Reserving risk, risk margins and solvency: Re-tuning your mind

Solvency II, with its requirement for a one year view of reserving risk, raises fundamental questions about the way reserving risk is defined. The wider consequences of risk margins and solvency with simulation-based internal capital models are also a topic for debate. Peter England considers the issues and possible ways forward.

Introduction

Solvency II, whether by accident or design, is creating a quandary for actuaries and risk specialists wishing to use simulation-based internal capital models. Not only is it difficult to see how to satisfy the requirements, but some common actuarial terms take on a different meaning under Solvency II, for example 'best estimate', 'reserve risk' and 'economic'.

Article 101 of the Solvency II Framework Directive states 'The Solvency Capital Requirement (SCR) shall... correspond to the Value-at-Risk (VaR) of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one year period'. Essentially, the basic own funds are defined as the excess of assets over liabilities, where assets and liabilities are at market value (or capital-market consistent value where a market does not exist).

So it seems straightforward to estimate the SCR using a simulation-based model: simply create a simulated distribution of the basic own funds over a one year period, then calculate the Value-at-Risk at the 99.5th percentile. But as soon as you actually try it, you realise that amongst the thousands of pages of requirements issued by CEIOPS, there is very little guidance on how the requirements can actually be met in practice. 'The devil is in detail' is the aphorism that springs to mind.

One of the principal problems is the capital market consistent value of liabilities, which requires a best estimate plus a risk margin, where the 'best estimate' is defined as the expected present value of all future cash-flows, and the risk margin is calculated using a cost-of-capital approach. So to calculate the SCR using simulation-based internal capital models, an opening balance sheet using discounted expected liabilities with risk margins is required along with a simulated balance sheet on the same basis after one year. That one year balance sheet in turn requires a distribution of the expected value of liabilities, with risk margins for each simulation. A balance sheet with risk margins is referred to as a Solvency II 'economic' balance sheet in this document.

To calculate the risk margin in the opening balance sheet using the cost-of-capital approach, it is necessary to estimate, for each Solvency II line of business, the notional solvency capital requirements to transfer the liabilities to a third party. So we need two different capital requirements: the overall capital requirement for the company, and notional capital requirements by Solvency II line of business.

Estimating capital requirements

Estimating capital requirements in a theoretically sound way requires three main components: a risk profile, a risk measure, and a risk tolerance criterion. A fourth component, the time horizon, is also usually specified.

Under Solvency II, for the overall capital requirement, it is clear from Article 101 that the risk profile is the distribution of basic own funds over a one year time horizon, the risk measure is Value-at-Risk (a 'percentile' in statistical terminology), and the risk tolerance criterion is 99.5%.

Under Solvency II, it is less clear what the risk profile should be for the notional line of business SCRs, but a picture is beginning to emerge, based on the change in the expected value of liabilities over a one year time horizon. The problem lies in the definition of liabilities for this calculation.

Line of business SCRs

Ignoring complications like operational risk loadings and credit risk on reinsurance recoveries, the basic 'risk profile' is the profit/loss on reserves held over a one year period. This is called the claims development result (CDR), or simply the run-off result, and is defined as the opening expected undiscounted reserves less claims paid (plus expenses) in the year less closing expected undiscounted reserves after one year (only in respect of existing liabilities: new business is not taken into account in the CDR). If the reserves are calculated on a discounted basis, allocated investment income on the reserves needs to be included. If the Solvency II 'economic' value of liabilities is considered, then the change in the risk margin is also required.

Ignoring discounting and risk margins, the CDR is simply the difference between the opening view of the expected ultimate cost of claims and the view of the expected ultimate cost of claims after one year, giving the one year view of reserving risk. The traditional actuarial view of reserving risk looks over the lifetime of the liabilities, that is, the difference between the opening view of the expected ultimate cost of claims, and the actual ultimate cost of claims after all liabilities have been extinguished. This distinction is most easily highlighted with reference to latent claims (like asbestos related claims): the change in the view of the expected ultimate cost of claims over one year could be negligible, but the actual ultimate cost of claims after all liabilities have been extinguished could be very different from the opening view.

Under Solvency II, for line of business SCRs, it looks like the most appropriate risk profile should be the distribution of the CDR, using discounted reserves (and hence including allocated investment income) with risk margins. The same risk measure and risk tolerance criterion as for the overall capital requirement (Value-at-Risk at 99.5%) can also be used here.

To calculate the risk margin, the line of business SCRs are required for each future year until the liabilities are run-off. Once the SCRs are known, they can be multiplied by the cost-of-capital rate, discounted and summed to form the risk margin. So the problem reduces to estimating the line-of-business SCRs for each year until the liabilities are run off.

Unfortunately, estimating the SCRs for each future year in a theoretically correct way is far from straightforward: the SCRs appear to depend on the risk margins, and the risk margins depend on the SCRs. Without going into technical details, the problem can only be resolved by starting at the final time period and working backwards recursively, requiring repeated simulation on simulation. The problem quickly becomes intractable without simplifications.

One simplification that has been suggested when calculating line of business SCRs for risk margins is the 'proportional proxy'. If the opening line of business SCR can be calculated, then future SCRs can be approximated by multiplying the opening line of business SCR by the ratio of expected (discounted) outstanding liabilities at each future time period to the opening expected (discounted) outstanding liabilities. So the problem reduces further to estimating the opening line of business SCR.

Ohlsson & Lauzeningks, in a paper published in Insurance: Mathematics and Economics in 2009, suggest that under the proportional proxy, risk margins can be dropped from the definition of the CDR for the purposes of calculating the opening line of business SCR. This is very convenient since backwards recursion, and repeated simulation on simulation, is not required. We simply create a distribution of the CDR over one year ignoring risk margins, apply Value-at-Risk at 99.5% to obtain the opening line of business SCR, then apply the proportional proxy and finish off the calculations to obtain the risk margins for the opening balance sheet. Note we still have the problem of calculating risk margins for the balance sheet one year ahead for the overall SCR, which is a problem that must be resolved.

Putting it into context

It would be even more convenient if the risk profile for line of business SCRs, the CDR, could be calculated using undiscounted reserves, thereby avoiding the issue of allocated investment income on the reserves held. A beneficial side effect of this is that it connects the one year definition of reserving risk and the traditional actuarial definition over the lifetime of the liabilities.

For example, let us consider Mack's well known model. Under specific assumptions, Mack's model provides mathematical formulae for the standard deviation of the future (undiscounted) outstanding liabilities (by origin period and in total), taking the traditional actuarial perspective over the lifetime of the liabilities. Note: Mack's formulae do not provide a distribution of outstanding liabilities, nor Value-at-Risk estimates.

Merz & Wüthrich (2008) provided an interesting development by deriving mathematical formulae for the standard deviation of the (undiscounted) claims development result (CDR) after one year, under the same basic assumptions as Mack's model. This is important since it highlights the difference in perspectives, showing that the standard deviation under the one year view is lower than the standard deviation measured over the lifetime of the liabilities.

The Merz-Wüthrich approach is closer to what is required under Solvency II, and has been used to help calibrate the Solvency II standard formula parameters in CP71 published by CEIOPS, and is part of two (out of four) alternatives for estimating undertaking specific parameters in CP75. However, it is important to note that the formulae are only appropriate using undiscounted reserves.

Although the mathematics involved is quite challenging, it is also important to realise the limitations of the Merz-Wüthrich approach. It only considers the pure chain ladder model (no tail) under Mack's assumptions, and only provides a standard deviation of the CDR. What if we need a tail factor, or alternative model assumptions are used? Equally, what if we want another risk measure (eg the 99.5% VaR of Solvency II)? Ideally we need a distribution of the CDR, not just a standard deviation, and we need a methodology that will work under alternative model assumptions.

Using simulation-based models, it is straightforward to devise an approach that links the traditional view over the lifetime of the liabilities, and the one year view.

This can be obtained in the following way:

1. Given the opening reserve triangle, simulate all annual future claim payments to ultimate using bootstrap (or Bayesian MCMC) techniques. This is a standard approach that considers variability in the outstanding payments over the lifetime of the liabilities.
2. Now forget that we have already simulated what the future holds.
3. Move one year ahead. Augment the opening reserve triangle by one year, that is, by the simulated payments from step 1 in the next calendar year only.
4. For each simulation, estimate the expected outstanding liabilities, conditional only on what has emerged to date. (The future is still 'unknown'). This gives the distribution of expected outstanding liabilities at the one year ahead position. A reserving methodology is required for each simulation – an 'actuary-in-the-box' is required. We call this 're-reserving'.
5. Calculate the CDR for each simulation (using undiscounted reserves), giving a distribution of the claims development result.

Note that if step 1 is performed in a way that is consistent with Mack's assumptions, and the 'chain ladder' method is used at step 4, then the standard deviation of the CDR calculated at step 5 will be analogous to the Merz-Wüthrich formula.

The beauty of a simulation-based approach is that it overcomes the limitations of a purely analytic approach. The simulation-based re-reserving approach is not restricted to the chain ladder model, and can include curve fitting and extrapolation for tail estimation. It can also incorporate a Bornhuetter-Ferguson step to smooth out the impact of extremes (if required), and can be extended beyond the one year horizon to look at multi-year forecasts. Another major benefit is that a simulation-based approach provides a distribution of the CDR, from which the 99.5th percentile can be obtained: this is precisely what is required under Solvency II.

This works well when calculating the one year CDR on an undiscounted basis. It becomes progressively harder if you broaden the definition of the CDR and use discounted reserves because you should take account of allocated investment income, and harder still if using discounted reserves plus risk margins since you need a risk margin for each simulation, conditional on that simulation and time period.

Bearing in mind these complexities, what is appropriate under Solvency II and how should companies address the issues?

Figure 1 shows three different options for the definition of outstanding liabilities that could be used when calculating the CDR. Let's consider the pros and cons of each.

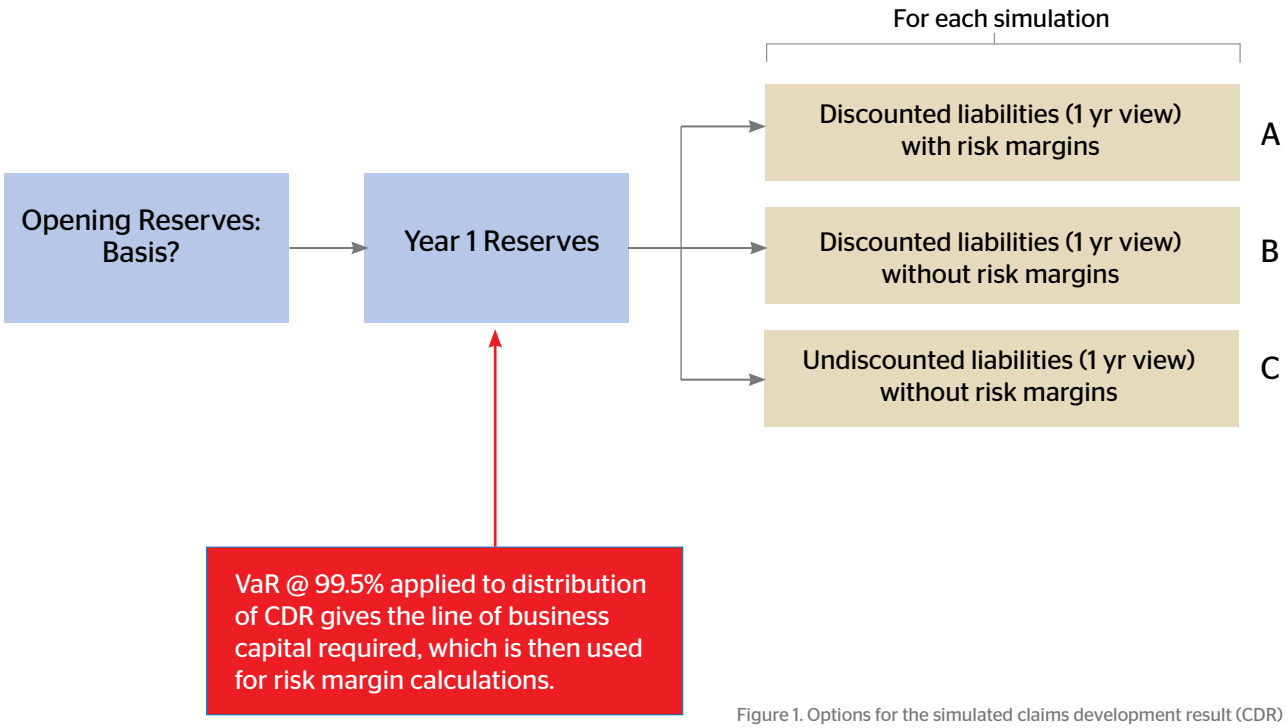


Figure 1. Options for the simulated claims development result (CDR)

Option A – discounted liabilities (1 year view) with risk margins
This approach appears to be the closest to obeying the rules within Solvency II. As already stated, it is extremely difficult (or impossible) to calculate the risk margins on a simulation by simulation basis without simplifying assumptions. Furthermore, the re-reserving approach results in a robotic calculation of the reserves after one year.

Option B – discounted liabilities (1 year view) without risk margins
Using simulation-based re-reserving this approach becomes straightforward. On the downside, it requires a similarly robotic methodology to Option A, and, at first sight, does not appear to match the Solvency II criteria. However, this is analogous to the approach of Ohlsson & Lauzeningks, who suggest that this is equivalent to using the 'proportional proxy' for estimating future expected capital requirements when calculating risk margins.

Option C – undiscounted liabilities (1 year view) without risk margins
Using simulation-based re-reserving this approach is even more straightforward than Option B, since allocated investment income does not need to be considered. On the downside, like Option B, it requires a similarly robotic methodology and, at first sight, does not appear to match the Solvency II criteria. However, under the same assumptions, this is analogous to the approach of Merz-Wüthrich, endorsed by CEIOPS in CP71 and CP75.

So, under the proportional proxy for estimating future line of business SCRs when calculating risk margins, it seems that Options B and C are options that could be used in practice. We still have the problem of a suitable definition of the liabilities in the simulated balance sheet when calculating the overall SCR.

The overall SCR

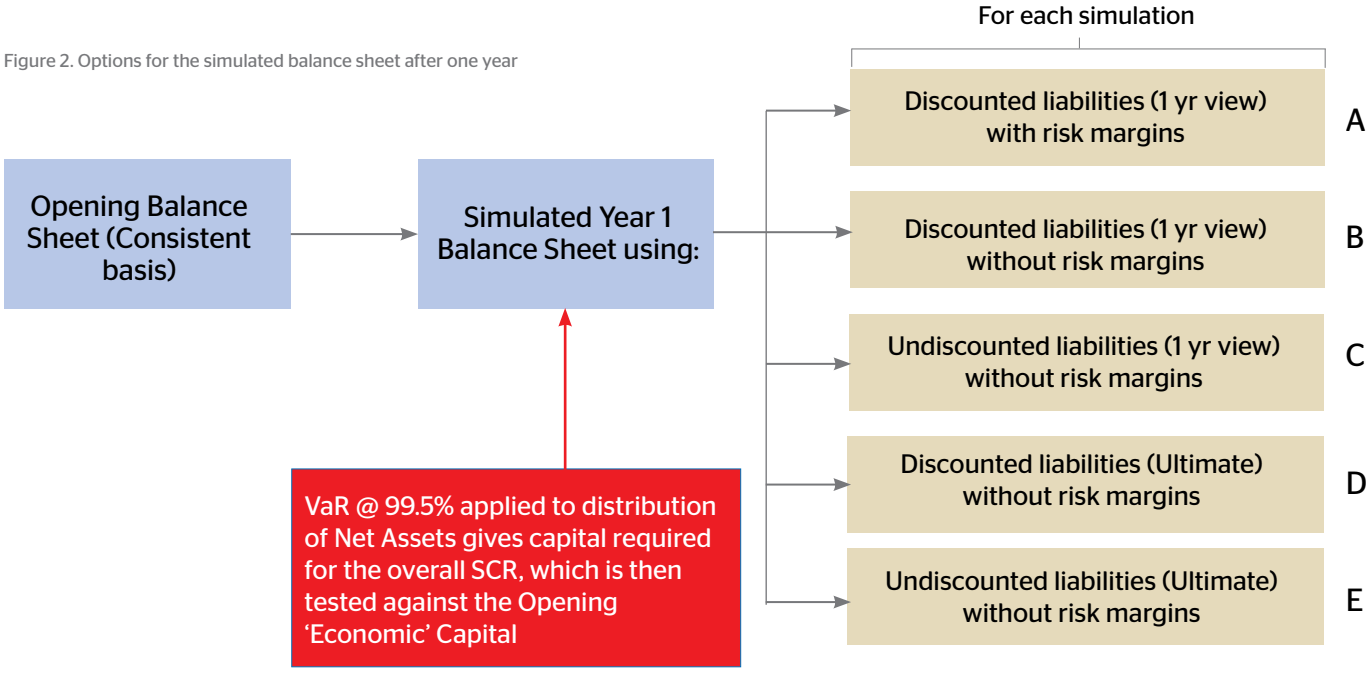
For the overall SCR calculation, we need an opening balance sheet and a simulated balance sheet one year ahead (taking new business into account). Given there appear to be several options that could be considered for the line of business SCR calculations, the crucial question now is 'What are the available options for the definition of the liabilities used for the balance sheet for the overall SCR calculation?'. In particular, can we use similar simplifications when calculating the overall SCR?

At first sight, it seems that only one option is possible: under Solvency II we need an opening balance sheet on a Solvency II 'economic' basis, and a balance sheet one year ahead on the same basis. But as we have discussed, this then requires a risk margin for each simulation in the one year ahead balance sheet, which causes considerable difficulties without simplifying assumptions.

An alternative is to choose another basis, the 'SCR calculation basis', and calculate the extra capital required on that basis by applying Value-at-Risk at 99.5%. The extra capital required on a Solvency II 'economic' basis can then be approximated simply as the extra capital required on the SCR calculation basis plus the difference between the opening net assets on the SCR calculation basis and the Solvency II 'economic' basis. For example, if the SCR calculation basis uses discounted reserves without risk margins, then the opening risk margin would need to be added to the capital required. Note that the extra capital required will be negative for a well capitalised company. The advantage of this approach is that risk margins are only required when calculating the opening net assets on the Solvency II 'economic' basis: they are not required for the net assets one year ahead.

Figure 2 shows five options that could be considered. The first three are the same as those used for the CDR, but there are two other options that could be considered for solvency purposes.

Figure 2. Options for the simulated balance sheet after one year



The pros and cons of options A to C are similar to those for the calculation of the line of business SCR, but there is more we can add. It could be argued that option A (which is closest to the Solvency II requirements) is taking a shareholder perspective, since it looks at the probability of maintaining a risk margin. A fundamental question is whether, when all other assets are exhausted except the risk margin, a further claim would be paid. That is, when does default occur? Option B considers the risk margin as capital available to pay claims, and is therefore closer to a policyholder perspective. Unlike Option A, Option B will not give different results if the basis for the risk margin is changed (for example, if the cost of capital is increased or decreased). Option C is included since it is easy to calculate, and is the most common basis used currently for setting reserves.

Options D and E recognise the full risk over the lifetime of the liabilities at the one year ahead position: that is, perfect foresight is assumed, and the 're-reserving' methodology is not used. This will give higher capital requirements than options B and C. It is included here since it could be argued that this is more appropriate from a policyholder perspective, and after all, a regulator's duty is to protect policyholders.

Options B and C are the two alternatives that are likely to be the most useful for Solvency II. Ignoring risk margins at this stage of the calculation seems inconsistent with Solvency II, but note that the extra capital required on either of these bases is converted to the extra capital required on a Solvency II 'economic' basis before comparing against the available capital on a Solvency II basis. A further justification of this approach is that there is a precedent in the formula-based approach of QIS4.

QIS4 spreadsheets

In the formula-based approach of QIS4, it is perhaps surprising that risk margins do not appear as an input to the overall SCR calculation. However, the calculated overall SCR is tested against a Solvency II 'economic' balance sheet that does include risk margins within the liabilities. So risk margins only appear at the point at which the calculated SCR is compared against available capital.

Under QIS4, there are also two different capital requirements: line of business SCRs for calculating the risk margins that appear on the Solvency II 'economic' balance sheet, and an overall SCR. The 'proportional proxy' was permitted when calculating risk margins.

Of course, the formula based approach in QIS4 will soon be superseded by QIS5, but fundamental changes are unlikely. It will be difficult to demonstrate that a formula based approach satisfies the requirements of Article 101. How can you know that the SCR formula (with a capital amount calculated by risk type) corresponds to a 99.5% VaR applied to the basic own funds? In the absence of a distribution of the basic own funds, it is pure speculation.

A simulation based approach is clearly the way forward for answering complex questions about risk and solvency, even if some challenges remain with the practical application.

Implications for claims reserving

Under Solvency II, the 'best estimate' of the outstanding liabilities is defined as the expected present value of all future cash-flows, so wherever the term 'best estimate' is used, discounted liabilities are implied. This is a fundamental change in thinking for most actuaries who are used to estimating outstanding liabilities on an undiscounted basis. Some common techniques to perform the calculations do not even produce cash-flows.

Actuaries will need to retune their minds, and think in terms of discounted outstanding liabilities and risk margins. This need not be as onerous as it may appear, but will involve some extra work. Approaches to estimating the undiscounted outstanding liabilities do not necessarily need to change, but as an extra step, actuaries may need to make assumptions about how the cash-flows emerge, to allow discounting. Discounted reserve estimates will be required not just at the valuation date, but also at all future valuation dates for the risk margin calculations. For those calculations, cash-flows are key.

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