Economic Capital and Financial Risk Management

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Abstract

The latest global financial crisis has highlighted the need for financial services firms to adopt comprehensive risk management techniques to identify, manage and mitigate risks promptly and efficiently. To this end, a key risk management tool is to hold sufficient capital to back the risks a business is running. In recent times, financial services regulators have also initiated a move towards risk-based economic capital approach with different regulations for banks (Basel 2 and 3) and insurance firms (Solvency 2). In this paper, a generic definition of economic capital is proposed using a stochastic approach, which is then used to quantify economic capital for a capital repayment mortgage, a lifetime mortgage, a life insurance annuity and a conglomerate operating a range of financial services. The paper highlights economic capital as a risk management tool that unifies capital calculation techniques across all financial services firms and conglomerates, irrespective of their line of operation.

Keywords

Economic capital, Solvency 2, stochastic model, risk management, financial risk, longevity risk, asset allocation strategies, conglomerates.

1. Introduction

Financial services firms are in the business of accepting risks. Customers pass on risks to financial services firms with the belief that the firms will provide appropriate protection when the need arises. To fulfil this role, firms need to be run on a sound financial basis which requires proper appreciation of the risks involved and putting in place adequate measures to mitigate these risks. However, history is full of examples where firms have either failed to identify risks or take actions to control them. For instance:

- Fall of Equitable Life in 2000 was triggered by the failure of its risk managers to comprehend the full impact of offering guaranteed annuity rates in conjunction with personal pension plans sold over three decades.

- Financial crisis of 2007, where defaults in high-risk mortgages in the US and worldwide, led to huge losses in the banking sector, bringing down mortgage lenders and investment banks, leading to a spate of takeovers and causing the entire banking sector map to be redrawn.

These and other examples have led to the increased need for financial institutions to implement mechanisms to protect their customers and their balance sheets.

Clearly, appropriate managerial actions and adequate capital backing are essential to run business on a sound financial basis. Traditionally, the amount of capital backing has been prescriptive in nature and has been specified by the regulators. With the advent of modern risk-management techniques, coupled with advanced risk theory, regulators are now moving towards a risk-based approach to capital calculation, with different regulatory requirements for banks (Basel 2 and 3) and insurance firms (Solvency 2).

However, development of a risk-based capital calculation technique that will work across the board for all financial firms would broadly ensure that all financial firms are treated on a level footing and eliminate inefficiencies in financial markets. The aim of this paper is to present and discuss such an approach. The capital calculated based on this approach will be referred to as economic capital.

Throughout this paper, we only consider risks that can be mitigated by holding capital, which include financial, demographic (mortality, persistency), credit and operational (external events like floods) risks. In our view, operational risks related to internal events, like fraud, cannot be effectively mitigated by holding capital. These risks need to be handled through better management, processes and controls. Similarly, liquidity risk can be mitigated only through proper financial planning. Holding extra capital in illiquid assets, like property, may not help if cash is required on an urgent basis.

The paper is structured as follows. In section 2, we will discuss the relevance of economic capital to various interested parties. In section 3, we will formally define economic capital. In section 4, we will outline the pros and cons of deterministic and stochastic approaches, followed by a description of the stochastic model developed by Porteous and Tapadar (2005, 2008a, 2008b) in section 5. In section 6, we will quantify economic capital for a capital repayment mortgage, a lifetime mortgage and a life insurance annuity products. In section 7, we will consider two further applications - firstly, impact of asset allocation strategies on economic capital and secondly, economic capital of a financial services conglomerate. We will summarise our conclusions in section 8.

2. Interested Parties

Quantification of adequate economic capital requirement, for financial services firms and conglomerates, is of interest to many parties including:

- Customers of financial services products.
- Regulators of the financial services industry.
- Financial managers.
- Capital providers – shareholders and debt-holders.
- Rating agencies.

2.1 Customers

Apart from competitive prices, customers will be mainly concerned about the ability of financial services firms to honour their obligations and the quality of service they receive. Economic capital can provide the customers an indication of the financial soundness of the firm they choose.

2.2 Regulators

Regulators are mainly interested in the protection of consumers of financial products. One way they achieve their objective is by asking firms to hold capital to back the risks they are running. In case of insolvency of a firm, this capital can then be used to provide compensation to the customers.

Traditional formula-based approach for calculating the amount of regulatory capital was perhaps quite practical at a time when computing resources were expensive and not widely available. However, the capital amounts calculated were ad-hoc, with no real connection to a firm's risks. Use of risk-based capital, or economic capital, will better reflect a firm's risks. Ideally, all financial services firms should be regulated on a single set of rules. We believe that economic capital can achieve this through a unified approach.

2.3 Financial managers

Sound financial management is about understanding business risks, being able to measure them and setting appropriate risk appetites and risk limits. Whatever the type of the financial services firm, the management should be pro-active and should not rely solely on holding regulatory capital as a risk mitigation technique. Moreover, regulators are becoming keen that firms demonstrate that their financial risk management is based on proper risk assessment. A good financial manager should actively assess the risk

profile of the business, and effect policies that can mitigate the risks, which includes holding an appropriate amount of economic capital.

2.4 Capital providers

Providers of capital (shareholders and debt-holders) will be concerned with the security of their investment and getting the best possible return on their capital. They will want to ensure that the capital provided is adequate for the risks and is being efficiently used to increase the firm's value and maximise returns. Economic capital can provide this reassurance.

2.5 Rating agencies

The primary objective of rating agencies is to investigate the fundamental risks facing a company and what measures it has taken to mitigate those risks. Economic capital can be a useful tool for them as they can compare the actual capital held by the company with the economic capital to get an idea of the soundness of the firm's financial position. They can also then compare the capital adequacy across business lines and different types of financial services firms.

In short, economic capital can be used as a concept and a practical tool that unifies the requirements of various parties and firms across the financial industry. We will also show in this paper, that it is based on sound actuarial techniques and can be a useful tool in effective capital management.

3. Economic capital

Although widely used within the industry, surprisingly, there is no commonly accepted standard definition of economic capital. Basel 2 defines it as the amount of capital, as self-assessed by a bank, needed to support a given set of risks and absorb losses up to a specified probability. Solvency 2 defines economic capital as the amount of capital that an insurer would actually require to bear the risks it takes on, in the absence of regulatory requirements. These initiatives show that regulators are striving to develop a unifying explicit risk-based framework for economic capital.

Some key features for the concept of economic capital are listed below:

- Firstly, economic capital needs to be assessed in conjunction with the realistic value of liabilities of a firm, where the realistic liability value should represent the best estimate of the firm's future obligation and economic capital should capture the excess assets required to ensure that the balance sheet remains solvent following

events that are unexpected, yet not so unlikely that they might never occur in practice. This entails stripping out any prudence from liability calculations in order to quantify the appropriate amount of economic capital requirement.

- Economic capital should be a probability statement, i.e., it should reflect the capital required to keep the balance sheet of a firm solvent with a required probability, over a specified time horizon.
- It should be based on sound actuarial techniques and should apply across all business risks for any financial services firms irrespective of the balance sheet in which it is written.

Based on the above characterisation, we will use the following definition for economic capital, which is generic and applies to any financial services firm:

Definition: *Economic capital is the amount of capital required to ensure that the market value balance sheet of the firm remains solvent, over a specified time horizon, with a prescribed high probability.*

The key issues to note here are:

3.1. Time horizon:

Although the above definition is generic in terms of time horizon for quantifying economic capital, we will specifically employ a long-term approach in our calculations. We will consider the business in-force at the start of our calculations and calculate the economic capital for the full period until the entire in-force business goes off the books. This is in contrast with the current practice of calculating capital requirements on a short-term one-year basis. The advantage of using a run-off approach for assessing risk is that a potentially critical risk manifests itself over longer time horizons which should be taken into account while quantifying economic capital.

3.2. Capital structure:

A firm will usually decide on how it will raise actual capital to back the economic capital requirement defined above. Traditionally firms have used either debt or equity capital. Currently there are more sophisticated forms of capital, known as hybrid capital, which try to make the most of the regulatory definitions and categories, but tend to go out of fashion when regulators re-define these categories. We will not consider hybrid capital further.

Incidentally, the actual debt/equity split can have a bearing on the amount of economic capital as debt capital needs to be serviced by interest payments specified upfront,

whereas returns on business depends on market movements. So the firm might have to continue paying interest even when the business environment is not favourable. This lack of flexibility means that a firm financed by debt capital would need to hold more capital than if the capital is entirely backed by equities as dividend payments are generally discretionary.

Although capital structure is a very important issue for most financial services firm, we will not discuss it here. Instead, we will assume that economic capital is backed fully by equity capital. For more detailed discussion on the capital requirement based on capital structure, please refer to Porteous and Tapadar (2008a).

3.3. Capital asset allocation

In this paper, we will assume that the assets set aside specifically to back economic capital requirements are only invested in low-risk cash. However, this is strictly not a requirement, and other investment strategies are also possible. Investing in equities, for example, will be more risky, but will provide a higher return. So on one hand a firm may need extra capital to counter the extra risk of equity investment, but on the other hand, the firm's capital requirement may be less, because of higher expected returns. Again we will not consider alternative investment strategies for assets backing economic capital here and refer interested reader to Porteous and Tapadar (2008b) for a detailed discussion.

4. Deterministic and Stochastic Models

Traditionally, companies have used deterministic models to calculate the level of regulatory capital. This entails individually stressing a particular aspect of risk and checking its effect on the balance sheet. However, this does not indicate the likelihood of such an event and thus is not a probability statement. The problem is compounded when we have multiple, dependent risks as the capital required to mitigate multiple risks is rarely additive. So a suitable model is required which will enable us to study and quantify the impact of risk on the balance sheet in a consistent and coherent way.

Stochastic models enable modelling of key variables along with their inter-dependencies. It is then possible to calculate the effect of multiple stresses and make a probability statement about the firm remaining solvent.

However, stochastic models are not without their disadvantages. First of all it requires parameterisation of the key variables underpinning the risks along with the modelling of the inter-dependencies between these different variables. These make stochastic

models complex to understand and communicate to other parties, including senior management and regulators. In addition, stochastic models also require more computing power and are generally more challenging to implement. However, for a proper assessment of risk, a stochastic model is fundamental to economic capital calculations which will enable coherent modelling of the impact of any risk on any type of firm. In this paper, we will henceforth use the stochastic model developed by Porteous and Tapadar (2005, 2008a, 2008b).

5. Stochastic Model

The model proposed by Porteous and Tapadar (2005, 2008a, 2008b) is a 23-dimensional model, with 21 economic variables and 2 demographic variables, as shown in Figure 1. It uses a graphical model approach to define the inter-relationships between the different variables. In a graphical model, a large multivariate framework is studied in small groups or cliques, generally shown as connected by straight lines. Graphical models are ideal for building a high-dimensional correlation structure from low dimensional conditional dependencies. For example in Figure 1, equity dividend yield is correlated to the cash yield, but only through their respective correlations with the intermediate retail price index variable. Since we are modelling correlations of small groups of variables at a time, the whole model is correlated, but only via a network of smaller tractable clusters. The actual parameterisation of the economic variables is given in Porteous and Tapadar (2005).

Our approach to modelling mortality improvement is to start with the base mortality tables PMA92Base and PFA92Base, for males and females respectively, published by the UK Actuarial Profession in their Continuous Mortality Improvement (CMI) papers. We then project the base tables forward to 2010 using middle cohort improvement factors for these tables published in CMI Working Paper 1. Future stochastic mortality is then handled using the approach of Sweeting (2008) who has developed a pragmatic approach of modelling stochastic uncertainty around a central mortality projection. Please see Sweeting (2008) for further details.

Regarding the choice of this particular stochastic model, the following are worth noting:

- This model can be applied to calculate economic capital for a large variety of financial services firms, since it is defined based on generic relationship between the different variables and are not specific to any particular type of firm.
- There are many stochastic models available in the actuarial literature, and elsewhere, which can be used to quantify risk in financial services entities. Equivalently calibrated stochastic models should produce similar economic capital requirements broadly independent of the choice of stochastic model.

6. Examples

As has been advocated throughout this paper, economic capital as defined here can be employed by any firm in the financial services industry - we will see three such examples in this section. We will only outline the high level assumptions for each. Interested readers can find the detailed assumptions underpinning these examples in Porteous and Tapadar (2005).

6.1 Capital Repayment Mortgage Example

Consider a bank which has just sold a portfolio of retail capital repayment mortgages with an average loan size of £100,000 and term 20 years. It is a variable interest mortgage product where the mortgage yield is modelled stochastically. If we assume that in the long-run the expected mortgage yield is 5.75% and cost of funding is 4.85%, the bank's interest rate margin is 0.90%.

The economic capital at different percentile levels calculated for this portfolio of business (per mortgage sold) is given in Figure 2.

The main features can be summarised as follows:

- More economic capital is required as the percentile levels go up. This is entirely as expected because increased capital indicates a lower probability of insolvency.
- Economic capital falls over time as the portfolio of business runs off the books.
- Initial surge in economic capital levels show the impact of high initial expenses not being recouped from future profit streams.

It must be noted though that not all banks will price their retail mortgage product the same way, and not all banks will have the same cost of funding their mortgages. For example, a large reputable bank might find it easier to arrange for cheaper funds. It may also have the strength of its brand name to charge a higher than existing mortgage yields. For this bank, the economic capital requirement will be lower at all percentile levels with very little risk of insolvency.

It is then possible for all interested parties to be able to compare the actual capital holding of any bank in the mortgage business with the economic capital at different percentile levels, thus obtaining a good perspective of the financial health of these banks. Regulators will have to consider what this means for the security of the customers. Customers will have to weigh up the advantages of low mortgage yield with the risk of a bank going insolvent. Credit rating agencies will find rating banks according to their financial strength much easier. And shareholders will have the choice to decide

whether to invest in a risky venture where the prospect of returns is greater but which has a greater chance of default.

6.2 Lifetime Mortgage Example

We will next consider a financial services firm, either a bank or a life insurance company, selling a portfolio of equity release lifetime mortgage product to couples, who own high-valued illiquid assets, like property, but have low running incomes. For our example, we will assume that a bank is selling this product to married couples with average age 65 years and with an average property worth £250,000. The bank provides a mortgage of 50% of the property value at an interest rate of 6.5% taken out on a joint life basis. The loan can be repaid any time. If not repaid, once both lives die, the bank takes possession of the property, sells it, recoups its loan and repays any balance to the couple's estate. The risk that the value of the loan exceeds the house price, also called No-Negative Equity Guarantee (NNEG), is taken on by the bank. Suppose for this portfolio of business the bank's long-term cost of funding is at a higher expected level of 5.5% reflecting the greater uncertainty involved, leaving an expected margin of 1% for the bank.

The economic capital at different percentile levels calculated for this portfolio of business (per lifetime mortgage sold) is given Figure 3. Contrasting the economic capital levels with those of the retail mortgage product, we find:

- Similar general features, like economic capital increasing with percentile levels and for each level, economic capital falls as the business runs off the books as customers leave the cohort through loan repayment or death.
- The product has a longer term, as is evident from the long run-off period.
- Unlike the retail mortgage graph, the economic capital graphs for lifetime mortgages peaks at around 23 years. As the rate of interest on mortgage is set at a much higher level compared to long-term expected house price inflation, it is around this time and beyond when the NNEG bites.

Of course as before, pricing and cost of funding will be different for different banks and will be reflected in the economic capital levels. However, now it becomes possible for all interested parties to compare the risks across different lines of business even if written by similar financial institutions, banks in this example. The capital employed against economic capital levels can be meaningfully compared across different lines of business and shareholders can weigh up risk and return across different business ventures.

6.3 Life Insurance Annuity Example

Finally, we will consider the economic capital requirements for a life insurance firm selling a portfolio of annuities. We will assume that the annuities are taken on a joint-life basis by customers aged 65, paying a single premium of £250,000. In return, a level annuity of £1,500 per month is paid until both lives have died. For the purpose of this example, we will assume that the life insurance firm invests the premium in long term UK corporate bonds.

The economic capital at different percentile levels calculated for this portfolio of business (per annuity sold) is given in Figure 4. Contrasting the economic capital levels with those of previous two examples, we find:

- The level of economic capital varies from one product line to another. For annuities, per policy economic capital is much higher than for both capital repayment and lifetime mortgages. This is not unexpected as the amount of risk involved and assets under management are much higher for each annuity sold.
- The economic capital graphs for all the firms considered have similar qualitative features while being quantitatively different. This is precisely what is expected as the principles underlying the calculations are the same, but the capital required to back different sources of risks are different.

7. Applications

In this section, we will consider two applications of economic capital as a risk management tool. Firstly, we will demonstrate that traditional solvency driven deterministic approaches to an annuity firm's asset allocation can yield sub-optimal results in terms of minimising economic capital. Secondly, we will quantify the diversification benefit of a financial services conglomerate by showing that the aggregate economic capital of a conglomerate operating a range of businesses is significantly lower than the sum of the constituent parts.

7.1 Impact of asset allocation strategies on economic capital

Traditionally, life insurance firms have tended to manage the asset allocation of their businesses at the firm-wide level across all business lines. Managing published solvency under existing regulatory rules applying to the firm has usually been a key consideration in firms' asset allocation strategies. As is now acknowledged, life insurance firm regulations can be somewhat ad-hoc and arbitrary and, in particular, regulatory capital requirements may not have been well aligned with economic capital.

As a consequence, allocating assets to achieve certain published solvency targets will usually not have a genuine risk rationale.

To examine how a capital constrained firm can allocate its business assets to minimise its economic capital requirement, we will extend the life insurance annuity example, in section 6.3, and analyse the effect of allocating business assets to a range of mixes of long term corporate bonds and equities. Figure 5 shows 99.5th percentile economic capital curves for a range of business asset mixes.

We first note that, as business assets are switched out of bonds and into equities, two counteracting effects occur. Firstly, equity returns being more volatile than bond returns, the volatility of the firm's market value balance sheet increases, resulting in higher economic capital requirement. Secondly, higher expected equity returns increases the returns on business assets resulting in reduced economic capital requirement. Whether the overall economic capital increases, or decreases, as business assets are switched out of bonds and into equities, depends on which of these two effects dominate.

Figure 5 shows that economic capital is generally high when the bulk of business assets is allocated to equities, rather than to bonds. The one exception to this is when business assets are invested 75% in bonds and 25% in equities. In this case, it can be seen that economic capital falls at most durations, beyond the short durations, relative to 100 per cent bond investment. That is, the higher expected asset return effect is dominant, except at short durations, and a small proportion of equity investment can actually reduce risk.

We are able to conclude that a capital constrained life insurance annuity firm can actually reduce risk by switching a small proportion of its business assets out of bonds and into equities. It is interesting to note that this type of asset allocation decision is not at all common in the market and challenges the conventional wisdom that the assets backing life insurance annuities should be invested in low risk, bond-type assets.

7.2 Economic capital of a financial services conglomerate

As not all financial products are susceptible to the same sources of risks at the same time, a particular stress scenario for one product may not turn out to be adverse for another. In this section we will show that the aggregate economic capital for a range of financial products is significantly lower than the sum of the economic capitals of the individual products involved. A financial services congomerate operating in a range of business lines can take advantage of the resulting diversification benefits and reduce their aggregate economic capital requirement.

To examine economic capital of a financial services conglomerate, consider a firm offering a lifetime mortgage product through its banking operation, while selling annuities through its life insurance arm. We will assume that the underlying assumptions for both the lifetime mortgage and annuity contracts are as provided in section 6.

Given that the per policy economic capital of an annuity contract is significant greater than per policy economic capital of a lifetime mortgage contract, we will assume that the conglomerate sells nine lifetime mortgage contracts for each annuity contract sold. This is to ensure that the large risks inherent in an annuity contract do not completely swamp the risks underlying a lifetime mortgage contract.

For this firm, we calculate the standalone total economic capital as the sum of the economic capital of the individual subsidiaries – the bank and the life insurer. We also calculate the aggregate economic capital of the entire conglomerate, taken as a single entity, by considering the combined cashflows. The 99.5th percentile standalone and aggregate economic capital are shown in Figure 6. We observe that the aggregate economic capital is less than half of the standalone economic capital required to back the combined risks of a lifetime mortgage and an annuity contracts.

We conclude that the diversification benefits for a financial services conglomerate operating in a range of financial services sectors are indeed substantial, with large reductions in the economic capital requirement and enhanced returns for the capital providers.

8. Conclusion

In this paper, we have discussed, a coherent approach to quantify an adequate amount of economic capital required to back business risks. We have demonstrated, using examples, that economic capital gives us the flexibility to compare financial strength across business lines and across financial sectors benefiting various stakeholders in the financial services industry, from regulators to management to customers. We have also shown applications of economic capital as a risk management tool to arrive at optimal asset allocation strategies as well as quantifying diversification benefits of operating a wide range of financial services products. This demonstrates the enormous potential of economic capital to unify the whole financial services industry and bring the entire sector under an overarching umbrella.

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Figure 1: Graphical model of economic and demographic variables.

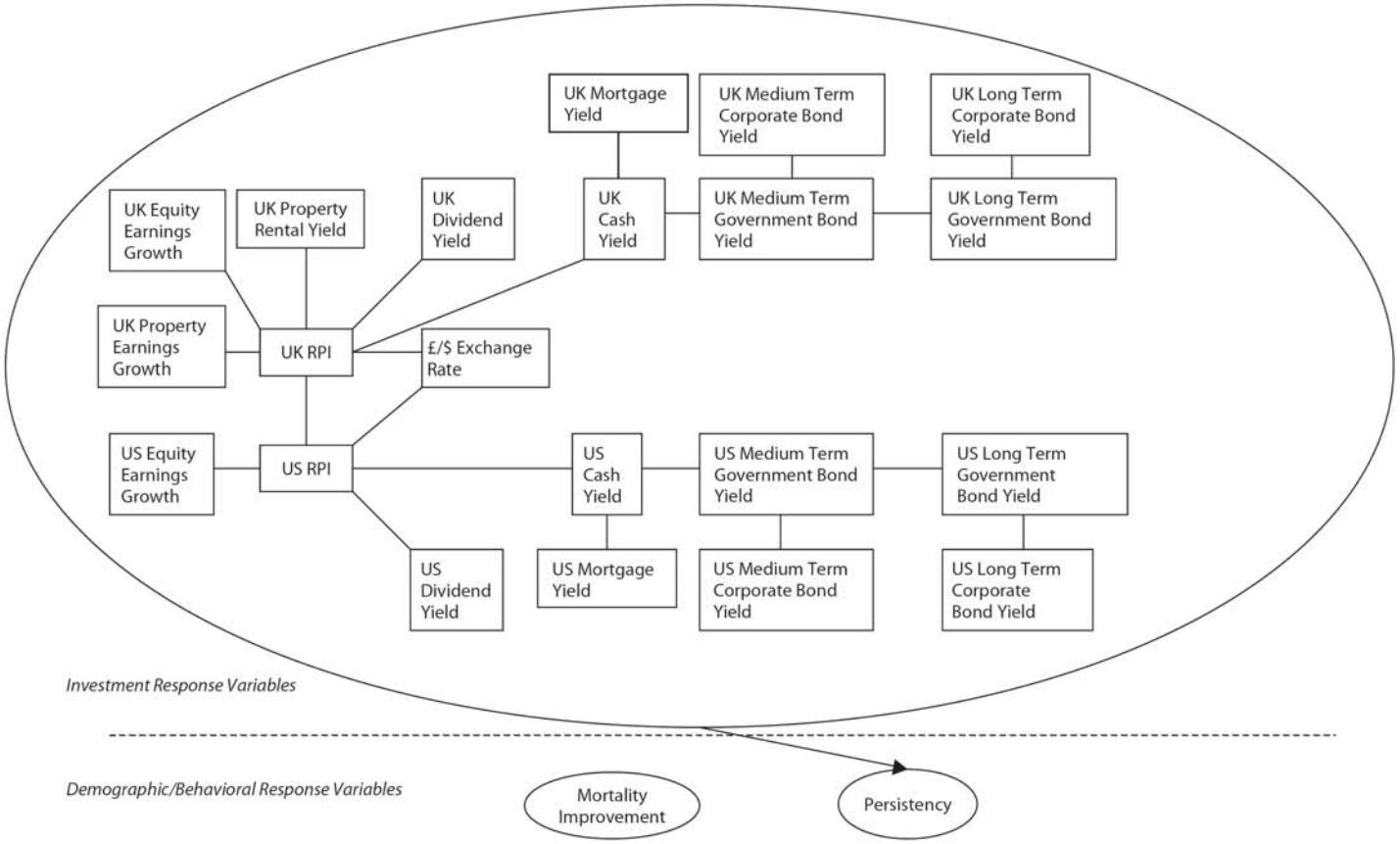

Figure 2: Capital Repayment Mortgage Economic Capital.

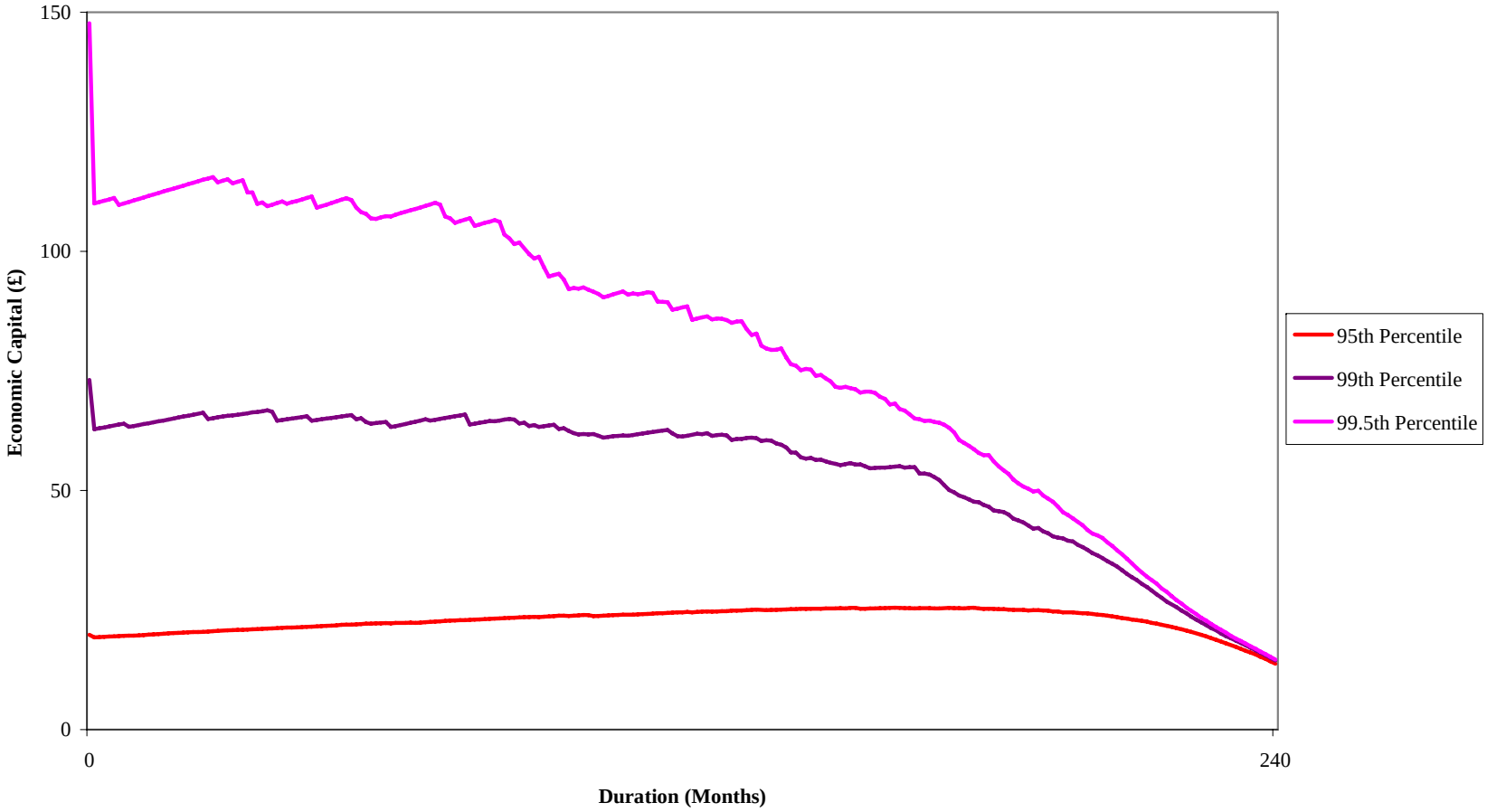

Figure 3: Lifetime Mortgage Economic Capital.

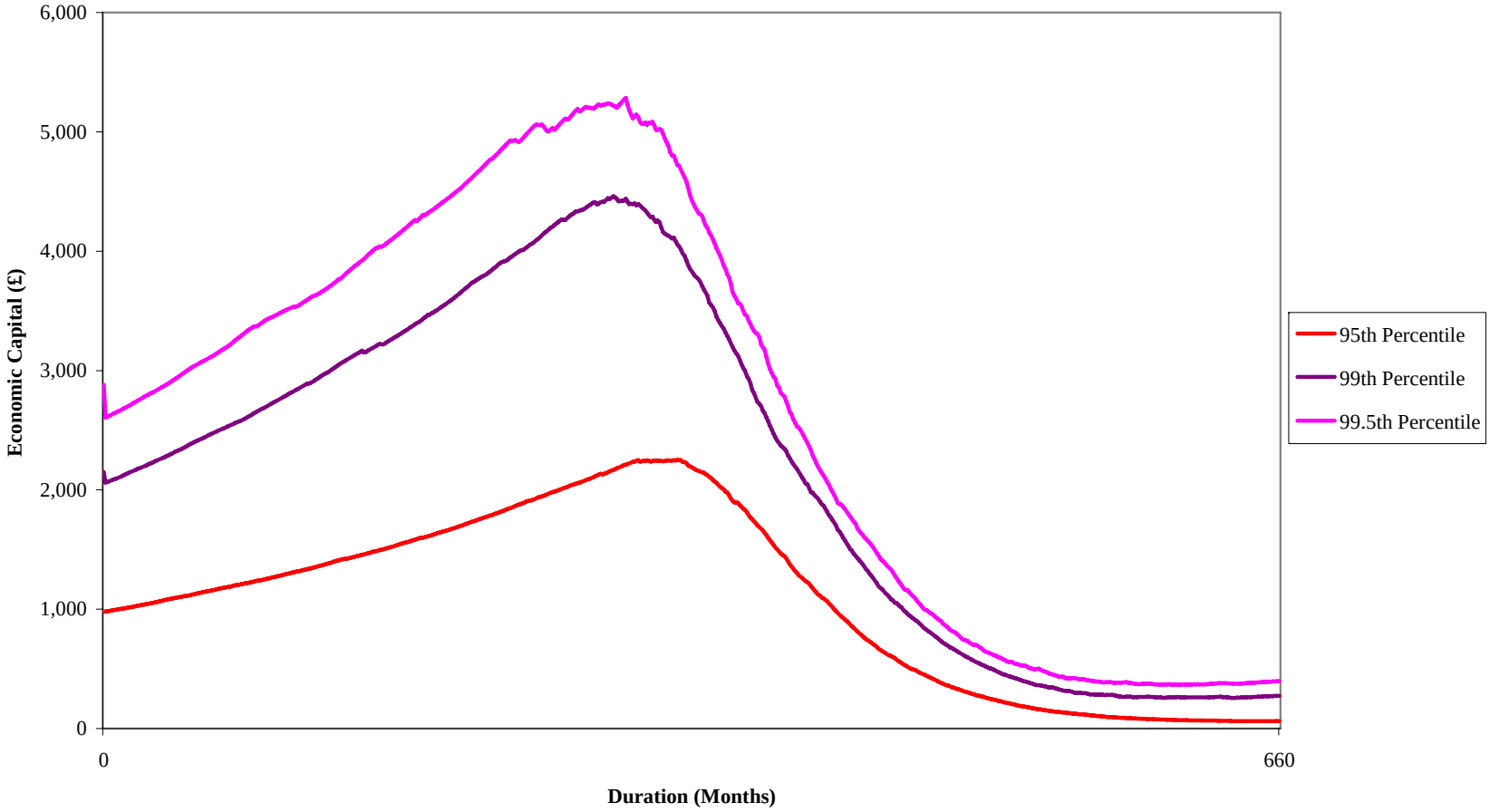

Figure 4: Life Insurance Annuity Economic Capital.

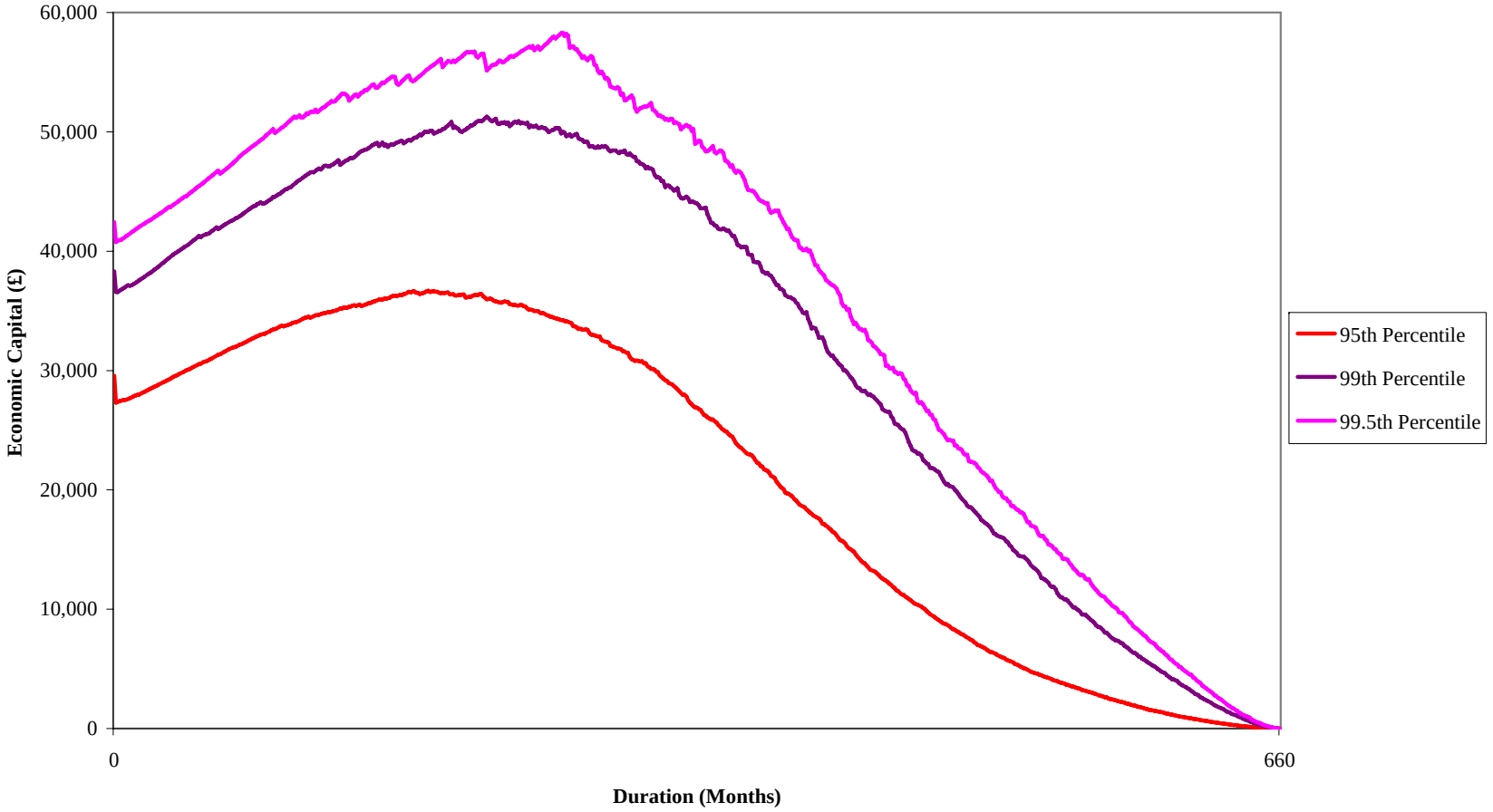

Figure 5: Impact of Asset Allocation on 99.5th percentile Economic Capital.

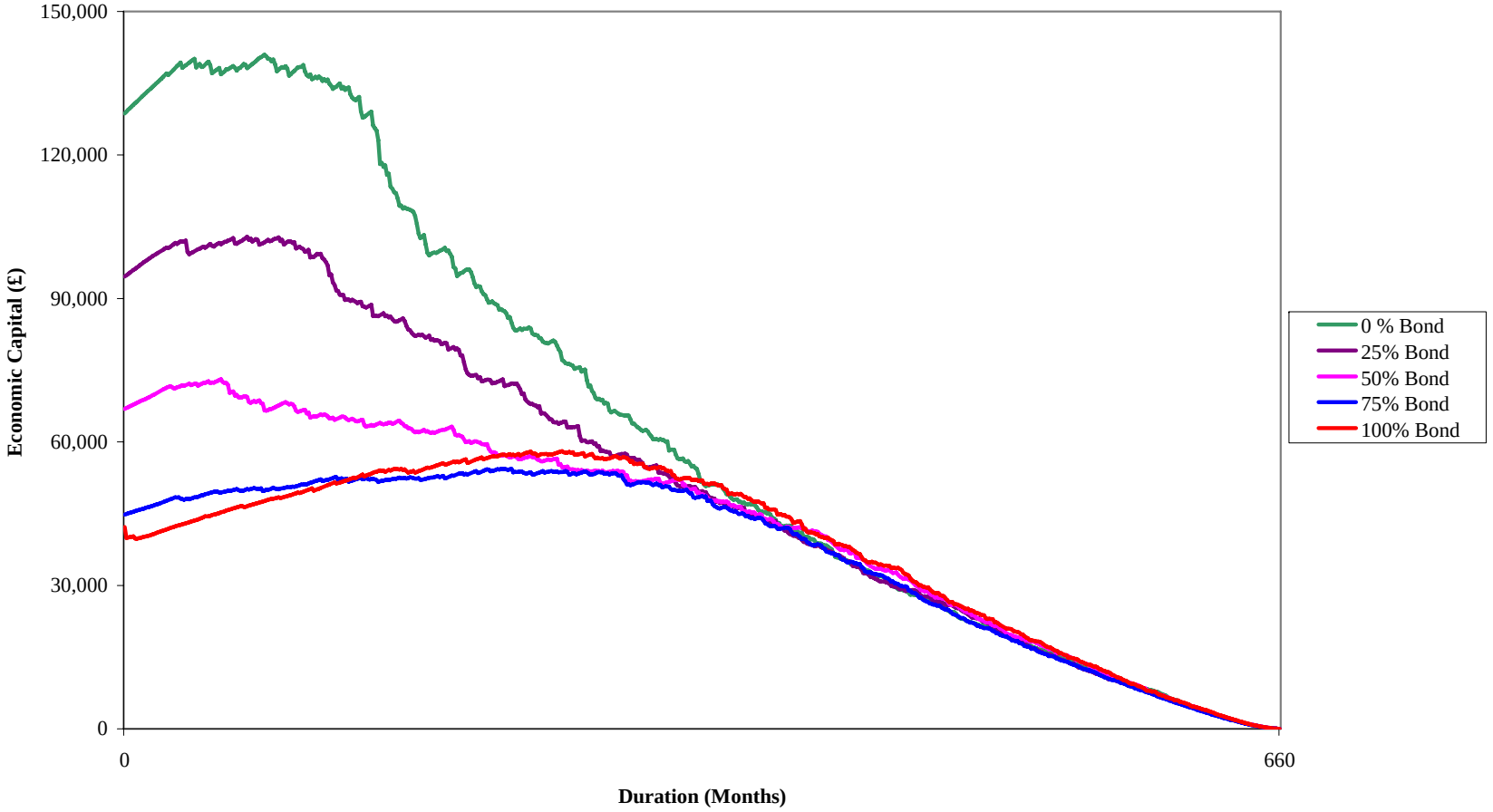

Figure 6: Conglomerate example: Standalone versus Aggregate Economic Capital.