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One of the more radical requirements of Solvency II is full stochastic modelling, a process that is currently technologically beyond the reach of most insurers. Proxy modelling techniques have fast become a popular alternative. *CLIVE DAVIDSON reports*

WHEN IT COMES to internal models, Solvency II is a regime somewhat ahead of its time. The blunt truth is that for large complex liability portfolios, today's technology is simply not up to the full stochastic modelling that the regime requires for internal model solvency capital calculations. It probably won't be for a number of years. So, what is to be done?

Fortunately, human ingenuity is good at solving this kind of problem. There are many areas of endeavour where full detailed modelling would be impossible and so require some form of estimation or use of proxies. Some of these techniques are transferable to insurance liabilities, while considerable creativity and invention is being applied to the problem within the industry itself. As a result, there are now a number of simplified methods available that will estimate or mimic the behaviour of a portfolio of complex liabilities with a reasonable degree of accuracy. Each method has its own pros and cons, but all enable the calculation of risk and solvency capital within a time frame that makes it practicable for both regulatory reporting and day-to-day business decision-making.

Two techniques that have already gained some traction in Solvency II internal model preparation are replicating portfolios and curve fitting. Replicating portfolios are being widely adopted for market risk, particularly in Europe. Curve fitting is a popular approach in the UK – and will be looked at in some detail in a later issue of *Life & Pension Risk*. Meanwhile, insurers are also exploring a number of other techniques. Among the newer methods that hold some promise are cluster modelling and replicating stratified sampling. No doubt others will appear in due course.

Replicating portfolios, as the name implies, are portfolios of relatively simple assets that replicate the behaviour of complex liabilities. First, a universe of candidate standard liquid assets is chosen whose cash flows have the potential to mimic the cash flows of the liability

portfolio. Then an optimisation process is undertaken to select the most appropriate portfolio of assets from the universe. This simplified portfolio can now be used to model the behaviour of the complex underlying liabilities under various economic scenarios.

Tom Wilson pioneered the use of replicating portfolios for liability modelling when he was chief insurance risk officer at ING in 2007. He took the technique with him when he moved to Allianz Group in 2008 and the company has been using replicating portfolios as the basis of its external financial risk disclosure and internal risk reporting since the beginning of 2010 (See *Life & Pension Risk*, July/August 2009, page 20). The technique will also form the cornerstone for the group's market risk in its Solvency II internal model.

"For a group as diverse as Allianz operating in around 70 countries, some form of representation is necessary as full bottom-up stochastic cash flow modelling of all life products is not feasible from a computational as well as closing process perspective," says Wilson. Before committing to replicating portfolios, however, Allianz reviewed the available alternative proxy techniques.

Among the key reasons for its decision was the fact that "replicating portfolios form an efficient approach for representing the profit and loss characteristics of complex financial products in a manner that does not require making assumptions regarding market risk factors," says Wilson. Furthermore, once a replicating portfolio is constructed, it can be readily used to calculate the change in the value of liabilities with the same relatively small computational effort as calculating the change in value on the asset side.

Allianz argues that replicating portfolios offer a number of additional advantages. One is that the way in which the replicating portfolio represents complex life products. "It provides deep financial engineering insights into the features of our products, including [their] guaranteed cash flows and the embedded options. These

insights should help us to develop greater financial engineering skills and market discipline for the construction of new products and the pricing of financial options,” says Wilson. Another advantage is that the replicating portfolio facilitates the process of risk management, for example by aiding the development and communication of strategic asset allocation strategies and hedge ratios, as well as in the attribution of market risk profit and loss.

The major disadvantage of replicating portfolios is that while they mimic the market risk in liability portfolios, they cannot be used to represent insurance or actuarial risk. Therefore, a different technique must be used for non-market risks with potential inconsistencies in modelling across risk factors. Other criticisms of the technique include the fact that creating the replications requires a deep understanding of both the assets and the liabilities, and that they can be a more lengthy and complicated process to implement than other proxy techniques.

Weighing up the pros and cons of replicating portfolios, UK closed life fund operator The Phoenix Group decided that it would be an appropriate technique for daily monitoring of market risk of its funds. It is currently implementing a project whereby it takes the output of quarterly liability portfolio valuations and creates replicating portfolios, which are then run on a daily basis.

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Tom Wilson, Allianz

“The replicating portfolios provide senior management with daily reports providing an estimate of the current capital position and indicating whether there are issues and if any actions should be taken,” says Pat Renzi, global practice leader at Seattle-based Milliman for its MG-Alfa financial modelling and actuarial projection system, who is working with Phoenix on the project. Because this process is incorporated into the company’s daily business decision-making, the replicating portfolios should comply with the Solvency II use test. However, they are not being used for the company’s internal model. For this, Phoenix has chosen cluster modelling.

The underlying idea of cluster modelling is borrowed from social sciences where it is used for segmenting large populations in order to carry out detailed studies. Put simply, cluster modelling pictures a portfolio of policies as objects in a multi-dimensional space and maps similar policies together in clusters.

The first step in the cluster modelling process is to decide on the variables that will be used to determine the ‘location’ of policies in the imaginary multi-dimensional space. The values of these location vari-

ables are what the compression process will aim to reproduce, such as best estimate liability (BEL) or year-one premium. Each policy is then assigned a ‘size’ – a measure of its value, such as annuity benefit amount for annuities or sum assured for life insurance.

The process then measures the ‘distance’ between all policies in terms of how close they are in the multi-dimensional space. It then calculates the ‘importance’ of each policy by multiplying the policy size by the distance from the nearest policy. The process then finds the policy with the lowest importance and maps it to its nearest neighbour, creating a cluster. This step is repeated until the portfolio is reduced to a pre-set target amount of clusters. The last step is to find the most representative policy in each cluster (the policy closest to the average location of all the policies in the cluster) and scale it up to represent the overall size of the cluster. These scaled-up representative policies form the compressed file, which can then be used for modelling tasks.

Milliman has adapted cluster modelling for liability modelling and initially introduced it in the US. There, companies such as Aviva USA, Transamerica Capital Management and Lincoln Financial Group have





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been using it, particularly for variable annuity liability modelling. (See *Life & Pension Risk*, December 2010, page 26.) Milliman is now working with The Phoenix Group and other companies in the UK on applying the technique to Solvency II internal modelling.

For its quarterly valuations of its current blocks of business, Phoenix is using a deterministic approach for its non-profit business, but is applying cluster modelling to enable it to undertake stochastic modelling of all the with-profit business for Solvency II reporting. The main attraction of cluster modelling in this context is the transparency it offers, says Renzi. “With cluster modelling you are still looking at actual policies and cash flows rather than a group of assets that you

think behave in a similar way to the liabilities. This gives information that the management team will find more familiar and allows them to test sensitivities to actual liability or management action changes.”

Phoenix is in the process of moving all of its business to the MG-Alfa system. To support its Solvency II internal model application, it has completed the transition for four funds, with cluster modelling a part of the internal modelling process. Phoenix has moved a certain portion of its business to the MG-Alfa system to support its Solvency II internal model application and cluster modelling is part of this internal modelling process. This phase of the project is currently undergoing testing and is anticipated to go live in October. At the same time, the rest of the funds are being brought into the cluster modelling process, with an aim of going live across all funds towards the end of 2012.

Cluster modelling can be seen as a more sophisticated version of traditional policy grouping techniques that insurers have used for some time to speed up their actuarial modelling. The advantages of clustering are that it reduces portfolios by a significantly greater amount while producing more accurate results, claim its proponents. US users of the technique, such as Aviva USA, Transamerica and Lincoln, say they have achieved about an 80% improvement in liability modelling run times. Renzi says Phoenix is creating cluster models that are 1% of the original model size, with results within a 0.2% tolerance for BEL on the valuation date and a tolerance of less than 1% for the BEL at projection year 30.

The other major advantage claimed for cluster modelling is its ease of implementation. Craig Reynolds, consulting actuary at Milliman, says finding a good cluster algorithm for a block of business typically takes a matter of days compared with the weeks it can take to find a good replicating portfolio.

Replicated stratified sampling is one of the newest techniques that could be helpful in Solvency II internal models. Sampling is a fundamental technique in statistical analysis and is widely used to make inferences about large populations of data. It is particularly useful where it is difficult to access an entire population, which is why it is used for things such as opinion polls and drug testing. However, access to the underlying data is not usually the problem in insurance – all the policies are there in a database. In addition, accuracy is usually critical in financial modelling, so the problem of sampling error combined with access to the underlying data means that sampling has not been much applied to finance in general. But the scale of the problem with liability modelling for insurance companies has prompted a second look at the technique.

Jay Vadiveloo, consulting actuary and Towers Watson professor of mathematics at the University of Connecticut, looked at the issue of sampling error and figured it could be reduced by applying another mathematical technique: the law of large numbers. Instead of just taking one sample – in the case of liability modelling it will be a sample of policies in a portfolio – and calculating a change in some risk metric, a series of samples is taken.

“You might initially have chosen a sample that understates the change in your measure, while the second one overstates it. And if you continue to replicate the sample and combine results, you will eventually get convergence of the results. So you get rid of the sampling error by the law of large numbers,” says Vadiveloo.

To test the technique, in 2010 Towers Watson implemented replicated stratified sampling in a pilot project at a major US life insurer. The technique was applied to a variable annuity block to analyse the impact of immediate drops of 15% and 30% in equity funds on variable annuity commissioners annuity reserve valuation method (VACARVM) reserves. The analysis was carried out for three legal entities both before

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and after reinsurance and compared the change in the VACARVM reserve using the entire population versus replicated stratified sampling, which used 50, 100, 150 and 200 samples of either 20 or 30 policies each. Across all three legal entity portfolios the technique captured changes in the reserves with an error rate of just 1% when using 200 samples, compared with using the full population. Furthermore, the portfolio size was reduced by 99%, as was the model processing time. “These were very complex calculations and the project showed that the technique was able to cope with them,” says Vadiveloo.

In addition, replicated stratified sampling has a number of other advantages as an approximation tool for liability modelling, says Vadiveloo. First, the convergence in the sampling results can be mathematically proven. Furthermore, it is simple and intuitive. Nor does it require the recalibration that other techniques do. “With replicated stratified sampling, no matter how often you do it – daily or monthly – you are always drawing the samples from the current in-force portfolio. So as the portfolio changes and moves, you don’t have to do any recalibration – it happens automatically because you are always sampling from the current in-force portfolio,” says Vadiveloo.

Finally, it does not require complex software. The replicated stratified sampling will run as an adjunct to traditional actuarial systems. The catch is that Towers Watson has a patent pending on the algorithm so would-be users will need to refer to the company for implementation. The company is currently talking to a number of insurers about

possibly using the technique, including for Solvency II modelling.

It is still early days in terms of internal models for solvency capital calculations and no doubt there will be further experimentation with modelling methods in the coming years. Meanwhile, technologists predict that computers will eventually catch up and have the performance to run full stochastic models of insurance liabilities in near real time. But that could be in another 10 years or so. Until then, companies will need to choose one or more proxy techniques to help them to achieve workable results that they can build into their business decision-making and Solvency II reporting. 

