Prepared by:
Joshua Corrigan
FIA, FIAA, CFA

Reviewed by:
Gary Finkelstein
FIA, ASA

October 2009

Implications of Solvency II for Product Development

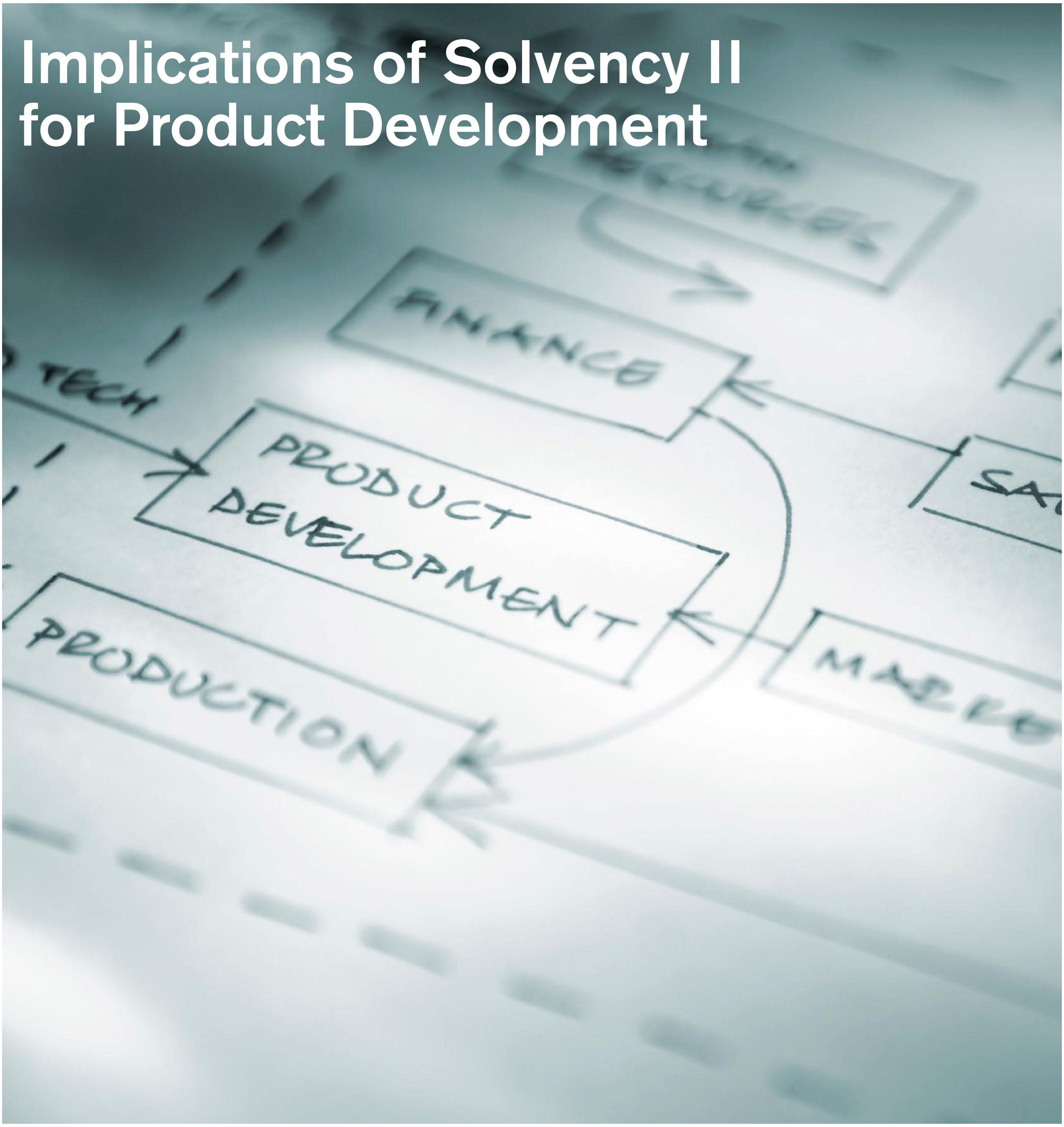


TABLE OF CONTENTS

ACKNOWLEDGEMENTS

I would like to thank the following Milliman consultants for their time and valuable feedback in helping with this report.

Henny Verheugen
Jeremy Kent
Jerome Nebout
Eric Serant
Gary Finkelstein

1. INTRODUCTION

This research report examines the role of capital in the product development process, and specifically the impact that Solvency II developments are likely to have on product development throughout the European Union (EU) over the coming years.

Capital plays an important part in the product development and risk management process, but it is likely to become significantly more so under Solvency II compared to the current Solvency I regime.

Capital plays an important part in the product development and risk management process, but it is likely to become significantly more so under Solvency II compared to the current Solvency I regime. This report is thus relevant to anyone involved in the areas of product development, risk management, or capital assessment.

The sale of insurance products involves a transfer of risk from the policyholder to the insurer in return for a fixed known price. Various risk management techniques can then be used by an insurer to mitigate some of these risks. However, there are always residual risks left. Economic capital is required to support these residual risks, with the amount held being a function of residual risk exposures. Solvency capital, however, is that amount of capital that is required to be held by the regulatory authority, whose ultimate purpose is to provide security to policyholders in the event of subsequent adverse events affecting the company's ability to meet policyholder obligations. One of the primary purposes of Solvency II is to better align solvency capital to economic capital, in order to reduce the market distortions that arise from any differences. This alignment will help level the playing field for companies to determine appropriate pricing margins such that they meet their required return on capital for the business.

Prices of insurance products should be set such that they:

- meet the economic cost of the policyholder benefits
- meet acquisition and maintenance expenses
- provide a return on shareholder capital at the rate demanded by the market for the residual risks involved
- maximise the franchise value of the firm

Traditional actuarial science has largely focused on determining the first two components, which can be determined quite objectively using standard actuarial techniques. Whilst not identical, solvency capital is closely related to total shareholder capitalisation, with the difference between the two being a measure of the firm's franchise value (ignoring other potential sources of net assets). To the extent that solvency capital can be reduced, franchise value will increase and lead to more attractive pricing terms.

The risk premiums demanded by investors are a critical factor in pricing, which should be directly related to the residual risks of the relevant product. Shareholders demand different risk premiums for different types of insurance risks, for example as illustrated in the pricing of catastrophe and mortality bonds. However, assessment of these risk premiums is unfortunately beyond the scope of this paper.

Lastly, to the extent that the market is able to bear it, any excess margins above what is required to meet the first three components above would help to meet the fourth objective of maximising franchise value.

2. OVERVIEW OF SOLVENCY II

2.1 Impact of Solvency II on Product Development

Under the proposed Solvency II standard, the balance sheet of an insurance entity will be assessed on a market-consistent basis: Both assets and liabilities (i.e., reserves) are valued consistently with market-based valuations. Reserves are set as the sum of best estimate market-consistent liabilities plus a risk margin to cover the cost of capital in transferring the liabilities to a third party. In addition to these liabilities, solvency capital is required such that it is sufficient to cover expected losses from a 1-in-200-year event over a one-year time horizon. This is the Solvency Capital Requirement (SCR).

Solvency II is a significant modernisation of the standard relative to Solvency I. Solvency I requires a fixed capital charge of 4% of reserves for all guarantee product classes, or 1% for non-guarantee product classes such as unit-linked products. These capital requirements are independent of the actual levels of risks in the products and the risk mitigation strategies that companies employ. The consequence of this is that there is little to no incentive for insurers to price and manage risks appropriately, which leads to higher systematic risk in the insurance industry.

Consequently, under Solvency II companies have a strong incentive to align their pricing, risk, and capital management decisions. The new framework is designed with this incentive in mind, with the result being a more robust insurance industry. With the same framework being adopted throughout all EU countries, it will hopefully lead to a levelling of the playing field, which will foster competition that will benefit the end consumer.

Under Solvency II companies have a strong incentive to align their pricing, risk, and capital management decisions.

2.2 Broad Solvency II Capital Framework

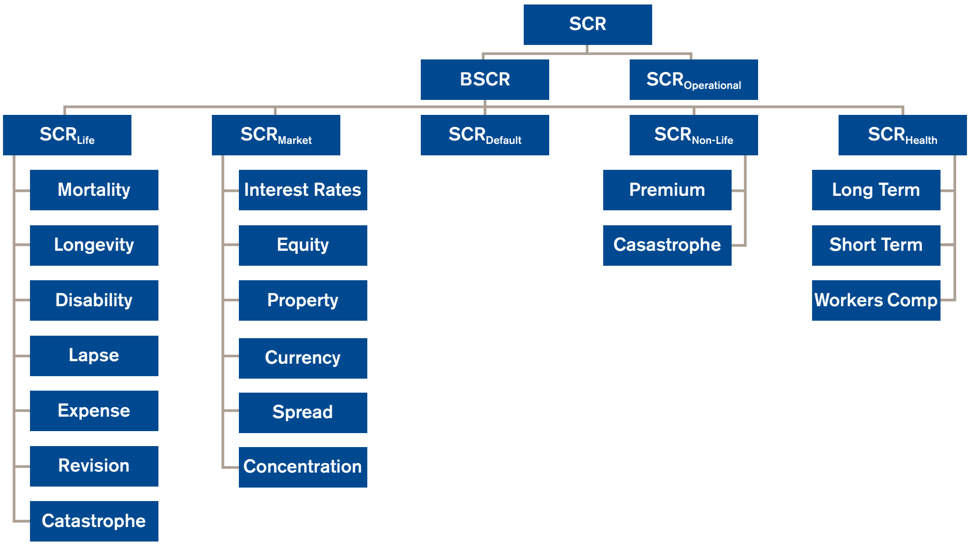
The SCR can be determined using either the standard formulaic approach or via the use of internal models. The formulaic approach derives the SCR from various modules relating to each risk factor. These modules translate the impact of a stress for each risk factor into a capital charge for each risk. Capital charges are calculated for each risk category, and then aggregated in a two-step approach linked to the modular structure:

1. All risks belonging to the same major risk category are combined, e.g., equity, property, interest rate, currency, and spread risks are aggregated using a correlation matrix to produce an overall market risk charge.

2. The major risk categories (market, non-life, life, default, and health) are combined using another correlation matrix to arrive at an overall basic SCR (BSCR).

The flowchart in Figure 1 shows the overall structure of the SCR with respect to each risk factor component.

FIGURE 1: RISK CATEGORY AND RISK FACTOR STRUCTURE OF THE SCR



Capital requirements are derived at the level of individual risk factors or risk modules. This involves applying an immediate shock to the relevant risk factor and revaluing the liabilities and assets on an economic, market-consistent valuation basis. The resulting change in the net asset position of the economic balance sheet reflects the risk capital that is required to be held against each risk factor.

The parameters and assumptions used for the calculation of the SCR are intended to reflect a VaR risk measure calibrated to a confidence level of 99.5% and a time horizon of one year. To ensure that the different modules of the standard formula are calibrated in a consistent manner, these calibration objectives have been applied to each individual risk module, while also taking account of any model error arising from the particular technique chosen to assess that risk.

Where hedging is in place, the change in the value of hedging assets is allowed to be taken into account in offsetting the impact from the change in liabilities.

For the aggregation of the individual risk modules to an overall SCR, linear correlation techniques are applied. The setting of the correlation coefficients is intended to reflect potential dependencies in the tail of the distributions, as well as the stability of any correlation assumptions under stress conditions.

The main risk factors relevant for variable annuity (VA) products include market, life, counterparty default, and operational risks. Non-life and health risk modules are rarely if ever relevant for these products.

The main technical challenges in the application of Solvency II relate mainly to the calculation of operational risk, risk margins, and the use of internal models for market risk.

The main technical challenges in the application of Solvency II relate mainly to the calculation of operational risk, risk margins, and the use of internal models for market risk.

For a further, more detailed discussion on the stresses applied to each risk module, refer to Milliman (2007) and the CEIOPS QIS4 Technical Standards (2007). The recent calibration suggested by CEIOPS in their consultation papers was not considered in the analysis.

3. ILLUSTRATIVE CAPITAL REQUIREMENTS USING THE STANDARD FORMULA APPROACH

3.1 Illustrative Products

In order to illustrate how the Solvency II SCR standards can be applied to various products, we have undertaken some indicative analysis on a few of the most important products used in the post-retirement market space. The products included are:

- Fixed annuity for life
- Variable annuity with guaranteed minimum withdrawal benefit for life (GMWB) and a three-year ratchet[1]

The fixed annuity for life product provides a fixed monetary amount that is payable each year to the policyholder whilst they are alive. No death benefit is payable under this simplified version of the product.

In contrast, the GMWB product allows policyholders access to their capital, which is invested in a range of managed funds whilst guaranteeing that they will be able to withdraw a certain amount each year for the remainder of their lives, even if the account value reaches zero. The ratchet feature enables the amount of the withdrawals to increase over time in the event that the underlying funds perform well.

Both of the above products can be used to meet post-retirement needs. In order to ensure a consistent comparison, we consider a 65-year-old male at retirement age, who invests a single premium of 100,000 and starts making immediate withdrawals.

Based upon early 2009 European capital market conditions, German mortality,[2] and typical policyholder behaviour assumptions,[3] a fixed annuity rate of around 7% could be offered, whilst a 4.5% GMWB guaranteed benefit level could also be offered for an additional charge of 1% p.a. For the purposes of this illustration, we have assumed an indicative asset allocation for the GMWB of 50% European equities and 50% European bonds.

3.2 Product Risks and Risk Management Strategies

From the insurer's perspective, both the fixed annuity guarantee and the guarantee rider component of the GMWB are general account business for which the insurer is subject to asset-liability risk. Consequently they require diligent risk management techniques for managing the risks. The table in Figure 2 shows the source of the risks involved in these two products.

From the insurer's perspective, both the fixed annuity guarantee and the guarantee rider component of the GMWB are general account business for which the insurer is subject to asset-liability risk.

1 This is consistent with the product used in Ledlie et al. (2008), with an updated guaranteed benefit level.
2 Based upon 100% of DAV2004R with T1=5 and T2=10.
3 For the GMWB, 5% lapse rates with dynamic lapses have been used.

FIGURE 2: RISK SOURCES BY PRODUCT		
RISK FACTOR	FIXED ANNUITY	GMWB FOR LIFE
EQUITY MARKET	NONE	SIGNIFICANT
INTEREST RATES	SIGNIFICANT	SIGNIFICANT
CREDIT SPREAD	MODERATE	LOW
VOLATILITY	NONE	MODERATE
LONGEVITY	SIGNIFICANT	MODERATE
POLICYHOLDER BEHAVIOUR	NONE	MODERATE
DEFAULT	MODERATE	LOW
OPERATIONAL	LOW	MODERATE

The fixed annuity product transfers significant interest rate and longevity risk to the insurer. In order to deal with these risks, insurers typically use corporate bonds investments to support the liabilities.

The fixed annuity product transfers significant interest rate and longevity risk to the insurer. In order to deal with these risks, insurers typically use corporate bonds investments to support the liabilities. These are typically investment-grade securities that are chosen to broadly match the duration profile of the liability. This exposes the insurer to credit spread and default risk. Perfect cash flow matching is not possible however, and there typically exists some residual risks such as interest rate term structure, credit spread, and default risks. Some companies may also choose to use interest rate swaps to achieve a closer match to reduce interest rate term structure risk further.

Based upon a sample analysis of some of the major European insurance company bond portfolios, we have assumed the allocations shown in Figure 3 as indicative credit exposures for the portfolio:

FIGURE 3: INDICATIVE CREDIT RATING PROFILE OF BOND PORTFOLIO	
CREDIT RATING	ALLOCATION
AAA	14%
AA	32%
A	36%
BBB	19%

Longevity risk is typically the dominant risk factor for fixed annuity writers. Reinsurance currently remains the predominant form of protection against this risk, although mortality bonds and other derivatives are starting to become a realistic alternative solution for transferring this risk to the capital markets, with a number of longevity swap transactions having taken place in the UK in 2008/09. Diversification within the book itself, in terms of age, gender, geographic location, etc., is also an important risk mitigation technique. Operational risks involved in managing a fixed annuity book are considered to be relatively low given the simplistic nature of the product and risk management strategy.

For the guaranteed rider component of the GMWB, equity market and interest rate risks are the dominant source of risk in the product. These risks can be and are typically hedged using liquid futures, forwards, and interest rate swap derivatives. Options may also be used to provide protection against volatility risk as well as potentially other second-order risks such as gamma and gap risk. Policyholder behaviour risks such as dynamic lapse rates are also a key concern for GMWB writers. Longevity risk is a moderate risk as it manifests itself only in those scenarios where markets perform poorly and the policyholder lives a long time, causing the policyholder to run out of money. Also, the size of the claim payments is likely to be smaller relative to the fixed annuity (e.g., 4.5% compared with 7%). Compared to fixed annuities, operational risk could be considered to be relatively higher (i.e., moderate), which is due primarily to the complexity of the risk management strategy centred upon hedging.

For the analysis undertaken in this report, we have examined two alternative hedging strategies: a delta-rho strategy involving futures and swaps, and a delta-rho-vega strategy involving futures, swaps, and vanilla options.

For the analysis undertaken in this report, we have examined two alternative hedging strategies: a delta-rho strategy involving futures and swaps, and a delta-rho-vega strategy involving futures, swaps, and vanilla options.

Figure 4 shows an indicative Solvency II economic balance sheet for a GMWB product, based upon an initial premium of 100,000.

FIGURE 4: GMWB SOLVENCY II ECONOMIC BALANCE SHEET

ASSETS		LIABILITIES	
UNIT ASSETS	100,000	UNIT LIABILITY	100,000
CASH	2,454	LOANS (FOR OPTION PURCHASE)	500
FUTURES	0	GUARANTEE LIABILITY	
INTEREST RATE SWAPS	0	– BEST ESTIMATE	0
OPTIONS	500	– PRICING MARGINS (PVIF)	- X
		RISK MARGIN	687
		SHAREHOLDER CAPITAL	
		ECONOMIC CAPITAL (SCR)	1,767
		ADDITIONAL SHARE CAPITAL	X

The underlying unit liabilities are perfectly matched against the unit assets. The value of the guarantee liability is decomposed into the best estimate liability plus a risk margin to cover the cost of non-hedgeable risks. The best estimate liability is zero at the start of the contract when assessed on a net premium basis (PV Claim – PV Premiums) and where the premiums used reflect the pure hedge cost excluding pricing margins. This valuation is undertaken on a stochastic market-consistent basis. The risk margin is calculated based upon a cost of capital approach, which is discussed in Section 3.5 below. The present value of in-force (PVIF) reflects the value of any positive pricing margins (shown as a negative liability). In this indicative example, the PVIF has not been calculated but rather represented by the variable *x*. The modelling of the PVIF of the base product requires more detailed cash flow modelling of these products, which is beyond the scope of this paper.

The value of futures and interest rate swap positions at the start of the contract is zero, despite a position being held that has risk exposures that match those of the guarantee liability. If options are used in the hedge, they will have a positive value at outset. As option premiums are usually financed through borrowing, a loan liability of an equivalent amount is also shown.

Shareholder capital is decomposed into that required, reflected by the SCR and additional share capital held above this for prudence. This is indicative only.

Figure 5 below shows an indicative Solvency II economic balance sheet for a fixed annuity product based upon a premium of 100,000.

FIGURE 5: FIXED ANNUITY SOLVENCY II ECONOMIC BALANCE SHEET

ASSETS		LIABILITIES	
CORPORATE BONDS	87,779	ANNUITY LIABILITY	
CASH	21,819	– BEST ESTIMATE	87,779
INTEREST RATE SWAPS	0	– PRICING MARGINS (PVIF)	-Y
		RISK MARGIN	10,038
		CAPITAL	
		ECONOMIC CAPITAL (SCR)	11,781
		ADDITIONAL SHARE CAPITAL	Y

Similarly to the GMWB balance sheet, the annuity liabilities can be decomposed into the best estimate liabilities and a pricing margin, as well as the risk margin to cover the cost of non-hedgeable risks. The best estimate liability and pricing margin for the product can be determined on a deterministic basis if there is a perfect cash flow match, or by using stochastic techniques if there is an element of reinvestment risk. Mortality is also increasingly being modelled on a stochastic basis. The risk margin is determined with respect to the residual non-hedgeable risks.

The majority of the initial premium is used to fund the purchase of a corporate bond portfolio to support the best estimate liability. Interest rate swaps may also be used to minimise any residual interest rate term structure risk. Any residual cash left over is used to help finance the initial capital strain. Additional share capital (Y) is held above economic/solvency capital.

3.3 Indicative SCR Calculations

We have assessed the SCR for the two general account products on both an unhedged and a hedged basis. The unhedged results provide a useful point of comparison from which to compare the impact that the risk management strategy has upon the SCR. The unhedged strategy for both the fixed annuity and GMWB is defined as an investment in cash, which is insensitive to all risk factors on an instantaneous stress basis.

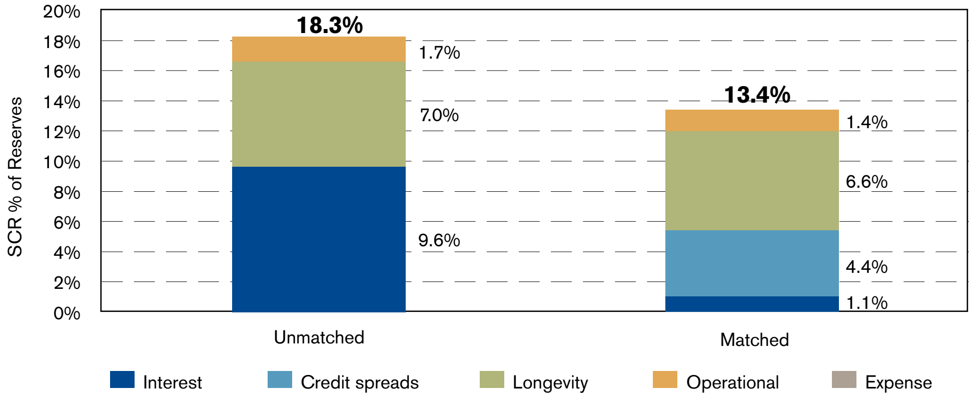
In calculating the capital requirement for each risk factor stress, we have focused on the impact on the value of the guarantee liabilities and the corresponding hedge assets.

In calculating the capital requirement for each risk factor stress, we have focused on the impact on the value of the guarantee liabilities and the corresponding hedge assets. The impact upon the embedded value/PVIF of the base product, which is an intangible, has not been taken into account.

SCR results have been derived using the standard formulaic method. The results are shown as a percentage of reserves (i.e., mathematical reserves for the guarantee and unit reserves for the GMWB).

Figure 6 shows the SCR results for the fixed annuity products, broken down into their risk factor components for each investment strategy. The unmatched basis assumes that the liabilities are backed by cash, whilst the matched basis assumes that the liabilities are backed by a corporate bond portfolio of equal duration. Note that the diversification effects have been prorated back across each risk factor in order to estimate risk factor contributions to the total SCR result.

FIGURE 6: SCR RESULTS FOR FIXED ANNUITY PRODUCT BY INVESTMENT STRATEGY



The analysis in Figure 6 shows that there is a significant reduction in interest rate risk, which is due to the use of fixed income investments. However, corporate bonds introduce credit risk, which forms a residual risk to the company. Longevity risk is a significant contributor to the overall SCR result. Note that the diversification benefit has been prorated back across each risk factor in order to determine the risk factor contributions.

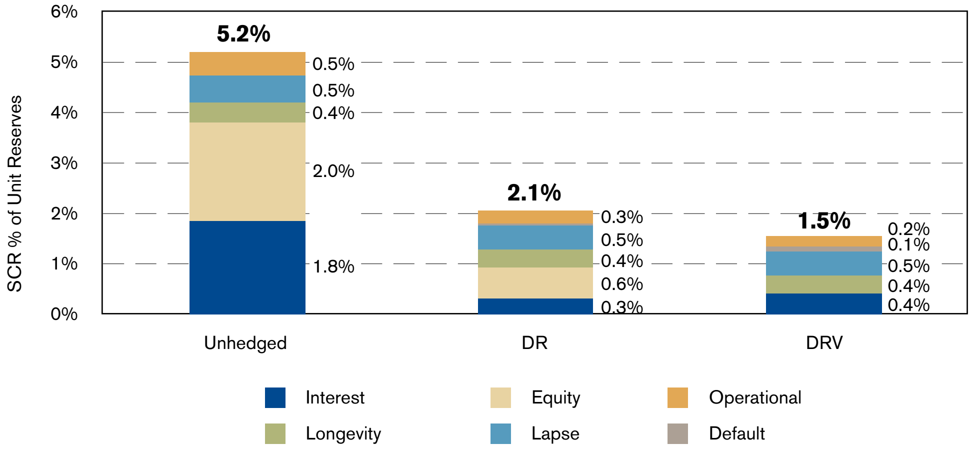
So, at face value, it appears that fixed annuity products are likely to be significantly more capital-intensive than GMWB products under Solvency II.

At face value, it appears that fixed annuity products are likely to be significantly more capital-intensive than GMWB products under Solvency II.

However, it should be noted that moving from a Solvency I world where capital requirements are 4% of reserves to a Solvency II one where capital requirements for a fixed annuity are circa 13% does not necessarily mean that insurers will need to inject an additional 9% of reserves to meet the shortfall. This is because, under Solvency I, liabilities are calculated on a prudent basis, which leads to additional reserves above the best estimate basis needed for Solvency II. As a consequence, these additional margins are effectively simply being moved around the balance sheet, reducing liabilities and increasing capital, with little overall change in total assets start.

Figure 7 shows the SCR results for the GMWB product, broken down into its risk factor components for each hedge strategy.

FIGURE 7: SCR RESULTS FOR GMWB PRODUCT BY HEDGE STRATEGY

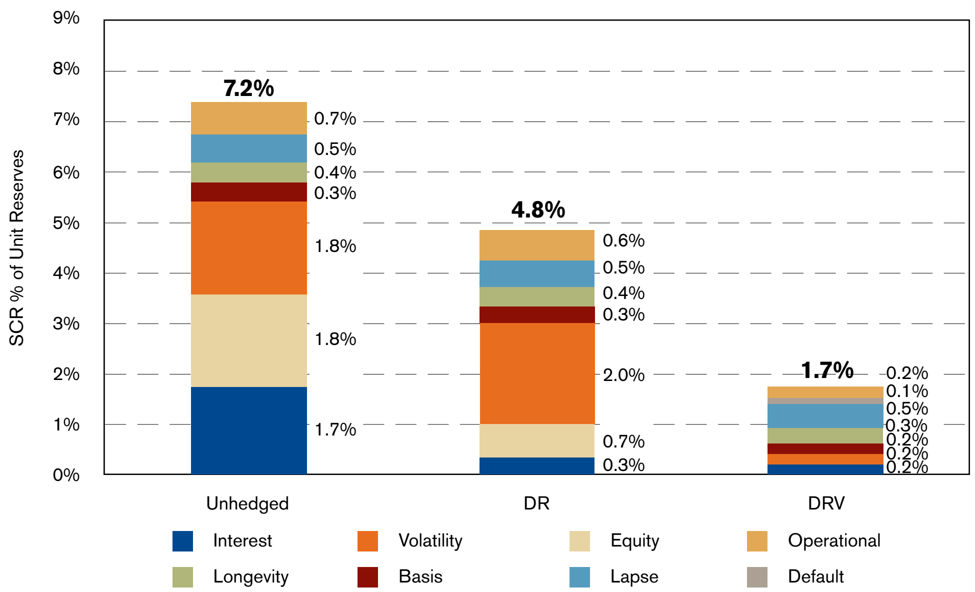


This shows that there is a significant reduction in the SCR from hedging. Equity and interest rate risks in particular are reduced significantly. The reduction from the delta-rho (DR) to the delta-rho-vega[4] (DRV) strategy is due to the mitigating impact on equity risk that the use of a put option has. Note that the diversification benefit has been prorated back across each risk factor in order to determine the risk factor contributions.

One of the limitations of the standard forumla approach is that under the QIS4 guidelines, there are no accounts for either volatility or basis risk. Examples of other risks not in the SCR include cross-Greek risks and correlation risks. In order to account for this, we have modified the above SCR calculation to incorporate these risk factors, based upon a relatively simple +10% absolute shock to implied volatilities, and a 3% shock to all fund exposures (hedge index levels remain constant). Note that these stresses are indicative only.[5] Basis risk is assumed to be independent of all other risk factors, whilst volatility risk is assumed to be strongly positively correlated to other market risk factors. The graph in Figure 8 presents a modified SCR result for the GMWB product on this basis (the fixed annuity product remains unchanged).

Basis risk is assumed to be independent of all other risk factors, whilst volatility risk is assumed to be strongly positively correlated to other market risk factors.

FIGURE 8: MODIFIED SCR RESULTS FOR GMWB PRODUCT BY HEDGE STRATEGY



Under this measure it is clear that volatility risk is a material risk that is left exposed under an unhedged or DR-hedged basis. The DRV hedge, however, is very effective at mitigating this risk, resulting in a capital requirement of slightly below 2%. Notably, the largest risks contributing to this result relate to lapse and longevity risk, with the residual capital market risks being negligible. The impact of this result clearly needs to be weighed against the additional cost involved in vega hedges, as well as the risk involved in paying for protection during times of higher market-implied volatility.

4 This strategy also partly mitigates convexity or gamma risk.

5 Stresses to other risk factors may also be included to the extent that they are relevant and material on a product-by-product basis.

3.4 Operational Risk

The standard formula for operational risk is somewhat meaningless in the context of new business including for variable annuity guarantees. This is because it provides a result of zero, which is due to the fact that technical reserves and earned premium are zero at time zero. As a consequence of this, we have used the following simplified assumptions for the BSCR gross-up factors in this analysis:

- 10% unhedged for both the fixed annuity and the GMWB product
- 12% for the fixed annuity backed by a portfolio of corporate bonds, reflecting the additional risk involved in managing the investment portfolio
- 15% for the hedged GMWB product, reflecting the additional risk in managing a portfolio of derivatives

As a consequence of the limitations of the standard formula for operational risk in this product class, the use of internal models is likely to provide a significantly more meaningful capital requirement as well as being a valuable tool in the ongoing management of operational risk.

The assessment of operational risk for variable annuity business involves a detailed analysis of the sources of risk, the likelihood and severity (i.e., distribution) of losses arising in the following areas:

- Administration processes
  — use of manual, labour intensive work
- Administration system
  — policy administration
  — unit pricing
- Hedge processes
  — liability management including model calibration
  — trade execution
  — hedge management
  — back-office trade validation and processing
- Hedge systems
  — liability valuation systems
  — hedge valuation
  — hedge management
  — trade execution
- Governance
  — financial reporting and performance attribution systems and processes
  — hedge strategy decisions
  — key person risks

The goal is not just an understanding and measurement of the possible sources of operational risk, but an identification of the ways in which they can be mitigated that is critical in order to minimise the amount of operational risk capital required to be held. Having the relevant expertise and experience is essential in being able to do this effectively, as is being able to compare against global industry benchmarks for the management of this product class.

The goal is not just an understanding and measurement of the possible sources of operational risk, but an identification of the ways in which they can be mitigated that is critical in order to minimise the amount of operational risk capital required to be held.

3.5 Risk Margins

Although not part of the SCR itself, one of the central elements of the Solvency II framework is the calculation of risk margins in addition to the best estimate liability. The additional calculation of risk margins is required for any contract that cannot otherwise be replicated reliably by financial instruments that have reliable market values that are observable. As discussed by the CEIOPS CP41,[6] most insurance contracts including variable annuities do not meet these criteria.

The risk margin represents the cost of capital that would need to be paid to a third party to take on the liabilities at the end of the year on a post-stress basis. They are calculated as the present value of 6% of future projected SCR amounts. Future SCR amounts are calculated on the basis that all market risk that can be hedged is, and thus only unavoidable market risks are captured. Thus the SCR with the lowest market risk element is used, which means that, in the case of the above hedge choices, a DRV strategy would be used. One additional element of this calculation is that counterparty default risk associated with financial derivatives contracts is not included.

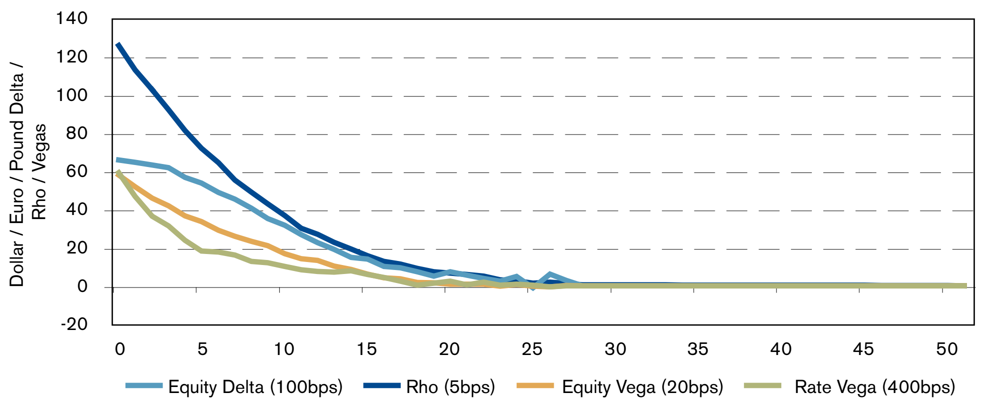
In order to do this calculation, a methodology needs to be formulated that estimates the residual risks that a company will be exposed to for the rest of the product lifetime after 12 months.

In order to do this calculation, a methodology needs to be formulated that estimates the residual risks that a company will be exposed to for the rest of the product lifetime after 12 months. This is a not a simple task for a variable annuity product like a lifetime GMWB, because the risk sensitivities of the liability are path-dependent. Consequently, to fully assess future SCR amounts, a nested stochastic projection is needed.

A simplified approach to undertaking this calculation is to assume a single representative scenario such as the market-consistent one.[7] For each period (e.g., annually), the best estimate liabilities, along with their risk sensitivities and SCR stressed amounts, are calculated. This requires a nested stochastic approach whereby capital market conditions are rolled forward each year. Hedge assets also need to be projected and stressed accordingly, in order for the SCR to be derived on a hedged basis.

Figure 9 shows the runoff of the liability risk sensitivities of the product under this scenario.

FIGURE 9: MARKET RISK PROFILES FOR THE GMWB PRODUCT



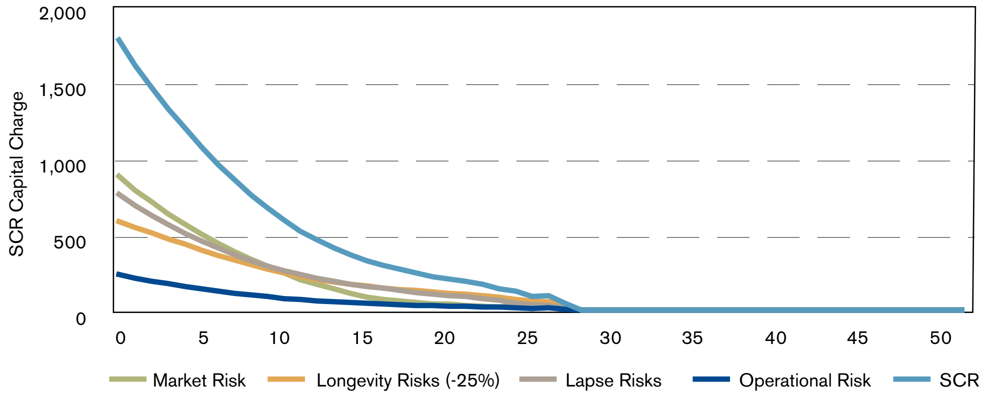
6 Refer to CEIOPS Consultation Paper 41: Technical Provisions – Article 85c Circumstances, in which technical provisions shall be calculated as a whole.

7 An alternative approach might be to assume a real-world outer scenario basis, although the Solvency II guidance is silent on this point.

As can be seen, the account value has run out by year 27, at which point all market risk factors are zero. Notably equity and rate vegas decline the fastest, whilst interest rate rho declines the slowest.

These profiles are important because not all market risks can be completely hedged. As shown by Figures 7 and 8, some residual interest rate, equity, and volatility risks remain. These residual risks will impact future market risk SCR amounts, in addition to life underwriting and operational SCR capital charges. Figure 10 shows the SCR capital charge profiles by risk factor for the DRV strategy.

FIGURE 10: SCR CAPITAL CHARGE PROFILES BY RISK FACTOR

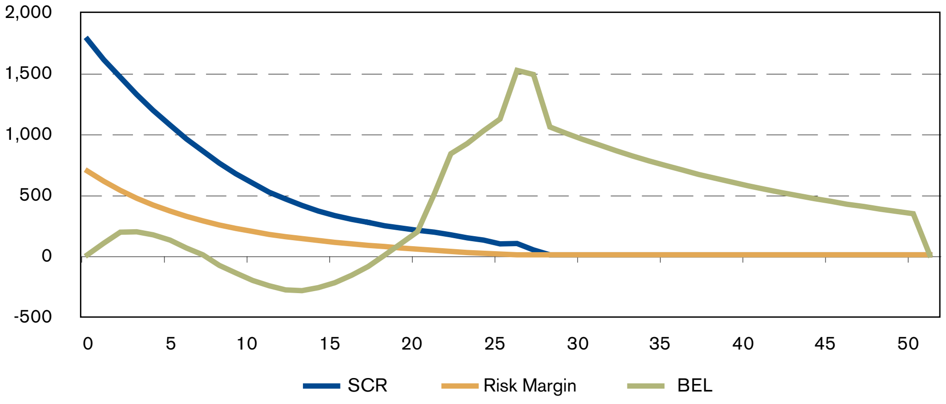


Not surprisingly, longevity and lapse risks independently become more significant than market risks after about 10 years. The SCR profile reduces quite rapidly to around one-third of its value after 10 years.

Not surprisingly, longevity and lapse risks independently become more significant than market risks after about 10 years.

Figure 11 shows the profiles of the balance sheet components: the best estimate liability (BEL), risk margin, and SCR at each future duration.

FIGURE 11: BEL, RISK MARGIN, AND SCR PROFILES FOR GMWB PRODUCT

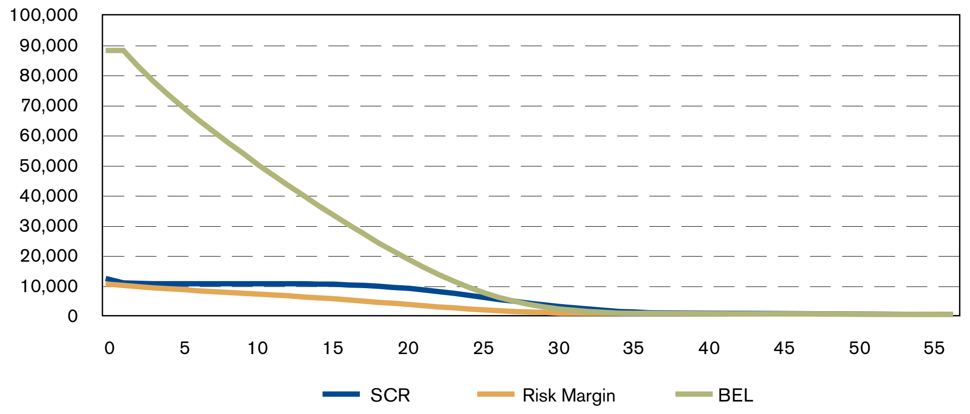


The best estimate liability remains around zero for the first 20 years, fluctuating in line with the (non-constant) risk-neutral forward rates as at the valuation date. It then rapidly increases as the account value approaches zero, before slowly tapering off once the annuity is in payment.

The risk margin at outset of the product is 687, or 0.7% of the initial unit reserves, which reduces over time in line with the runoff of the SCR itself. If the guarantee is to be funded through a single up-front charge, then this would also need to be included in order to avoid any balance sheet strain. Alternatively, if the guarantee is to be funded through a regular charge on the product over its lifetime, then this would translate into an additional amount of, say, 3-10 bps p.a.

By way of comparison, Figure 12 below shows the equivalent graph for the fixed annuity product.

FIGURE 12: BEL, RISK MARGIN, AND SCR PROFILES FOR ANNUITY PRODUCT



For the fixed annuity product, the best estimate liability declines relatively linearly over the first 25 years, before gradually running down over the following 10.

For the fixed annuity product, the best estimate liability declines relatively linearly over the first 25 years, before gradually running down over the following 10. Note the difference in scale between this liability and that for the GMWB product in Figure 11. The GMWB liability is smaller due to the fact that it is a net premium liability reflecting future guarantee charges, the lower size of income payable, and the impact of the additional decrement of lapses.

The SCR remains relatively stable over the first 20 years before slowly decaying towards zero as survivorship declines. Because of this, the risk margin profile declines more slowly when compared to the GMWB.

It should be noted that the above results are highly dependent upon the scenario chosen. An adverse market scenario would likely lead to little change in the results for the fixed annuity, but would increase the BEL, SCR, and risk margin profiles for the GMWB product.

3.6 Discussion

In comparing the fixed annuity to the GMWB results, it is clear that capital requirements are significantly higher for the fixed annuity than for the GMWB. This is primarily due to the longevity risk in the fixed annuity product. This longevity risk manifests itself as additional payments that need to be made in the event that policyholders live longer than expected. In comparison, longevity risk in the GMWB product is relatively smaller. Longevity risk tends not to be very significant for this product because:

- It only leads to additional claims under scenarios that also involve poor market returns leading to the account value running out. Longevity risk is partially mitigated by scenarios where market returns are good.

- Unlike an annuity product, policyholders are able to lapse the product, which reduces the number of policyholders still active at long durations.

- Claim sizes are lower under the GMWB (4.5%) relative to the fixed annuity (7%).

The other major source of SCR divergence is related to credit risk, which is again significant for the fixed annuity. This highlights an interesting structural difference between the risk management practices of the two products: fixed annuities are supported by corporate bonds, whilst GMWB products (like other VA products) are supported by *risk-free* bonds (i.e., swaps). The use of corporate bonds for fixed annuity products enables insurers to offer more attractive benefits because of the higher yield on these investments compared to (credit) risk-free bonds. In effect, insurers are taking a gamble on being able to harvest the liquidity premium on investments supporting a fixed annuity as the liability is illiquid due to the fact that the policyholder is unable to lapse. In doing so, however, they take on credit risk, which will be explicitly assessed for SCR purposes under Solvency II.

This highlights an interesting structural difference between the risk management practices of the two products: fixed annuities are supported by corporate bonds, whilst GMWB products (like other VA products) are supported by *risk-free* bonds (i.e., swaps).

Under the GMWB product, the insurer does not own the underlying assets as these are held in trust as separate account business. Thus they are not able to harvest the liquidity premium directly. Through the collection of guarantee charges, the insurer builds up a pot of assets that is designed to meet the guarantee liabilities. However, as the guarantee isn't lapsable for its market value (i.e., it has a zero surrender value), similar arguments could be applied such that the insurer could harvest the liquidity premium through the use of corporate bonds rather than "risk-free" bonds. This would lead to a levelling of the playing field between the two products, as the same risk management strategy would then be applied to meet the same liability cash flows. One alternative consequence of Solvency II could be that it incentivises insurers to use *risk-free* bonds to support fixed annuity products in order to reduce or eliminate the credit risk SCR component. This would, however, lead to an increase in annuity prices, making the product less attractive.

It should also be noted that the above SCR results for an in-force block of GMWB policies will vary as capital market conditions change, leading to movements in the moneyness of the guarantee. They will also vary for both products as the age profile of the policy shortens over time, which has a tendency to reduce residual risks such as longevity and interest rates.

The standard formulaic SCR methodology has some clear benefits to it. It is relatively simple to understand, it is easy to calculate, it ensures consistency between companies, and it works well for standard or traditional products.

However, it also has some clear limitations. Perhaps the biggest one is that it ignores stresses that occur over a period of time. As a consequence, it is also unable to properly account for dynamic risk management strategies such as dynamic hedging and management actions. A limitation often commented upon is the assumption that all risk factors are joint normally distributed. This is clearly not the case when markets are in a stressed state: markets tend to fall in unison, volatility tends to rise, and rates tend to fall because of a flight to quality and easing monetary policy. These *perfect storm* conditions are what the Solvency II standards are meant to help companies withstand.

In addition to volatility and basis risks, the QIS4 standards do not include other risk factors that may be relevant for non-traditional products such as variable annuities. These include dividend, cross-Greek, correlation, and benefit utilisation risks. It could be argued that for an SCR calculation for a variable annuity product to be complete, these risk factors should also be taken into account.

In addition to volatility and basis risks, the QIS4 standards do not include other risk factors that may be relevant for non-traditional products such as variable annuities.

These limitations of the standard formula approach mean that the SCR result may not be the most accurate measure of the amount of economic capital at risk.[8]

These limitations of the standard formula approach mean that the SCR result may not be the most accurate measure of the amount of economic capital at risk.[8] In some cases it will lead to a prudent estimate of the SCR, which may as a consequence mean that margins need to be higher than otherwise and have a detrimental effect on market positioning.

As an alternative to the standard formula, companies are able to also use internal models to calculate their SCRs, which may more accurately quantify the economic capital at risk. The use of internal models is discussed in the next chapter.

8 These residual risks should be accounted for in the company's Own Risk and Solvency Assessment (ORSA).

4. USE OF INTERNAL MODELS

4.1 Internal Model Requirements

An internal model is a risk management system developed by an insurer to analyse the overall risk position, to quantify risks, and to determine the economic capital required to meet those risks. Their purpose is to fully integrate the processes of risk and capital management within the insurer, rather than solely being used to calculate regulatory SCR.

An internal model typically involves the use of financial projections to model cash flows in addition to balance sheet items. The main benefits of using an internal model approach to calculate the SCR include:

An internal model typically involves the use of financial projections to model cash flows in addition to balance sheet items.

- More accurate assessment of solvency capital that is specific to the company. The SCR will be more risk-sensitive to the specific risks of the company.
- Potential reduction in solvency capital compared to the standard formula approach, which may be a source of competitive advantage.
- Better understanding of the risks in the business, leading to better internal and external communication and discussion of risks.
- Alignment of regulatory capital with economic capital and how risk is actually managed in the business.
- Encouragement of innovation in risk management methodology, potentially leading to lower costs of capital.
- Potential cost efficiencies through the use of a single risk model, infrastructure, and framework for discussion with all stakeholders.

The main limitation to the use of internal models is that they are more resource-intensive. They can require more sophisticated modelling approaches such as nested stochastic projections, which are complex, computationally intensive, and can consume the time of expert in-house or consultant modellers. Consequently, internal models will at least initially be used to address the major sources of risk capital where the business case to do so is strongest.

The main limitation to the use of internal models is that they are more resource-intensive.

In order to use an internal model for SCR calculation purposes, it is necessary to obtain approval from the local regulator. The proposed criteria for regulatory approval of an internal model are outlined in the Framework Directive Articles 110 through 114 (see Appendix B of this report).

Partial internal models may also be used for a subset of SCR modules. In addition to the above requirements, companies using partial internal models must be able to justify the reason for the limited scope and show that it leads to a more appropriate risk assessment.

The QIS4 survey results (see Appendix A of this report for further details) suggest that that use of internal models will become quite widespread for at least those risks where it results in a capital reduction. However, we think that over time it is also likely to become increasingly used also for those risks that result in an increase in capital relative to the standard formula, which is due to the benefit of it being a more robust risk assessment methodology. Regulators are also likely to view with suspicion those who apply internal models to only some risk factors when it would make equal sense to apply them consistently across a number of related risks.

4.2 Indicative Example

For a variable annuity product such as a lifetime GMWB supported by a dynamic hedging strategy, it makes sense for an internal model to be used to assess the largest components of the SCR. These include equity, interest rate, volatility, and dynamic lapse risk factors, which are intimately related to other risk factors. Such an internal model would be based upon a nested stochastic projection model. This model would calculate the forward guarantee liabilities each week based upon a risk-neutral stochastic valuation model, consistent with the real-world market conditions in the projection scenario. The liability Greek sensitivities would need to be calculated such that hedge positions in relevant derivative assets can be established and rebalanced each time step. The P&L and Balance Sheet would then be constructed each time step for each scenario from which a distribution of results can be obtained.

The dimensions of the analysis would typically be:

- **Weekly time steps**: Anything longer than this would likely not be sufficiently accurate to reflect a dynamic hedge that is typically rebalanced on average once to twice a week.

- **Projection years**: This could either be for one year, which ties in with the Solvency II basis, or for any longer period up to the entire lifetime of the product. These two extremes may yield different results depending upon the economic scenario generator used.

- **Number of projections**: This is a function of the projection years used and the computational resources available. For a one-year projection, at least 1,000 real-world scenarios would be considered the minimum necessary in order to obtain a reasonably accurate VaR 99.5 result. For a lifetime projection over, say, 40 years, fewer scenarios can be used to obtain a result at the equivalent confidence level.

A key part of this analysis is the choice of what real-world economic scenario generation methodology is most appropriate to use.

A key part of this analysis is the choice of what real-world economic scenario generation methodology is most appropriate to use. Decisions need to be made regarding the statistical distribution of risky returns (normal vs. fat-tailed), risk factor correlations (static or dynamic), and interest rate dynamics (1-, 2-, or 3-factor models). In addition to these methodological issues, the models will also need to be parameterised, which is also not a simple task. They will need to be parameterised such that they are consistent with the basis specified by the standards, namely at the 99.5 percentile level over a one-year horizon. Whilst history is of some guide, ultimately assumptions will need to be made regarding what parameters are considered most appropriate for the future. It is critical that both the modellers and users understand the nature and materiality of these assumptions as they may have a significant influence on the results.

The graphs in Figures 13 and 14 present some *indicative* analysis using nested stochastic projections over a 20-year time period. The graphs show various percentile results of the P&L distribution at each duration (i.e., each line does not represent a single scenario), based upon an initial single premium of 100,000. The impact of the delta-rho-vega hedging strategy can be clearly seen in the reduction in P&L volatility.

FIGURE 13: UNHEDGED QUARTERLY P&L

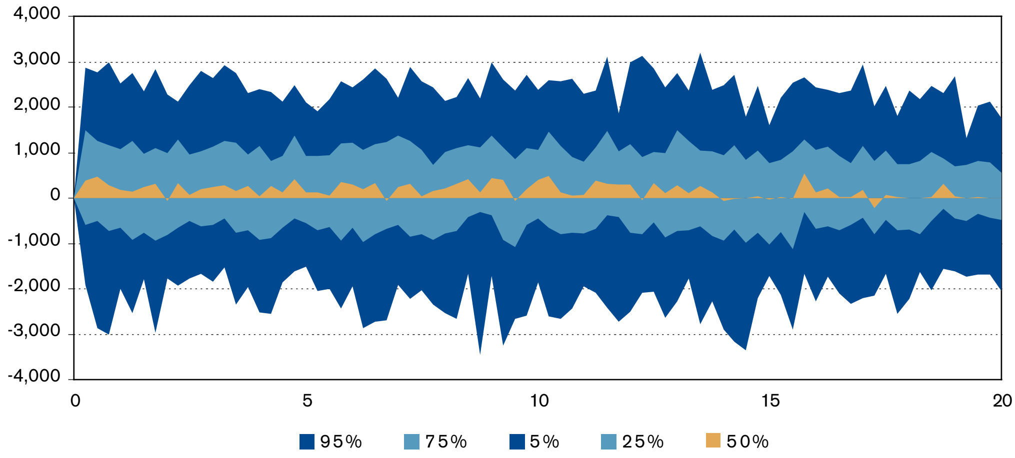
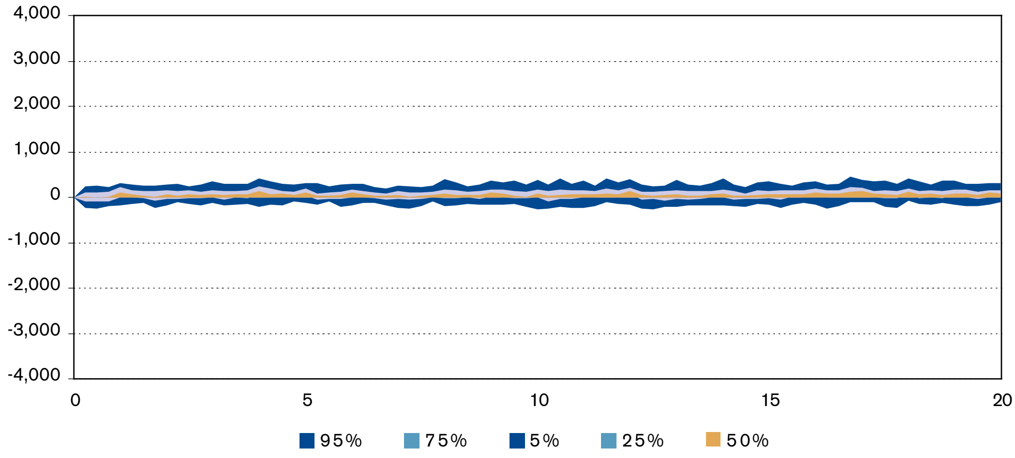


FIGURE 14: DELTA-RHO-VEGA HEDGED QUARTERLY P&L



These results highlight that whilst the product on an unhedged basis is expected to have a positive median embedded value (because of the use of a positive equity risk premium), there is a significant chance that it will generate a loss over the 20-year period. By hedging the product, the distribution of results is significantly reduced, such that the median result is roughly zero with a 50/50 chance of a relatively small positive or negative result.

The translation of this calibration is a significant open issue in the development of the Solvency II standards, and one that can have a material impact upon the capital efficiency of dynamic hedging strategies.

Assessing capital at risk based upon the first 10-year projection period, a roughly equivalent capital at risk statistic for this projection is a VaR95 of the NPV of P&L over the projection period.[9] On an unhedged basis, this is 9.0% of initial unit reserves, whilst on a delta-rho-vega hedged basis, it is 1.4%. Note that these results are indicative only–the projection scenarios are not necessarily calibrated to being statically equivalent to the immediate stresses used in the standard formula. The translation of this calibration, from an immediate stress to, say, a weekly projection for 10, 20, or 40+ years, is a significant open issue in the development of the Solvency II standards, and one that can have a material impact upon the capital efficiency of dynamic hedging strategies.

Additional capital will also be required for other risks such as longevity, counterparty default, and operational risks. Decomposing this result into each risk factor component is also possible; however, it requires additional runs with each of these risk factors either sequentially included or analysed independently, which is beyond the scope of this paper.

4.3 Discussion

The above analysis is a simplified example of what could be considered to be a partial internal model. The risk factors included in this model are equity, interest rate, equity volatility, and lapse risks. The resulting market risk SCR (9% unhedged and 1.5% hedged) is larger than the equivalent results for these risk factors calculated using the standard formula approach (5.9% unhedged and 0.8% hedged). This illustrates that the use of an internal model will more appropriately capture the true nature of risk in the business as well as how effective the risk management strategies are in mitigating these risks.

This partial internal model could be extended to include other stochastic risk factors such as interest rate volatility, correlations, and mortality/longevity to move it towards a full internal model. This would require stochastic modelling of these risk variables, as well as any relevant interdependencies (covariance). Inclusion of additional risk factors will affect the number of scenarios needed to achieve sufficient statistical convergence in the result.

The implementation and use of such models does, however, present significant theoretical and practical challenges to an organisation. These include:

- Choice of economic scenario generation methodology/model and its calibration.
- Choice of model points/replicating portfolio to be used as the most appropriate representation of the full book of business.
- The modelling of guaranteed business will require use of nested stochastic modelling techniques. This increases the complexity of the model and the computational processing requirements, necessitating a distributed grid computing solution.
- The modelling of hedge assets such as derivatives may also require nested stochastic modelling techniques.
- Validation testing of such a complex model requires significant expertise and experience.

The use of internal models is expected to become a key source of competitive advantage once Solvency II is introduced.

The use of internal models is expected to become a key source of competitive advantage once Solvency II is introduced. This is because it offers better insight into the risks faced by a specific business, and it more closely aligns with actual risk management, thus giving greater control over capital management. Whilst the effort involved in its implementation and maintenance is not small, the benefits will likely outweigh the costs for the tier one (multinational and large national) and tier two (medium-sized national) players. In order to be prepared in time, it is necessary to start thinking, designing, and planning for its implementation now.

9 Alternatively, a 20-year horizon with a lower VaR or equivalent CTE measure could be used.

5. SUMMARY CONCLUSIONS

Solvency II provides a direct link between economic capital and the residual risk resulting from product features and their associated risk management strategies. As shown above, Solvency II is meant to be more than just a simple calculation for regulatory purposes–the allowance for use of internal models is designed to incentivise companies to embed the risk management and capital framework deep into the business.

Solvency II is meant to be more than just a simple calculation for regulatory purposes–the allowance for use of internal models is designed to incentivise companies to embed the risk management and capital framework deep into the business.

As such, it is meant to provide a framework upon which product pricing can be set with respect to both the economic cost of the guarantees being provided, as well as to additional margins required to meet the cost of residual economic capital at risk. This is a significant change from Solvency I, whereby the regulatory capital for a business line was and is largely independent of product risks and associated risk management strategies.

Under Solvency II, liabilities are valued on a market-consistent basis. Consequently, any guarantees that are sold will need to take into account the current market price (or an estimate thereof) of the guarantee benefit. To the extent that the market price of risk increases, such as it did in 2008, this will have a direct impact upon the guarantee benefit levels that can be provided on an economically affordable basis to the market. Product developers will need to be very conscious of this at the earliest stages of the product design process.

Product features will tend to move more towards solutions that minimise risk capital, both hedgeable and non-hedgeable, in order to maintain competitive pricing. This will particularly be the case for the more homogenous, single risk factor products such as fixed annuities and term assurances. More complex products such as variable annuities provide more opportunity to optimise capital as exposure to a range of less than perfectly correlated risks leads to greater diversification benefits.

As illustrated in Section 3.3, fixed annuities are likely to have higher capital requirements than a GMWB for life. Given that both products broadly compete to meet the same post-retirement needs, we may see a structural shift away from fixed annuities towards GMWB products that are significantly more capital-efficient on a hedged basis.

Solvency II incentivises finding more efficient risk mitigation solutions for each source of risk. Consequently, risk management will become more tightly integrated into the product design process.

Solvency II incentivises finding more efficient risk mitigation solutions for each source of risk. Consequently, risk management will become more tightly integrated into the product design process.

Pricing margins for benefits such as lifetime GMWB products will need to be sufficient to produce a return on the capital required over the lifetime of the product, such as is captured in the risk margin calculation. Where margins are levied as annual charges from the account value, these need to be sufficient to cover the cost of capital required to support the annuity once the account value has run out. Consequently, the profile of the SCR over the lifetime of the product, as well as its distribution, is important to consider when determining pricing margins.

The optimisation of risk capital will become more important as it will become a source of competitive advantage. Risk budgeting approaches are likely to become more widespread.

6. MILLIMAN EXPERTISE AND FUTHER INFORMATION

Milliman has significant expertise in developing economic capital models, in particular for market and operational risks related to guaranteed business such as variable annuities. Our experience in this field is unmatched, having developed and used such models for countless clients on a global basis since 2000.

Milliman has significant expertise and experience in the field of economic capital, having assisted a significant number of clients on the impact of Solvency II and how to best prepare for it. Given our industry-leading hedge maintenance support services, we are ideally positioned to assist companies in developing operational risk models and to provide advice on ways in which operational processes can be managed to global best practice standards in order to minimise operational risk capital. For more information on how we can help both current and prospective clients in this area, please contact any of the authors of this paper.

Further research reports on Solvency II can be found on the Milliman Web site at milliman.com.

APPENDIX A: IMPACT OF QIS4

As part of the implementation process, CEIOPS[10] has conducted a series of quantitative impact studies (QIS) with the aim of refining the detail of the standard by working with industry. The latest of these studies, QIS4, was completed in 2008, with the results released in October 2008. The key summary results and findings of the survey are summarised below.

FIGURE 15: QIS4 SUMMARY RESULTS AND FINDINGS

AREA	FINDING	COMMENT/IMPLICATION
SOLVENCY RATIO	Majority report better ratios for QIS4 compared to Solvency I (but not unanimous).	Solvency II solvency capital not likely to be materially different overall to Solvency I.
METHODOLOGY	Support for general design and methodology.	Not likely to change in nature, more a refinement of the detail in some modules.
BSCR COMPONENTS FOR LIFE COMPANIES	Broad median result: 70% market, 45% life, 5% other, -20% diversification.	Some differences at national level.
EQUITY RISK	Shock questioned as to whether it is prudent enough.	Given recent market experience, this shock size might increase in future.
COUNTERPARTY RISK	Unanimously criticised by participants and supervisors as too complex.	Methodology likely to change in QIS5.
LIFE UNDERWRITING RISK	Comments by some countries that biometric risks (mortality, longevity, morbidity) more suited to a gradual trend scenario.	Gradual trend scenarios unlikely to be adopted to ensure consistency with broad SCR methodology.
OPERATIONAL RISK	Represents 5%-10% of total SCR. Formula seen as simple, risk-insensitive, and assumed correlation of 1 with other risks was disliked.	This is an area of ongoing active debate, which may result in changes to the QIS4 methodology.
CORRELATIONS	Criticism of lack of current objective correlation matrix.	An area of ongoing discussion. It is likely that some diversification will be allowed, but the degree may be tightened based upon recent experience.
INTERNAL MODELS	Refer to Appendix A.	Refer to Appendix A.

A detailed summary and commentary of the results can be found in CEIOPS (2008).

10 Commitee of European Insurance and Occupational Pensions Supervisors

APPENDIX B: INTERNAL MODEL REQUIREMENTS

The proposed criteria for regulatory approval of an internal model are outlined in the Framework Directive Articles 110 through 114. For full internal models, these include the following:

1. Use test
   - Model must be widely used and plays an important role in governance systems, risk management system, decision-making, and the capital allocation process.
   - Model must be embedded and used in the business.

2. Statistical quality standards
   - Based upon robust actuarial/statistical techniques.
   - Use of accurate current and credible data, methodology, and assumptions.

3. Calibration standards
   - Model must be consistent with SCR framework (99.5% over one-year horizon); i.e., other time horizons and equivalent risk measures are allowed.

4. Validation standards
   - Independent review, qualitative and quantitative aspects, sensitivities.
   - Control cycle process: comparison of actual against experience.

5. Profit and loss attribution
   - Into risk factor sources for each business unit.

6. Documentation standards
   - Sufficiently detailed and complete to enable replication by third party.
   - Theory, assumptions, and methodology.

As part of the QIS4 process, CEIOPS provided a questionnaire on internal models, which was completed by around half of the 1,412 solo participants. When asked about their plans to use internal models in the future for at least part of their SCR calculations, 63% responded said that they do have plans, whilst 13% said they have no plans and 24% don't yet know. The main reasons given for adopting an internal model included better risk and capital management, as well as more transparent decision-making.

The majority of these respondents indicated that the SCR will decrease with an internal model, with slightly half of respondents reporting a decrease of more than 20%. Across the entire sample of insurance companies, use of internal models led to a reduction in the SCR of 11%, with life insurance companies reporting a reduction of 5%.

Risk modules where internal models seem to create lower capital requirements than the standard formula include the overall SCR, BSCR, market risk (interest rate risk in particular), life underwriting risk (longevity risk, lapse risk), health underwriting risk (health short-term underwriting risk), non-life underwriting risk, and premium/reserve risk. Risk modules where internal models seem to create higher capital requirement than the standard formula include operational, equity, property, and mortality risks.

BIBLIOGRAPHY

CEIOPS (December 2007). QIS4 technical standards. Retrieved Oct. 9, 2009, from http://www.ceiops.eu/content/view/118/124.

CEIOPS (October 2008). QIS4 summary results and main messages. Retrieved Oct. 9, 2009, from http://www.ceiops.eu/media/docman/public_files/consultations/QIS/Stakeholders-QIS4.pdf.

Milliman (Spring 2007). Implications for insurers of Solvency II.

Milliman

Milliman, whose corporate offices are in Seattle, serves the full spectrum of business, financial, government, and union organizations. Founded in 1947 as Milliman & Robertson, the company has 51 offices in principal cities in the United States and worldwide. Milliman employs more than 2,300 people, including a professional staff of more than 1,100 qualified consultants and actuaries. The firm has consulting practices in employee benefits, healthcare, life insurance/financial services, and property and casualty insurance. For further information visit milliman.com.

Joshua Corrigan
joshua.corrigan@milliman.com

Gary Finkelstein
gary.finkelstein@milliman.com

London
11 Old Jewry
London EC2R 8DU

milliman.com