Industrialising Financial Reporting Working Party

Text of 2015 Momentum Conference presentation

There was once an actuary who saw that a process was being run in ten or more steps when, with modern technology, it could be done in just one. So he resolved to devote the rest of his career to supporting businesses in developing the method consisting of just one step. That's how I became interested in the topic of this talk. I'll say at the start that I'm happy to take questions as I go along, but obviously I've also planned to leave time for questions at the end.

So the original **motivation** was that, in my first role after qualifying, I was responsible for financial reporting for a block of annuity business which was one of the most financially significant blocks of business in my employer at the time, a life insurance company. It soon became apparent that the existing analysis of surplus process was inadequate to provide the required level of understanding of the reported results within the timescales demanded by stakeholders and that a fundamental redesign of the process was called for. Issues frequently arose where items in the analysis did not look reasonable compared with stresses from the ICA, resulting in queries from the capital management function.

Comment [OL1]: The bold red highlighting shows when to move to the next slide.

The key insight I had was that the existing process depended fundamentally on a **fixed order** in which the risks affecting the company were assumed to occur, which in general bore no relation to how risks had actually occurred over the reporting period. The process was time-consuming because of the need to perform a sequence of steps one after another. There were also issues with reliability of the output, because it was not always straightforward in practice to verify that the fixed ordering of the steps was being applied consistently throughout the process. I saw that if the analysis could be performed in a way that did not depend on a fixed choice of order, and quantified the impacts of all the risks simultaneously, then substantial improvements in efficiency and reliability could be achieved. I wrote a paper entitled 'Risk-based profit and loss attribution' for the 2012 Life Section Colloquium of the International Actuarial Association, in Mexico City, describing such an analysis methodology. Subsequently I volunteered to chair an actuarial Working Party with the same title to articulate the methodology in a way more accessible to practitioners. As I'll explain later in the talk, the Working Party has since decided to change its name and extend its remit.

This slide has a list of the **members** of the Working Party.

Although the techniques I'm going to describe are completely general, the example I'm going to present in this talk again relates to **annuity business**, consistently with my original motivation for setting up the Working Party and with my IAA paper. As there's nothing in the Working Party's terms of reference to say it should focus on annuity business, it's worth thinking briefly about the reasons for this focus. Annuities are one of the simplest types of business to use to illustrate the concepts because there's no dependency of the liability cash flows upon asset performance. They are also amongst the most financially significant liabilities of the UK life insurance industry, given the compulsory annuitisation that existed on pensions business before the 2014 Budget.

We need to define the **risk factors** in which the analysis of surplus, or profit and loss attribution, is to be performed. For internal model firms, given that Solvency II emphasises embedding the internal model in the business, the logical starting point is the risk factors in the internal model, and indeed this is a requirement of the Solvency II Directive for P&L attribution. In the example in this talk, the assets are a mixture of sterling, euro and US dollar-denominated government, supranational, and corporate bonds and swaps backing sterling annuity liabilities, and the reporting currency is also sterling. There are some inflation-linked cash flows on both the asset and liability sides. So the relevant risk factors in the internal model include interest rates, inflation, government bond spreads, supranational bond spreads and corporate bond spreads for all three currencies, together with currency risk from movements in the euro and the US dollar relative to sterling. The table shows how many risk factors there are in each category.

This slide has some more **detail** on how the risk factors are defined. As you can see, the risk-free yield curve is the swap curve less a credit risk adjustment, which is mandated by EIOPA for calculating Solvency II technical provisions, and this is taken as the starting point for measuring spreads. The three risk factors for each of interest rates, inflation and government bond spreads in each currency are derived essentially by principal component analysis, but with some adjustments to smooth the stresses and to taper them down to the fixed ultimate forward rate in the base yield curve. The inflation and government bond spread risk factors are defined as changes in forward rates, but in order to avoid negative forward rates, the interest rate risk factors are defined as changes in the logarithm of the forward rates. It's probably worth noting at this point that if one believed negative forward rates should be allowed, then one could choose a different definition of the interest rate risk factors and the methodology would still work. For supranational bond spreads and corporate bond spreads of each rating, there's only one risk factor for each currency, representing a level spread movement across all terms, in order to keep the number of risk factors in the internal model to a manageable level. The corporate bond spread risk factors for ratings below AAA are defined relative to corporate bonds of the next higher rating rather than relative to the risk-free yield curve. Otherwise the correlations between the spread risk factors for different ratings would be close to 1, which would give rise to numerical difficulties when simulating from the risk distributions in capital calculations. And it's important to note that the risk factors are defined in terms of movements in yield and spread curves calibrated to the market as a whole, not just the assets held by our hypothetical annuity fund. Any movements in the assets held relative to the market as a whole will not be picked up as risk factor impacts in the internal model.

I haven't mentioned **credit rating migration risk** on corporate bonds yet. We can derive a base and a stressed credit transition matrix by reference to historic rating agency data. The first aspect of credit migration risk is then that assets may transition between rating classes over the reporting period at different rates from those implied by the base transition matrix. This will have an impact on the asset value in terms of assets transitioning between the spread curves for different ratings. If our hypothetical annuity fund has been approved for a matching adjustment under Solvency II, then we'd expect a partial offsetting impact on the liability side. The matching adjustment has the effect that only movements in fundamental spreads, the part of the spread relating to default and downgrade risk, go through to own funds, and the difference in total spreads between two rating classes will typically be greater than the difference in fundamental spreads.

The **second aspect** of credit migration risk, which applies only when there's a matching adjustment, relates to changes in future fundamental spread assumptions. If the future credit transition matrix used to assess the fundamental spread assumptions is stressed, then higher fundamental spreads will result, firstly because more assets will default. In addition, if assets are assumed to be sold on being downgraded below investment grade, then the increased rate of downgrading will again produce higher fundamental spreads. However, Solvency II regulations impose a floor of 35% of the long-term average spreads on the fundamental spreads, so changes in fundamental spreads will only come through when the fundamental spreads are above this floor.

So far I haven't mentioned **longevity and expense risk**. These risks can be brought into the same P&L attribution framework as the asset risks but it obviously requires a look-through to how the liability cash flows are derived. For expense risk it's relatively straightforward provided the expense cash flows can be extracted from the liability model separately from the benefit cash flows. Longevity risk is more complex because the stresses will vary by age and gender, and possibly also between blocks of business with different mortality assumptions. I'm not proposing to discuss longevity and expense risk further in this talk.

We need to specify the **value metric** in which the P&L attribution is to be performed. Here again, as with the class of business, the theoretical framework is completely general. In a reporting exercise, 'bottom line' value metrics such as Solvency II own funds will be most relevant. However, particularly where a matching adjustment is used, many of the items in a P&L attribution of own funds will be differences between two numbers that are relatively close together on the asset side and on the liability side, so it's useful for illustrating the concepts to show the asset and liability P&L attributions separately before taking the difference between them to give a P&L attribution of own funds. So in this example, we'll analyse the change in assets in terms of the risk factors in the internal model. We'll then bring in the best estimate liabilities, firstly without a matching adjustment and secondly with a matching adjustment, to get a P&L attribution of own funds. We should note at this point that there's no risk margin in this example to allow for the cost of non-hedgeable risks because all the risk factors are hedgeable, with the exception of credit migration risk, for which a bespoke allowance is made via a deduction from the liability discount rates.

The methodology essentially involves performing a **Taylor series expansion** of the change in the value metric in terms of the risk factors. The key point to note on this slide is that each first-order term in the Taylor series is a figure for the amount of a risk factor that has occurred over the reporting period multiplied by a figure for the sensitivity of the value metric to that risk factor. It makes the P&L attribution much more amenable to validation to have these two components available separately for each item. Similarly, each second-order term in the Taylor series is the amount of the first risk factor that has occurred multiplied by the amount of the second risk factor that has occurred multiplied by the sensitivity to the risk factor combination.

As the risk factors are defined in terms of instantaneous stresses, the **expected position**, or the constant term in the Taylor series, doesn't fall out automatically but needs to be defined. It needs to be something that is commercially acceptable as a forecast but, at the same time, the rigour of the P&L attribution process requires it to be defined in a realistic way. Any deviation from the assumptions underlying the expected position has to be reported as a variance in the P&L attribution, and it won't look reasonable if a large negative variance has to be reported when experience has really been in line with what would have been expected. So how the expected position is defined is open to debate subject to meeting these criteria. We've shown a simple example on the next slide to illustrate the type of considerations required.

Suppose the opening **forward rate** is 0.5% for the first year, 1% for the second year and 1.5% for the third year. If those rates relate to the risk-free yield curve, then the usual no-arbitrage argument suggests that the expected forward rate in a year's time should be 1% for the first year and 1.5% for the second year, and that line of reasoning is what's been used in this example for all four of swaps, swaps including the credit risk adjustment, government bonds and inflation. If, however, the rates relate to, say, A-rated corporate bond spreads, then the no-arbitrage argument doesn't apply because some of the reason why the forward spread for the second year is higher than for the first year will be due to bonds that are downgraded below A in the first year. One option is to assume that the expected forward spread in a year's time is still 0.5% for the first year and 1% for the second year, and that's what's been done in this example.

Now in general, the actual shape of the movement of each yield curve over the reporting period won't be in line with any of the shapes included as risk factors in the internal model. Therefore we need to define what we've called **deviation terms**, representing the differences between the actual closing yield curve and the yield curve implied by a given linear combination of the risk factors. My IAA paper referred to 'error terms' but the Working Party has since decided that the term 'deviation terms' is less likely to cause confusion. We introduce deviation terms into the Taylor series expansion in a similar way to the risk factor terms. There's some flexibility around how the deviation terms are set up. We could define a separate deviation term for the forward rate for every month, but that might result in excessive run times because 1,440 deviation terms would be required for a 120-year yield curve. Alternatively we could look through to how the yield curves are calibrated and have a separate deviation term for each calibration point, but that would create complexity with the expected roll-forward because some of the calibration points for government bonds are fixed terms from the valuation date and others are specific government bonds maturing on specific calendar dates.

On the next slide we've shown the **other** places in the attribution where deviation terms are required. For the corporate and supranational bond spread curves, the considerations are similar to those for the yield curves. For credit migration experience over the reporting period, there needs to be a deviation term for each asset and each possible rating the asset could transition to. For future credit transition assumptions, affecting the fundamental spreads, there needs to be a deviation term for each entry of the transition matrix. And finally for the inflation experienced over the reporting period, there needs to be a deviation term for the difference between each actual RPI figure emerging over the reporting period and the figure implied by a given linear combination of the inflation risk factors, observing that previous RPI figures are required as well as the latest one because there are likely to be indexation lags on both the asset and liability sides.

We can now **solve** for the amount of each risk factor that has occurred over the reporting period. To illustrate the concepts, I'll first discuss the situation where there are no experience variances over the reporting period, only assumption changes at the end of the period. The more straightforward risk factors are corporate bond spread risk, supranational bond spread risk and credit migration risk, because there's only one quantity to be solved for at a time, so we equate the sum of the relevant deviation terms to zero to get a linear equation to be solved for the amount of each risk factor that has occurred. For inflation there's a complication in that there are three risk factors to be solved for at a time, so simply setting the sum of the deviation terms to zero won't determine them uniquely. So we need to impose the condition that the vector of deviation terms should have a zero component in the direction of each of the risk factors, giving us three simultaneous linear equations to be solved for the risk factors. For interest rates and government bond spreads, we also need to solve for both sets of risk factors at once because it's government bond spreads over the risk-free yield curve, rather than government bond yields, that are the risk factors. So there are six simultaneous linear equations to solve for each currency.

Regarding bringing in **experience variances**, we'd suggest including the experience variance deviation terms in the same equations as the assumption change deviation terms before solving the equations for the amount of each risk factor that has occurred, rather than setting up separate experience variance risk factors. This means that consistency is maintained with the risk categorisation in the internal model. If the experience variance impacts need to be reported separately from the assumption change impacts for presentational purposes, then this can still be done by reporting the deviation terms out of the P&L attribution process.

On the next few slides we've illustrated some of the key features one would expect to see in the **outputs** when applying the methodology to this problem. If we think firstly about the sterling interest rate risk factors, then these will affect the values of all the sterling-denominated assets, together with foreign currency assets where swaps are used to convert the foreign currency interest rate exposure into sterling interest rate exposure. They will affect the liability value discounted using the risk-free yield curve, if there's no matching adjustment, or using the risk-free yield curve plus the opening matching adjustment, if there is a matching adjustment. Theoretically they will also affect the matching adjustment itself, by changing the weights given to different assets in the matching adjustment calculation. However, we might intuitively expect this matching adjustment effect to be small, and it has actually been ignored in this example. We should keep in mind the fact that the matching adjustment effect has been ignored, as it might give rise to unexplained movements in the attribution. Overall, for the sterling interest rate risk factors, clearly we'd expect to see substantial sensitivities for the assets in isolation. For own funds including a matching adjustment, the sensitivities would be expected to be small because of the requirement for the assets to closely cash flow match the liabilities in order to be eligible for a matching adjustment. For own funds excluding a matching adjustment, the sensitivities would also typically be small. Interest rate risk is generally regarded as an unrewarded risk, so it makes sense to hedge it even when there's no regulatory requirement to do so. There are two further points to note on this slide. Firstly, the amount of assets we've shown in each column takes account of the fact that an annuity fund without a matching adjustment would need to hold more assets to back the best estimate liabilities than one with a matching adjustment, and so the impacts shown in both the 'own funds' columns are pure mismatching impacts. Secondly, the percentages of the risk factors that have occurred, derived by solving the simultaneous equations, are slightly, but not substantially, different in each column because the weights given to the different deviation terms depend on the value metric being analysed.

For sterling **inflation** risk, the picture is similar to that for sterling interest rate risk in that there are substantial sensitivities for the assets in isolation, but these are largely cancelled out when the liabilities are included, whether with or without a matching adjustment. The only difference is that the magnitudes of the asset stresses are smaller, because the stresses only apply to index-linked assets, and also because market-implied expectations of future inflation over long time horizons tend to be less volatile than interest rates.

If we move on to **currency** risk, then we see zero liability impacts because the liabilities are denominated in sterling and the reporting currency is also sterling. Again there is theoretically a small matching adjustment effect which has been ignored. On the asset side we see non-zero impacts, but they will be small provided the currency risk is hedged, which would normally be a requirement where a matching adjustment is used. So in this example we see the same small non-zero impacts in all three columns. And similar comments also apply to interest rate and inflation risks for currencies other than sterling.

The remaining risk factors are government, supranational and corporate bond spreads, together with credit migration risk. Clearly the difference for the **first three** of these compared with interest rate, inflation and currency risk is that a matching adjustment needs to be used for there to be liability movements that offset the asset movements. In some circumstances, there will still be material spread risk remaining even with a matching adjustment because there are regulatory restrictions on the credit that can be taken for a matching adjustment for certain types of asset, such as callable bonds.

For **credit migration risk**, there's a difference in that we only get a partial offset via the matching adjustment when the asset value changes due to migration experience over the reporting period being different from that expected. The downgrading of an asset will increase its fundamental spread as well as its total spread. For example, if fundamental spreads are 25% of total spreads for all rating classes, then the matching adjustment will offset 75% of the asset movement. There's also a difference in that the future fundamental spread assumptions may change and have an impact on the matching adjustment only, without affecting the asset value or the liability value excluding the matching adjustment, but only if the fundamental spreads are above the floor. In the example on the slide, we've shown a relatively adverse outcome for credit migration experience over the reporting period, but no change in the future fundamental spreads because they are equal to the floor.

The P&L attribution will, as with most analysis of surplus processes, produce an **unexplained**. Because of the rigorous way in which the risk factor impacts have been quantified, there are only two possible causes of this unexplained – either it's due to changes in the data that haven't been mapped to any of the risk factors or it's due to higher-order terms in the Taylor series than have been quantified to date. If the unexplained is too large, then we'd recommend attempting to rule out the first of these possibilities before quantifying any higher-order terms. Firstly the unexplained might have arisen from data errors, and secondly it might have arisen from risks not allowed for in the internal model, such as the risk of the actual assets held moving differently from market indices. However, if higher-order terms are found to be necessary, then we'd recommend considering the structure of the risk factor definitions to identify which higher-order terms are likely to be significant. For example, for interest rate risk, the second-order sensitivities of the asset and liability values might be expected to have the opposite sign to the first-order sensitivities because of convexity, but this is mitigated by the fact that the interest rate stresses are applied to the logarithm of the forward rates rather than to the forward rates themselves. For inflation risk, however, the second-order sensitivities of the asset and liability values would be expected to have the same sign as the first-order sensitivities because increasing the inflation assumptions itself increases the amount of assets and liabilities subject to the inflation stresses.

Now the Working Party has to date only applied its techniques to closed books of annuities. We've had some thoughts about extending the techniques to include **new business** risks, and I've shown them on this slide. Treating new business risks in a different way from all the other risks affecting an insurance company generates additional complexity in a traditional analysis of surplus process. So we'd suggest bringing new business risks into the P&L attribution in the same way as any other type of risk. The expected position would assume that a volume of new business in line with business planning forecasts is sold, at a level of profitability consistent with what the pricing process is targeting. The new business liabilities would need to be identified separately in the closing balance sheet, and this would provide independent verification that the levels of profitability targeted in pricing were being achieved in practice. There would be risk factors in the P&L attribution for variances in sales volumes and in levels of profitability against those expected.

I haven't discussed so far how to deal with the situation where the Taylor series expansion is valid only over a limited range because the value metric doesn't vary **smoothly** with the underlying risk factors. One example of that is the point I mentioned earlier about changes in fundamental spreads in line with the credit transition matrix only coming through when the fundamental spreads are above the floor. Another example relates to limited price-indexed annuities, where, before any allowance for time value, the liability value might be sensitive to inflation rates when the rates are between zero and 5%, but not when they are below zero or above 5%. A similar problem has to be dealt with in Economic Capital modelling, where fitting a smooth formula to quantities that don't actually vary smoothly with the underlying risk factors is unlikely to produce sensible results. The problem can be dealt with by adding indicator variables as additional risk factors. The values of the indicator variables will be determined by the other risk factors. For example, if the value of limited price-indexed annuity liabilities has changed from being sensitive to inflation rates to being insensitive to them, because the market-implied inflation rates for certain periods have fallen below zero or risen above 5%, then the relevant indicator variables will change from 1 to 0. The P&L attribution will then need to include items both for the changes in the indicator variables and for the interactions between the indicator variables and the inflation risk factors. One could also set up a single risk factor representing the weighted average of the indicator variables and let the movements in the individual indicator variables appear as deviation terms relative to that.

I mentioned earlier that the Working Party had decided to **extend** its remit. This was because it became increasingly clear that the tools the Working Party was developing had wider applications than simply in P&L attribution. Practical Solvency II and Economic Capital modelling tends to use instantaneous stresses as opposed to a Taylor series expansion. However the only real difference here is that the P&L attribution sensitivities from the Taylor series are calculated on an expected rolled-forward balance sheet, whereas the instantaneous stresses are calculated on an actual balance sheet. So, without substantial further work, we have a means of quantifying instantaneous stresses without performing a separate model run on each set of stressed assumptions. The potential for improving the efficiency of Solvency II and Economic Capital reporting processes is very significant. It's also possible to calculate projected instantaneous stresses at future dates. If we take only those stresses that relate to non-hedgeable risks, then this gives us an efficient but rigorous means of calculating the risk margin. There's also a natural extension of the P&L attribution methodology to analyse the change in risk margin.

The Working Party has been developing an **Excel-based tool** into which the asset data and liability cash flows can be imported to provide a P&L attribution and calculate instantaneous sensitivities for any annuity fund. To date no versions of the Excel tool have been released outside the Working Party as limited testing of the tool on actual data has been carried out. However the Working Party is not of the view that the Excel tool should be developed to perfection before being released publicly. Releasing the Excel tool publicly, once a reasonable amount of testing has been performed, will maximise the range of businesses able to benefit from the Working Party's outputs. The Working Party is considering adopting a Wikipedia-like model, whereby anyone can submit variable definitions and associated documentation for the Excel tool and the bar to having them accepted is relatively low, but extensive use will be made of comments from Working Party members regarding potential improvements to the material in the Excel tool. There will be a macro to analyse the dependency structure of the variables and identify the ones that are needed for the current application. There will also be a version control process to enable companies to use the Excel tool with variable definitions cut off at a fixed date.

The Working Party has recently amended the Excel tool to use **common code** for the sensitivities of a variable to all the risk factors. For example, the matching adjustment is the difference between the discount rate that equates the present value of the liabilities to the market value of the assets required to meet the liability cash flows and the risk-free rate. The sensitivities of the matching adjustment are therefore the differences between the sensitivities of this discount rate and of the risk-free rate. It's useful to be able to specify this for all the risk factors and all the deviation terms simultaneously, rather than separately for each one. Using common code for all the risk factors also creates the flexibility to use different risk categorisations. One reason why that's useful is that different companies will be using different risk categorisations in their internal models, and some companies will be on the Standard Formula. But more generally, the risk categorisations in a typical internal model and in the Standard Formula are designed primarily for efficient calculation of the SCR and are not necessarily the most useful categorisations for using the model to manage the business. For example, for monitoring investment managers, one needs to be able to assess the performance of each investment mandate relative to its benchmark. There are also some applications where it's useful to consider risk factors at a higher level than the most granular level, for example by representing the liability value in terms of the risks to the liability cash flows, the risks to the risk-free yield curve and the matching adjustment, without continually having to look through the matching adjustment to the underlying risk factors.

The Working Party decided to **rename** itself the Industrialising Financial Reporting Working Party. The techniques the Working Party has developed are applicable to all forms of financial reporting, not only the Economic Capital metrics that the Working Party has focused on to date, and to any type of business, not only annuities. This could offer a real opportunity for increased consistency and transparency of reporting practices across the industry. The Working Party is also of the view that the implementation of the techniques is unlikely to be something that is progressed separately by each insurance company, given that companies are currently emerging from Solvency II projects that have been highly costly and have, in many cases, produced models very similar to those developed by competitors. The implementation of the techniques can then only be achieved by developing a tool into which any company can import its data.

That was **everything** I was planning to cover. I think we've got about *x* minutes for questions, or you can contact the Working Party by e-mail at the address shown on the slide.