

TAIL RISK MANAGEMENT: A PRACTICAL GUIDE TO IDENTIFYING AND QUANTIFYING RISKS

Tail risk management has been widely discussed in the financial press since the dramatic market events which started in late-2007¹. However, whereas most articles have treated the topic with a singularly broad brush, ignoring the fact that management of tail risks has a different meaning for almost every investor, in this article we address the more fundamental question of how to identify and quantify tail risks. As our overall focus is on UK pension funds, we illustrate the general framework by considering a simple pension fund example.



Dr Jo Simon Clyde

Head of Retirement LDI, Aviva Investors - United Kingdom

Joined investment industry in 1999.

Main responsibilities

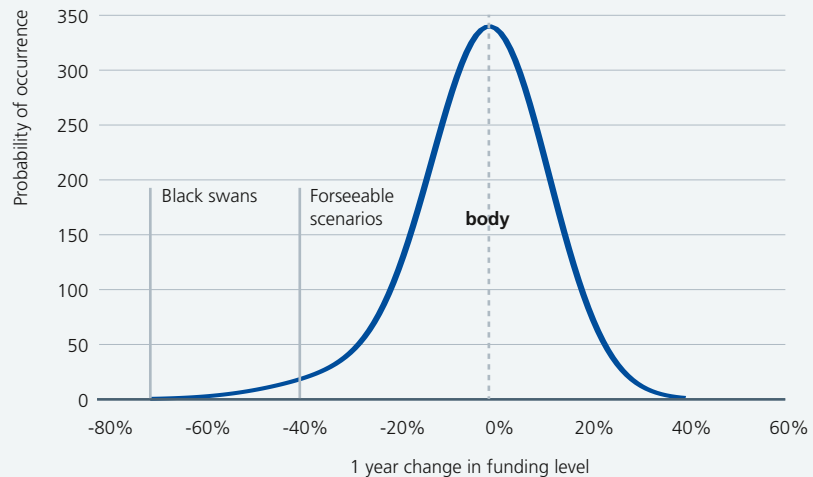
Jo's main responsibility is establishing an LDI solution framework for pension fund clients, making use of the wide asset class competencies and asset allocation skills within Aviva Investors.

Experience and qualifications

Jo has 11 years of investment and pensions experience, spanning pensions actuarial work, solution design, portfolio optimisation and fund management. Previously Jo was the lead LDI fund manager at Schroder Investment Management, where he was responsible for the design, launch and management of a market-leading series of leveraged pooled LDI funds. Jo was also previously responsible for portfolio construction at Man Investments and prior to this trained as an actuary at Aon Consulting.

1. For example, see "Popular tail-risk hedging is under attack", FTfm, Monday 25 July 2011 p.3.

Figure 1. Tail risk management – part of the risk management continuum



Source: Aviva Investors

2. Taleb, Nassim Nicholas, *The Black Swan: The impact of the highly improbable*. Penguin 2007.
3. Bhansali, Vineer and Davis, Josh, *Offensive Risk Management: Can Tail Risk Hedging Be Profitable?* (February 2010). Available at SSRN: <http://ssrn.com/abstract=1573760>.

What are tail risks?

A good place to start is with a definition. In academic terms, tail risk is generally described in standard deviation multiples – a typical definition is a movement of greater than three standard deviations. However, a layman's definition of tail risk as a low probability, high cost event is more useful as pension funds will generally think of tail risks as falls in funding levels which are too painful to bear.

What is tail risk management?

Tail risk management for a defined benefit (DB) pension fund is the process of identifying the tail risks and the financial ramifications that the scheme potentially faces and then designing, executing and managing a series of non-linear positions (typically options strategies) which protect against these risks. The positions will generally be fairly insensitive to normal market volatility, but generate a significant profit to offset the scheme's losses if certain financial tail events occur. As usually the intention is to protect the funding level, the design must take into account the liabilities and their valuation methodology.

Identifying and quantifying tail risks

As Figure 1 illustrates by a probability distribution of potential DB funding level outcomes over a one-year period, tail risk management should be seen as part of a continuum of risk management.

This distribution of outcomes is mainly controlled by the asset allocation and liability hedging of the fund and can be split into three regions. Within the body of the funding level distribution are those outcomes that result from normal market volatility. Further out in the left tail are those adverse outturns which derive from a series of unlikely but foreseeable scenarios. These are often described as known unknowns. In the extreme tail is the result of those often devastating events that are unpredictable in either magnitude or probability – what have been called black swans² or unknown unknowns.

An ideal risk management framework will take into account all of the sections of the distribution to arrive at an optimal risk-return position. For example, for a DB pension fund, asset allocation and the extent of liability matching are the major determinants of tail risks, and thus the major drivers of the tail risk program. At the same time, any tail risk positions executed will affect the performance of the fund even under normal market conditions and may lead to a change in the asset allocation and/or hedging. Bhansali et al³. go further and argue that by limiting the downside, an effective tail risk hedge can allow investors to increase risk at the asset allocation level.

The key differences between the two types of tail risk, which we touched upon earlier, are as follows:

Foreseeable scenarios: These are risks that can be identified by qualitative and quantitative analysis of the current economic environment and, while unlikely, are not so unlikely that they can't be foreseen. With foreseeable scenarios, the aim is to identify specific risks which might harm a scheme and use these to determine targeted mitigation. In this way, tail risk management aims to provide a high level of protection at a reasonable cost. However, the approach may fail to identify the appropriate risks and thus fail to provide the requisite protection. In fact, the method could be regarded more as downside-focussed asset allocation.

Black swans: These are the low probability, potentially high impact tail events where no attempt is made to identify the type or size of the potential risks. Indeed, Taleb⁴ argues that it is impossible to measure the risks in the extreme tails of the distribution. Instead, the method aims to simply identify those financial variables which will be strongly affected by the occurrence of these unknown unknowns. These are likely to include credit spreads widening, sizeable equity market falls, and dramatic movements in sovereign bond yields and inflation. Positions can then be put in

place to protect against the ramifications of the tail events. The strategy is aimed at providing a lower level of protection than the scenario-based approach in that it will only protect against the most extreme events. As a result it is likely to be significantly cheaper to implement.

Implementing tail risk management

Part of the client engagement process requires an understanding of whether protection is required against foreseeable scenarios or black swans. For a DB pension scheme this is typically driven by a number of factors, such as cost, sponsor strength and trustee risk appetite. Once the client has identified what to hedge and the level of protection required, the hedge provider needs to identify the cheapest approach to providing the protection. This process is essentially the same for the two types of tail risk identified above. The provider will seek to obtain the most effective hedging instruments at the lowest cost. This will require a delicate relative value analysis and a good understanding of the changing correlation structure of asset classes. It is likely to be an active process as relative value considerations may shift rapidly.

In the remainder of this article, we focus on foreseeable scenario-type tail risk and use a simple pension fund model to illustrate how the risks to be mitigated could be identified.

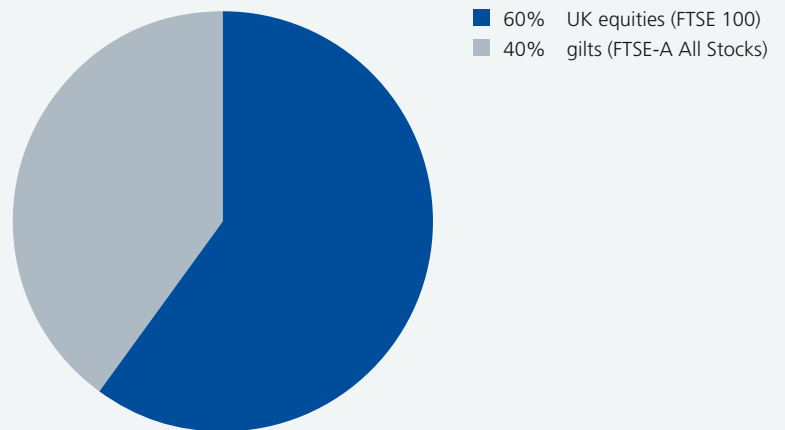
4. Taleb, Nassim Nicholas, Why did the Crisis of 2008 Happen? (August 26, 2010). Available at SSRN: <http://ssrn.com/abstract=1666042>.

Table 1. Possible states of the world over the next three to five years

Scenario	Probability	Description
Central	50%	<ul style="list-style-type: none"> Moderate global growth with significant variation between countries/regions Inflationary pressure rising in emerging markets but subdued in developed markets Monetary and fiscal policy to remain supportive for some time
Sovereign crisis	5%	<ul style="list-style-type: none"> Peripheral insolvency in Europe comes to a head Knock-on effects to global debt markets – US, UK and Japan all vulnerable Global growth turns down, commodity prices fall and inflation slows
Banking crisis	5%	<ul style="list-style-type: none"> Banking sector version of sovereign crisis – rerun of 2008 centred in Europe Key difference with sovereign crisis: flight to safety – US Treasuries and dollar rally Global growth and inflation fall, as in sovereign crisis case, though Europe and UK suffer disproportionately
Global rebalancing	10%	<ul style="list-style-type: none"> The most benign scenario – high savers raise their spending to compensate for low demand from those deleveraging Global growth surprises on the upside; inflation benign thanks to large output gaps
Emerging market bust	10%	<ul style="list-style-type: none"> Overly loose monetary policy in emerging markets leads to bubbles that burst and precipitate banking crisis. Asian property markets a key concern. Japanese earthquake has much bigger impact than in central case
Inflationary burst	10%	<ul style="list-style-type: none"> Huge expansion of liquidity associated with QE in US and China coincides with fall in precautionary money demand to generate inflation especially in emerging markets Money multiplier rises again as banks start to lend out excess reserves
Growth choke	10%	<ul style="list-style-type: none"> Large rise in oil and other commodity prices inflicts large terms of trade losses on developed markets – not offset by increased spending by commodity producers

Source: Aviva Investors at September 2011.

Figure 2. A simple pension fund asset allocation



Source: Aviva Investors

Pension fund example

Let's consider a DB pension fund with an asset allocation as depicted in Figure 2.

The scheme's liabilities are inflation-linked and have a 20-year duration valued using gilt-derived inflation and long-dated gilt yields. We assume that the scheme has a funding ratio of 100 per cent. In this example, the funding level is affected by only three financial variables. These are:

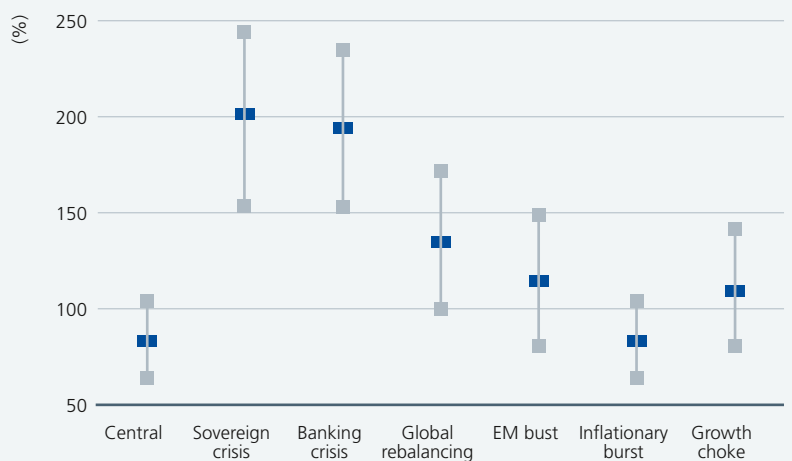
- Equity returns
- Gilt-derived inflation
- Nominal gilt yields

Table 1 sets out the foreseeable scenarios that were identified by the Aviva Investors Strategy Team in mid-2011 as possible states for the world over the next three to five years.

Each scenario is associated with a probability of occurrence and a distribution of outcomes. For example, it is estimated that there is a five per cent chance of a banking crisis occurring. However, if it does, it could range from a mild to a severe crisis, in which case the financial variables would be affected to different degrees.

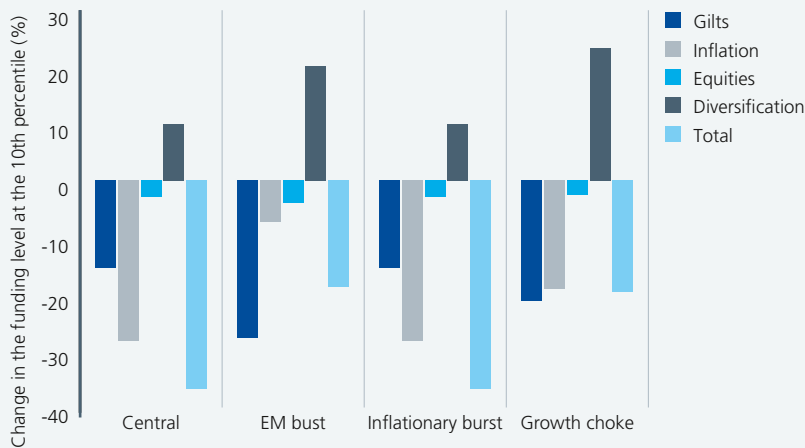
By combining these scenarios with information about the pension fund's assets and liabilities, we can identify the range of outcomes for the funding level in the event that each scenario occurs. If we regard the lower ten per cent point of the funding level as a tail event, we can then identify the changes in the financial variables which have led to the tail event.

Figure 3. The pension scheme's expected and 10%/90% confidence interval funding level after 12 months under each scenario



Source: Aviva Investors

Figure 4. Attribution of tail event between key financial variables



Source: Aviva Investors

Figure 3 shows the range of outcomes – the expected funding level and the 10%/90% confidence interval for the funding level – for the pension scheme under each scenario after 12 months.

It is clear that in two of the scenarios (Sovereign crisis and Banking crisis) outcomes for the funding level are positive. Even in the most adverse ten per cent of outcomes the funding level should improve by 50 per cent. While this may be counter-intuitive, it occurs principally because inflation falls in both scenarios, reducing the liabilities dramatically. In one further scenario (Global rebalancing) the tail outcome is a small fall in the funding ratio. As a result the tail risks in these scenarios should not concern the pension fund.

In the remaining four scenarios, in a tail event the funding level falls by between 20 per cent and 35 per cent.

We analyse the tail events for these four scenarios in more detail in Figure 4. For each of the three key financial variables we have estimated the effect on the funding level at the 10th percentile – the lower ten per cent point – keeping the other two variables unchanged. This is shown in the first three bars for each scenario. The total bar represents the

effect on the funding level at the 10th percentile when all three variables are allowed to vary. The diversification bar is the difference between the sum of the first three bars and the total. It represents the reality that the tail outcome for each of the key variables is unlikely to occur at the same time.

Figure 4 demonstrates several important dynamics of tail events:

- The major risks to funding levels come from changes in gilt yields and inflation, not equity returns. This occurs because although equities are more volatile than gilts, gilt yields and inflation volatility are multiplied by the liability duration. In addition, equities are only a proportion of the assets.
- The major contribution to funding level falls varies across the scenarios. In Central and Inflationary burst, inflation is the culprit; in EM bust it is falls in gilt yields due to the flight to quality; in Growth choke rising inflation and falling gilt yields contribute in equal measure. As a result, the design of the tail risk program must take a view on the likelihood of each scenario occurring. In particular, the Central scenario has by far the largest probability at 50 per cent. Hence protection against rising inflation should form a core component of any tail risk programme.


- The diversification varies by scenario. Low diversification observed in Central and Inflationary burst scenarios indicates that the key financial variables tend to move adversely together, i.e. in these scenarios the correlation of bad outcomes is high in tail events. Conversely, in the EM bust and Growth choke scenarios diversification is significantly higher in the tail events. Scenarios with high diversification will lead to less efficient hedging as it is less clear which financial variables will be affected in a tail event. It is interesting to note that the difference in total risk across the scenarios is largely a result of differences in diversification.

Summary

The framework set out above allows pension funds to identify the scenarios of most concern. Within each scenario, it further allows identification of the financial variables which cause the bulk of the losses in the tail event and which, in most circumstances can be directly hedged by implementing a suitable strategy. Although a simple example was used for illustration, much more complex and realistic client situations can be analysed.



Key points

- Although press coverage of tail risks and their mitigation tends to be quite generic, in reality each investor faces a very specific set of risks, which need to be mitigated with a bespoke programme.
 - DB pension funds face additional complexity as generally protection will be required for the funding level, which is a function of both assets and liabilities.
 - Tail risks can be usefully described as foreseeable scenarios which can be quantified to some extent, and black swans which cannot. Understanding this distinction allows an appropriate analysis of the risks that a client faces and wishes to be protected against.
 - Where the objective is to mitigate risks arising from foreseeable scenarios, a series of econometric simulations can be used to identify the most appropriate risks to mitigate.
 - Once this analysis is complete, a suitable portfolio of positions can be designed to control the risks.
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Contact us at
Aviva Investors North America
215 10th Street, Suite 1000
Des Moines, IA 50309

Aviva Investors North America
375 Park Avenue, 21st Floor
New York, NY 10152

Aviva Investors North America
300 North LaSalle Street, Ste 1600
Chicago, IL 60654

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