Annuities ALM—A Practical Approach

1. Introduction

The second part of today's presentation is on attribution analysis of investment profit.

Normally, an analysis of profit on a life insurance portfolio will only provide one item called "investment experience", which is basically the difference between what we have assumed the assets to earn and what the assets actually have actually earned. Now this is not particularly helpful in an annuity portfolio because, due to the reasons Chris explained earlier, as investment profits in the portfolio are caused by a combination of factors which may need to be managed in different ways.

The objective of attribution analysis is to break down the investment profit or loss into various factors. There is more than one way to analyse investment performance of fixed income assets and liabilities displaying fixed income characteristics, such as annuities. The one presented here is just one of many different ways in which this can be done.

We are going to break down investment income into:

- what we can loosely call "income"—that is, the unwinding of the market yield of the assets and the unwinding of the risk-free discount rate for the liabilities; and
- market value factors, which represent changes in the market yields and discount rates due to changes in the yield curve, credit spreads and implied inflation assumptions and the like.

[Pause. Next slide.]

2. Attribution Factors

(a) Income Factors

As stated before, the income factors represent the unwinding of the market yield of the assets and the unwinding of the risk-free discount rate for the liabilities. It's basically the market value at the beginning of the period, multiplied by the market yield or the discount rate.

Now on the asset side, the market yield can be decomposed into the risk-free rate, and the credit spread, and the income can be calculated for each. There are various ways of calculating the credit spread; what we do is to solve for a constant spread which can be added to the risk-free yield curve so that the present value of the cash flows equals to the quoted market value.

There will be a residual component from this analysis, which we will call "calendar" income, due to the fact that the yield curve is not flat, as these calculations imply.

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(b) Market Value Factors

The next set of factors is the market value factors. These represent changes in the market yields and other discount rates, which in turn affects the value of the assets and liabilities.

[Pause.]

(i) Yield Curve Factors

The first factor is the change in market value due to the change in the yield curve over the analysis period. In turn, we can break this down into two components.

The first component is the change in market value as a result of **parallel** shift of the yield curve. Now you can define the parallel shift in any way you like, but it's generally helpful to define the shift as the change in yield at the duration of the assets or liabilities. In this way, you will be able to measure the effectiveness, or lack thereof, of a duration matching strategy.

The second component is the change in market value as a result of **non-parallel** movements, or twists, of the yield curve. This is basically what's left after taking into account the shift return.

We will illustrate these concepts later.

(ii) Changes in Credit Characteristics

The second factor is the change in market value due to the change in the credit spreads. Credit spreads can be driven by:

- Credit migration—that is, changes in the inherent credit rating or probability of default; and
- Movements in credit spreads, or how much the market expects to be rewarded given a credit rating.

As liabilities are valued at the risk-free rate, this factor, which we will call spread return, only applies to assets.

(iii) Inflation

And finally, for inflation-linked assets or liabilities, the inflation return represents the change in market value resulting from changes in the inflation assumption.

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(c) An Illustration

The graph here illustrates the concept of yield curve shifts and twists. Here we've got two yield curves, the blue one representing the curve at the beginning of our analysis period, and the pink one representing the curve at the end. We can select a term, say here [or where the middle arrows are], as the point to define parallel shift. Then the shift return is the change in market value as a result of the yield curve moving from the blue line to the dotted blue line. And the remaining movement, from the dotted blue line to the pink line, will end up in the twist return.

[Next slide. Pause.]

3. How to do it

We now turn to the annuity attribution process.

What we want to emphasise is that there is more than one way to do this. The methodology will depend on various things, such as the availability of data and what makes most sense to management given the nature of your business.

The first thing we need is cash flow projections for both assets and liabilities. Generally, you would have, as part of your liability valuation process, an existing process to project liability cash flows. However, you may need to set up or improve your systems and models to provide cash flow projections for assets.

What we found when we tried to implement this was the need to be very precise when modelling exactly when asset cash flows occur. Most securities have ex-coupon or ex-dividend periods of up to about 3 weeks. Because what we are essentially trying to explain is the change in market value, we need to model the cash flows as occurring on the ex-coupon date rather than the payment date. Otherwise you end up with the cash flows not matching the market values, which will distort the results significantly.

Ideally you would want to perform the analysis at the security level, although it would be possible to do this at a portfolio level if you don't have the data.

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This is basically the process. We start off by separating the asset market yields into the risk-free rate and the credit spread. Then we calculate the income factors using the formula market value at the beginning of the period, plus weighted cash flows, multiplied by the yield. The residual income can be calculated by valuing the cash flows with a yield curve shifted one period forward and comparing it against the market value at the beginning of the period.

Calculating the market value factors is very similar to an analysis of profit process. We basically start off with the yield and discount rate position at the beginning of the analysis period, change one factor at a time and revalue both the assets and liabilities.

The profit and loss attributable to a particular factor is then given by the formula, change in assets – change in liabilities. And we repeat this until we reach the yield and discount rate position at the end of the analysis period.

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As an example, to determine the profit due to parallel yield curve movements, you would first value assets and liabilities using the risk-free yield curve at the beginning of the period, then revalue them using the yield curve shifted up or down by a defined amount (say, movement in the risk-free curve at the portfolio duration), and take the difference.

From experience, the whole attribution process takes about two weeks, including performing the asset and liability cash flow projections.

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4. Simple Example

To illustrate the whole process we are going to have a look at a simple example. The example will consider how different matching approaches deliver different profit and loss outcomes, and how attribution analysis can be used to explain these outcomes to management.

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Here is the set up. We will first look at two asset and liability portfolios. This slide shows the asset and liability cash flows of the first portfolio. You will notice that this portfolio is completely cash flow matched, with the asset being a credit-wrapped structured finance security with a rating of AAAsf.

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This is the second portfolio. The liability cash flows are the same as the previous portfolio, but the asset cash flow profile is different.

Here, the liabilities are backed by two separate assets, with different maturity dates and different credit characteristics, the shorter one being rated AAAsf and the longer one being a more conventional AA-rated bond. The assets are weighted so that the duration of the asset portfolio is matched to the duration of the liability portfolio.

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Next we will look at the market changes that have occurred during our analysis period. The first slide shows the hypothetical risk-free curves at the beginning and the end of the analysis period. You can see that the curve has shifted upwards, and also has twisted so that the movement is much larger at the longer end of the yield curve than the shorter end.

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Here are the movements in credit spreads of the two assets during the period. The spread of the AAAsf-rated asset has widened substantially from 15 to 60 basis points, while the spread of the AA-rated asset has widened slightly from 60 to 70 basis points.

As you would recall, our first portfolio only invests in the AAA-sf rated asset, and so we should expect a large negative spread return due to the widening of the credit spread for that asset. Our second portfolio invests in a mixture of assets, so we should expect a slightly lower, but still negative, spread return on the second portfolio.

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If we run the attribution process on the example we will arrive at these results. Note that some of the numbers in this table may not add up due to rounding.

This first slide shows the attribution results for the cash flow matched portfolio. What you can see is that there is no profit and loss impact due to yield curve movements. However, we can see that there is a loss of 2.3 as a result of the widening of asset spreads during the period. This is quite a substantial result given the market value of the assets is about 80, and so we are talking about almost 3% of assets.

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The second slide shows the attribution results for the duration matched portfolio. There are a few things you will notice from the result.

Firstly, you will notice that we have a very small positive shift return, but we have a negative twist return of about 0.7. The movement in the risk-free curve is much larger at the longer end of the curve. As a result, the impact is higher on the asset side than on the liability side because more of the asset cash flows are exposed to the longer end of the curve.

What we can say is that while duration matching provides some protection against parallel shifts of the yield curve, it does not provide must protection against non-parallel twists of the curve.

Secondly, there is a negative spread return of 1.0, which is as expected lower than the loss under the previous portfolio of 2.3.

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This slide summarises the major findings from the example. We managed to explain almost all of the investment experience into various factors, which provides much more helpful information to management than just a single number. And duration matching may not necessarily work during significant volatility in the markets.

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The same attribution analysis process can be used to stress test the portfolio. You can define various scenarios in relation to yield curve and credit spread movements, and use the same process to analyse the impact of these movements on the portfolio. The results can then be used for various things from testing different strategies to hedge out the market risk of the portfolio, to setting the level of capital required to support the portfolio.