business optimization are (a) governance and control; (b) capital management, measurement and allocation; (c) capital planning, performance management and risk appetite; (d) risk strategy and core strategy (Ozdemir, 2015).

2.5 Solvency Ratio and Liquidity Ratio

Theoretically, solvency ratio is the ratio of "own funds". Essentially, it is the capital available to cover losses, as prescribed by the solvency capital requirement (SCR). Scholars e.g., Zhou-Richter and Kuschel (2012) investigated the Solvency 2 as an indicator of insurance companies' financial ability to handle the risk related to their businesses. Philosophov and Philosophov (2005) has taken the liquidity ratio as a prognosis to manage the bankruptcy. In this research, we replace the solvency ratio with the liquidity ratio appreciating that the fact that solvency ratio is slightly different from the liquidity ratio. However, when defining the liquidity ratio as the ability of the company to meet its obligations, we can take the risk as an obligation if the unfavourable event happened. Thus, liquidity ratio can fit and replace the solvency ratio; more specifically liquidity ratio can act as a constraint in the Optimisation model so that the company can still have the ability to meet its obligations.

$$Solvency\ II = \left[\frac{Net\ Profit + Depreciation}{Short_{Term}Debts + Long_{Term}Debts}\right] \approx Liquidity = \left[\frac{Short_{Term}Debts + Long_{Term}Debts}{Total\ Equity}\right]$$

[Equation 5: Solvency and liquidity]

2.6 Research Gap

The aim of this study is to optimise insurers' capital structure with the use of CAT-BOND. We achieve the aim by considering several steps. First, we analyse the Insurative model of Shimpi (Shimpi, 2004). From the previously analysis of the literature, the Insurative model, covers all the aspects of the capital components, and can better estimate the cost of insurance capital (Doherty, 2005). Second, we analyse the ORSA (Own Risk and Solvency Assessment). For the purpose of this study we considered Solvency II regulation (following Goes et al. (2016) optimisation model on the BASEL III regulation) as a benchmark of the insurance optimum capital structure. Based on the Insurative model and the ORSA we develop the optimisation model with constraints. Finally, with empirically test the model with industry data.

Our study is heavenly motivated by Shimpi (2004) that aims to link the firm's cost of capital to the ERM decision within the firm as integrating corporate risk management. The objectives of his research start with stating the problem by defining the firm as a collection of risky productive activity. Then building an integrated framework based on his assumption that Insurance is a form of capital. This objective also linked to our study since it considers that the ILSs can help add value to insurance. Finally, we analyse and develop the Insurative model, define the Insurative model, and show how it addresses the problem of the relationship between the risk management and the capital structure).

As discussed earlier Shimpi’s (2004) Insurative model deals with the estimation of the cost of capital and links risk management with the capital management. This Insurative model along with the integrated risk management and the capital management concepts cover a wide area of the topic of the research. However, it does not answer a key question i.e., what is the optimum insurance the firm can use to minimise the cost of capital?

To understand reducing the cost of capital and its implications, Exely and Smith (2006) on the other side aim to understand the deferent factors that have an impact on product pricing, performance measurement and capital structure optimisation. They describe the classical theories of the cost of capital in the financial firms and apply these theories of the cost of capital to banking and financial firms such as insurance companies. They reflect their experience and knowledge when they define the cost of capital. Their study focuses on the financial firms, but they did not mention how the contingent capital affect the cost of capital. The other limitation of their research is the subjective definition of the cost of capital concept, although they run an empirical experiment. However, most scholars did not clearly answer is how to mix the capital components to minimise the cost of capital, the reinsurance and insurance cost capital and reserve, in particular.

2.7 Comparison of Philosophov vs Shimpi Models

Philosophov and Philosophov (2005) developed a new probabilistic approach to estimate the optimum capital structure based on the probability of bankruptcy. Their model did not consider the subjective definition of the cost of capital as they look much deep on the financial ratios and the probability of bankruptcy to determine the optimum capital structure. They first analyses the prediction of the optimum capital structure and the prediction of the bankruptcy.

They proposed four financial ratios as prediction of bankruptcy [Modelling the probability of bankruptcy] and optimal capital structure existence.

$$Group\ 1\ \left(\frac{Interest}{Total\ Assets};\ \frac{Current\ Liabilities}{Total\ Assets}\right);\ Group\ 2\ \left(\frac{EBIT}{Total\ Assets};\ \frac{Rate\ of\ Return}{Total\ Assets}\right)$$

These four prognoses, two of them are to indicate the quantity and quality of debt (Group 1) while the others indicate the ability to pay the debt [Determining the value of the optimum debt to equity]. Taking the bankruptcy one hand, it clearly related to the optimum capital structure, and also one can assume that the systematic risk can cause a severe loss, which in turn can be a reason of bankruptcy. On the other hand, the model developed by Philosophov and Philosophov did not take into account all the capital component that Shimpi, (2004) proposed. This makes the effect of ILSs on the capital and the cost of the capital unsolved question. However, Shimpi (2004) consider the standard model for the capital structure not suitable for discussing the capital structure of the insurance firms as the insurance and other types of capital are neglected.

2.8 Summary of Goes (2016) paper

Goes et al. (2016) aim to verify the influence of using CoCos on banks risks, evaluating the effectiveness of this Basel III recommendations, and to compare them with the use of subordinated debts on capital. Considering the contingent convertibles as a source of capital, then Shimpi`s Insurative model should be exercised. Goes et al. (2016) analysed the capital structure of the ten Brazilian banks. First they analyse net equity and subordinated debts. Then they compare the current structures in terms of BASEL III ratios and constraints. This comparison considers the subordinated debts with the structure proposed in Basel III and on the other hand, the impact of CoCos whether it meets the recommendations of Basel III. The constraints they developed for the optimisation of the capital is not adequate for the optimisation of the insurance capital optimisation. This because the Insurance capital structure is different from the banking structure. Also, the Contingent convertible bond is distinct from the catastrophe bond, because the catastrophe bond issued to cover the natural events, and the risk that it covers is not speculative as the CoCo bond.

2.9 Summary of Upreti (2013) paper

Upreti (2013) explains the effect of reinsurance on the cost of the equity of the insurers in terms of decision to reinsure and the extent of reinsurance. In other words, the aim is to examine the impact of reinsurance on the cost of the equity capital of UK non-life insurance companies. With this aim, Upreti first considered the key institutional features of the UK's non-life (re)insurance market that could influence the reinsurance – cost of equity relation. Then he selected a theoretical framework using an extensive review of the academic literature relating to the risk management and financing decisions of a firm. The conceptual framework helps to identify and select the suitable method to estimate the cost of equity of an insurer by reviewing the relevant accounting and finance literature.

Then he developed and tested his hypotheses empirically using univariate and multivariate (panel data) statistical analyses. Finally, he explains and evaluates the empirical results. We understand that Upreti's (2013) finding covers part of our study's assumptions.

Risk capital as defined by Shimpi (2001) is the amount of capital that can be used to cover the retained risk. By adding CAT-BOND, the amount of retained risk will be reduced (Shimpi, 2001). Whereas, (Karabey, 2012) aims from his thesis to investigate risk capital allocation methods for both life and non-life insurance. His objective for this aim is to examine the measurement of factor risk contribution to the portfolio loss and the allocation of risk capital methodologies. The risk capital, in general, can be defined as the capital to cover the expected loss (Shimpi, 2001). Thus, Karabey cover an important area of the topic, which deal with how much to hedge.

The ultimate conclusion of the papers discussed above is that there are several literature exists on CatBond in Capital Structuring. However, no study (other than Upreti) focuses exclusively on the insurance industry. Consequently, the gap not filled yet, which hedging strategy and what is the amount of insurance the firm need. Moreover, all the above researches are somehow depending on the standard model that neglect the insurance. Although Upreti's objectives are very straightforward, but his research generalised the reinsurance concept. Reinsurance can include the CoCo bond and the CAT-bond or the Sider-CAR. Also, the influence of the reinsurance on the cost-of-equity has a direct relation to the cost of capital, and that means the capital structure by somehow. The data analysis technique, on the other hand, statistical and the classical cost of capital model. For the purpose of the proposed study, the optimisation requires constraints and conditions.

In reviewing the existing literature (as above) we concluded the following three points:

1. The model for estimating the insurance optimum capital structure is not available in the literature.
2. The unsolved question is that the amount of insurance and ILSs that optimise the capital.
3. To develop the optimisation model, we need to develop the constraints of the model and the conditions first.

Thus, the objectives of this study are to analyse the Insurative model first, because the Insurative model takes into account the off-balance sheet items as sources of capital, such as the cat-bond. After that, analysing the ORSA to develop an adequate constraint for the optimisation model. Then designing and testing the model.

Based on the results from this optimisation model we will discuss the implications of using the cat-bond as a potential source of capital and also verify whether the cat-bond can help optimise the insurance capital and reserve.

At this point, taking the aim of the research on one hand. To maximise the amount of CAT-BOND that used to optimise the capital and reserve of insurance companies, we need the conditions for that to be verified. The first condition is the optimum capital structure must have the lowest cost of capital (Weston *et al.*, 1996). The second condition the optimum capital structure must maximise the firm value (Weston *et al.*, 1996). In addition, the optimum capital structure based on the Insurative model, and when considering the CAT-BOND as a source of capital, the CAT-BOND must maximise the risk leverage (Shimpi, 2004). The cat-bond must maximise the risk leverage because the cat-bond according to the (Diacon and Carter,1992) CAT-BOND is a risk transfer tool, while according to Shimpi (2004) the risk leverage measure to what extent the firm retain or transfer the risk.

Our hypothesis assumes that the when using CAT-BOND to optimise the capital it adds value to the firm. On this hypothesis, the insurer and the investor both are risk neutral, as if this appetite changed to become risk taker or averse the situation might change significantly.

3 Section 3: Methodology

3.1 Research Hypothesis

H: O*ptimum allocation of capital using CAT-BOND add value to the insurance company.*

The previous literature review confirms that the cost of capital and the firm value are two faces of a coin. According to WACC, the cost of capital is the sum of the cost of all the capital components. Considering the CAT-BOND as a source of capital then, its cost can be added to the model above. From these facts, the hypothesis developed from the reviewing of the literature is that the Optimum allocation of capital using CAT-BOND adds value to insurance companies. This assumption can be broken down into two main parts. The first part is the optimisation of capital structure using the Cat-Bond as a source of capital. The second part is the firm value. Firm value and cost of capital are two faces of one coin (Shimpi, 2001). The challenging point is that the CAT-BOND will only be part of the capital when there is a catastrophe occurs.

To verifying the optimum amount of cat-bond that used to optimise the capital and reserve of insurance companies, we need to analyse the Insurative model proposed by Shimpi (2004). This Insurative model considered being suitable to estimate the cost of capital when the CAT-BOND, one of the capital sources, because the model has considered the ILSs as one of the capital components. After that, to understand the optimum mix of capital sources, we need to have a benchmark. The ORSA can help us to set the constraints of the model, as the solvency ratio in the insurance companies is necessary so that we analyse the ORSA framework. Developing the Optimisation model based on the

Insurative model and the ORSA framework will allow us to analyse an actual data testing the optimisation model.

3.2 Variables

Table 1: Variables and their definition

VARIABLE	DEFINITION
T.C.S	Total capital based on the standard model; the sum of equities. Short-term debts and long-term debts
$T.C.S_O$	Optimised Total Capital based on the standard model
T.C	Total Capital based on the Insurative model
$T.C_O$	Optimised Total Capital based on the Insurative model
EQ	Total Equities
EQ_O	Optimised Total Equities
D	Short-term and Long-term Debts
D_O	Optimised Short-term and Long-term Debts
C.B	Cat-Bond Size
$C.B_O$	Optimised Cat-Bond Size
c.e	Cost of Equity
c.d	Cost of Debts
c.b	Cost of Cat-bond
WACC	Weighted Average Cost of Capital
TACC	Total Cost of Capital
$TACC_O$	Optimised Total Cost of Capital
e.c.l	Expected Claim and Loss from the Catastrophe
p.c.b	Probability of the Catastrophe
Mat.	Maturity of the Cat-Bond
L	The Risk Leverage (Lambda)
S	Solvency ratio and the liquidity ratio
V^C	Value of the Firm based on the Insurative model
V	Value of the firm
EBIT	Earnings Before Interest and Taxes

3.3 Developing Constraints for the Optimisation Model

The Insurative model projects the capital components of the insurance company as follow:

$$T.C. = EQ + D + C.B$$

[Equation 6: Insurative Model]

In line with ORSA (Ozdemir, 2015) and (Fairall and Murphy, 2013) we define Solvency 2 ratio as:

$$S = \frac{N.I}{D}$$

[Equation 7: Solvency Ratio]

Where, N.I. = Net Income After Tax

However, the liquidity ratio can give the same constraint for exceeding the optimum amount of DEBTs

$$LEQUIDITY\ RATIO = \frac{D}{EQ}$$

[Equation 8: Liquidity Ratio]

THE RISK LEVERAGE (L) is measured as:

$$L = \frac{C.B}{T.Co}$$

[Equation 9: Risk Leverage]

Weighted Average Cost of Capital is measured as:

$$WACC = \left[\left(\left(\frac{D}{T.C.}\right) * c.d\right) + \left(\left(\frac{EQ}{T.C.}\right) * c.e\right)\right]$$

[Equation 10] Total Average Cost of Capital (TACC) is measured as:

$$TACC = \left[(WACC) + \left(\left(\frac{C.B}{T.C}\right) * c.b\right)\right]$$

[Equation 11]

THE OPTIMISED TACC is measured as:

$$TACCo = \left[\left(\left(\frac{Do}{T.Co} \right) * c.d \right) + \left(\left(\frac{EQo}{T.Co} \right) * c.e \right) + \left(\left(\frac{C.Bo}{T.Co} \right) * c.b \right) \right]$$

[Equation 12]

The Optimised Model

$MAXIMISE \;\; C.B = T.C - EQ - D$ …..

[Equation 13]

s.t:

$TACCo =< TACC$

$S < 1$

$L < 1$

4 Section 4: Data Analysis and Results

This chapter starts with describing the characteristics of the data, their sources and the technique used for the analysis. Also, this chapter will discuss the adequacy, sources and justification of the data suitability and their relevance to the aim and objectives of this research. Along with the appropriateness of the data, the validity and reliability of the data will also be discussed. These sections followed by the analysis, results and justification of the findings.

4.1 The Types and Characteristics of Data

Considering the aim and objectives of the study we collected data relevant to capital components such as the debts, equities, and the total capital, along with the cost of these sources of capital. They are required for the analysis of the Insurative model and developing the optimisation model, and compare the results, so that the hypothesis can be tested.

The first criteria we used to select data, is to identify the companies that have already issued CAT-BONDs and variables of the standard model of capital structure described by Shimpi (2004). The dataset consists of capital components of twenty-two insurance companies covers the period between 2006 until 2015. In particular, the dataset (collected from Bloomberg platform) included total capital, total equity, short term and long term debts, total liabilities, EBIT, and WACC. In addition, relevant data e.g., bond size, the probability of the catastrophe events, expected loss, types of catastrophe, class, and price of the cat bond issued. about the cat-bond issued by these companies are also obtained. Furthermore, the solvency ratio (as recommended by Solvency 2 regulation) of the companies (cat Bond issuers) are also obtained.

These data required by the optimisation model (chapter two, section 4.4), in order to verify the optimum amount of CAT-BOND that can help optimise the capital structure are as follows:

The total capital, total liabilities, short-term and long-term debts, and the size of the CAT-BOND. While the objectives of the research require data about the Solvency 2 ratio, because this solvency ratio links the debts and the equities, and can act as a constraint when changing the values of the variable to find the optimum mix. Moreover, the CAT-Bond properties data, such as the cat bond price and the probabilities of the catastrophe. In addition to that, and in order to develop the optimisation model constraints, data about the cost of capital and cost of the cat-bond obtained as well.

The Table 2 (see Appendix 1) shows the summary statistics of the data related to the capital, short- and long-term debts, and the equity of twenty-four insurance company for the period between 2006 until 2015, while Table 3 [see Appendix 2] shows the data related to CAT-BOND.

4.2 Data Analysis Technique

This study aims to optimise the capital structure of the insurance companies using the cat-bond as a source of the capital. This goal justifies the optimisation techniques for analysing the data. Philosophov and Philosophov (1999, 2005) developed a non-linear[1] optimisation model to optimise the capital structure, taking into account the probability of the bankruptcy and the financial ratios as a prognosis. Unlike Philosophov and Philosophov (1999, 2005) and Goes et al. (2016) non-liners model we used linear optimisation model[2] to facilitate several important variables e.g., debts, equities, and cat-bond size.

The cat-bond properties are the probability of the trigger, the expected loss, the price of the cat-bond, and the maturity (Coval et al., 2009). The Maturity and the expected loss will be considered constants along with the probabilities of the Catastrophe[3]. These parameters deemed being constant, because in this research, aim to find out what is the maximum amount of CAT-BOND that optimises the capital structure when all these parameters are known. We used @RISK for linear modelling.

4.3 Data Analysis – results from the optimisation model and constraints

By analysing the capital structure of twenty-two insurance companies, initially, we found that the insurance companies considering the standard model of capital structure. This standard capital structure model as described by Shimpi (2004), it considers the (short-term and long-term debts and equity) as the sources and components of capital Table 2. Total Capital and Capital Structure as described by the standard model has the following equation:

$$Total\ Capital = Total\ Equity + Short_{Term}Debts + Long_{Term}Debts \quad \ldots$$

[Equation 14: Total capital according to the standard model]

The above equation 14 represents part of the Insurative Model (Shimpi, 2004).

Obviously, from Table 4 (see below), only three insurance companies have been changed significantly (Oriental Land Co., Swiss RE, and Tokio Marine), while the other companies remain unchanged. The model satisfies all the constraints[4] as seen in Table 5. It shows that for fourteen companies the liquidity ratio is less than 1, while the constraints failed to satisfy for the remaining six companies. These six companies i.e., AIG US Equity, ARGO LN Equity, CHUBB Group, DOMINION Reinsurance, East Japan Railway Company, and EDF) failed the optimisation test. These companies have a problem with Solvency Ratio, where the debts exceed the equities (see Table 4 in Appendix 3) shows that AIG US Equity has debts (108557.9) more than Equity (99991.5).

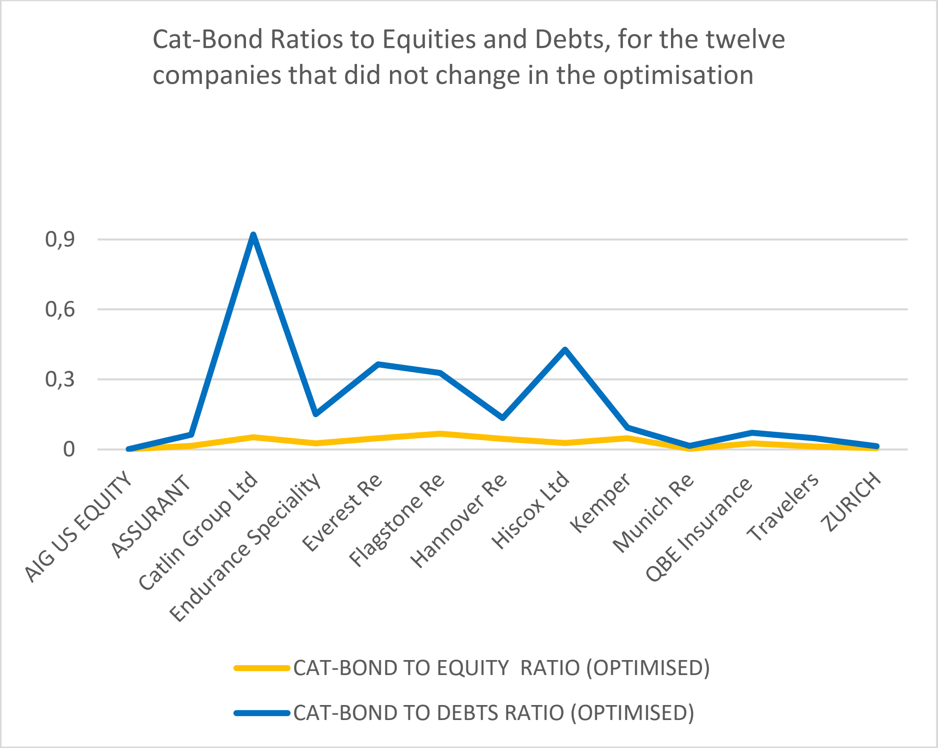
If we take the CAT-BOND as a debt, then in order to add more CAT-BOND to the portfolio the equities must be larger than the debts, so that the liquidity ratio (solvency regulation) is fulfilled.

Although these six companies failed to meet the model optimisation constraints (as $Liquidity\ Ratio > 1$), they might not affect the analysis significantly, thus excluded from the analysis. ARGO LN, has short-term and long-term debts equivalent to zero, that why the liquidity ratio equals zero, and the CAT-BOND to debts equals zero[5].

4.4 Analysis of Optimisation Results

From Figure 2 below, we can see that the equities of all the thirteen companies exceed their debts. However, the ratio of the debts to equity (the liquidity ratio) are irregular, or in other words, every business has its ratio with irregular pattern to describe the relationship between the debts and the equity. The optimisation test results with all the constraints met, and the size of the CAT-BOND is the maximum refer to Table 5 (above) and Table 6 (below) shows that the size of the CAT-BOND didn’t change. However,

Figure 1: Cat Bond Ratios



From the graph above Figure 2 it is evident that the equities are larger than the debts for twelve companies (from Table 5 the size of debts is less than equities). That is why the liquidity ratio already at the recommended level.

However, the size of the CAT-BOND is tiny (see Table 6; the average ratio of CAT-BOND to Equities is 3.1%). The ratios follow the irregular pattern and the difference between them are high (Figure 1 and Table 5 show that the variance the variance from the mean of the amount of debts is about 13% while the average is 24%). Thus, the variance between the ratio and its mean is massive.

Table 5: Descriptive Statistic for Companies [Cat-Bond size didn't change]

Descriptive statistics for the twelve companies that remained unchanged							
Variable	CAT-BOND TO EQUITY	CAT-BOND TO DEBTS	debts to equity	total capital	CAT-BOND SIZE	TOTAL EQUITIES	SHOT DEBT+LONG DEBT
Average	0.031641	0.219672	0.245522	12908.76	159.5175	9953.481	2795.766
Standard Deviation	0.020685	0.262036	0.134653	14530.15	99.71522	11014.48	3607.647

Figure 2: Capital Structure [Template 1]

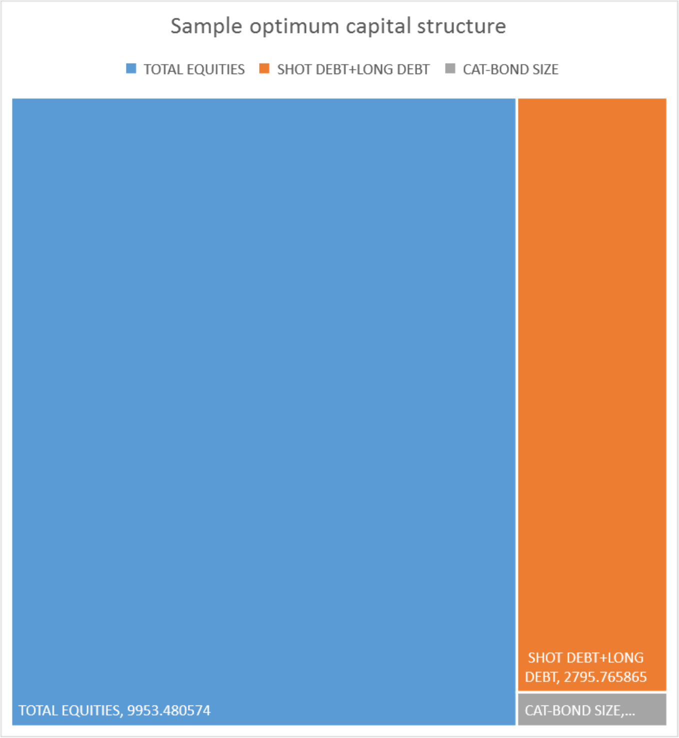


Figure 3 derived from Table 5 by calculating the average of the CAT-BOND, equities, and the debts. It illustrates the allocation of the CAT-BOND, where it is of course tiny size (159.5), which might not be able to cover the catastrophe that brings any loss exceeds the equity or the debts obligations. Nonetheless, the condition of minimising the cost has been satisfied Table 7 shows the cost of capital. From this, it is clear that the size of the CAT-BOND is the maximum that keeps the cost of capital optimum.

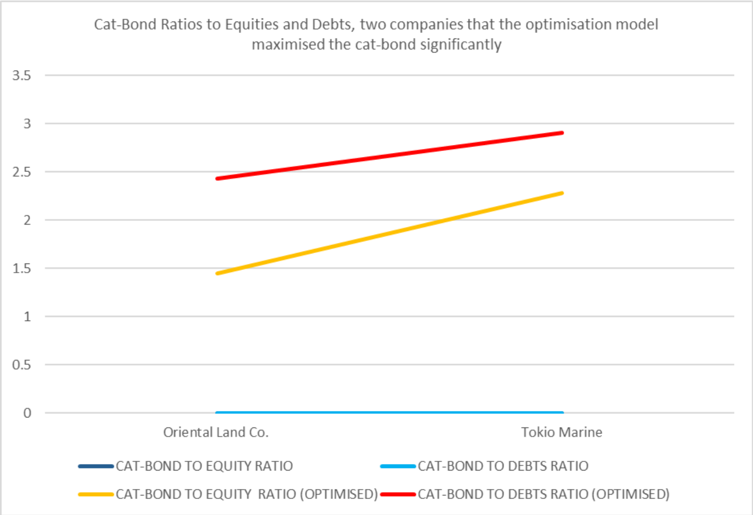
Table 6: Cost of Capital

Variavble	TACC	TACC FOR
Indicator	optimised	Original
ASSURANT	316.5118	316.5118
Catlin Group Ltd	300.8834	300.8834
Endurance Speciality	195.0471	195.0471
Everest Re	429.0709	429.0709
Flagstone Re	76.57604	76.57604
Hannover Re	346.2863	346.2863
Hiscox Ltd	89.04883	89.04883
Kemper	139.7738	139.7738
Mitsui Sumitomo	83.24998	83.24998
Munich Re	1792.719	1792.719
QBE Insurance	694.0569	694.0569
Travelers	1658.711	1658.711
ZURICH	2151	2036.116

Moving to the three companies where the model has maximised the CAT-BOND size significantly. Table 5 shows the size of the CAT-BOND compared with the other companies and with the other components. For example, the size of the CAT-BOND of Oriental Land Co. (412020.8), size of the CAT-BOND of Swiss RE (20775.286), and size of CAT-BOND of Tokio Marine is (5020268.1).

Figure 4 (see below), which derived from Table 8, shows how the cat-bond after optimisation exceeds the equity and the debts.

Figure 3: Cat-Bond Ratios to Debt and Equities



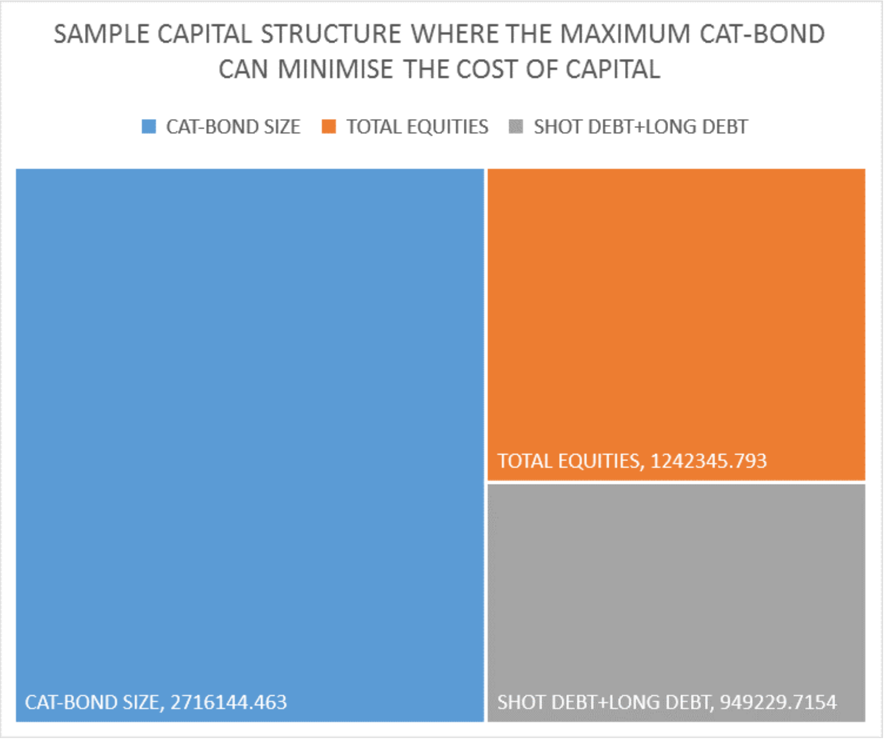
Swiss Re has been excluded from the graph above Figure 4 because the CAT-BOND size to DEBTs is much bigger than the other one for the other two companies (351.5649) compared to (2.9) and (2.4) for Tokio Marine and Oriental Land Co. respectively (see Table 8 below).

Table 7: Cat-Bonds [Optimised]

THE CAT-BOND THAT HAS BEEN MAXIMISED, RATIOS, DEBTS AND EQUITIES												
Variavble	CAT-BOND SIZE	TOTAL EQUITIES	SHOT DEBT+LONG DEBT	original size of cat bond	original debts	original equities	CAT-BOND TO EQUITY	CAT-BOND TO DEBTS	CAT-BOND TO EQUITY	CAT-BOND TO DEBTS	TACC	ORIGINAL TACC
Indicator	optimised	optimised	optimised	mean	mean	mean	RATIO	RATIO	RATIO (OPTIMISED)	RATIO (OPTIMISED)	optimised	CALCULATED
Oriental Land Co.	412020.8	283721.49	169613.8	100	169613.8	412020.8	0.000243	0.00059	1.452202	2.42917	12940.78	19542.51
SWISS RE	20775.29	20775.286	59.093741	59.093741	20775.28569	29266.842	0.002019	0.002844	1	351.5649	1518.77	1689.552
Tokio Marine	5020268	2200970.1	1728845.6	179	1274760.2	2549858.2	7.02E-05	0.00014	2.280934	2.903827	169342.8	195794.2

Tokio Marine and Oriental Land Co. are the two companies that the optimisation model maximised the size of the CAT-BOND significantly. For example, the size of CAT-BOND of Tokio Marine has changed from 179 to 5020268 Figure (4) below derived from Table 6, representing the average of CAT-BOND, Debts and Equities of Tokio Marine and Oriental Land Co. shows, the size of the CAT-BOND compared to the equities and debts. The size of the CAT-BOND is larger than the equities or debts.

Figure 4: Capital Structure [Template 2]



The size of the CAT-BOND is far larger than needed, that if we take the probability and the expected loss into account. However, that size can represent the maximum amount of the CAT_BOND by which the cost of capital is optimum. Also, the solvency ratio (liquidity ratio) is according to the constraints of the model. That means the companies have excess equity that can cover the obligations. For example, Table 6 shows that Tokio Marine Co. equities are (2200970.1) and the debts are (1728845).

5 Section 5: Findings from Data Analysis & Results

The successful optimisation resulted with two capital structure templates, Figures 2 & 3. Template 1 shows that the CAT-BOND can represent 1.24% of the total capital. Considering to decrease the full cost of capital, we can reduce the Size of the CAT-BOND, which in turn increase the amount of the retained systematic risk. Shimpi (2004) discussed the risk leverage (L) defined earlier in the literature review chapter, the risk leverage has a positive correlation with the insurance and the contingent capital, while it has a negative correlation with the total amount of paid-up capital.

Decreasing the amount of Total Debts, directly affect the solvency ratio and the minimum required capital, as well as increasing or decreasing the equities Equation 3 chapters two. Thus, considering higher or lower amount of CAT-BOND requires estimating and predicting the maximum expected loss in case of the occurrence of the catastrophe. This is in contrast with the second capital structure template as seen in Figure 4. Interestingly, from the template, we see that the CAT-BOND represent 55.34% of the capital. By taking the ratios of the CAT-BOND to Debts and Equities, are 2.7 and 1.9 respectively. That means the CAT-BOND should double the size of the debts and triple the size of the equity. According to Ozdemir (2015), economic capital is the capital required to stay solvent, while the risk capital refer to the capital that required for investments. The templates of the capital structure that have been concluded to (Figures 2 and 4) considering the issues with the solvency, as the ratio of the debts to the equity are always less than one (Table 5), which means that the firm can meet its obligations, while the cat-bond size covers the risk.

However, deciding between Figures 2 and 4 depend on the expected loss, because initially the CAT-BOND issued to cover an uexpected loss. Thus, according to Philosophov and Philosophov (2005) and Shimpi (2001) the decision of mixing the capital components requires decision making process. Shimpi's opinion is to integrate risk management with the capital management, these two opinions justify that both mix (Figures 2 and 4) can be viable, as the decision requires taking into account the expected loss from the catastrophes.

5.1 Hypothesis Testing

According to Michalak (2014) the value of the firm is a function of the cost associated with capital, whether the sources of the capital are external or internal.

$$VU = VL = \frac{EBIT}{WACC} = \frac{EBIT}{CeU} \quad 6$$

[Equation 15]

Although Goes et al. (2016) used a different method for estimating the value of the firm, this definition is suitable for this research because of the lack of the data and the simplicity of the equation. The Table 9 (see below) shows the variables that will be used for testing the hypothesis and the expected result from when we accept the hypothesis.

Table 8: Hypothesis Testing and Expected Result

PARAMETER	**Description**	**EXPECTED RESULT**	**Justification**
$T.C.S_O$, T.C.S	cost of capital	$T.C.S_0 \leq T.C.S$	CAT-BOND minimise the Cost of Capital
V, V^C	Value of insurance firm	$V < V^c$	Cat-Bonds adds value to insurance firm

Table 9: EBIT

Variable	**EBIT**	**Variable**	**EBIT**
Indicator	**Mean**	**Indicator**	**Mean**
AIG US EQUITY	1806	Hannover Re	331
ARGO LN Equity	0.688857	Hiscox Ltd	N/A
ASSURANT	265	Kemper	43.7
Catlin Group Ltd	379	Mitsui Sumitomo	N/A
Chubb Group	697.6667	Munich Re	N/A
Dominion Resources	3077.9	Oriental Land Co.	64762.27
East Japan Railway Company	398374.3	QBE Insurance	12.829
EDF	7938.4	SWISS RE	938
Endurance Speciality	93.45	Tokio Marine	6.006
Everest Re	212.5	Travelers	1003.5
Flagstone Re	33.5	ZURICH	8.79

Table 10 (see above) shows the EBIT of the twenty-two companies[7].

Table 11: Firm Value[8]

Variavble	TACC	EBIT	Firm Value after optimisation	TACC FOR OPTIMIATION	firm value before optimisation
Indicator	CALCULATED	MEAN	calculated	CALCULATED	calculated
AIG US EQUITY	6958.249	1806	0.259548059	6958.249	0.259548059
ARGO LN Equity	#DIV/0!	0.688857	#DIV/0!	0	#DIV/0!
ASSURANT	316.5118	265	0.837251491	316.5118	0.837251491
Catlin Group Ltd	300.8834	379	1.259624019	300.8834	1.259624019
Chubb Group	981.9498	697.6667	#NAME?	895.1431	0.779391174
Dominion Resources	1110.653	3077.9	2.771252238	1110.653	2.771252238
East Japan Railway Company	134821.4	398374.3	2.954830414	134821.4	2.954830414
EDF	2839.887	7938.4	2.795322622	2839.887	2.795322622
Endurance Speciality	195.0471	93.45	0.479114944	195.0471	0.479114944
Everest Re	429.0709	212.5	0.495256148	429.0709	0.495256148
Flagstone Re	76.57604	33.5	0.437473641	76.57604	0.437473641
Hannover Re	346.2863	331	0.95585656	346.2863	0.95585656
Hiscox Ltd	89.04883	N/A	#VALUE!	89.04883	#VALUE!
Kemper	139.7738	43.7	0.312647946	139.7738	0.312647946
Mitsui Sumitomo	83.24998	N/A	#VALUE!	83.24998	#VALUE!
Munich Re	1792.719	N/A	#VALUE!	1792.719	#VALUE!
Oriental Land Co.	12940.78	64762.27	5.004508918	19542.51	3.313917529
QBE Insurance	694.0569	12.829	0.018484076	694.0569	0.018484076
SWISS RE	1518.77	938	0.617604977	1689.552	0.55517669
Tokio Marine	169342.8	6.006	3.54665E-05	195794.2	3.06751E-05
Travelers	1658.711	1003.5	0.604987742	1658.711	0.604987742
ZURICH	2151	8.79	0.004086472	2036.116	0.004317043

Table 11 (see above) compares the firm value of the twenty-two companies. It is evident from the Table 11 that three companies i.e., Oriental Land Co. Swiss Re and Tokio Marine increased their value after reducing the cost of capital and maximising the size of Cat-Bond. Michalak (2014) states that the value of the firm is proportion of the cost associated with the capital. In this consideration, the findings of the above analysis prove that the low cost of capital results with high value of the firm. Nonetheless, the taxation associated with the EBIT can be considered as fixed.

$$VALUE\ OF\ THE\ FIRM = [(\frac{EBIT*(1-TAX)}{COST\ OF\ CAPITAL}]$$ [9]

[Equation 16: Value of the Firm and Taxation]

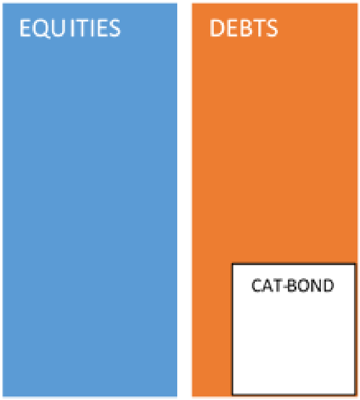
The Equation 16 (see above) shows that whenever the cost of capital changed the value of the firm changes as negative relation. Taking the tax rate as fixed, which affect only the value of the EBIT, but anyway the influence of the cost of capital is obvious from Table 11 (the results derived from Equation 1: Firm Value).

Elaborating more about the EBIT and the maximum size of the CAT-BOND, any change in the capital structure affect the EBIT similar to the cost of the capital. Regarding the firm value, according to Modigliani and Miller cited from (Weston et al., 1996) the capital structure does not affect the firm value. However, the taxation benefit from the debts might affect the firm value (Weston *et al.,* 1996). Regardless, this test is quite enough to prove that the optimum allocation of the CAT-BOND can add value to the firm. According to Michalak (2014) equation (Equation 1: Firm Value) the cost of capital affect the firm value negatively. Thus, by allocating the CAT-BOND optimally, it adds value to the firm. Although the CAT-BOND is a defaultable debt and belongs to the contingent convertibles, it has its properties and attributions that make the allocation of this bond requires risk management decision.

Both the two templates (Figures 2 and 4) depend on the specifications of the anticipated catastrophe. For example, considering the Template 2 (Figure 4) while the expected loss represents 1% of the total capital, in this case the template is not suitable, and should consider the other template (Figure 2).

Revisiting the gap in the literature, which basically the ILSs as a source of capital within the scope of the Insurative model and the ORSA, the finding of this research covered the reasonably good part of it.

Figure 5*:* Capital Structure



Shimpi (2004) argues about considering the ILSs as sources of capital. This research investigated the viability of using the CAT-BOND as a source of capital, and what is the maximum amount that satisfies the principles of mixing the capital components and identifying the capital structure. The finding of this analysis, suggests that, there are two optimum capital structure that can fulfil the conditions of the optimum capital structure (see Figures 2 and 4)

Philosophove and philosophove (2005) developed a model to determine the optimum capital structure, taking the probability of bankruptcy as an issue. They also depend on the financial ratios as a prognosis. However, they did not take the off-balance sheet items as a source of capital as shimpi did. However, the gap in the literature regarding the capital structure and the off-balance sheet items, partially covered by this study. The two missing concepts in philosophov and philosophov (2005) are the Cost of Capital and the Firm Value, which both has been considered in this study. The data analysis concluded to the that, the CAT-BOND can be added to the capital portfolio while keeping the cost minimum and adding value to the firm.

In summary, in orde to maximise the size of the CAT-BOND and to optimise the capital structure we used a linear optimisation model. The conclusion of the optimisation model and to minimise the cost of capital the CAT-BOND size are either to be around 1.2% or 55% of the total capital.

6 Conclusion

Insurance is a risk transfer tool that deals intensively with risk and uncertainty. From the perspective of risk management, insurance capital and the reserve is of vital importance, taking the insurance as a financial service industry, the classical definition of insurance as a hub, where individuals and other firm transfer their risk (Diacon and Carter, 1992). Insurance has always been to cover pure risk and unsystematic risk. However, the alternative risk transfer tool, such as ILSs, which Shimpi (2004) considers them to be sources of capital. The aim of this study is to allocate the CAT-BOND to the capital structure optimally. We set the first objective as to analysing the Insurative model, which accommodate the ILSs as a source of capital. The second objective was to understand the ORSA framework to develop a condition and constraint for the optimisation model. Both objectives are a complement for developing the optimisation model. We set the last two objectives are developing the optimisation model and analysing the data to test the hypothesis.

6.1 Research agenda

The optimum capital structure that has been studied previously in the literature review chapter depends on the understanding of the cost of capital, that on one hand. In addition to that, the optimum capital structure is determined by issues related to business lines, such as bankruptcy, speculative risk, and systematic risk.

Regarding the speculative risk, and contingent convertible bonds, they have been studied intensively (Wilkens and Bethke, 2014; Ammann et al., 2016). For example, in (see Chapter 2: Literature Review), where the allocation of the contingent convertible for the banking system within the scope of Basel 3 regulation (Goes et al., 2016), has been discussed. The influence of Contingent Capital on the capital structure has been confirmed as it adds value to the firm (Goes et al., 2016). However, in this study, we tested the the effect of the cat-bond on the value of the firm.

Although the contingent capital and the CAT-BOND have the same properties, CAT-BOND is different from the CoCo, because the CAT-BOND covers pure risk and specifically the systematic one. However, the allocation of CAT-BOND has not been studied in the previously literature, and specifically within the Insurative model scope as it combines both the standard and insurance models. Thus this model accommodates the ILSs and the off-balance sheet items. The equation used in the linear optimisation model derived from this Insurative model.

This study attempts to maximise the amount of CAT-BOND that can be part of the capital in the Insurative model. Through the identification of the optimum allocation of the CAT-BOND, this research might fill part of the gap in the literature in this subject area, where the distribution of CAT-BOND has not been studied intensively yet.

6.2 Collection and Analysis of Data

We began data analysis (Section 4) with descriptive statistics, to extract the mean, median and the variance, this descriptive helps in understanding the robust of the data of each company. The variance shows how the companies' data changes over time, because the data represent 10 years' period, while the mean used in the analysis, as this technique used by Goes et al. (2016).

The finding of this analysis shows that the allocation of CAT-BOND is a risk management decision, as the optimisation model resulted with two templates for the capital structure with CAT-BOND. The gap in the literature, show that there is lack investigation on how to allocate the CAT-BOND to the capital structure adequately. Thus, the result from the analysis covers this gap to the extent that a general view of where the CAT-BOND can be in the structure.

The hypothesis of this study is the optimum allocation of CAT-BOND adds value to insurance firms. The research confirms that this hypothesis is true, by comparing the value of the firm after the optimisation with the original one. This finding is similar to the conclusion of Goes et al., (2016) who tested whether the CoCo can add value to the firm or not.

6.3 Limitation and Recommendation

As mentioned earlier this study focuses on the CAT-BOND and how to be allocated optimally in the capital structure. There are other off-balance sheet items that can be considered as a source of capital, such as CoCo Bonds and the insurance contracts (Shimpi, 2004). This research did not examine these items because the limited time allocated to the research and the availability of the data related to insurance companies and their off-balance sheet items.

The results of this research can be taken to further studies on the same topic, bearing in account the CoCo bond and the insurance contracts along with the ILSs. For all these items to be considered in the capital structure, more sophisticated optimisation model need to be considered. Goes et al. (2016) used the stochastic optimisation technique. However, the optimisation technique used by Goes et al. (2016) one of its limitation is that it accommodates only one type; either optimise the coco size or the subordinated bond, but not both. Therefore, a new optimisation model needs to be developed to accommodate all sources of capital components within the scope of shimpi`s Insurative model. Also, single or multiple case studies might be more efficient than taking the research as a literature review because of the lack of data.

To conclude from above, the future studies on the same topic may focus on a particular firm because it can insure the availability of the data. Moreover, developing a stochastic optimisation model that accommodate all the relevant sources of capital that Shimpi (2001, 2004) mentioned considering the change of EBIT with the change in the in the capital structure.

6.4 Originality of this study

The study developed two templates of capital structure and as they describe the amount of CAT-BOND that can be optimally embedded in the structure.

The new feature of this study is the optimisation model that has been used. The previous studies used simulation and stochastic optimisation, while this study uses a simple linear optimisation. The linear optimisation model that has been used is restricted in its constraint, which means that the constraints used in the model are not flexible, but they define the requirements of the optimum capital structure accurately. Also, the two templates that have been developed are simple in the sense that gives a general view of describing the location of the CAT-BOND and its size in within the portfolio.

The finding of this study is that the optimum allocation of the CAT-BOND adds value to the insurance firms. In addition to that, the ultimate achievement of this research can be divided into two parts:
Firstly, the research confirms the strong link between the capital management and the risk management. This concept has been developed by Shimpi (Shimpi, 2001) in his studies, where he talked about the importance of linking both the risk management and the capital management as integrated risk management. The two templates developed in this research can be applied in practice if it needs an intensive risk management decision about whether to be conservative or risk taker.

Secondly, both templates can help to maintain the optimum cost of capital. According to Exley and Smith (2006) cost of capital related to the price of products. Thus, the optimum cost of capital can help Insurance firms to compete in the market efficiently. Also, the optimum allocation of the CAT-BOND can help release capital (Doherty, 2005), which allow the firm to expand its insurance pool.

In general, we find that the outcome of this research is simple and understandable for a managerial level.

Notes:

[1] Non-linear optimisation according to Bazaraa and Shetty (1979) is optimisation model where, one or more of the constraints are non-linear. Non-linear means no direct relation between the variables. The model proposed in this study is a linear one; its purpose is to find the optimum mix of the equities, debts and the CAT-BOND with constraints that has a linear relation, such as the liquidity ratio.
[2] Linear programming is a powerful mathematical tool for the optimisation of an objective under a number of constraints in any given situation. Its application can be in maximising profits or minimising costs while making the best use of the limited resources available (Coval et al., 2009).
[3] Refer to the literature review; the aim of the research is allocating the cat-bond, after defining its properties.
[4] The liquidity ratio, act as a constraint, because when mixing the components of the capital portfolio, the ratio of debts to equity must be less than 1. In other words, the equities must be larger than debts.
[5] CAT-BOND to DEBTS is equal to infinity, but the result from the software shows an error that we can consider as Zero.
[6] Refer to chapter two the literature review section 2.3 Equation 1 firm value.
[7] The EBITs of Hiscox Ltd. Mitsui Sumitomo, and Munich Re, were not available on Bloomberg. Hence, tested only nineteen remaining companies.
[8] The error on cell due to the missing data, however, these companies are excluded from the hypothesis testing.
[9] The value of firm equation cited (Michalak, 2014) page 26.
[10] This table shows the capital components of 24 companies, it shows the descriptive statistics: The mean (average), the median and the Variance. The average will be used in the analysis.
[11] This table shows the CAT-BOND properties in term of (size, probability of the catastrophe, maturity, expected loss and the price.

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Appendix:

Table 2: Capital Components[10] [Appendix 1]

Variavble	TOTAL CAPITAL			TOTAL EQUITY			SHOT DEBT+LONG DEBT			WACC			EQUITY WACC		
Indicator	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D
AIG US EQUITY	208549.4	204899.5	71449.371	99991.5	103717	14833.789	108557.9	92605	73700.059	6.66	0	0	13.51713	13.05925	3.7506472
ARGO LN Equity	33.861	28.495	9.7978052	33.861	28.495	9.7978052	0	0	0	5.8011714	5.6578	2.0907919	5.8011714	5.6578	2.0907919
ASSURANT	5671.5572	5795.584	616.86928	4586.286	4807.008	532.69441	1085.2712	988.07	209.74489	7.51	10.42909	0	10.42909	9.7766	1.5403358
Catlin Group Ltd	3384.1524	3390	475.73396	3201.8917	3298	622.8541	182.26078	105	225.40184	10.016789	8.6448	2.5184502	10.987544	10.4274	2.8985634
Chubb Group	18699.889	19397	1192.8354	15188.667	15574	1019.7027	3511.2222	3575	479.28952	8.18321	8.11685	0.9099216	9.11473	8.75265	1.3281439
Dominion Resources	32592.3	32407.5	4880.8811	11701.4	11829.5	1197.2433	20890.9	20144	4043.9839	5.7888	5.84565	0.912772	8.18715	8.0732	1.1707734
East Japan Railway Company	5315226	5243379	236765.28	1834745.5	1821051	291535.08	3480480.5	3438953	118707.88	4.38855	4.3941	0.7749994	9.13567	8.8787	2.3554707
EDF	81790.8	86607.5	15054.276	33400.1	33669.5	5943.0739	48390.7	49718	9980.6136	6.42002	6.48555	1.9529705	10.51312	10.7175	0.7873449
Endurance Speciality	3431.4087	3236.4415	903.49912	2917.0417	2748.94	826.81113	514.367	525.478	81.568762	8.06315	7.97305	1.3557914	9.09197	8.56235	1.6951331
Everest Re	7288.3634	7135.6415	924.14967	6424.2665	6192.6195	1107.5286	864.0969	843.1105	232.5371	8.01619	7.97205	0.8547842	8.73994	8.5686	1.0523616
Flagstone Re	1370.1515	1441.8775	279.19981	1135.3645	1190.029	248.27577	234.787	251.762	48.125152	8.5463667	8.4521	0.4063733	9.7475667	9.6718	0.5253059
Hannover Re	7468.6168	7357.865	2247.4291	5601.5393	5362.2615	1932.8643	1867.0775	1866.3735	421.02176	7.93933	7.37635	1.6036059	9.96448	9.12835	2.2556351
Hiscox Ltd	1262.9476	1272.9695	288.8991	1185.8576	1261.0065	284.22059	77.09	55.882	90.680438	8.49638	8.76645	1.5309875	8.67151	8.81875	1.440955
Kemper	3134.73	2943.7	522.14375	2066.75	2102.05	186.96155	1067.98	841.65	493.42449	8.59575	8.44935	1.2356714	12.04974	11.5477	2.4018594
Mitsui Sumitomo	1262.9476	1272.9695	288.8991	1185.8576	1261.0065	284.22059	77.09	55.882	90.680438	8.49638	8.76645	1.5309875	8.67151	8.81875	1.440955
Munich Re	31529.2	31207	2880.9787	25638.1	25823	3301.6537	5891.1	5750.5	866.87811	8.37914	8.4396	1.2849331	9.98897	9.41455	1.8025494
Oriental Land Co.	581634.6	561506	57251.653	412020.8	384042	66786.023	169613.8	161455	80265.063	6.19303	6.5578	1.7763415	7.433	7.24075	2.1615974
QBE Insurance	12969.93	13560	2904.8574	9505.1696	10398	2021.7304	3464.76	3280.3143	1138.1074	9.92873	9.5185	1.8636703	11.19675	11.26535	2.3229982
SWISS RE	50042.128	51736	7303.3499	29266.842	29669.468	5228.839	20775.286	20283	7629.3107	6.53105	5.9458	1.5499533	11.52347	10.9278	4.57772
Tokio Marine	3824618.4	3898781.5	581737.63	2549858.2	2471261	685558.52	1274760.2	1358054.5	565538.4	9.05603	9.1709	1.6013545	14.17895	14.2052	4.2022956
Travelers	31638.7	31342.5	1116.4962	25307.2	25227	1070.6822	6331.5	6347.5	247.0786	8.27775	8.22855	0.8029603	9.47727	9.4485	0.8205819
ZURICH	43841.2	44558	4327.6327	31872.3	33072.5	4368.0865	11968.9	12210.5	758.27384	8.54058	8.4515	1.6220219	10.81074	10.89555	2.1850138
THE SOURCE OF THE DATA: BLOOMBERG															

Table 3: Cat-Bond data[11] [Appendix 2]

Variavble	Size of CatBond $m			Expected Claims Loss (CatBond) $m			CatBond Trigger Prob			CatBond Maturity (years)			CatBond Coupon (or price)		
Indicator	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D	Mean	Median	S.D
AIG US EQUITY	165.625	132.5	85.667026	2.7639375	1.957	2.0354625	0.0205125	0.01635	0.0087553	3	4	2	0.064375	0.065	0.0108356
ARGO LN Equity	74.4	75	30.648002	3.4803	3.765	1.8796387	0.04785	0.05265	0.0266574	4	5	2	0.1325	0.12	0.0401559
ASSURANT	68.333333	75	29.047375	1.0653333	1.014	0.3668836	0.0269429	0.0233	0.0144091	3	3	0	0.077	0.08	0.042901
Catlin Group Ltd	167.9	137.5	94.880732	5.805125	1.748125	9.114585	0.0349286	0.014	0.053528	3	3	0	0.0656429	0.0695	0.037365
Chubb Group	145.41667	125	81.755131	1.887	1.512	0.7647316	0.020025	0.01515	0.0173531	4	4	1	0.0600833	0.06125	0.0357655
Dominion Resources	50	50	0	0.67	0.67	0	0.028	0.028	0	1	1	0	0.025	0.025	0
East Japan Railway Company	260	260	0	1.222	1.222	0	0.0071	0.0071	0	5	5	0	0.0275	0.0275	0
EDF	115.4	104.95	33.780107	2.03183	1.3583235	2.4170159	0.04715	0.04715	0.0210011	5	5	1	0.050925	0.04825	0.0323051
Endurance Speciality	78	60	41	1	1	1	0.0171667	0.0149	0.0089187	2	2	0	0.0783333	0.08	0.0028868
Everest Re	315	300	114.01754	7.425	7.3	4.439054	0.03302	0.0226	0.0174932	4	4	0	0.058	0.0475	0.0222486
Flagstone Re	77	75	14.832397	2.7459	2.3775	1.3093136	0.03195	0.03195	0.01492	4	4	1	0.12406	0.1231	0.0288969
Hannover Re	252.5175	265	88.992413	3.6535729	2.37	2.0969616	0.0173667	0.01805	0.0072398	3	3	0	0.0512857	0.0525	0.0126914
Hiscox Ltd	33	33	0	0.3762	0.3762	0	0.0155	0.0155	0	3	3	0	0.0675	0.0675	0
Kemper	100	100	0	0.5	0.5	0	0.012	0.012	0	3	3	0	0.0369	0.0369	0
Mitsui Sumitomo	130	90	50.33223	1.365	0.954	0.527514	0.0171	0.0113	0.0033486	5	5	0	0.0375	0.0315	0.0041633
Munich Re	91.309048	100	43.393611	1.8112408	1.686896	1.3247081	0.0268889	0.0236	0.0112751	3	3	1	0.0635368	0.065	0.0328531
Oriental Land Co.	100	100	0	0.42	0.42	0	0.0062	0.0062	0	5	5	0	0.031	0.031	0
QBE Insurance	250	250	0	3.375	3.375	0	0.0152	0.0152	0	4	4	0	0.0375	0.0375	0
SWISS RE	59.093741	50	49.343039	1.6920479	0.95	2.431381	0.0352885	0.0245	0.0351941	3	2	1	0.0985267	0.075	0.0801973
Tokio Marine	179	200	88.769364	1	0	1	0.00928	0.0041	0.0085183	4	4	1	0.03236	0.025	0.0147859
Travelers	308.33333	275	97.039511	2.8705	2.7215	0.8983627	0.01139	0.01128	0.002446	3	3	1	0.05	0.05375	0.009083
ZURICH	172.81667	190	77.9269	2.2799317	1.596	2.0053233	0.0176167	0.01835	0.0090572	3	3	1	0.0659167	0.07125	0.0165542

SOURCE OF DATA : DR MADHU ACHARYYAH

Table 4: Optimised Cat-Bond (Appendix 3]

OPTIMISED CAT-BOND AND THE OTHER CAPITAL COMPONENTS										
Variavble	CAT-BOND SIZE	TOTAL EQUITIES	SHOT DEBT+LONG DEBT	original size of cat bond	original debts	original equities	CAT-BOND TO EQUITY	CAT-BOND TO DEBTS	CAT-BOND TO EQUITY	CAT-BOND TO DEBTS
Indicator	optimised	optimised	optimised	mean	mean	mean	RATIO	RATIO	RATIO (OPTIMISED)	RATIO (OPTIMISED)
AIG US EQUITY	165.625	99991.5	108557.9	165.625	108557.9	99991.5	0.001656391	0.001525684	0.001656391	0.001525684
ARGO LN Equity	74.4	33.861	0	74.4	0	33.861	2.197218038	#DIV/0!	2.197218038	#DIV/0!
ASSURANT	68.333333	4586.286	1085.2712	68.333333	1085.2712	4586.286	0.014899492	0.062964293	0.014899492	0.062964293
Catlin Group Ltd	167.9	3201.891667	182.2607778	167.9	182.26078	3201.8917	0.001656391	0.921207525	0.052437752	0.921207525
Chubb Group	145.41667	15188.66667	3511.222222	145.41667	3511.2222	15188.667	0.009574024	0.041414829	0.009574024	0.041414829
Dominion Resources	50	11701.4	20890.9	50	20890.9	11701.4	0.004272993	0.002393387	0.004272993	0.002393387
East Japan Railway Company	260	1834745.5	3480480.5	260	3480480.5	1834745.5	0.000141709	7.47023E-05	0.000141709	0.0000747023
EDF	115.4	33400.1	48390.7	115.4	48390.7	33400.1	0.003455079	0.002384756	0.003455079	0.002384756
Endurance Speciality	78	2917.0417	514.367	78	514.367	2917.0417	0.026739419	0.151642699	0.026739419	0.151642699
Everest Re	315	6424.2665	864.0969	315	864.0969	6424.2665	0.049032835	0.364542449	0.049032835	0.364542449
Flagstone Re	77	1135.3645	234.787	77	234.787	1135.3645	0.06781963	0.327956829	0.06781963	0.327956829
Hannover Re	252.5175	5601.5393	1867.0775	252.5175	1867.0775	5601.5393	0.045080019	0.135247466	0.045080019	0.135247466
Hiscox Ltd	33	1185.8576	77.09	33	77.09	1185.8576	0.027827962	0.428071086	0.027827962	0.428071086
Kemper	100	2066.75	1067.98	100	1067.98	2066.75	0.048385146	0.093634712	0.048385146	0.093634712
Mitsui Sumitomo	130	1185.8576	77.09	130	77.09	1185.8576	0.109625304	1.686340641	0.109625304	1.686340641
Munich Re	91.309048	25638.1	5891.1	91.309048	5891.1	25638.1	0.003561459	0.01549949	0.003561459	0.01549949
Oriental Land Co.	412020.8	283721.4904	169613.8	100	169613.8	412020.8	0.000242706	0.000589575	1.452201592	2.429170268
QBE Insurance	250	9505.16962	3464.76	250	3464.76	9505.1696	0.026301477	0.07215507	0.026301477	0.07215507
SWISS RE	20775.286	20775.28569	59.09374101	59.093741	20775.286	29266.842	0.002019136	0.002844425	1	351.5649092
Tokio Marine	5020268.1	2200970.095	1728845.631	179	1274760.2	2549858.2	7.02E-05	0.000140419	2.280934274	2.903826713
Travelers	308.33333	25307.2	6331.5	308.33333	6331.5	25307.2	0.012183621	0.048698307	0.012183621	0.048698307
ZURICH	172.81667	31872.3	11968.9	172.81667	11968.9	31872.3	0.005422159	0.014438809	0.005422159	0.014438809