Solvency II for long-tail liabilities:

Variation in mean ultimate
One-year and ultimate year risk horizons

Insureware
Innovative Statistical Solutions for P&C Insurance

Contents

1. Introduction

1.1. Solvency II objectives

The European Parliament's Solvency II Directive introduced new regulation for insurance and reinsurance business for all member states in the EU. This regulation has been in development for a long time and has evolved in consultation with the Industry.

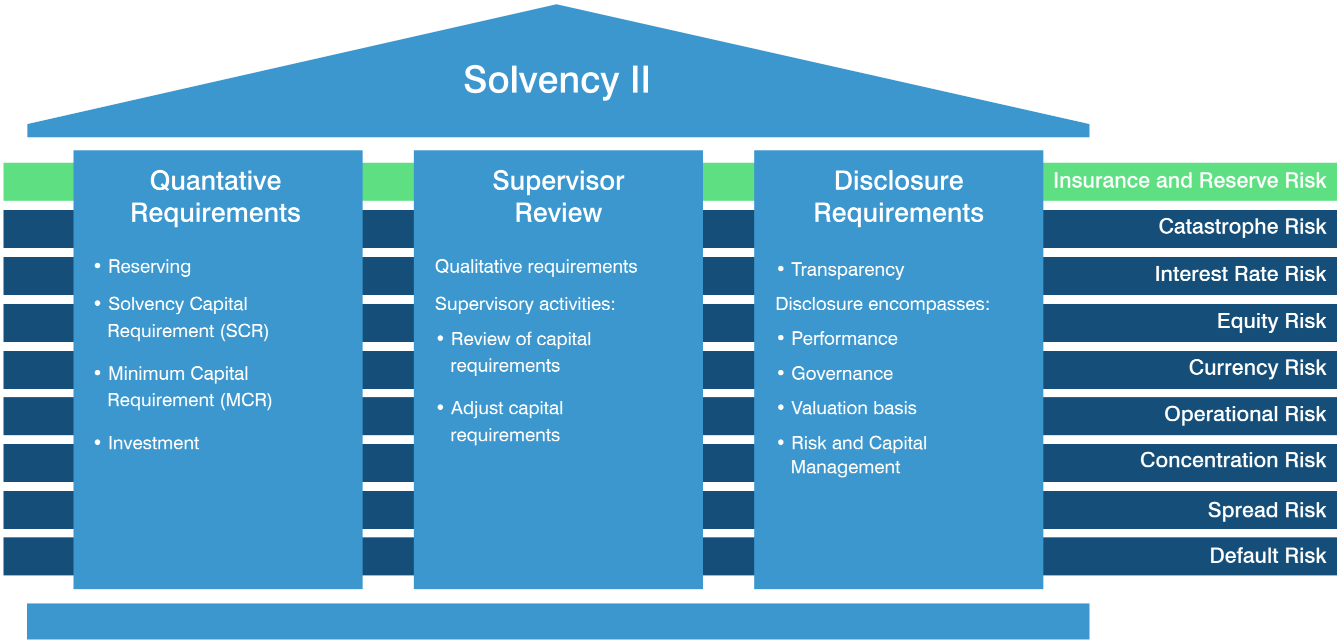
This regulatory regime is designed to:

- Establish a consistent insurance market across the EU;
- Improve policy-holder protection;
- Align capital requirements of asset and liabilities;
- Add supervision and quantification of risk profiles, capital level, and governance;
- Reward active risk management; and
- Reform reporting information on a company's financial position to increase transparency and competitiveness.

In summary, Solvency II aims to establish a Solvency regime that is better suited to the true risks of an insurance company.

1.2. Framework structure

The framework uses a three-pillar structure – bringing the regulation in line with the banking industry. These pillars detail the quantitative and financial requirements (Pillar 1), governance and supervision procedures (Pillar 2), and reporting and disclosure standards (Pillar 3).



New challenges to actuaries arise in the first two pillars; in particular in developing accurate risk measures based on stress scenarios and establishment of an effective risk management system.

1.3. Quantitative requirements

Solvency II requires precise calibration of Capital to a mandated 1/200 stress level over the one year horizon. Calibration must be done for individual Lines of Business (LoB) as well as aggregates of multiple Lines of Business – with appropriate credit for diversification benefits.

Insolvency is a risk associated with running any company. Within insurance business framework, some risks can be hedged against – eg currency exchange fluctuations – however others, particularly reserve risk, are non-hedgeable. It is critical to both manage and calculate reserve risk appropriately.

The risk margins to offset the insurance risk are regulated by the Solvency II Quantitative Requirements.

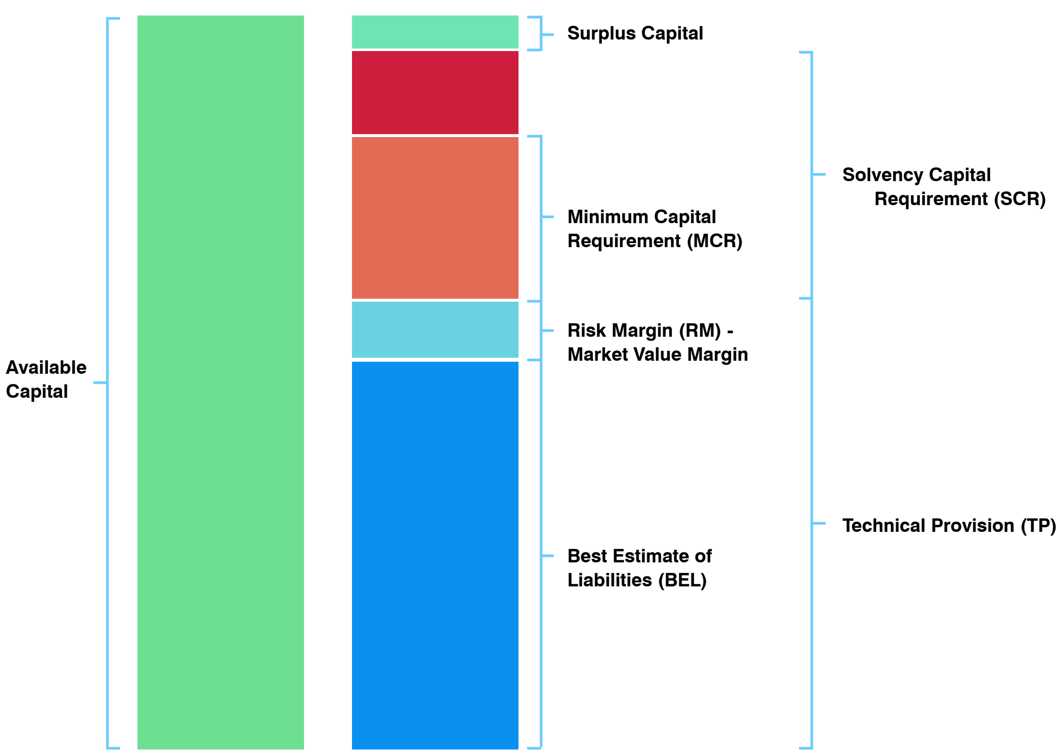
In summary, the risk is characterized by:

- The distribution of basic own funds;
- Value-at-Risk, applied to Solvency Capital Requirements (SCR);
- Tolerance: set at 99:5% with a one year time horizon (1-in-200-year distress event);
- Risk Margins: determined by using the Cost-of-Capital method and set in the specifications as a rate of 6%.

There are three basic elements to the Solvency II directives in respect to risk capital:

- Risk Capital is raised at the beginning of each year and any unused capital is released at the end of the year;
- The analyses are conditional on the first future calendar year being in distress (99.5%);
- At the end of the first year in distress, the balance sheet can be 'restored' in such a way that the company has sufficient technical provisions (fair value of liabilities) to continue business or to transfer the liabilities to another risk bearing entity.

Economic Balance Sheet



Solvency II Technical Provisions (TP) are to be estimated as a probability-weighted estimate of expected future liabilities taking into account the time-value of money (Best Estimate of Liabilities) along with a Risk Margin (sometimes referred to as the Market Value Margin) defined below. That is, the mean cash-flow projections can be discounted (adjusted to present value) at the risk free rate, r. The discounted cash-flows are the Best Estimate of Liabilities (BEL).

Risk capital, whether to pay for unexpected losses in a calendar year or to restore the balance sheet after those losses, has a premium attached; there is a cost for having access to it. In the Solvency II definitions, this premium is referred to as the Risk Margin (RM). The cost of holding the capital is specified in the Solvency II directives as fixed at 6%. We refer to this rate as the spread, s. Like the mean cash-flows, the Risk Margin is to be present value adjusted.

Technical Provision (TP) is then the sum of the BEL and the Risk Margin.

$$\mathbf{TP = BEL + RM}$$

The Solvency Capital Requirement consists of sufficient capital to cover the risk for the next calendar year and to restore the Economic Balance Sheet should a distress event be encountered.

To calculate these quantities, actuaries will need access to accurate and precise distributional information about future liabilities and their modifications after a distress event.

Only a unified approach to reserving which treats trends, volatility and correlations under a single distributional paradigm can achieve this result.

1.4. Are existing long-tail line methodologies sufficient?

In recent years, actuaries have added the Mack method and the bootstrapping technique to their toolkit in order to produce distributions which can be associated with their point estimates.

Methods for calculating the variation in the Claims Development Result (CDR) for Mack have been developed by Merz-Wüthrich. Possibly due to the popularity of the Mack method, this measure of one-year variation is included in the Solvency II standard formula.

We postulate techniques or adjustments based on link ratios are not adequate for Solvency II purposes. They do not directly model the process volatility or identify all the trends in the data. The cautionary note regarding model specification error in the regulation, linked particularly with the Merz-Wüthrich calculation, applies to any link ratio model. Many studies have shown that Link Ratio methods very often provide inaccurate projections of future calendar year losses.

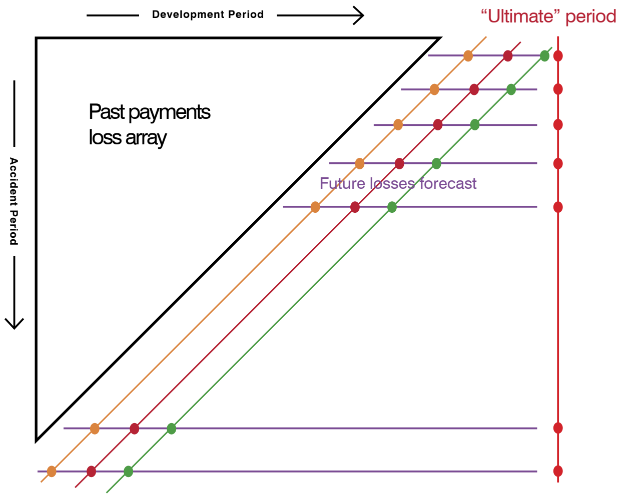
The limitations of link ratio based methods prevent drivers of distress from being accurately incorporated in the stress scenario or for correct capital requirement calculations under the stress scenario. Rather, additional (and unverifiable) assumptions have to be made regarding future payments. This runs counter to the objectives of Solvency II to increase transparency and policy holder protection.

The Probabilistic Trend Family (PTF and MPTF) modeling frameworks provide the full probability distributions and correlations necessary for the calculation of Solvency II risk measures for long-tail liabilities. Since probability distributions are projected for every future cell, distributions of the payment stream by calendar year (and its distribution) are immediately available. Further, model specification error is mitigated since all parameters described in the model can be explicitly tested and distributional assumptions validated.

Distributions of the payment streams by calendar year conditional on the first calendar year being in distress can also be easily calculated by simulations while maintaining consistency with the model and forecast assumptions. Distress events arising from identified PTF (or MPTF) models and forecast scenarios provide an appropriate measure of reserve risk for those calculated reserves.

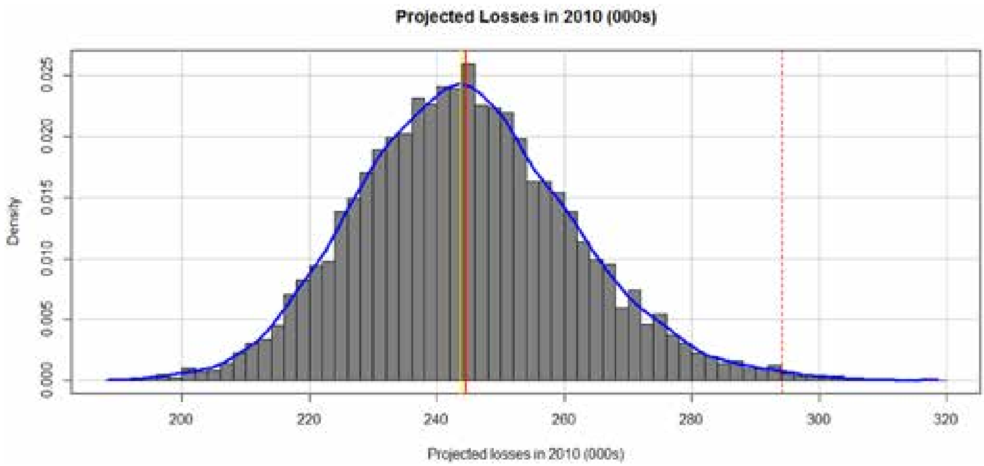
1.5. The Solvency Capital Requirement for long-tail liabilities

The Solvency Capital Requirement (SCR) should provide sufficient capital to cover the risk for the next calendar year and to restore the Economic Balance Sheet at the start of the next calendar year.



Summing future losses along the calendar year axis produces projections of the cash-flow, and the actual calls on the reserves. This is the dimension in which solvency issues arise.

In the Case Study (Section 5) discussed later in this brochure, the distribution of the first future calendar year (2010) is shown below. Measures of the center of the distribution (median (yellow) and mean (red)) are displayed along with the 99.5th percentile (dashed red line).

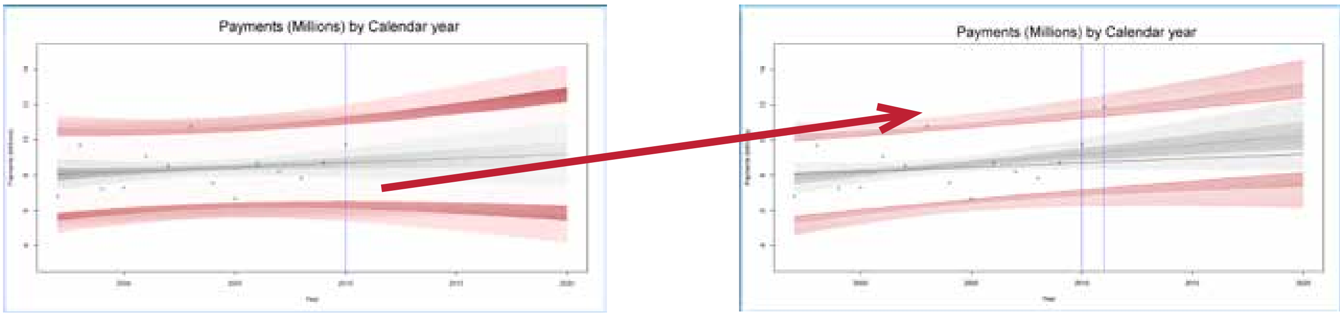


Using the Solvency II 1/200 distress level, the minimum risk capital to be available to remain solvent (not to be confused with the Minimum Capital Requirement) is the Value-at-Risk at the 99.5th percentile, $V@R_{99.5}$, for the next calendar year. The $V@R_{99.5}$ is the difference between the mean loss and the 99.5th percentile.

If the losses exceed the mean cash-flow projections for a calendar year then sufficient risk capital must be available to draw on so the reserves for subsequent calendar years are not jeopardized.

Correlations between future calendar years are positive. So, in the event of drawing on the risk capital due to losses exceeding the mean, the losses in subsequent calendar years are more likely to exceed the mean for that year. An adjustment to the mean for future calendar years is required to restore the Economic Balance Sheet.

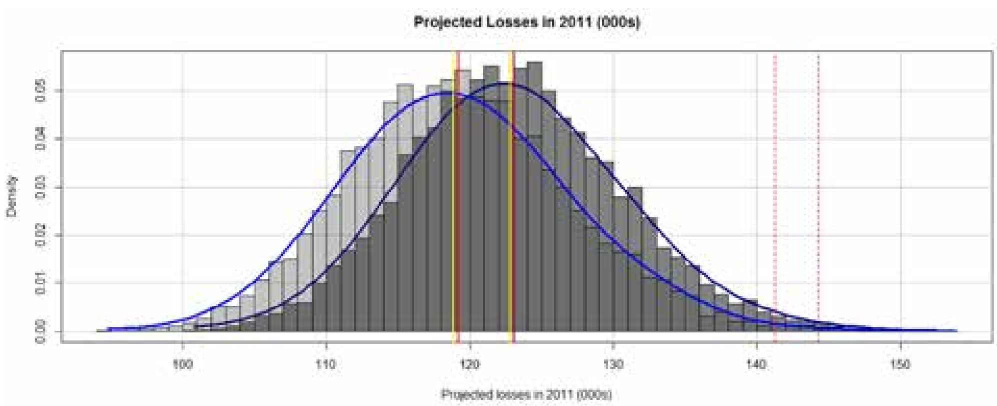
See below how a single observation (the loss at the 99.5th percentile) results in an updated estimate of the final distribution.



Consider if the losses in 2010 reached the dashed red line (the 99.5th percentile).

The new distribution for the second future calendar year (2011) can be recalculated.

A comparison of the two distributions (no conditioning on a distress event) versus conditioning on a realization of a distress event can be made. The distress event shows a clear shift to the right (an increase in the mean).



The range of the second year's distribution has narrowed and is centered on a mean higher than the previous estimate. This shift in mean is expected due to the positive correlation between the calendar year distributions. Therefore, in addition to the $V@R_{99.5}$ there must be capital available to adjust the provision for calendar years following the distress event.

The $V@R_{99.5}$ for the second year is also expected to change after conditioning on distress. The V@R is not affected in the same way as the means however. The risk capital required does not necessarily increase even in the event of a distress event in earlier years. This is perhaps surprising, but arises from the combination of the correlations with the reduction in forecast horizon – and perhaps reduced uncertainty of the future trends.

1.6. Solutions for calculating SCR

The regulation does not dictate how SCR should be calculated. Rather, the onus is on the insurer to show that the SCR is sufficient to restore the Economic Balance Sheet to fair value after a distress event.

The 'standard formula' is provided as a baseline where an internal model is not applied or not deemed satisfactory. There is also an option of a partial internal model where internal models are used for some components and a standard formula provides a mechanism of tying together all the components.

A natural definition of SCR

The decomposition of the directives into the three basic elements of managing risk capital leads to a natural definition of SCR.

The SCR can be defined as sum of the capital needed to cover losses to the 99.5th percentile in the next calendar year and the additional (Δ) technical provision to restore the Economic Balance Sheet to fair value should this event occur. This definition satisfies the Solvency II directives prescribed by EIOPA (previously known as CEIOPS).

That is,

$$\mathbf{SCR = VaR_{99.5}\%(1) + \Delta TP(2) + \Delta TP(3) + \ldots + \Delta TP(n);}$$

where n is the number of years until run-off.

This natural definition is explored further in Section 3.

The Variation in Mean Ultimate proxy of SCR

One option in the standard formula is to take the 99.5th percentile of the Variation in Mean Ultimate (VMU) – that is, the negative of the Claims Development Result (CDR) mentioned previously. However, unless correlations between calendar years are very low, this method grossly overstates the total risk capital actually required to satisfy Solvency II regulation.

The VMU is very sensitive to calendar year correlations. High correlations result in an estimate of the SCR being too high (high movements in the VMU are likely to be caused by many losses across calendar years being high [close to or at distress]). Similarly, low correlations result in understatement of the required SCR as too much credit is given to risk diversification.

Finally, the VMU should be closely linked with the distributions describing the actual losses. The parameterization of these distributions should be data driven. Each company is unique and the causes of distress are also distinct to each company. These parameters cannot be obtained accurately by extrapolating from the Industry or positing relationships between lines.

As the regulation states, all assumptions must be supported by the data.

Insureware's modeling framework design process is critically linked with validation. The identified model is customized to individual company's experiences and is validated to provide credibility for the future.

Diagnostics, whether for the Probabilistic Trend Family (PTF) modeling frameworks or the Extended Link Ratio Family (ELRF) modeling framework (which includes Mack), provide indications of how reliable the model is.

If the model does not describe the past, how can we trust it to represent the future?

1.7. Causes of distress

If the model and associated forecast scenario are correct, then there are two potential causes of distress – extreme observations or high trends from the tail end of the projected trend distribution.

In the probabilistic trend family (PTF/MPTF) modeling frameworks, distributions are fitted to describe trends and individual periods. These distributions therefore also describe extreme values.

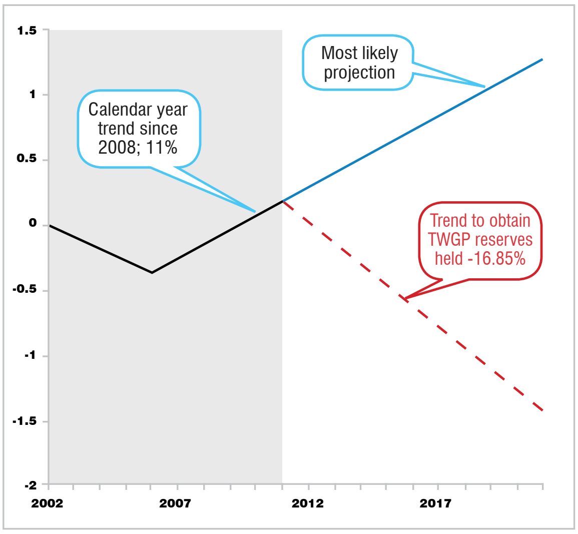
To illustrate, if a calendar year trend of 10%$\pm$2% is used for projection, a distress scenario may be a realized future calendar year trend of 16%. This trend has a low probability of occurring, just over 0.1% if a normal distribution is assumed, but is still a potential realization of the future forecast.

However, what is a distress event if we use a trend assumption of 10%$\pm$2% when the real trend should have been 15%$\pm$2%? From the projection a 16% trend has a 0.1% probability, but in fact a realization of 16% or higher could occur more than 30% of the time. This is likely to result in catastrophic loss.

Thus inaccurate modeling or projections could result in a company being in distress not due to a 1 in 200 year event, but rather because the projected probability distributions by calendar year and associated correlations were wrongly estimated.

Tower Group (TWGP) provides a nice case study.

Using Schedule P data at the end of 2011, the future calendar year trend required to reach the reserves held by Tower Group is -16.85%.



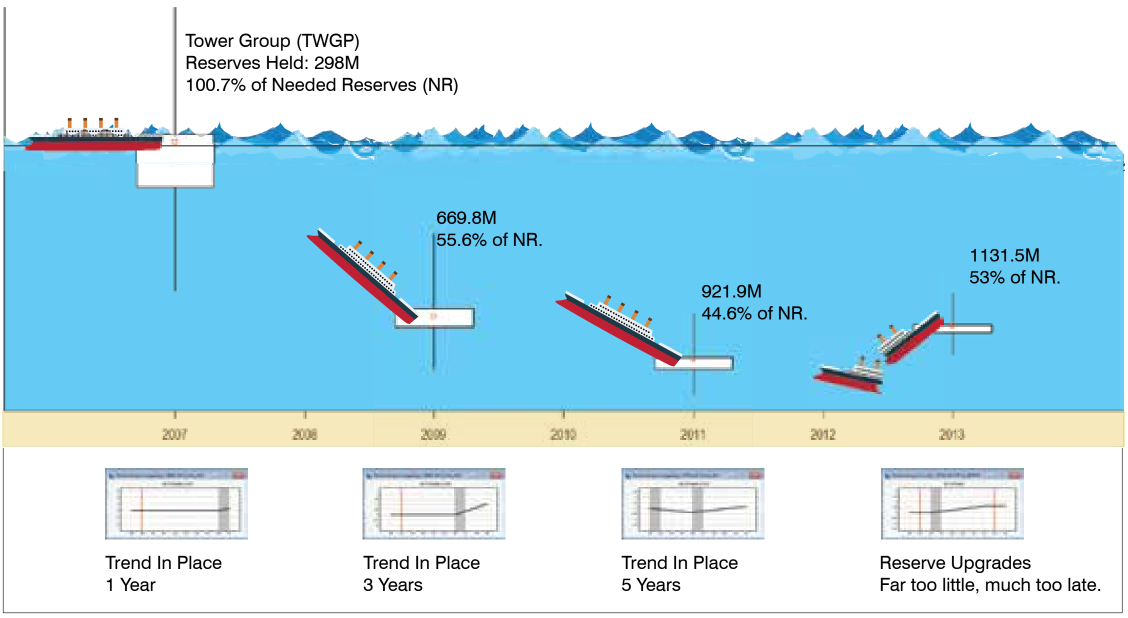
This is after observing an +11% trend most recently (left).

Looking at this graphic, you can immediately see the -16.85% trend is extremely unlikely to eventuate.

However, if the trends in the past were not measured, or were measured incorrectly, then the credibility of this outlook may never have been questioned.

See Tower Group Brochure

Not even Solvency II regulation can save a company if the company's projection of the future is vastly out of sync with reality.



2. Prerequisites

In order to compute Technical Provisions Risk Margins using the Cost of Capital approach, and the Solvency Capital Requirement for the one-year risk horizon for the aggregate of all long-tail LoBs (and each LoB), the following critical information is required:

- Probability distributions of the paid losses by calendar year (k=1,…,n), and their correlations for each LoB and the aggregate of all LoBs where complete run-off is achieved at the ultimate calendar year n.
- Probability distributions of the paid losses conditional on the first calendar year's losses being at the 99.5th percentile; that is, the year is 'in distress' with a 1/200 year event.

Armed with the above distributions, any risk measure can be computed, including Value-at-Risk (V@R) for calendar year k, for each LoB, and the aggregate of all LoBs.

Correlation should be measured from the data in order to determine each company's unique interline correlation. Taking these into account results in alterations in parameter and volatility estimates and hence in reserve distributions. These effects cannot be replicated by the imposition of off-the-shelf correlation matrices or copulas. As the brochure 'Understanding Correlations' illustrates, each company's trends and mix of risk is unique and must be taken into consideration.

Correlation is an intrinsic component of a good model.

2.1. Sources of correlation between multiple LoBs

There are three types of correlations between LoBs: process (volatility) correlation, parameter correlation, and reserve distribution correlation.

Process correlation is the correlation in the pure volatility component of the liabilities. This is measured after all trends have been accounted for. Failure to fully describe the trends in the data results in spurious correlations be measured – see Insureware's brochure on Understanding Correlations.

Parameter correlation can arise from the action of external effects, but is also induced via process correlation because estimation of model parameters depends on data subject to correlated random effects.

Reserve correlations between calendar year liability streams are a function of process variability and parameter uncertainty; higher parameter uncertainty results in higher reserve correlations.

Individual companies have a unique set of risks and correlations. These are model dependent and cannot simply be extracted from Industry calculations and imposed on a different data meaningfully. The only exception is when data are insufficient so that approximations from the Industry are the best metric available for calculations.

2.2. The effect of correlations on risk diversification and SCR

Modeling multiple Lines of Business simultaneously leads to significant aggregate risk diversification credit where the level of diversification is dependent on the correlations between the LoBs.

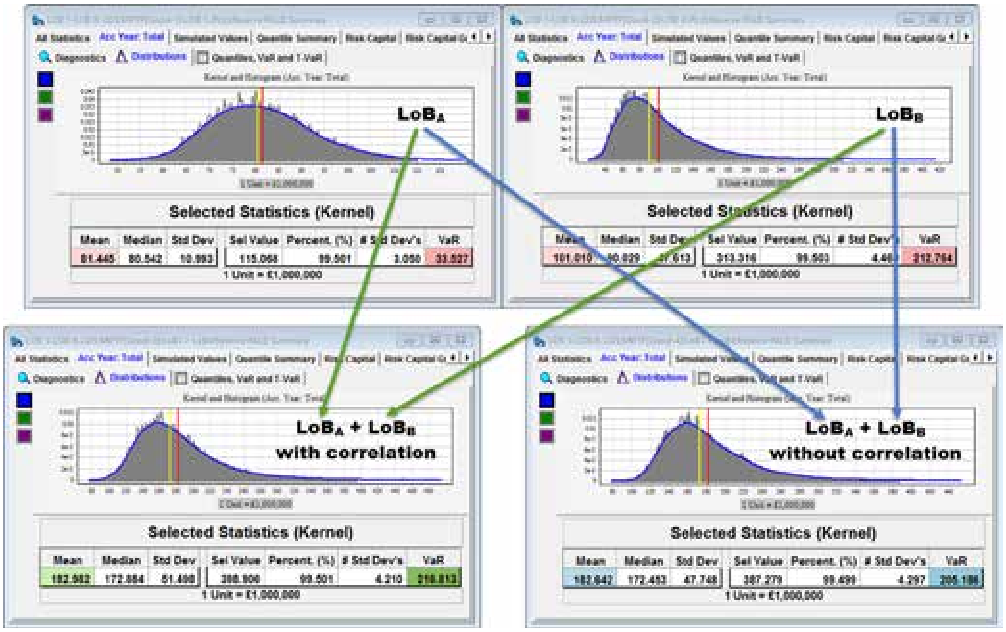
For instance, consider two lines LoB A and LoB B.

Line A has a total mean reserve of 81.4M and a total reserve standard deviation of 11.0M. Line B has a total mean reserve of 101M and a total reserve standard deviation of 47.6M.

The two distributions for LoBs A and B are shown below.

The total process correlation between these two lines is 0.567. The total reserve distribution correlation between the same two lines is 0.296.

What happens to the mean and risk capital calculations if we use the correlations as measured in the model and forecast compared to a forecast where all correlations are set to zero?



Here we see that the $V@R_{99.5}$ (highlighted red) are 33.5M and 212.7M for lines A and B respectively. If process and parameter correlations are treated as zero in the forecast, the mean is the sum of the two LoB means and the $V@R_{99.5}$ is 205M (much less than the 246M required if the quantiles were additive). If the correlation is included in the forecast, then (since it is positive), the $V@R_{99.5}$ at 216.8M is higher than the independent case 205M.

The difference between the $V@R_{99.5}$ calculations is 11M – a difference of about 5%!

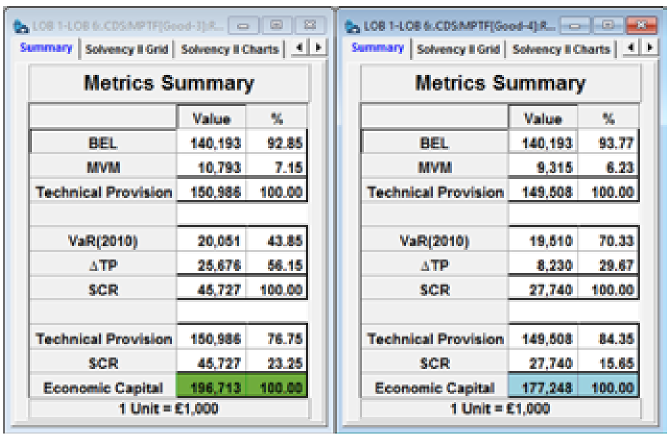
Holding the incorrect amount of capital can be very costly especially with the additional requirements imposed by Solvency II. It is imperative that a company's risk volatility characteristics are modeled accurately.

Accurate modeling has two immediate benefits:

(1) risk capital is accessed at the most optimal and cost-effective rate; and

(2) timely and critical financial information is provided regarding emerging trends enabling efficient management of liability risks.

Correct treatment of correlations also leads to risk diversification of SCR and TP.



Metrics Summary

	Value	%
BEL	140,193	92.85
MVM	10,793	7.15
Technical Provision	150,986	100.00
VaR(2010)	20,051	43.85
∆TP	25,676	56.15
SCR	45,727	100.00
Technical Provision	150,986	76.75
SCR	45,727	23.25
Economic Capital	196,713	100.00

1 Unit = £1,000

Metrics Summary

	Value	%
BEL	140,193	93.77
MVM	9,315	6.23
Technical Provision	149,508	100.00
VaR(2010)	19,510	70.33
∆TP	8,230	29.67
SCR	27,740	100.00
Technical Provision	149,508	84.35
SCR	27,740	15.65
Economic Capital	177,248	100.00

1 Unit = £1,000

Using the same example as previously, the Economic Capital total is nearly 20M higher when the positive correlation between the LoBs is properly included. Conversely, if the process correlation between the datasets was zero (the most common situation), then assuming a positive correlation between the LoBs will result in an unnecessarily high risk capital charge (20M higher than required in our example)!

3. One year risk horizon

In this section, we illustrate the one year risk horizon which decomposes the directives into the three basic elements of managing risk capital – Best Estimate of Liabilities, Risk Margin, and Solvency Capital Requirement (SCR).

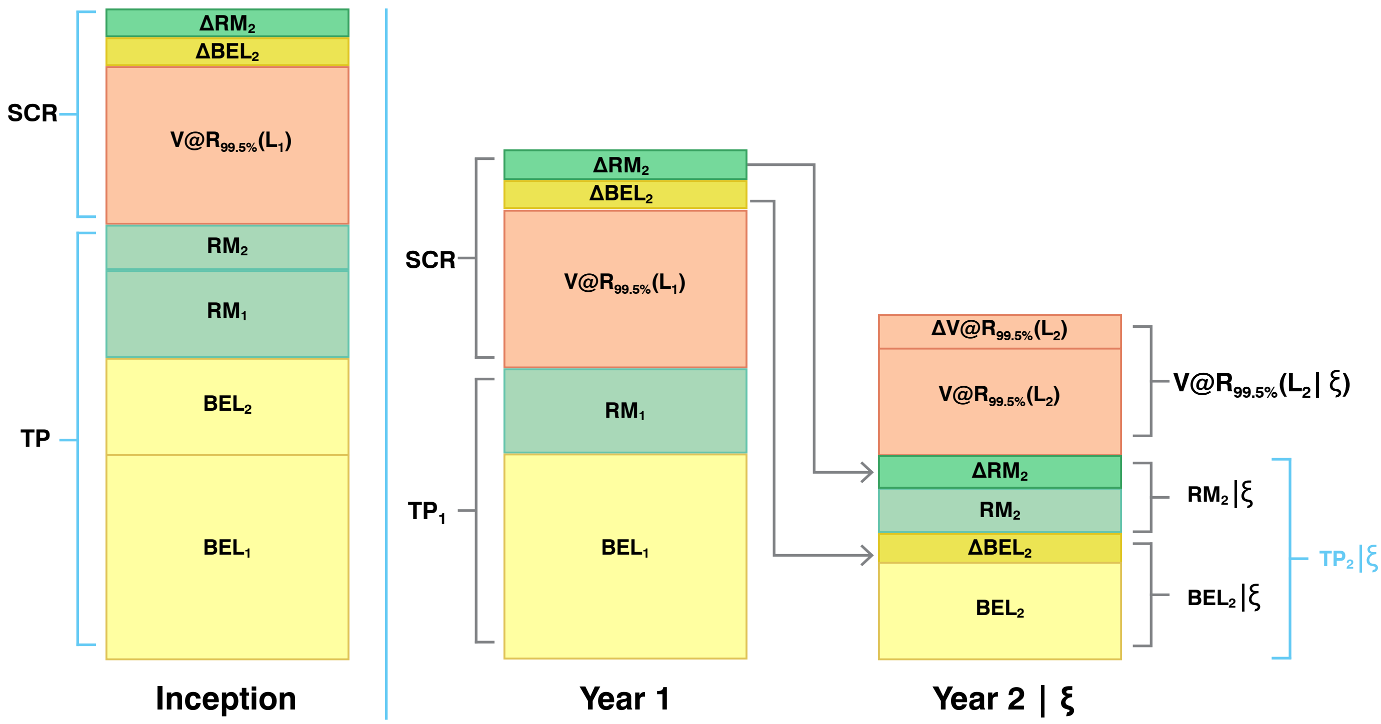
The Best Estimate of Liabilities are the expected losses by calendar year discounted for the time-value of money. The Risk Margin is the cost of holding the risk capital (including the SCR).

The SCR we define as previously to be the sum of the risk capital to cover losses to the 99.5th percentile plus the additional capital to restore the balance sheet to fair value should this event occur:

$SCR = V@R_{99.5\%}(1) + \Delta TP(2) + \Delta TP(3) + \ldots + \Delta TP(n);$

where n is the number of years until run-off.

For a two-year run-off the breakdown of the SCR and associated capital to restore the Economic Balance Sheet can be shown graphically.



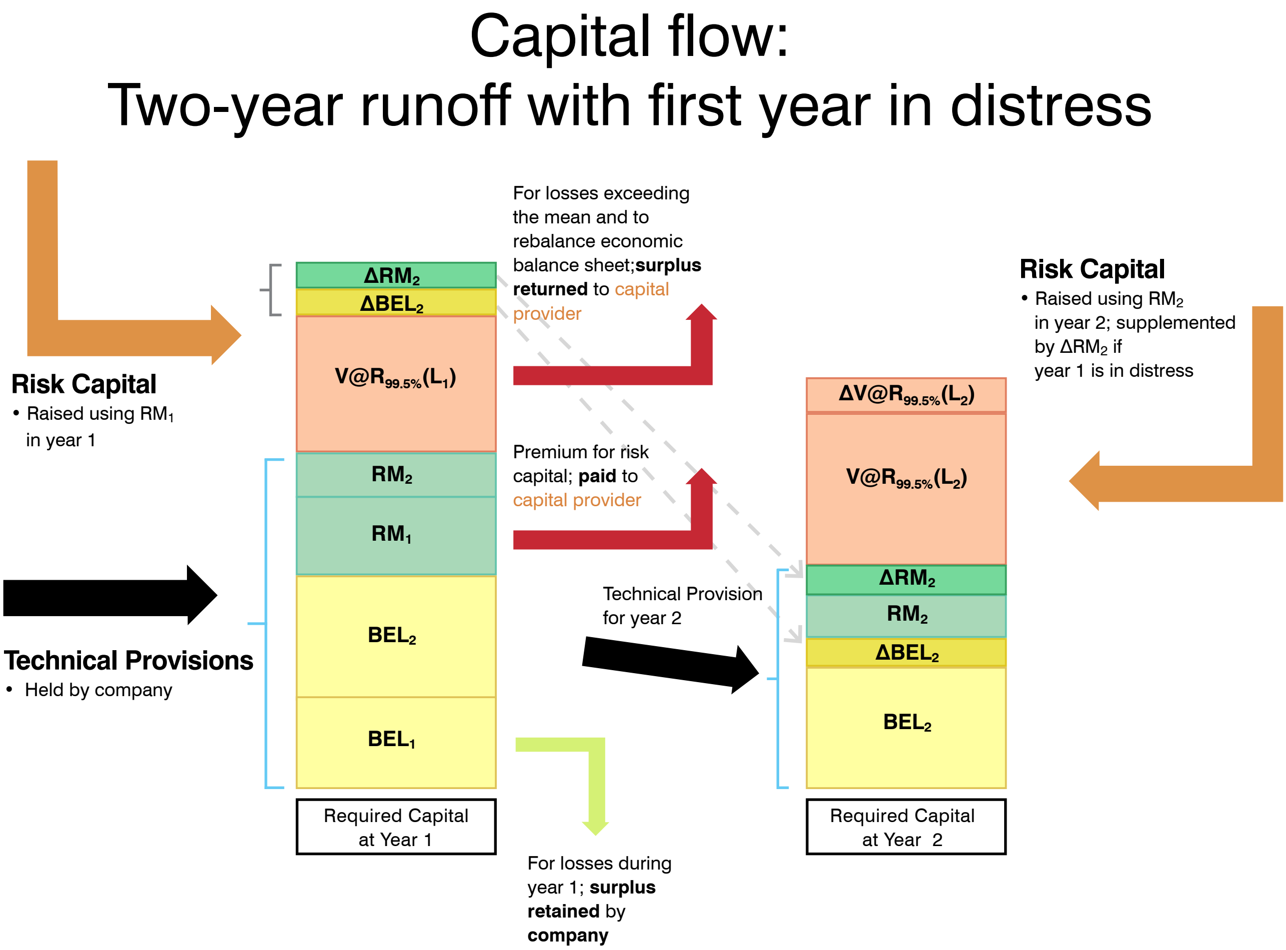
The first year being in distress (ξ) impacts the subsequent years. Both BEL and the required Risk Margins change in the second year – thus the change in Technical Provision in the formula above.

The estimates of SCR and Risk Margins for the first year are then dependent not only on the risk capital, but also the restoration of the Economic Balance Sheet. Further recursion is not required if only the first year in distress is considered.

Calculated in this way, the SCR is adequate to restore the balance sheet to a fair value of liabilities at the end of a distressed first year so that the portfolio can then be transferred or sold to a reinsurer at the beginning of the second year.

3.1. Flow of capital for the one-year risk horizon solution

The flow of capital in this Solvency II solution is straightforward to track.



Premiums are raised to cover the Technical Provision – the Best Estimate of Liabilities for the two years and the Risk Margin for the risk capital to be raised over the two years. Included in the first year's risk capital are any adjustments to be made should the first year be in distress.

At the end of the first year:

- BEL_1 is used to pay the losses in the year.
- If the losses exceed BEL_1 then the risk capital is accessed.
- The risk capital provider receives RM_1
- The risk capital provider receives any unused risk capital after all losses in the first year have been paid and adjustments for the second year's BEL and/or risk capital are applied.

The two year run-off solution described above is easily extended to multiple years. The same principles apply where capital is raised to cover the value at risk in the first calendar year plus any amendments should that first calendar year be in distress.

3.2. If the first future year is in distress…

In summary, if the first future year is in distress, then the following events occur:

- BEL_1 and $V@R_{99.5}(L_1)$ are exhausted (the losses incurred were at the 99.5% quantile).
- RM_1 is returned to the capital providers and is not used to pay claims since BEL_1 and $V@R_{99.5}(L_1)$ are sufficient to pay for claims. Total capital returned is: SCR*(spread + risk free rate).
- The change in technical provision, ΔBEL_k and ΔRM_k, are assigned to the respective future calendar year BEL_k and RM_k respectively.

It is emphasized that any return on ΔBEL_k, ΔRM_k in the first year is returned to the capital providers as part of the risk free rate calculated on the SCR. These adjustments cannot be used to pay for losses in the first calendar year as otherwise the Economic Balance Sheet cannot be returned to fair value.

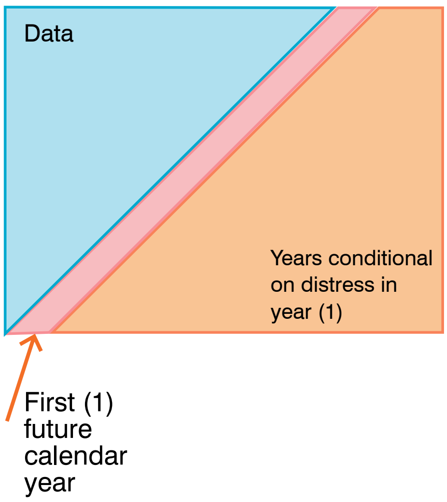
At the beginning of the second year the economic balance sheet has been restored to fair value after a distress scenario in the first year.

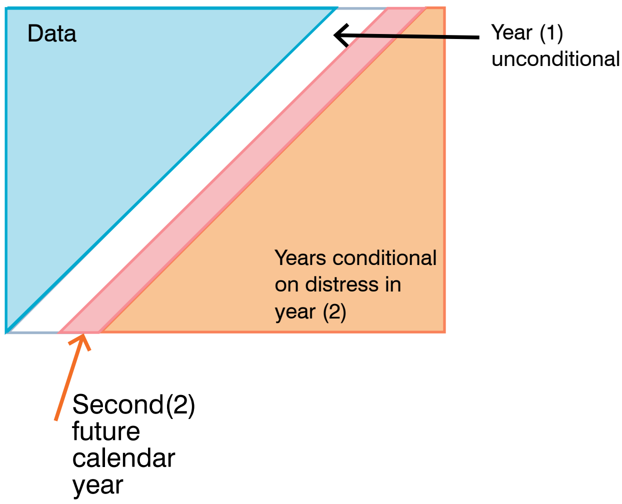
3.3. One-year risk horizon: multiple calendar years in distress

The SCR as calculated for one year in distress is adequate to restore the balance sheet to a fair value of liabilities at the end of a distressed first year such that the portfolio can then be transferred or sold to a reinsurer. In this section, we consider the solution where it is expected that fair value incorporates that the receiver also subscribes to Solvency II.

If the receiver also subscribes to Solvency II then the receiver must also hold sufficient capital for their next year being in distress (the second future calendar year) and being able to provide sufficient fair value to the receiver of the liabilities should they have to transfer them. Since this naturally applies to any receiver, the result is that the analysis must consider a distress scenario for every year.

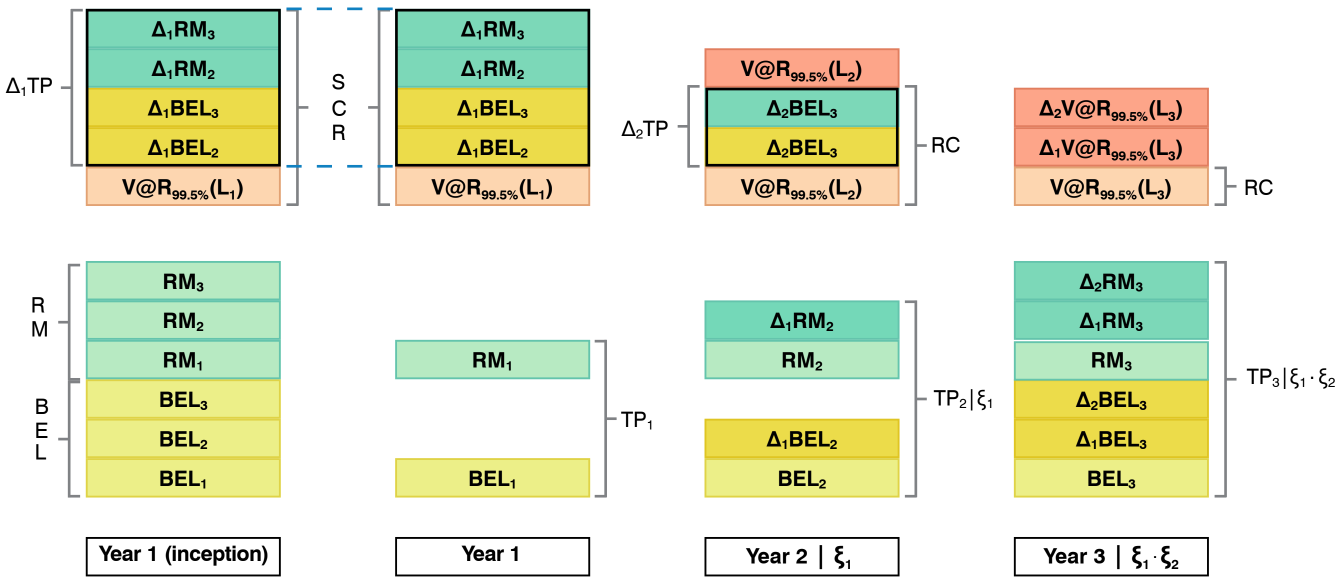
The solution is not recursive if the transferrer only considers the situation where the future receiver is in distress and does not consider any adjustments to the risk capital fund to account for the multiple combinations of potential distress scenarios. That is, a single step procedure is performed where each future year is analyzed as being in distress without conditioning on the losses in prior future years. Since Solvency II only refers to a one-year time horizon, the single-step restriction is reasonable.





Example: Three year run-off (correlated)

In a three year run-off there are two distress years to consider conditionally – the first and second future calendar years. The new terms in the diagram are Δ_2RM and Δ_2V@R. The additional risk capital required in the third year should the second year be in distress is Δ_2V@R. The cost of raising this capital is Δ_2RM. For the purpose of this calculation, Δ_1RM and Δ_2RM are considered additive – an adjustment for year 1 and year 2 both being explicitly in distress is not included.



For this solution the steps are as follows:

1. Simulate all future calendar years – these are the unconditional distributions
2. Select simulations around the 99.5th percentile for the first year from the unconditional distribution (there are multiple ways to reach distress and it is unwise to condition on just one simulation). Simulate the conditional distributions arising for all subsequent future years to run-off.
3. From the conditional simulations in (2), calculate the adjustments to Technical Provisions required for subsequent years should the prior year be in distress. Add the cost of the sum of the adjustments, suitably discounted, to the RM for this year.
4. Repeat (2-3) for the second year through to run-off – 1 (the last calendar year in run-off has no future calendar year to condition for).

The selection of the distress samples from the unconditional distributions eliminates recursion.

This solution also provides a novel mechanism for pricing reinsurance programs. The Best Estimate of Liabilities is the reserves expected to be paid and Risk Margin (assuming multiple years in distress) is a method of pricing the risk capital charge. In this pricing algorithm the 85th percentile is more reasonable, and a spread of more than 6% may be expected depending on risk appetite.

4. ICRFS™, Solvency II and IFRS 17

The new standard, IFRS 17, published by the International Accounting Standard Board (IASB) is the result of a comprehensive review of the accounting for insurance contracts. Known as 'IFRS 4 Phase II' in its development, the nal standard incorporates feedback from various exposure drafts along with eld test activities. The accounting standard diverged from Solvency II standards - though both standards incorporate similar concepts. Both standards require accurate estimation of cash flow distributions - not just means, but a measure of the risk margin which are then incorporated into the respective balance sheet.

The standard requires entities to group insurance contracts into portfolios which are subject to similar risks. For the purpose of aggregation, these portfolios are then to be subdivided into at least three categories depending on their likelihood of being onerous.

Like Solvency II, IFRS 17 species that the contracts are to be measured as the total of future cash flows, adjusted by the time value of money, and a margin to account for nancial and non-nancial risk. In Solvency II, the margin is for the raising of risk capital, whereas in IFRS 17, the margin is to cover any unexpected losses. Note that any discounting applied to the losses is included in the IFRS 17 balance sheet as the contractual service margin (CSM).

The risk adjustment techniques, specied in the standard, require the measuring of probability distributions by calendar year of the underlying cash flows. Cost of capital, conditional tail expectation, and condence levels (V@R) necessitate models that project distributions by calendar year.

The Probabilistic Trend Family (PTF) and Multiple Probabilistic Trend Family (MPTF) modeling frameworks within ICRFS™ provide the distributions required to compute the risk adjustment measures.

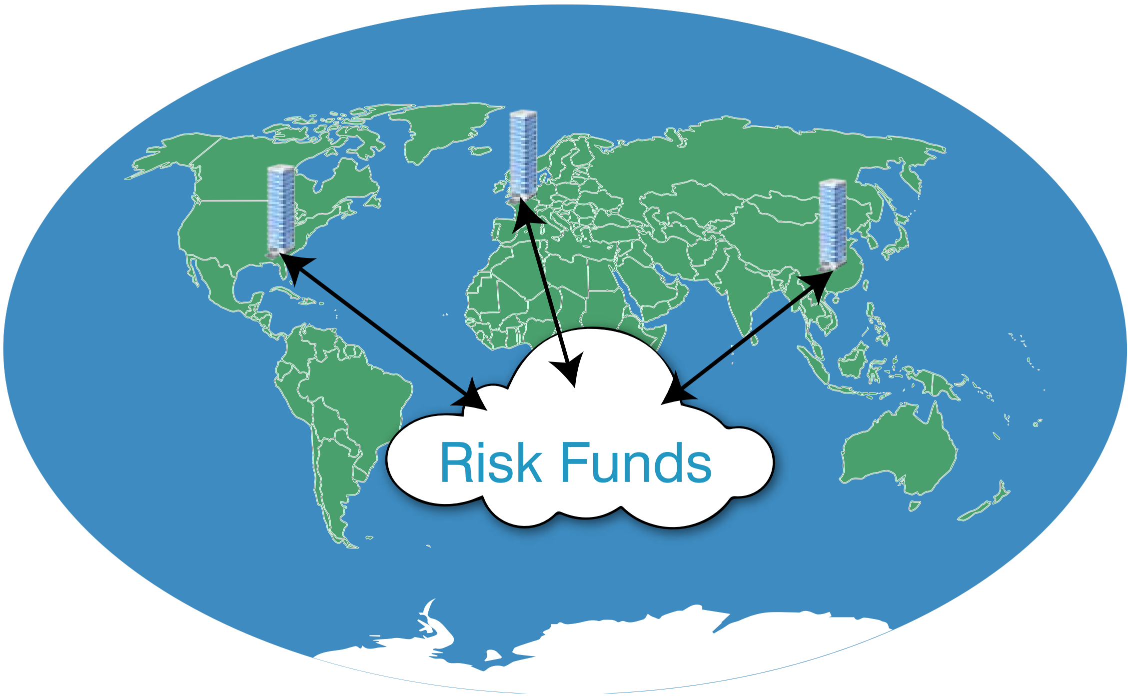
In MPTF, a single composite model for a portfolio, identied from the data, succinctly describes the volatility in each sub-category and the correlation structure between them. Easily interpretable parameters forecast lognormal distributions for each cell for each sub-category. From these parameters, distributions and correlations are computed by accident year, calendar year, and total for each sub-category and the aggregate of the sub-categories (the portfolio). Multiple portfolios can also be aggregated - providing maximum fexibility and comprehensive analysis for both IFRS 17 and Solvency II purposes.

Since Solvency II calculations also require the same distributions by calendar year, ICRFS™ is the ideal tool to construct internal models that meet both Solvency II and IFRS 17 requirements for long-tail liabilities. Calculation of the core components can be sourced from the same model. The joint use of ICRFS™ internal models for both applications implicitly reduces implementation costs.

4.1. IFRS 17 risk margin and ring-fenced funds

The IFRS 17 standard does not specify how the risk margin is to be calculated - or the level of diversication that can be considered. Previous exposure drafts (2010) suggested risk adjustments be applied at the portfolio level. If applied at too ne a level, then the benets of pooling risk are not fully realised.

In any case, when considering aggregation over LoBs, portfolios, or indeed any other meaningful categorisation, it is unlikely to be appropriate that risk capital is fully shareable between all categories or that excess capital (losses lower than expected) in one line is available to supplement a decit (losses greater than expected) in another line. This particularly applies under the IFRS 17 standard since there are conditions on how losses are recognised in the prot/loss statement.

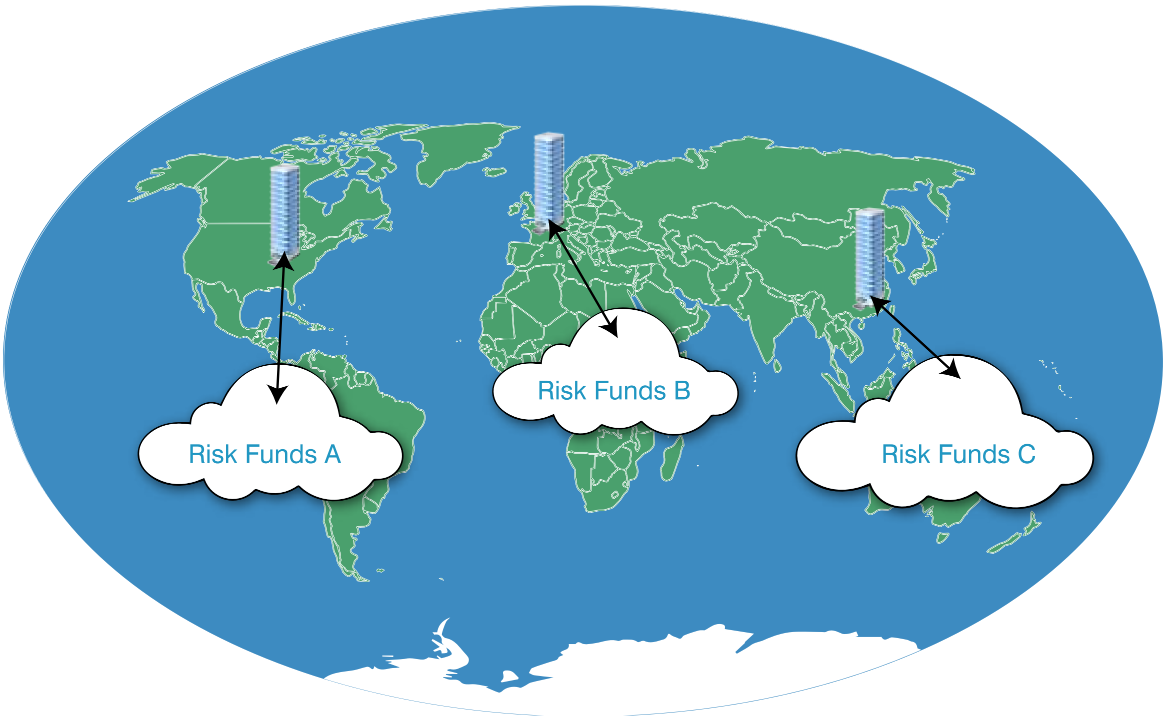


Ring fenced funds where excesses in a group of LoBs do not supplement losses in another LoB or have other restrictions are discussed in the EIOPA Report on the fth Quantitative Impact Study (QIS 5) for Solvency II. A ring fenced fund as referred to in the level 1 text arises as a result of an arrangement where:

a) There is a barrier to the sharing of prots/losses arising from dierent parts of the undertakings business leading to a reduction in the pooling/diversication related to that ring fenced fund; or

b) Own funds (restricted own funds) can only be used to cover losses on a dened portion of the undertakings (re)insurance portfolio or with respect to particular policy holders or in relation to particular risks such that those restricted own funds are only capable of fullling the criteria in Article 93(1) (a) and/or (b) in respect of that dened portion of the portfolio, or with respect to those policy holders or those risks; or

c) Both a) and b) apply (11.2)



There are solutions which include diversication credit of the risk fund, while not diversifying excesses arising from losses below the means. Consider the structure where a risk fund is pooled for all LoBs written. Under this structure, a number of options for fungibility (sharing of risk capital including excess capital from losses realised lower than expected), or lack thereof, can be considered.

1) Full fungibility; an excess in one line can supplement a decit in another 2 line.

2) No fungibility; excesses in a line are retained in that line and do not supplement the risk fund.

3) Partial fungibility; excesses in a portfolio are fungible within the LoBs comprising the portfolio, but not between portfolios. Here a portfolio refers to a group of LoBs (possibly in a cluster) which are ring fenced as a whole.

The options can be broken down further since excesses and decits arrive in calendar time. Applying the above reasoning, the following scenarios can be considered:

1) No sharing of excesses by calendar year In this case funds are treated as if already allocated to each calendar year according to the forecast estimates. If the losses for the next calendar year exceed the estimated mean, the dierence is made up by drawing from the risk pool. If the losses are below the allocated reserve the dierence is released as prot immediately; the excess amounts are not rolled over into the reserve fund.

2) Buered diversifcation by calendar year The accumulated excess from previous calendar years is retained as a buffer fund to be drawn on before calls are made on the risk fund. In this case pooling occurs only in relation to past years (drawing on a future excess is not permitted). The retention of funds allocated to future years retains a higher priority than drawing on the risk fund, so that funds allocated to future calendar years cannot be accessed. When the contracts are concluded, any excess capital is released as profit.

The calendar year scenarios are readily extended to multiple LoBs where fungibility between LoBs is limited.

This second case allows the accumulation of prot to be unlocked to cover onerous losses in a later period - similar to the behaviour of the IFRS 17 contract service margin which is 0+.

The cases can be unied by thinking in terms of a buer fund, or funds which delay calls to the risk fund. There may be a single buer fund or separate ones for each LoB. A buer fund may have access to the unused reserve fund for that line, or only to the current aggregate excess, or may always be zero. In all of these cases the risk fund is held in common, but what changes is the trigger for a call on the risk fund.

The various combinations provide for a broad range of reserving policies, and can be adapted to respond to dierent regulatory or prudential regimes. Present value accounting can also be adapted to the timing inherent in each set-up.

IFRS 17 species that the risk adjustment reflects both favourable and unfavourable outcomes reflecting the entitiy's risk aversion. Accordingly, the entity can select the most appropriate degree of fungibility - however, the calculations and expectations should be transparent. Using ICRFS™ internal models, forecast scenarios, and simulations, all of the above situations can be considered.

Example: L_A and L_B

Consider two LoBs: L_A and L_B

Case 1: The aggregate loss distribution, $L_A + L_B$, assumes L_A and L_B are fully fungible.

Case 2: If L_A and L_B are restricted such that the surplus arising from any loss less than the mean of L_A or L_B are retained by L_A or L_B respectively, then the aggregate distribution becomes:

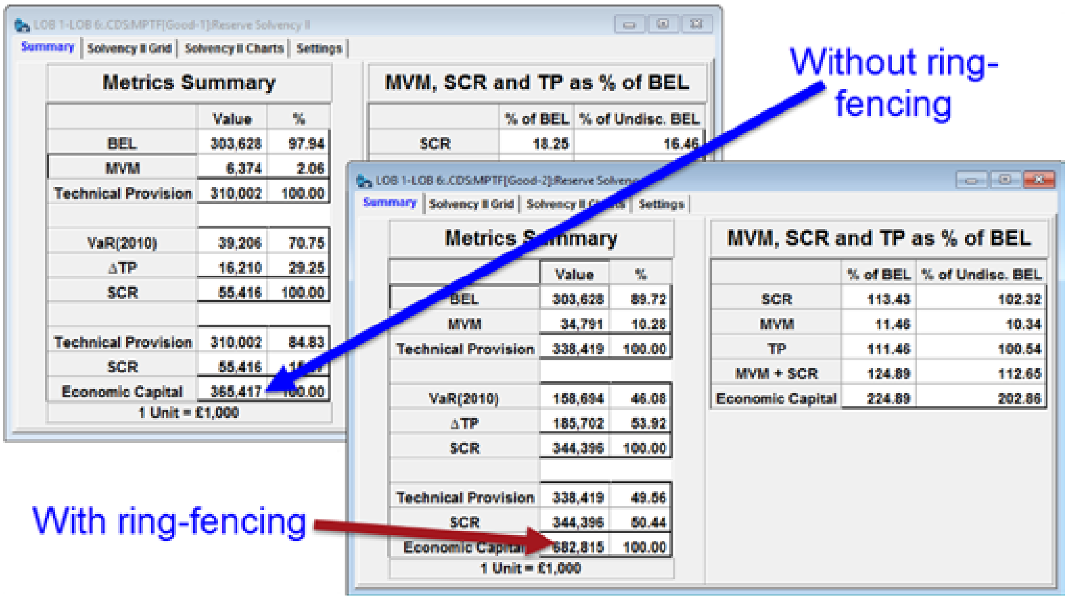
$L^*_A + L^*_B$ where:

$L^*_A = \text{Max}(L_A, \text{mean}(L_A))$, and

$L^*_B = \text{Max}(L_B, \text{mean}(L_B))$

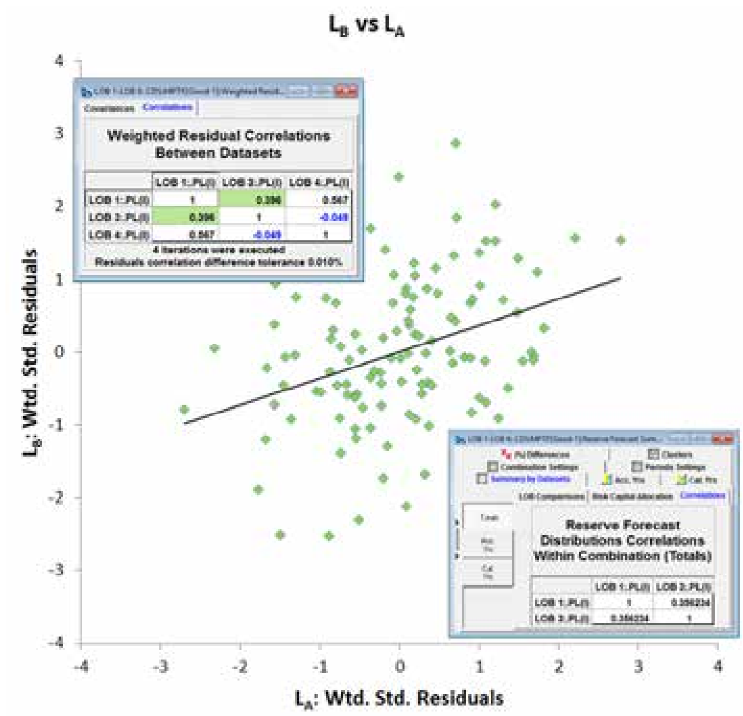
The above implicitly implies that any loss less than the mean of either LoB does not contribute to the risk pool, and can be managed according to company policy (release or retention) without any loss of risk cover. This represents a loss of diversification credit for writing multiple lines.

In the case of two independent lines, the loss of diversification can be in the order of 5-10%. If the two lines are positive-correlated, then the loss could be significant (eg: below).



In the above example, the loss of diversification credit (two lines, LA and LB) is significant. Both the V@R for the next calendar year along and the ΔTP are substantially higher in the event of a distress scenario.

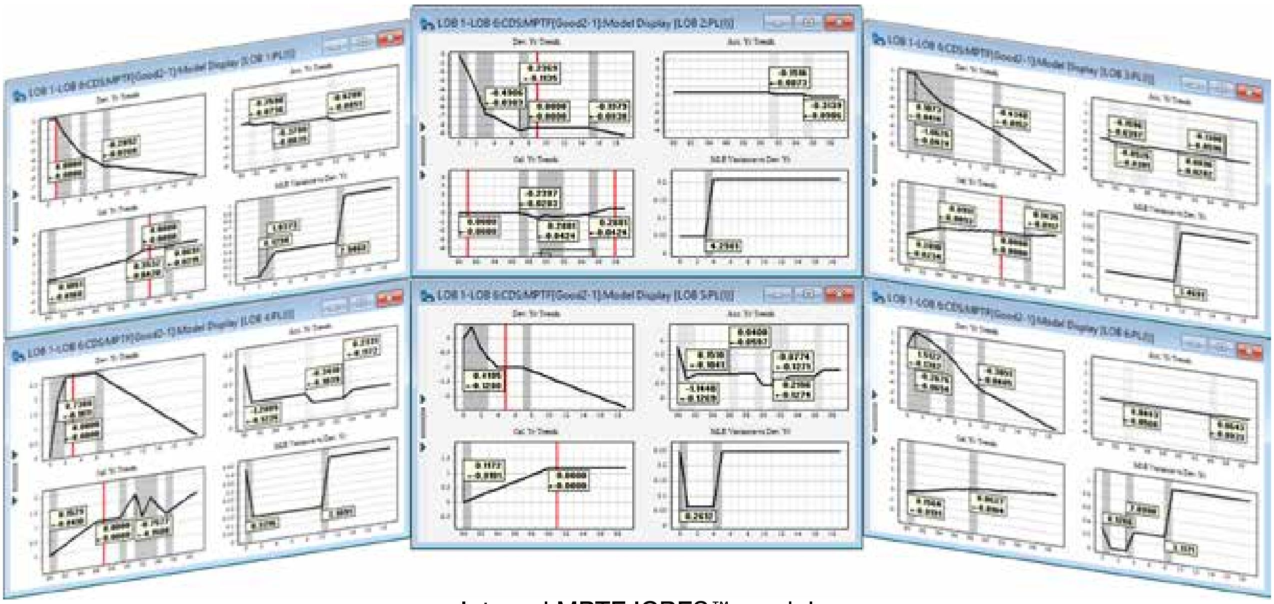
The reserve distribution correlation for this example is 0.356 – which while not that high, still has significant impact. The volatility correlation is of similar magnitude (0.396). For a discussion of the relationship between volatility correlation, parameter correlation and reserve distribution correlation please see the brochure ‘Understanding Correlations’.



Risk capital structures are an important consideration when calculating Solvency II metrics. While ring-fencing may be desirable, the impact on risk capital must be taken into account.

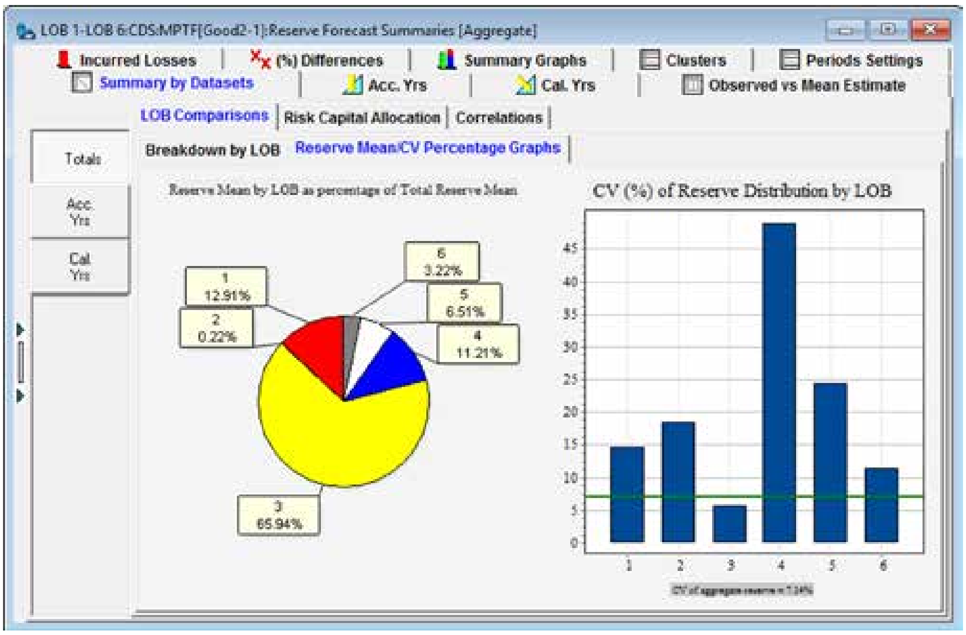
5. Case study: One Year Risk Horizon

In the following discussion we consider six LoBs (labelled LoB 1 through LoB 6) with the following internal ICRFS™ model. The displays highlight the trends (clockwise from top left) in the development, accident, volatility around the development trends, and trends in the calendar direction.

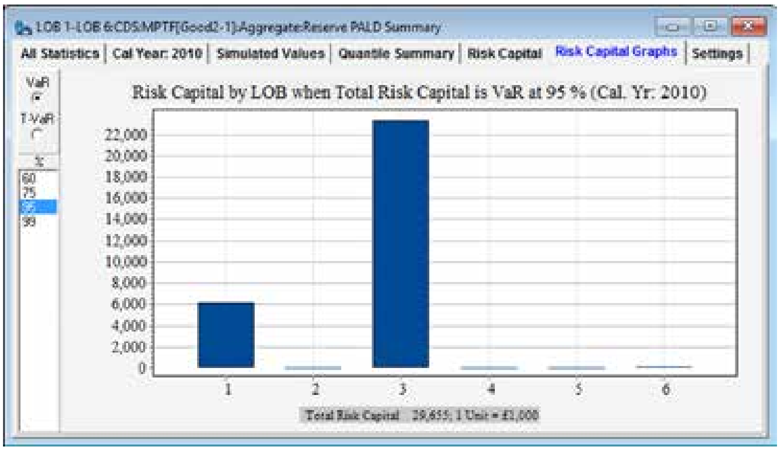


Internal MPTF ICRFS™ model

LoB 4 is the most volatile of the LoBs due to very unstable calendar year trends. The high uncertainty in the parameters results in high calendar year correlations which in turn impact risk capital requirements in future calendar years. The comparative volatility for the LoBs and for the aggregate is illustrated in the following displays.

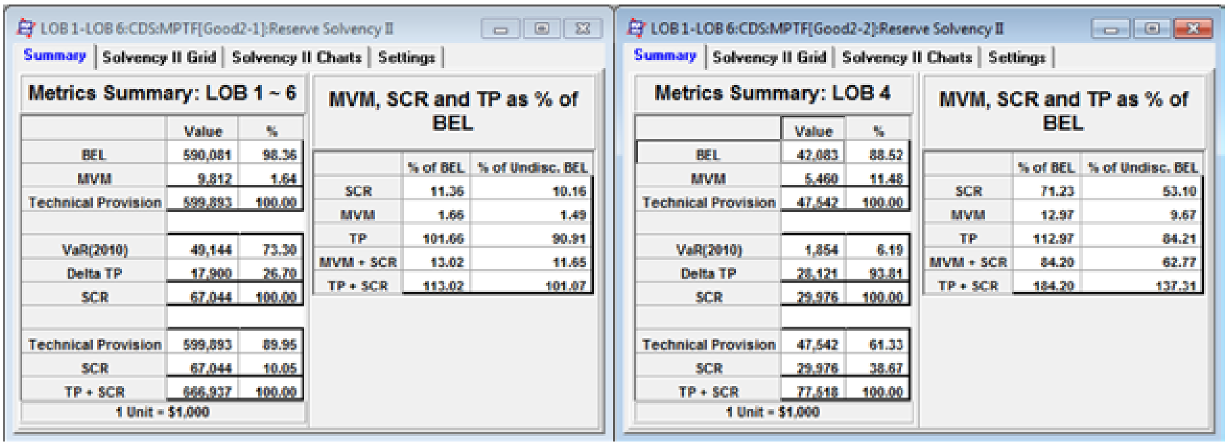


Almost all the risk capital allocation for the next calendar year (2010), is primarily allocated to LoB 1 and LoB 3!



The other lines do not require risk capital till later in the run-off, thus Solvency II one-year risk horizon (one year in distress) capital requirements are effectively driven by these two LoBs only. This result emphasizes the importance of not only having the right mean and standard deviation estimates, but also the correlations to be able allocate capital to each calendar year correctly.

The total capital required for the aggregate of the six lines is almost the same as the mean of the undiscounted reserves.



LOB 1-LOB 6:CDS:MPTF[Good2-1]:Reserve Solvency II
Summary | Solvency II Grid | Solvency II Charts | Settings

Metrics Summary: LOB 1 ~ 6

	Value	%
BEL	590,081	98.36
MVM	9,812	1.64
Technical Provision	599,893	100.00
VaR(2010)	49,144	73.30
Delta TP	17,900	26.70
SCR	67,044	100.00
Technical Provision	599,893	89.95
SCR	67,044	10.05
TP + SCR	666,937	100.00

1 Unit = $1,000

MVM, SCR and TP as % of BEL

	% of BEL	% of Undisc. BEL
SCR	11.36	10.16
MVM	1.66	1.49
TP	101.66	90.91
MVM + SCR	13.02	11.65
TP + SCR	113.02	101.07

LOB 1-LOB 6:CDS:MPTF[Good2-2]:Reserve Solvency II
Summary | Solvency II Grid | Solvency II Charts | Settings

Metrics Summary: LOB 4

	Value	%
BEL	42,083	88.52
MVM	5,460	11.48
Technical Provision	47,542	100.00
VaR(2010)	1,854	6.19
Delta TP	28,121	93.81
SCR	29,976	100.00
Technical Provision	47,542	61.33
SCR	29,976	38.67
TP + SCR	77,518	100.00

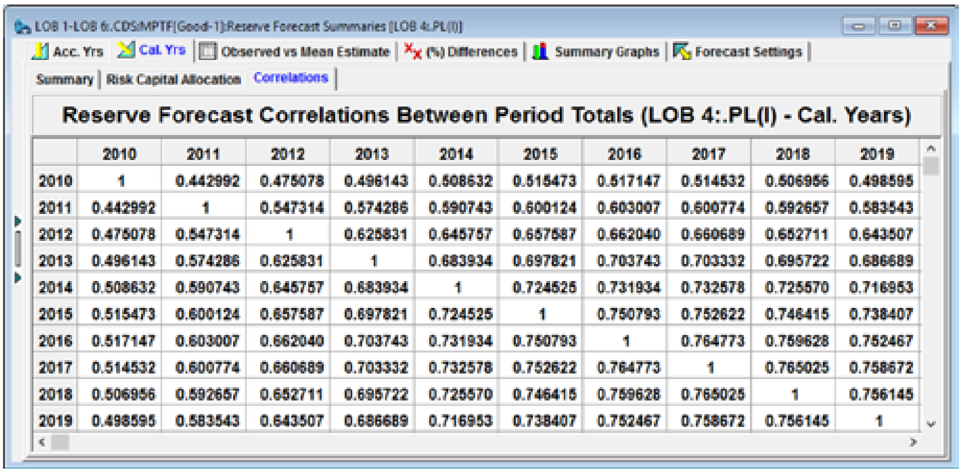
1 Unit = $1,000

MVM, SCR and TP as % of BEL

	% of BEL	% of Undisc. BEL
SCR	71.23	53.10
MVM	12.97	9.67
TP	112.97	84.21
MVM + SCR	84.20	62.77
TP + SCR	184.20	137.31

For the aggregate (left), the metrics are dominated by BEL – the other components do not form a large percentage of the total capital required.

If LoB 4 was written on its own (right), significant additional capital is required compared to the undiscounted reserves. This additional capital is principally allocated to ΔTP, capital needed to restore the balance sheet should the next year be 'in distress' – a result of the high calendar year correlations.



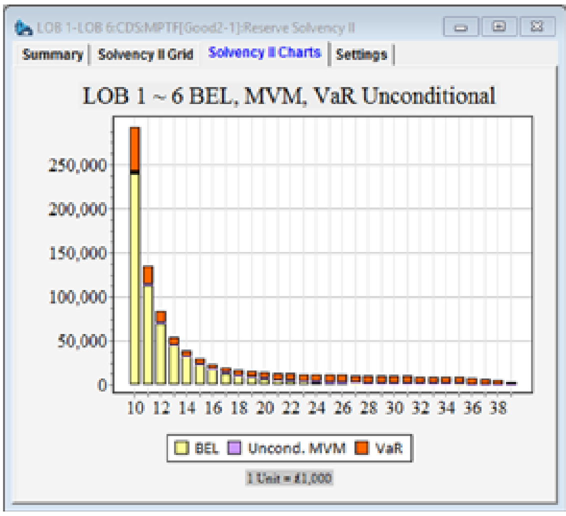
LOB 1-LOB 6:CDS:MPTF[Good-1]:Reserve Forecast Summaries [LOB 4:.PL(I)]
Acc. Yrs | Cal. Yrs | Observed vs Mean Estimate | (%) Differences | Summary Graphs | Forecast Settings
Summary | Risk Capital Allocation | Correlations

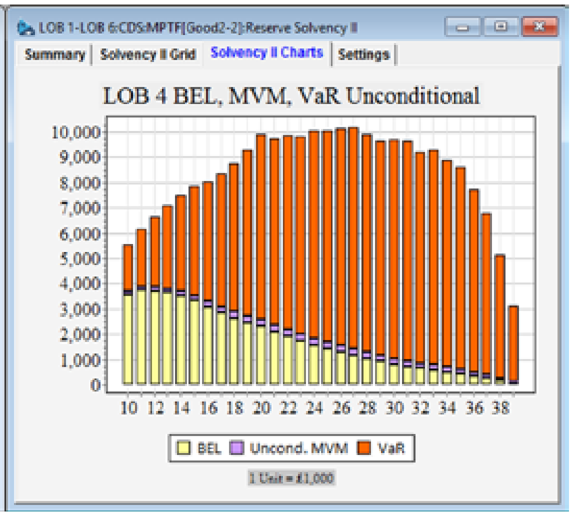
Reserve Forecast Correlations Between Period Totals (LOB 4:.PL(I) - Cal. Years)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
2010	1	0.442992	0.475078	0.496143	0.508632	0.515473	0.517147	0.514532	0.506956	0.498595
2011	0.442992	1	0.547314	0.574286	0.590743	0.600124	0.603007	0.600774	0.592657	0.583543
2012	0.475078	0.547314	1	0.625831	0.645757	0.657587	0.662040	0.660689	0.652711	0.643507
2013	0.496143	0.574286	0.625831	1	0.683934	0.697821	0.703743	0.703332	0.695722	0.686689
2014	0.508632	0.590743	0.645757	0.683934	1	0.724525	0.731934	0.732578	0.725570	0.716953
2015	0.515473	0.600124	0.657587	0.697821	0.724525	1	0.750793	0.752622	0.746415	0.738407
2016	0.517147	0.603007	0.662040	0.703743	0.731934	0.750793	1	0.764773	0.759628	0.752467
2017	0.514532	0.600774	0.660689	0.703332	0.732578	0.752622	0.764773	1	0.765025	0.758672
2018	0.506956	0.592657	0.652711	0.695722	0.725570	0.746415	0.759628	0.765025	1	0.756145
2019	0.498595	0.583543	0.643507	0.686689	0.716953	0.738407	0.752467	0.758672	0.756145	1

The calendar trend is very sensitive to new observations which, if high, result in a higher estimate of the calendar year trend requiring substantial revision of future calendar year BELs (the probability of being in distress as a result of a poor estimate of the calendar year trend is high). The risk of LoB 4 is not a result of process variability but the uncertainty associated with future trends.

The allocation of technical provisions to each future calendar year given the first year is in distress is very different for the aggregate of the six lines (left) versus LoB 4 (right).





Both V@R and BEL taper off quickly for the aggregate, although the later years have proportionally higher V@R. For LoB4, however, the V@R increases rapidly by calendar year and does not decrease till the last few calendar years. Similarly, the BEL increase before slowly decreasing. V@R is a huge proportion of the mean for most calendar years for LoB 4.

5.1. Diversification and fungibility

The changes in risk capital required for differing degrees of fungibility (or ring fencing) are detailed as follows. Full fungibility has the lowest risk capital requirement, with a low additional increase in risk capital related to a buffered fund. Holding all LoBs as individual entities and only pooling the risk capital incurs the largest penalty (as could be expected).

LOB 1 through LOB 6				
One year in distress (2010)				
Fungibility	SCR	MVM	% charge in risk capital	% charge in cost capital
Across LOB, Forward	68,660	9,879	-	-
Across LOB	68,546	10,053	-0.17%	1.73%
not Across LOB, Forward	69,206	10,167	0.79%	2.80%
None	69,131	10,451	0.68%	5.47%
Multiple years in distress (2010~2029)				
Across LOB, Forward	68,660	26,799	-	-
Across LOB	68,546	26,935	-0.17%	0.50%
not Across LOB, Forward	69,206	27,108	0.79%	1.14%
None	69,131	27,399	0.68%	2.19%

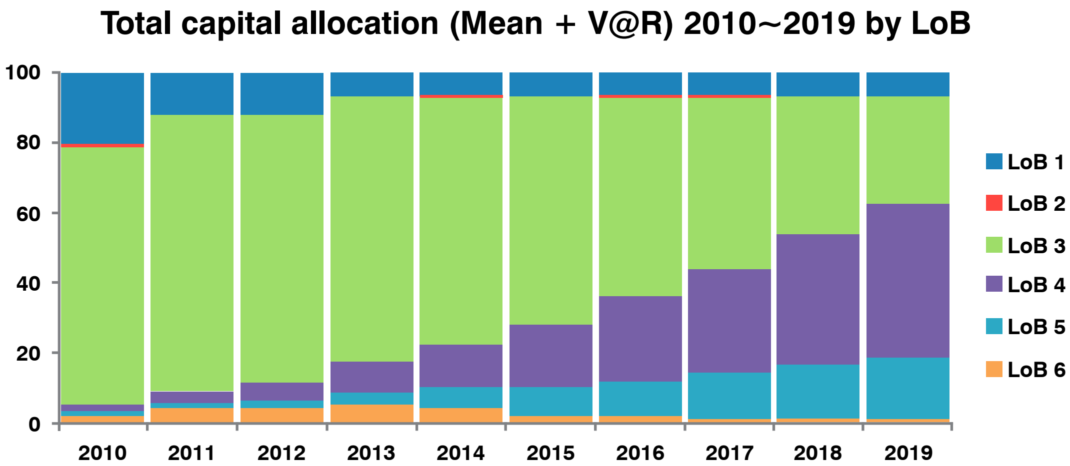
It should be noted, however, there may be significant variability in SCR irrespective of the fungibility selection if fewer simulations are conducted; Risk Margin generally is expected to be more consistent.

Not all results are intuitive. For instance, for multiple years in distress, not Across LoB, forward has a significantly lower cost of capital. This is a result of LoB 4 not being a significant contributor to distress in the next few years – thus giving a greater probability of accumulating a surplus which then supplements subsequent distress scenarios where LoB 4 is highly likely to be in distress. The net result is a lower cost of capital.

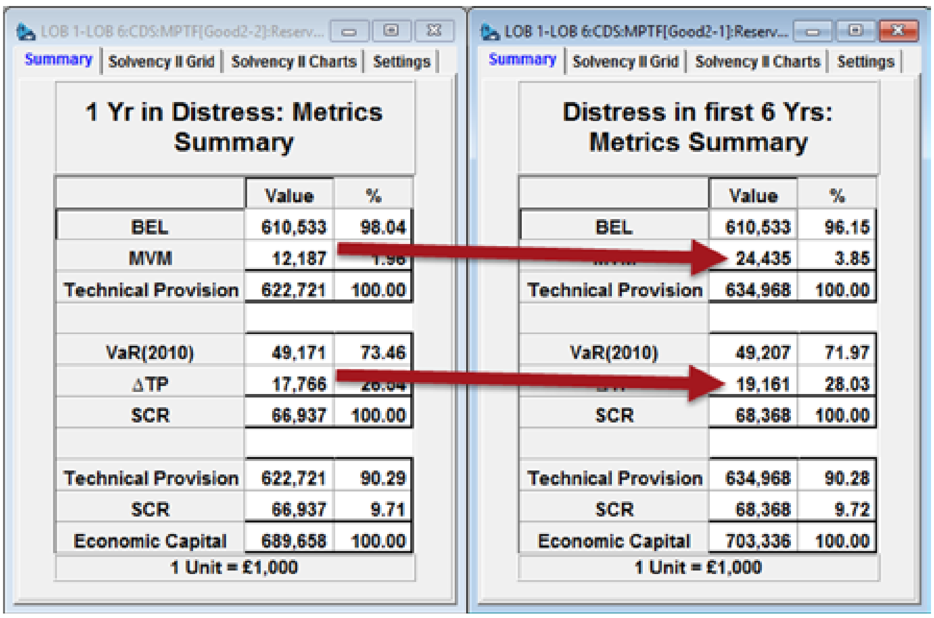
5.2. Multiple years in distress

If multiple years are considered as being potentially 'in distress' then more risk capital allocated to each future year is required in order to restore subsequent economic balance sheets. The capital requirements and adjustments reflect the driver of distress in each calendar year.

Risk capital contributes significantly to the total capital requirements as the calendar year's progress. Furthermore, the proportion of the risk capital by LoB varies; the proportions are indicative of the expectations of distress over time. In 2010, the most likely causes of distress are LoB 3 and LoB 1 respectively, whereas by 2019, the most likely origin of distress is LoB 4.



From 2013 the V@R is a low percentage of risk capital and the majority of the risk capital is required to adjust future BELs. This is primarily reflective of the high calendar year correlations in LoB 4 as this line becomes increasingly prominent over the emerging liability stream.



1 Yr in Distress: Metrics Summary

	Value	%
BEL	610,533	98.04
MVM	12,187	1.96
Technical Provision	622,721	100.00
VaR(2010)	49,171	73.46
ΔTP	17,766	26.54
SCR	66,937	100.00
Technical Provision	622,721	90.29
SCR	66,937	9.71
Economic Capital	689,658	100.00

1 Unit = £1,000

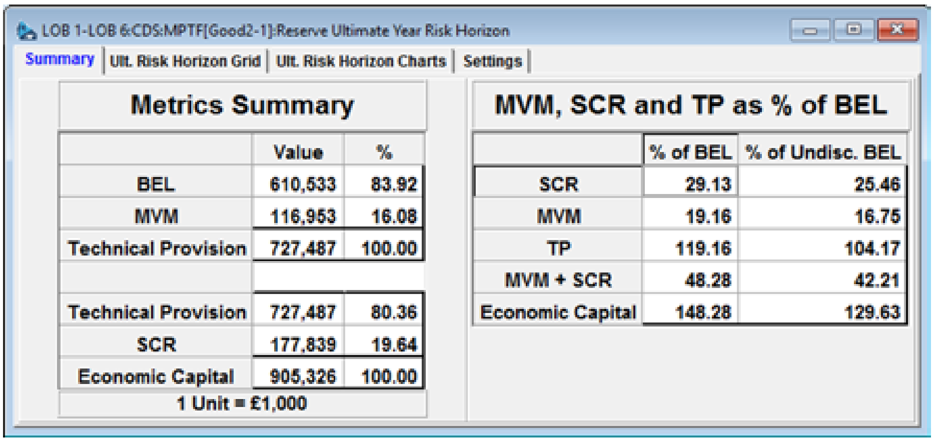
Distress in first 6 Yrs: Metrics Summary

	Value	%
BEL	610,533	96.15
MVM	24,435	3.85
Technical Provision	634,968	100.00
VaR(2010)	49,207	71.97
ΔTP	19,161	28.03
SCR	68,368	100.00
Technical Provision	634,968	90.28
SCR	68,368	9.72
Economic Capital	703,336	100.00

1 Unit = £1,000

6. Ultimate year risk horizon, risk capital, and Risk Margin

In the ultimate year risk horizon paradigm, risk capital is sufficient to cover adverse development up to a certain (eg 99.5%) quantile in the reserve distribution for the whole run-off period. The entire risk capital, that is, Value-at-Risk for the aggregate reserve (V@R[Aggregate] = V@R*(1)) is raised at inception and unused capital released back to the capital provider(s) at the end of each calendar year.


LOB 1-LOB 6:CDS:MPTF[Good2-1]:Reserve Ultimate Year Risk Horizon

Summary | Ult. Risk Horizon Grid | Ult. Risk Horizon Charts | Settings

Metrics Summary

	Value	%
BEL	610,533	83.92
MVM	116,953	16.08
Technical Provision	727,487	100.00
Technical Provision	727,487	80.36
SCR	177,839	19.64
Economic Capital	905,326	100.00

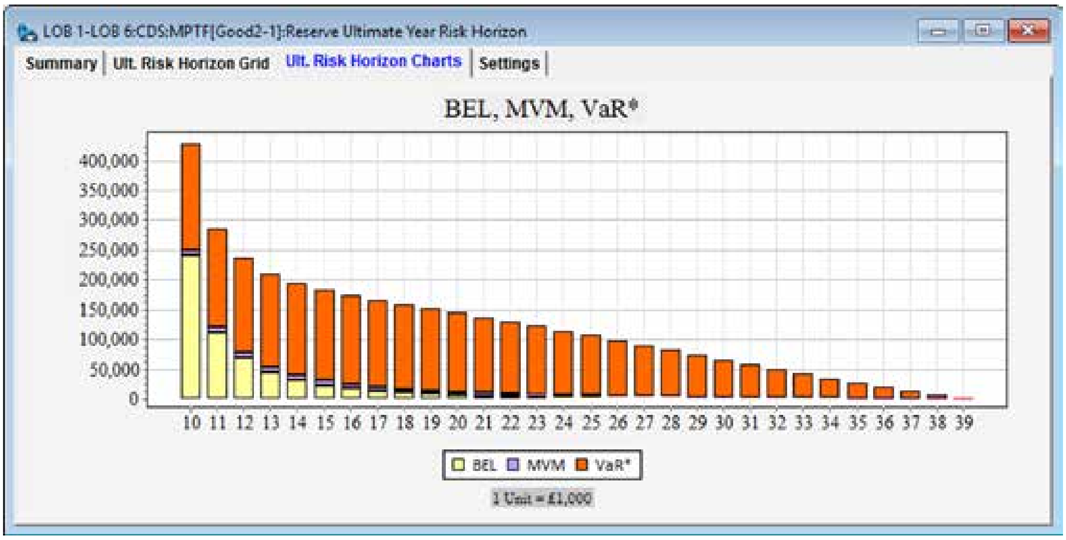
1 Unit = £1,000

MVM, SCR and TP as % of BEL

	% of BEL	% of Undisc. BEL
SCR	29.13	25.46
MVM	19.16	16.75
TP	119.16	104.17
MVM + SCR	48.28	42.21
Economic Capital	148.28	129.63

At the beginning of calendar year k (for k>2) the amount of risk capital retained for the remaining run-off period is V@R*(k). The amount of risk capital released back to the capital providers at the end of calendar year k (for k=1,…,n) depends on the total loss in year k, the mean loss for year k, risk capital V@R*(k) retained at the beginning of year k, and risk capital V@R*(k+1) retained at the beginning of year k+1.

The principal difference between the one-year risk horizon and the ultimate year risk horizon in respect of computing risk capital and RM is when capital is raised from the capital providers not when capital is returned to the capital providers.



7. Consistency of Solvency II risk measures and prior accident year ultimates on updating

The Solvency Capital, raised each year on updating, should not be subject to major shocks due to model errors.

Solvency II risk measures and estimates of prior year ultimates will be statistically consistent on updating from year to year if the forecast assumptions for the next calendar year play out and subsequent forward assumptions are statistically equivalent.

For instance, consider a company that writes the same mix of risks each year with the same exposure level each accident year. Risk capital is raised from the same provider with no changes in required return (risk free or spread).

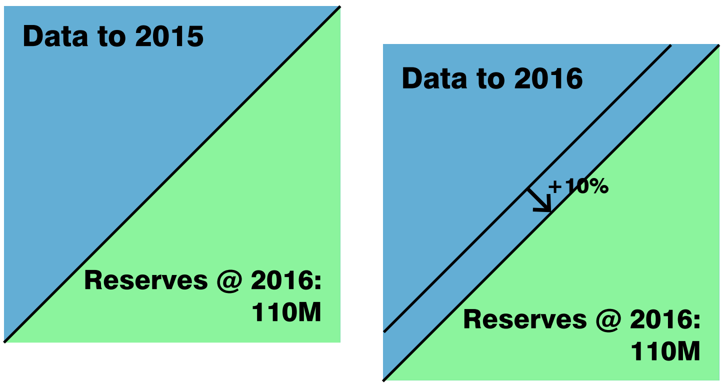
Suppose a calendar year trend is stable, say 10%±2% in the most recent years. For reserves to be computed accurately, the company assumes this 10%±2% trend going forward along the calendar years.

In this scenario, the following applies:

- Each year the company needs to increase its total reserve by at least 10%.
- Each year the company needs to increase its premium (price) by at least 10% to maintain the same level of profitability.
- The mean ultimates for prior accident years will remain consistent with each increase in total reserves.
- Mean ultimates increase by at least 10% from one accident year to the next.

The principal reason for these facts is that the calendar year trend projects both onto all the accident years and development years.

The calendar trend also impacts all prior accident years.



The increases in total reserves each year should not be regarded as an upgrade. If the costs in running the business increase by 10% each year then the company should at least increase the price of the products by 10% to maintain the status quo. If the total reserves are not increased each calendar year, then each year it is more and more likely the company is under-reserved.

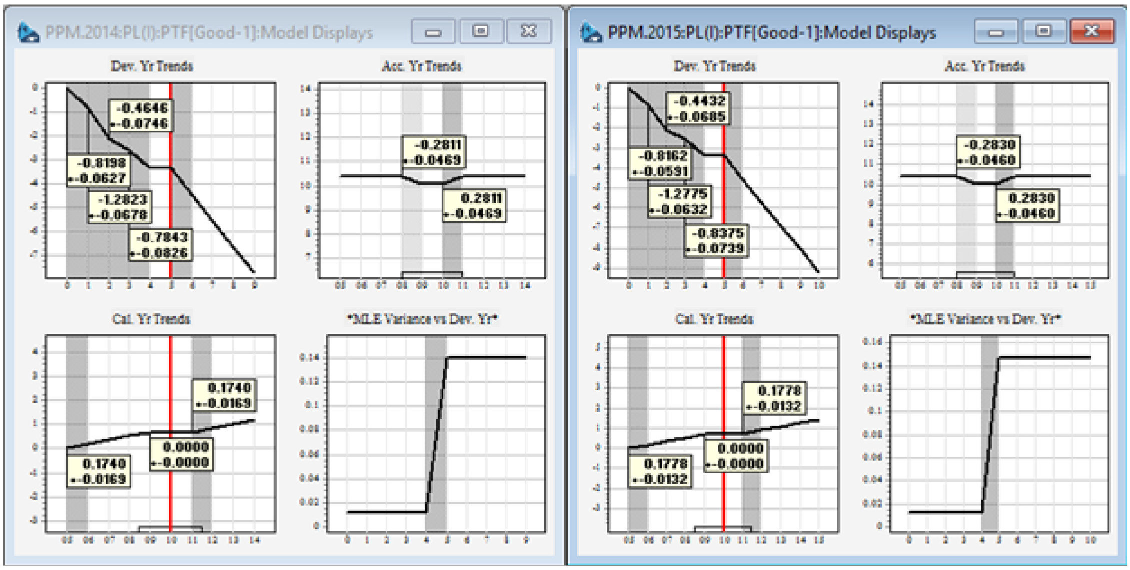
Estimates of prior accident year ultimates remain consistent from year to year if forecasting assumptions remain consistent.

For example, if a forecast scenario assumes a calendar trend of 10% ± 2% for next year followed by 5% ± 1% thereafter, then, for an accident year ultimate to be consistent from this year to next year requires that the next year's data fall on the 10% ± 2% trend line and that the subsequent calendar trend at the next year end continues to be set to 5% ± 1%.

It is only possible to maintain consistency if all the assumptions made in forecasting are explicit and auditable. The Probabilistic Trend Family modeling frameworks, both single and multiple, a foundation for such consistency.

7.1. PPM example – Variation in Mean Ultimate

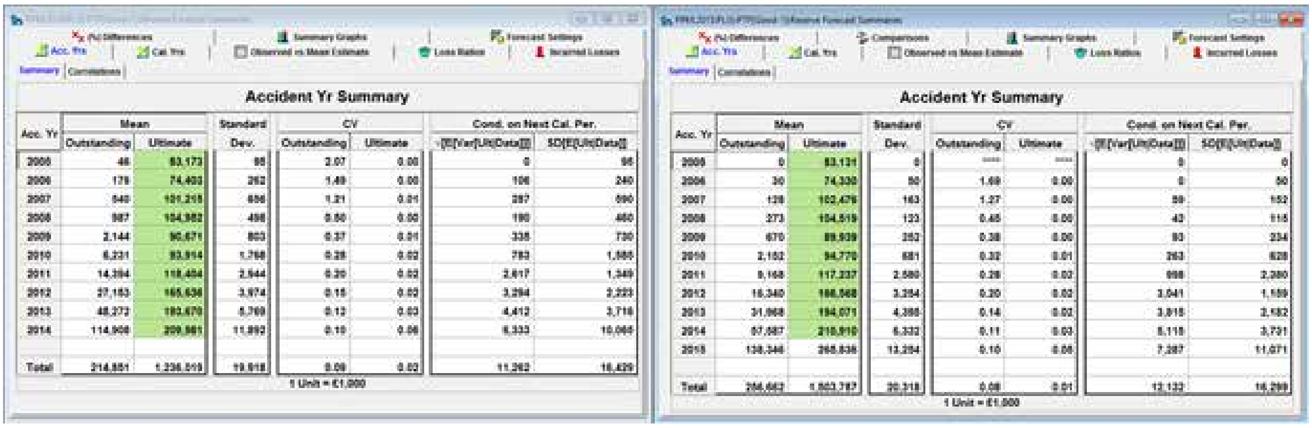
Consider a company writing Personal Private Motor insurance with the following model trends identified in 2014 (left) and 2015 (right) respectively.



The trend parameters are updated with the new data, but otherwise there are no major differences between the models. The model parameters are statistically the same.

Given no new trends have emerged in the data, we expect the new estimates of the mean ultimate (2015) to be within the Variation in Mean Ultimate predicted in the previous valuation period (2014).

Comparing the statistics and risk measures above we find that there is consistency between the two valuation periods - 2014 and 2015 (mean ultimates highlighted).



Accident Yr Summary

Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate	Cond. on Next Cal. Per. √[E[Var[Ult|Data]]]	Cond. on Next Cal. Per. SD[E[Ult|Data]]
2005	48	83,173	98	2.07	0.00	0	98
2006	179	74,403	262	1.49	0.00	106	240
2007	540	101,215	656	1.21	0.01	287	690
2008	987	104,982	498	0.50	0.00	190	460
2009	2,144	90,671	803	0.37	0.01	338	730
2010	6,231	93,914	1,768	0.28	0.02	783	1,585
2011	14,394	118,404	2,944	0.20	0.02	2,617	1,349
2012	27,183	165,636	3,974	0.15	0.02	3,294	2,223
2013	48,272	193,670	5,769	0.12	0.03	4,412	3,718
2014	114,908	209,981	11,892	0.10	0.06	6,333	10,066
Total	214,851	1,236,019	19,918	0.09	0.02	11,262	16,429

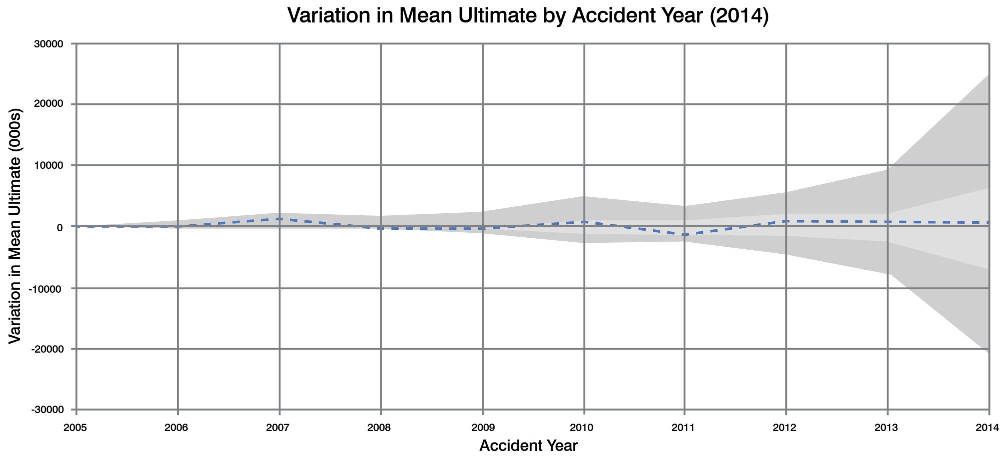
1 Unit = £1,000

Accident Yr Summary

Acc. Yr	Mean Outstanding	Mean Ultimate	Standard Dev.	CV Outstanding	CV Ultimate	Cond. on Next Cal. Per. √[E[Var[Ult|Data]]]	Cond. on Next Cal. Per. SD[E[Ult|Data]]
2005	0	83,131	0	----	----	0	0
2006	30	74,330	50	1.68	0.00	0	50
2007	128	102,476	163	1.27	0.00	59	152
2008	273	104,519	123	0.45	0.00	42	116
2009	670	89,939	252	0.38	0.00	93	234
2010	2,152	94,770	681	0.32	0.01	263	628
2011	9,168	117,237	2,580	0.28	0.02	898	2,380
2012	16,340	166,568	3,254	0.20	0.02	3,041	1,159
2013	31,968	194,071	4,398	0.14	0.02	3,815	2,182
2014	67,687	210,910	6,332	0.11	0.03	5,118	3,731
2015	138,346	268,836	13,294	0.10	0.05	7,287	11,071
Total	266,662	1,503,787	20,318	0.08	0.01	12,132	16,299

1 Unit = £1,000

The Probabilistic Trend Family (PTF) modeling framework forecasts distributions for every cell. Using these forecast distributions we can obtain the distribution of the Variation in Mean Ultimate. We calculate this distribution in 2014 for each accident year. Quantiles (1%, 25%, 75%, and 99%) of the VMU (2014) are produced for each accident year and the updated estimate of the mean ultimate in 2015 is overlaid in the figure below.



In this particular example, most of the updated estimates of the mean ultimate lie in the interquartile range (25%-75%). Not unexpected since the losses in 2015 arrived as projected in 2014.

The mean reserves are consistent between the valuation periods. The total mean reserve in 2014 is 215M GBP. In 2015, the total mean reserve is 257M GBP. The increase in total mean reserve of 42M GBP is in line with a 17.4%+_1.69% increase as projected in 2014.

The expected variation in 2014 of the mean ultimate (1,236M) is 16.4M. The new estimate of the ultimate in 2015 for those same accident years is 1,238M – almost no change.

7.2. PPM example – Economic Capital

The calculation of Solvency II Economic Capital is also consistent between the valuation periods.

The total capital (Technical Provision + SCR) is 245M in 2014 (left). The same calculation performed on the updated data in 2015 (right) produces a figure of 286M. The difference of 41M is a 17% increase on the 2014 calculation – again perfectly consistent with the calendar year trend measured from the data in 2014 and continuing in 2015.

PPM.2014.CDS.MPTF[1].Reserve Solvency II

Summary | Solvency II Grid | Solvency II Charts | Settings

Metrics Summary

	Value	%
BEL	200,107	97.14
MVM	5,893	2.86
Technical Provision	206,000	100.00
VaR(2015)	24,482	62.38
ΔTP	14,762	37.62
SCR	39,245	100.00
Technical Provision	206,000	84.00
SCR	39,245	16.00
Economic Capital	245,245	100.00

1 Unit = £1,000

MVM, SCR and TP as % of BEL

	% of BEL	% of Undisc. BEL
SCR	19.61	18.29
MVM	2.95	2.75
TP	102.95	96.03
MVM + SCR	22.56	21.04
Economic Capital	122.56	114.32

PPM.2015.CDS.MPTF[1].Reserve Solvency II

Summary | Solvency II Grid | Solvency II Charts | Settings

Metrics Summary

	Value	%
BEL	239,841	97.53
MVM	6,066	2.47
Technical Provision	245,907	100.00
VaR(2016)	29,233	72.81
ΔTP	10,916	27.19
SCR	40,149	100.00
Technical Provision	245,907	85.96
SCR	40,149	14.04
Economic Capital	286,056	100.00

1 Unit = £1,000

MVM, SCR and TP as % of BEL

	% of BEL	% of Undisc. BEL
SCR	16.74	15.65
MVM	2.53	2.36
TP	102.53	95.86
MVM + SCR	19.27	18.02
Economic Capital	119.27	111.51

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