

Liability Driven Investment Explained

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Chapter 1

Introduction to asset/liability management

The first chapter of Liability Driven Investment (LDI) explained deals with the building blocks of pension management: assets, liabilities and the factors that influence them. Understanding these elements is the critical first step towards getting to grips not just with LDI, but with all the various investment strategies trustees can use for their schemes.

Section one: What do we mean by pension scheme liabilities?

First, we need to understand what is meant by liabilities, how these are calculated, the various factors affecting their value, and how they move and change over time.

What is a pension scheme liability?

A pension scheme pays an income to its members when they retire. These payments are the pension scheme's liabilities. For many defined benefit (DB) pension schemes, liabilities stretch far into the future and can be understood as a series of payments that a scheme must meet over the lifetime of the membership.

What is a liability cashflow profile?

A liability cashflow profile is a schedule of aggregated monthly or annual payments the scheme is projected to have to make over its lifetime. Using membership data including length of service, salary, rate of accrual and age, the scheme's actuary will calculate the cashflow projections for the lifetime of the scheme.

The example below shows a typical DB scheme's liability cashflows. Each bar represents how much must be paid for every year over the life of the scheme. Liabilities in this example peak between 30 and 35 years into the future when the scheme will need to find the most amount of money in any given year to meet its payment obligations.

How are liabilities calculated and valued?

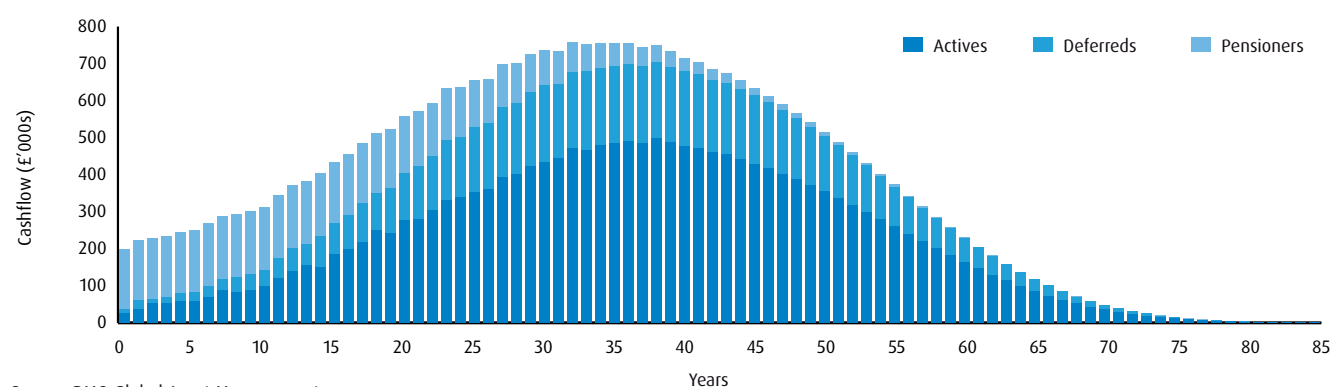
The scheme's actuary advises the trustees when calculating the value of a pension scheme's future liabilities. The actuary forecasts what each member will receive when he/she retires and when that payment is due. The figures for all members are aggregated to give a projection of the total amount a scheme is expected to pay out in the future.

The actuary takes into account a variety of factors in order to value the liabilities. These include membership data (how long members are predicted to live, the rate of salary increases, member age etc.) together with market factors such as anticipated inflation and interest rate levels. These factors form the basis for actuarial assumptions which will vary from scheme to scheme. The actuary also takes into account the scheme's investments when determining the assumptions used to value the liabilities. By valuing the liabilities, the actuary is calculating how much money the scheme needs today to meet all of its future liabilities. This is often called the "present value" of the liabilities. We explain in greater detail how pension payments are valued in Chapter 2.

What is a discount rate?

The discount rate is used to decide how much money a pension scheme needs to hold today to meet future liabilities. Essentially, a discount rate is an assumed rate of interest that the scheme will earn based on its assets. For example, if you need to pay £100 in five years you do not need £100 in the bank today. You can assume a rate of return on your money (the discount rate) such that if the discount rate is 5% you only need £78.35 in the bank today (compound interest on £78.35 for 5 years at 5% equals £100). Mathematically this can be calculated as $100 / ((1+5\%)^5)$.

Projected pension payments vs time



Source: BMO Global Asset Management

Section two: Factors affecting liabilities

The way in which final salary pension schemes are constructed means they are sensitive to numerous external factors and risks. Some risks are 'rewarded', which means pension schemes anticipate a clear benefit from taking a certain course of action (such as a return on an investment) that exposes it to risk. Some factors, however, expose the pension scheme to risk from which there is no anticipated benefit, these are known as 'unrewarded' risks.

Broadly speaking, the main unrewarded risks pension schemes face are interest rate risk and inflation risk. Liability Driven Investment products are designed to minimise a pension scheme's exposure to these unrewarded risks.

Interest rate risk

The present value of a scheme's liabilities depends on the discount rate used to value them. This value varies as interest rates/discount rates change. This means that the present value of the liabilities can change independently of changes in the scheme's asset value, giving rise to interest rate risk. All of a scheme's liabilities must be discounted back to a present value and are therefore sensitive to changes in interest rates. It is a regulatory requirement to link the discount rate to a market based rate of interest, such as long-term gilt or swap yields thus, as these yields change the value of a scheme's liabilities will also change.

Inflation risk

A proportion of a scheme's liabilities (typically 50-90%) will be linked to inflation therefore, changes in inflation will affect the amount a scheme pays out when a liability falls due. When valuing inflation linked liabilities the actuary will apply an assumption about future anticipated inflation. If the level of anticipated inflation changes this will have a direct knock-on effect on the value of any inflation linked liabilities. Changes in inflation expectations

can therefore have a knock-on effect on the value of a scheme's liabilities independent of any changes to a scheme's asset value, giving rise to inflation risk.

Inflation linked liabilities are often known as "real" liabilities, referring to the fact that these liabilities are sensitive to changes in real interest rates (i.e. the combination of interest rates and inflation). The remainder of a scheme's liabilities are just sensitive to interest rates and are often referred to as nominal liabilities, fixed liabilities or non-inflation linked liabilities.

How do interest rates affect pension liability values?

Interest rates present an unrewarded risk to pension schemes. Movements in interest rates can have a significant impact on the present value of liabilities. The discount rate is linked to long-term market interest rates. If long-term interest rates fall, the actuary will assume a lower rate of return on scheme assets which means we need more money today to meet our liabilities in the future, essentially the present value of the liabilities increases. The opposite is true for a rise in interest rates. The impact is significant because of the long dated nature of pension scheme liabilities. A reduction in the discount rate from 4% to 3% is the same as saying that we expect to earn 1% less each year for the life of the liability. If the liability is 20 years in the future this equates to an impact of approximately 20% (1% multiplied by 20 years).

This is explained in the numerical example below.

Example

If a pension scheme invests £100 at an interest rate of 4.00% over three years it would receive £112.49 at the end of three years.

$$£100 \times 1.04 \times 1.04 \times 1.04 = £112.49$$

So, if the pension scheme uses that 4.00% interest rate to discount a liability cashflow of £112.49 in three years' time, it only needs £100 today to match future liabilities.

$$£112.49 / (1.04 \times 1.04 \times 1.04) = £100$$

However, if interest rates fall to 3.00% the scheme would need to hold £102.94 today to meet the cashflow.

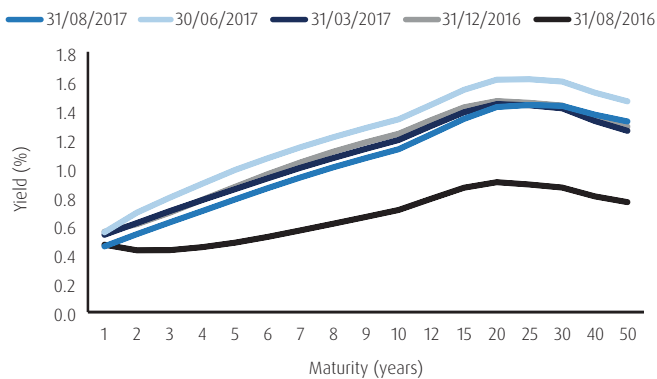
$$£112.49 / (1.03 \times 1.03 \times 1.03) = £102.94$$

What is the yield curve?

In the previous example, the interest rate of 4.00% is the rate that is applicable at the time of investment for three years. Similarly, we can derive longer-term interest rates by considering the market implied yields on longer dated bonds. Using all the gilts available in the market, we can derive a “yield curve” that shows the yields for all the various maturities. The two common yield curves in the UK are the gilt and swap curves, derived from the full maturity spectrum of gilt and swap yields respectively. When considering the interest rates used in discounting pension scheme liabilities, it is not the prevailing central bank base rate (a very short-term interest rate) that is relevant but the entire yield curve. This is because the majority of the liabilities go out many years into the future and hence longer-term interest rates are more relevant than short-term interest rates.

The chart below shows the swap yield curve as at 30th November 2016 and the range of the levels seen in the preceding 1 year period.

Interest rate swap rates through the year to August 2017



Source: Bloomberg as at August 2017

How do you measure the magnitude of change in liability values as a result of changes in interest rates?

Duration is a measure of sensitivity to changes in interest rates, quoted in years. A liability or bond with a 10 year duration will go up in value by approximately 10% for every 1% fall in interest rates or yields. The relationship between duration and its impact can be assumed to be linear for small changes in yields or interest rates. The relationship is a little more complex for larger changes in yields or interest rates but assuming a linear relationship still provides a useful ballpark estimate. Therefore, something with a duration of 20 years is roughly twice as sensitive to changes in interest rates as something with a duration of 10 years.

Duration is the average remaining life of a bond or liability. For a single liability payment due in 15 years the duration will be 15 years. We can work out the duration of an entire pension scheme by aggregating all the liabilities. The average duration of a typical scheme is around 20 years and tends to fall in the range of 15-25 years.

The duration of a bond is not the same as its maturity because a bond will typically pay periodic coupons (interest) in addition to the final repayment of capital. This means that the duration of a bond is shorter than the time to maturity. A bond with 10 years to maturity might have a duration of 8 years for example.

How does inflation affect pension liability values?

One of the most important factors that causes final salary retirement benefits to increase is inflation.

Final salary schemes are linked to inflation in order to provide some protection against increases in cost of living and therefore, as inflation rates rise, so do the scheme's liabilities. Conversely, in the case of falling inflation, the scheme's projected payments would fall. There are a number of different measures of inflation, described below:

Retail Price Index (RPI) – The traditional long standing measure of inflation in the UK, which is based on the cost of a basket of goods as determined by the Office for National Statistics and published monthly. This basket of goods includes housing costs such as mortgage payments and rental payments. The contents of the basket are revised periodically to reflect evolving buying habits. Most pension schemes have historically linked pension benefits to RPI or a measure derived from RPI.

Consumer Price Index (CPI) – Similar to RPI in being based on a basket of goods, CPI is the measure of inflation targeted by the Bank of England when setting monetary policy (2% target). CPI is more consistent with the measure of inflation used across Europe and excludes housing costs. CPI is typically lower than RPI due to the way it is calculated and the composition of the basket of goods. Since 2010, Government funded schemes have linked benefit payments to CPI rather than RPI and a number of private sector schemes have followed suit.

Limited Price Indexation (LPI) – LPI is simply RPI but with a cap and a floor applied to it. For example, LPI (2,5) is RPI with a floor of 2% and a cap of 5%. Thus if benefits are linked to this the scheme would still pay out 2% even if inflation fell below this level but would not pay out more than 5% if inflation rose above this higher level. There are many different variations or “flavours” of LPI with the caps and floors set at different levels. Government legislation dictates that pension liabilities built up between April 1997 and April 2005 must increase in line with LPI (0,5). For those accumulated after April 2005 the cap falls to

2.5%. With the introduction of CPI described above, this cap will now refer to CPI for schemes that do not have an explicit RPI linkage in their rules.

Most inflation linked assets (e.g. index linked gilts and swaps) reference RPI. There are very few CPI linked instruments available in the market so on the basis that CPI and RPI are highly correlated most schemes invest in RPI linked instruments when hedging CPI linked liabilities. It is possible to trade LPI linked swaps but these tend to be relatively illiquid and thus expensive to trade.

Why do real interest rates matter?

A significant proportion of most pension scheme liabilities are linked to inflation. To calculate their present value we apply an inflation assumption to determine how much we pay out when the liability falls due, and then discount back to a present value to work out how much we need today to make the required payment in the future. This means the liability in question is sensitive to both interest rates and inflation. The combination of interest rates and inflation is known as the real interest rate (i.e. the rate of interest net of inflation) so an alternative to the calculation explained above is to simply discount the liabilities by a real rate of interest.

In summary, if real interest rates rise, the value of a pension scheme's liabilities will fall and vice versa.

The following table shows the present values under different scenarios of an inflation linked liability that is payable in one year's time.

	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b
Nominal interest rate	4.0%	5.0%	4.0%	5.0%
Inflation rate	3.0%	4.0%	3.5%	3.0%
Real interest rate	1.0%	1.0%	0.5%	2.0%
Index linked liability in one year's time	£100	£100	£100	£100
Present value of the index linked liability	£99	£99	£100	£98

In scenarios 1a and 1b, the real interest rate is similar and hence the present value of the liability remains broadly the same. The real interest rates in scenarios 1a and 1b are similar because the gap between the nominal interest rate and inflation rate in both scenarios is the same. However, as real rates decrease (scenario 2a), the present value increases and vice versa (scenario 2b).

What is the effect of wage inflation on liabilities?

The very nature of a final salary scheme means that any changes to a member's remuneration package over their period of employment will alter their final pension payments. Fundamentally, of course, final salary pensions are linked to how much an employee earns, and so any increase in wages will of course lead to an increase in pension payments. Throughout an employee's tenure, their wages will hopefully increase, either through promotion or simply to keep up with inflation.

Example

A 60-year-old employee earns £21,000 and accrues a pension of 1/60ths final salary for each year of service; he expects to retire in five years' time. So far, he has amassed an annual pension of £7,000 during 20 years' service. During the remaining five years of service he receives a pay rise of £3,000, so at retirement, with 25 years of service and a final salary of £24,000 he is due a pension of £10,000. Had he remained on a wage of £21,000, he would only be entitled to £8,750; the additional £3,000 of his salary equates to an extra £1,250 in his annual pension. Therefore, final salary pension liabilities increase as salaries increase.

Section three: Understanding your assets

There are a wide variety of asset classes available to trustees when managing their portfolios. Some trustees target high returns whilst others aim for steady consistent returns. How these different strategies are employed and the strategic asset allocation chosen by the scheme is critical in the success of meeting liabilities as and when they fall due in the future.

What assets are typically included in a pension scheme's investment strategy?

There is a huge variation in the portfolios of DB pension schemes, but over the past 20 years, investment strategies have been dominated by equities and bonds. These two asset classes have made up 90% of total asset allocation, on average, with the majority of the remaining 10% coming from cash and property.

More pension schemes have started to include 'alternatives' such as commodities, infrastructure, private equity and hedge funds, as well as increasing their exposure to overseas assets.

This change in investment strategy has been prompted by a growing acceptance that traditional approaches involving just a few asset classes limit investment opportunities. Pension schemes are now more inclined to diversify their portfolios by spreading risk across a number of asset classes, investment styles, geographies and sectors.

What is the role of investments in paying liabilities?

The choice of asset mix for a pension scheme is paramount. We can assess a scheme's financial health by looking at its funding level, which is a measure of whether a scheme's assets are a match for the present value of the scheme's liabilities. The funding level is expressed as a percentage; a scheme that is 100% funded would in theory be able to meet all its future liabilities. Poor performance from assets relative to the liabilities

can cause this funding level to deteriorate and the lower the percentage the worse the scheme's financial health, making it less able to meet future liabilities.

There is also an indirect effect on the liabilities of a pension scheme, in that the asset mix determines the expected return which is often used to discount the liabilities to calculate their present value. The UK Pensions Act 2004 states that pension schemes are obliged to meet a statutory funding objective which means they must have enough assets to meet their 'technical provisions' (their liabilities). The underlying assumptions used to reach the liability valuation are at the trustees discretion. For this reason, the rate used by a scheme's actuary to calculate the present value of a pension scheme's liabilities (technical provisions) can be a conservative assumption of the expected rate of return on the scheme's assets.

This makes determining the right asset mix of great importance; choosing a riskier asset mix with the potential of higher returns will reduce the present value of the liabilities. However, such a strategy comes with risks such as higher overall volatility, tracking error and potential shortfall in assets to meet the liabilities as they arise. The right mix is, therefore, a trade-off between risk and return. Given that pension scheme sponsors prefer a relatively stable contribution rate over the long-term, choosing the right asset mix and hence, the right discount rate, can be a delicate balancing act.

Chapter 2

Understanding volatility in assets and liabilities

In Chapter 1, we introduced the key concepts of assets and liabilities and then explored some of the factors that influence them. In this chapter, we provide some examples of how the liabilities are valued to illustrate the significant impact of changes in interest rates and inflation expectations.

A fundamental concept in pension scheme funding is “present value”. This is the amount of money needed today to meet all future liabilities. This chapter illustrates how the present value of fixed and inflation linked liabilities is calculated.

Section one: Calculating the present value of a fixed liability

To calculate today's value, the "present value", of a fixed payment of £100,000 in 30 years' time, we ask how much needs to be put aside today such that with interest we can meet the £100,000 payment in 30 years.

Example

As an example, assume a rate of interest of 4% per year over the next 30 years:

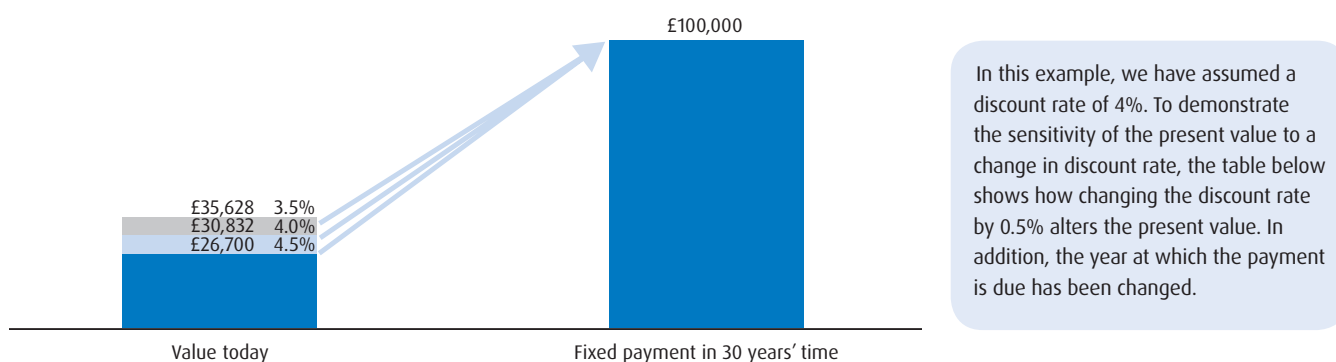
$$\text{Present value} = \frac{\text{nominal cashflow}}{(1 + R)^N}$$

Where: N = number of years until the payment is due 30
 nominal cashflow = future fixed cashflow £100,000
 R = discount rate per year 4%

In this case, the present value of the future cashflow would be:

$$\text{Present value} = \frac{\text{nominal cashflow}}{(1 + R)^N} = \frac{£100,000}{(1 + 4\%)^{30}} = £30,832$$

This shows how a single payment in the future, which is fixed in nature, can be valued today using an assumption for the discount rate over the relevant period. The present value is highly sensitive to the discount rate that is chosen, as can be seen in the chart below:



Years until due	Discount rate = 4% pa	Discount rate falls by 0.5%		Discount rate rises by 0.5%	
	Present value (PV)	PV	% change in PV	PV	% change in PV
10	67,556	70,892	5%	64,393	-5%
30	30,832	35,628	16%	26,700	-13%
50	14,071	17,905	27%	11,071	-21%

The table above shows that the further into the future the payment is due, the lower the present value is, as there is more time to gain the benefit of interest. Therefore, the sensitiveness of present value to changes in interest rate increases with time.

This is particularly relevant for pension schemes, whose liabilities are very long-dated and therefore the present value of pension scheme liabilities are extremely sensitive to movements in interest rates.

Section two: Calculating the present value of an inflation-linked liability

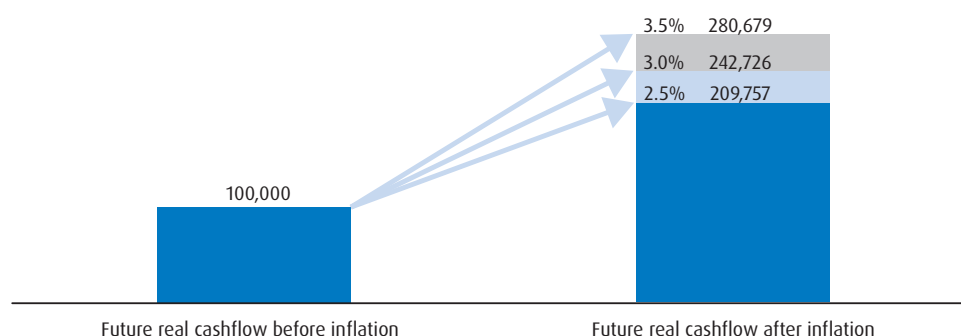
Let's now assume that a pension scheme needs to make a payment linked to inflation in 30 years' time of £100,000. As this amount will change with inflation over the next 30 years, the actual amount to be paid is unknown. To calculate a present value we need to first project what we expect the amount paid to be. We do this by making an assumption for what inflation will be over this period.

Example

As an example, assume inflation will be 3% per year, then a £100,000 payment linked to this inflation rate will be equal to an expected payment of:

$$=£100,000 \times (1+3\%)^{30} = £242,726 \text{ in 30 years}$$

This has converted the inflation linked payment into an expected fixed payment of £242,726 in 30 years' time. This expected cashflow is highly sensitive to the inflation assumption that is chosen, as can be seen in the chart below:



By adopting a similar method as described in the previous example, we can calculate the present value of this payment.

$$\text{Present value} = \frac{\text{cashflow} \times \text{expected inflation over period } N}{(1 + R)^N}$$

Where:	N = number of years until the payment is due	30
	R = Discount rate per year	4.00%
	Cashflow = Future real cashflow before inflation	£100,000
	expected inflation over period N	$(1+3\%)^{30}$
	Future real cashflow before inflation × expected inflation over period N = Future real cashflow after inflation	

In this case, the present value of the future cashflow would be:

$$\begin{aligned} \text{Present value} &= \frac{\text{cashflow} \times \text{expected inflation over period } N}{(1 + R)^N} \\ &= \frac{£100,000 \times (1+3\%)^{30}}{(1+4\%)^{30}} \\ &= £74,837 \end{aligned}$$

This shows how a single payment in the future, which is linked to inflation, can be valued today using assumptions for expected inflation and a discount rate over the relevant period.

In the example above, we have assumed an inflation rate of 3% and a discount rate of 4%.

To demonstrate the sensitivity of the present value to changes in inflation expectations, the table below shows how changing the inflation assumption by 0.5% alters the present value. In addition, the year at which the payment is due has been changed.

Years until due	Inflation = 3% pa	Inflation falls by 0.5%		Inflation rises by 0.5%	
	PV	PV	% change in PV	PV	% change in PV
10	90,790	86,478	-5%	95,295	5%
30	74,837	64,672	-14%	86,539	16%
50	61,687	48,364	-22%	78,587	27%

The table above shows that the further into the future the payment is due, the lower the present value is. This is due to the inflation assumption being lower than the interest rate, so the benefit of gaining interest outweighs the increase in the payment amount due to inflation. Therefore, the sensitivity of present value to changes in inflation increases with time.

This is particularly relevant for pension schemes, whose liabilities are very long-dated and inflation-linked. Therefore,

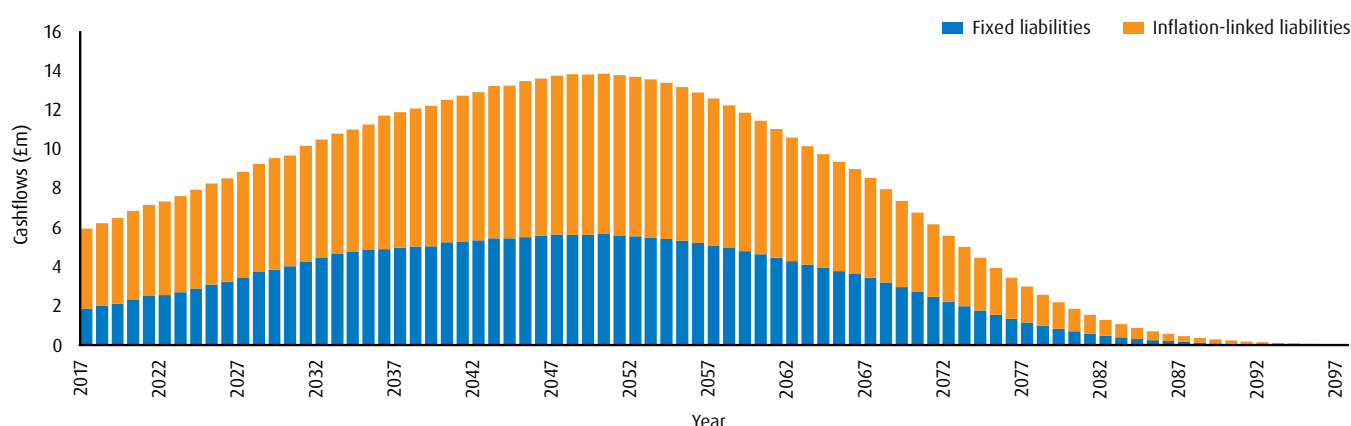
the present value of pension scheme liabilities are extremely sensitive to movements in inflation rates.

Note that although interest rates affect the present value of a scheme's liabilities, i.e. the amount of money required to be held today, interest rates and changes to interest rates have no impact upon the actual amount paid out. Compare this with inflation which affects both the (inflation-linked) amount paid as well as the present value of the liabilities.

Section three: What about assets?

The two previous examples are simple, but they help understand factors that affect the present value of a pension scheme's liabilities.

When the scheme actuary undertakes a valuation, they look at the current position of the scheme and then project what benefits the members are expected to receive and when these benefits are expected to be paid. An example of this is shown in the following cashflow profile:



The expected payments are then discounted to obtain the present value of the scheme's liability at the valuation date. Here we have gained an understanding of the liability side of a pension scheme, but what about the asset side?

Pension schemes typically invest in a variety of asset classes, such as equities, diversified growth funds, property and bonds. Each of these assets offer different rates of expected returns and consequently have different levels of risk. However, asset classes with a higher rate of returns carry a greater risk of failing to deliver the expected return, which could leave pension schemes with a shortfall.

If a pension scheme chooses to invest in asset classes with a high expected rate of return, then the current value of assets required to fund the future liability would be lower. Here, there is a greater benefit of interest and therefore we need to hold less money today to be able to fund any future liability payments. Whilst a scheme's investment strategy should be set to meet its

future funding obligations, many schemes are less than 100% funded which means they need to invest in assets with a higher expected return to help plug the shortfall.

The balance between expected return and potential shortfall risk makes setting the investment strategy a particularly difficult challenge for trustees. However, a strategy designed to better match assets to liabilities can limit the risk of assets moving in a different direction to the liabilities.

Unrewarded risks such as future movements in interest rates and inflation can pose a big threat to scheme funding. As the earlier examples highlighted, the present value of pension scheme liabilities is highly sensitive to movements in interest rates and inflation.

In the forthcoming chapters, we explore how pension schemes can mitigate these unrewarded risks from their portfolios without sacrificing the scope for higher returns from their investment strategies. One way to do this is to implement an LDI strategy.

Chapter 3

Investment toolkit

In the last chapter we examined the effects external factors have on pension liabilities and the risks these pose to a scheme's ability to make future benefit payments.

Now we explore how bonds and derivatives can be used in an LDI strategy.

The aim of an LDI strategy is to make the scheme's assets move in line with the value of its liabilities as interest rates and inflation change. We say the assets in an LDI strategy hedge the scheme's interest rate and inflation risk as they are designed to match all (or a portion of) the interest rate and inflation risks in the pension liabilities. In doing so, the scheme's funding ratio is (largely) protected from volatility arising from changes in the liability valuation.

Section one: Matching liabilities using bonds

Hedging interest rate and inflation risk can be done by investing in fixed income assets such as government and corporate bonds. These take many forms but we shall concentrate on traditional fixed rate and inflation-linked bonds [here](#).

A bond is a debt instrument whereby the bond holder loans the bond issuer a sum of money for which they will receive a fixed rate of interest over the life of the bond before receiving full repayment of capital at maturity. The bond issuer will usually pay a fixed annual coupon which can be likened to the annual payment of interest.

A bond has a “notional” or “principal” which is the amount referenced by the coupon and the amount that will be repaid at maturity. It is worth noting however, that the coupon is not the same as the “yield” on the bond.

The yield can be thought of as the average per annum return you will receive by holding the bond to maturity and can be calculated by summing all the coupon payments with the repayment of capital and dividing by the purchase price. This number then needs annualising to convert it into a per annum percentage. If all the payments you receive as a bond holder are fixed but the yield on the bond goes up then the price of the

bond must have fallen and vice versa. This means that a bond’s price behaves in exactly the same way as a pension scheme liabilities and so by holding a portfolio of bonds, a pension scheme can protect itself against changing interest rates/yields. If long-term interest rates (i.e. yields) fall, then a pension scheme’s liabilities will rise. This will then be offset by a similar rise in the value of the bonds that are held and thus one offsets the other.

Bonds are widely tradeable and investors can buy or sell them on the financial markets. Amongst the most widely traded bonds are gilts (debt issued by the UK Government) and corporate bonds (debt issued by companies). Gilts are seen as very low risk given the financial security of the UK Government. Corporate bonds are seen as more risky as they are issued by companies that are generally less financially secure than the Government. You would expect to earn a higher yield on a corporate bond to compensate you for this additional risk.

Example

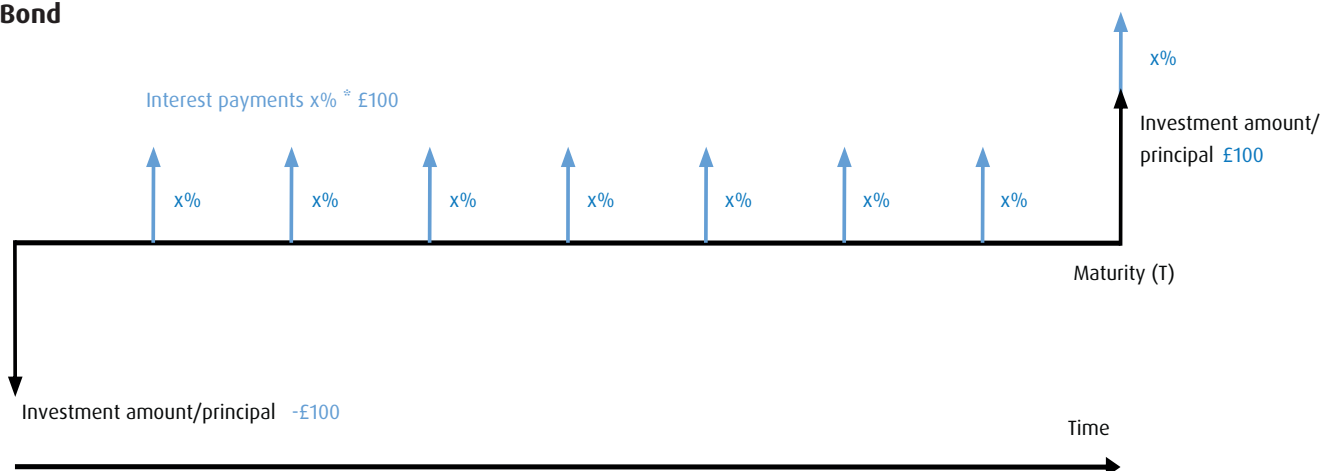
For example, if the notional is £100, the coupon is 5%, but the prevailing market yield is 4% you would need to pay more than £100 to buy the bond, this premium over the notional serving to dilute the 5% coupon payment down to the 4% market yield, so the bond has a yield of 4% as well.

Fixed rate bond

With a fixed rate bond, the investor receives the coupon payments over the life of the bond, with the final payment also containing the capital repayment amount (the notional, or principal).

The chart below shows bond cashflows based on a bond with a notional of £100, a maturity term of 10 years, and an annual coupon of 4.00%. Each year a cashflow of £4 (i.e. $4.00\% \times £100$) is received until year 10 when the final receipt is £104 (i.e. the £100 debt is repaid along with the final coupon).

Bond

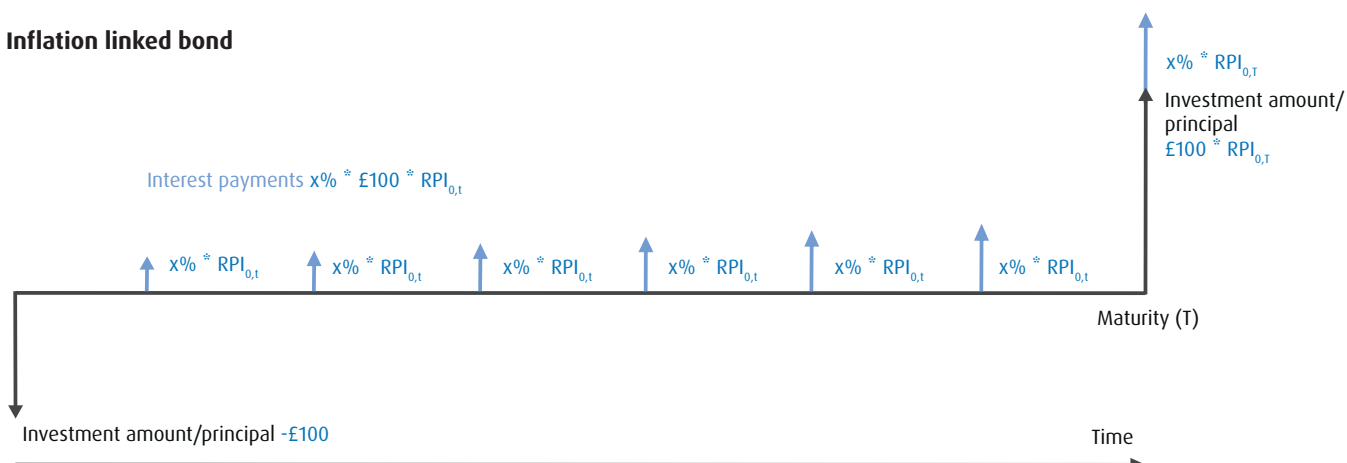


However, a fixed rate bond will only hedge fixed liability payments. If the liability cashflows increase with inflation, then bonds which provide only fixed income (rather than income linked to inflation) do not provide a good match to the liabilities. This is where inflation-linked bonds become useful.

Inflation-linked bonds provide a series of payments which are linked to inflation – that is inflation applied to both the coupon and the notional of the bond.

The chart below shows bond cashflows based on an inflation-linked bond with a notional of £100, a maturity term of 10 years, and an annual coupon of 1.00%. Each year the interest payment is increased to allow for inflation, in this case RPI, therefore the cashflows received until year 10 will be £1 (i.e. $1.00\% \times £100$) increased in line with RPI. The final payment received is $£101 \times RPI$ over the period (i.e. the £100 debt is repaid along with the final coupon).

Inflation linked bond



Example

If inflation in year 1 and year 2 was 3.00% and 4.00% respectively, then RPI_{0,1} and RPI_{0,2} would be equal to 1.03 and 1.07 respectively calculated as follows:

$$\text{RPI}_{0,1} = (1 + \text{RPI in year 1}) = (1 + 3.00\%) = 1.03$$

$$\text{RPI}_{0,2} = (1 + \text{RPI in year 1}) * (1 + \text{RPI in year 2}) = 1.03 * 1.04 = 1.07$$

Based on the diagram below, if $x = 1.00\%$ then the cashflow in year 1 and 2 will be equal to:

$$\text{Year 1: } 1.00\% * 1.03 * £100 = £1.03$$

$$\text{Year 2: } 1.00\% * 1.03 * 1.04 * £100 = £1.07$$

And so on for each year in the future until maturity. At maturity, the payment will include the inflated interest payment in line with the calculations above and the inflated principal.

How a bond matches a pension scheme's liabilities

Changes in interest rates (and inflation in the case of inflation-linked bonds) will affect the value of a bond in the same way that it affects the value of the liabilities. A fall in interest rates will increase the present value of a scheme's liabilities, and the bond will also increase in value, as the future cashflows are being discounted by a lower rate. Similarly, a rise in inflation will increase the liability value and the value of an inflation-linked bond as the future inflation-linked coupon payments are expected to be higher.

Limitations of bonds

In spite of bonds' obvious merits in providing a hedge for interest rate and inflation risk, they are subject to some limitations.

Certain bonds, such as long-dated index-linked gilts, can be scarce. The issuance of gilts is subject to the needs of the UK government to raise capital and, therefore, makes supply unpredictable.

The maturity spectrum of the corporate bond market is skewed such that the majority of bonds have relatively short maturities and there are few long-dated or ultra-long-dated bonds in existence. There is also a problem of sector concentration in the UK whereby most long-dated corporate bonds are predominantly issued by financial institutions. What this means is there is a scarcity of suitable long-dated bond assets available

to pension schemes to set against their long-dated liabilities. Corporate bonds also introduce credit risk to the portfolio which is the risk that the bond issuer is unable meet its payment obligations in respect of the bond, creating a loss for the investor. The yield on corporate bonds is higher than that of gilts in order to compensate investors for this risk but it does make it desirable to limit exposure to corporate bonds. Additionally, the creditworthiness of the issuer will change over time which can influence the price of a bond independently of changes in interest rates/yields. This means that corporate bonds are generally used as a subset of a wider hedging portfolio rather than forming the core of the portfolio. The majority of bond based hedging is done using gilts and in most instances an allocation to corporate bonds (if desired) will be made separately to the core hedging portfolio.

More importantly, in order to buy bonds a scheme needs to raise cash by moving out of growth assets (equities, property, hedge funds, diversified growth funds etc.). Growth assets are expected to provide higher returns over the long-term and therefore, by switching into bonds, the scheme is sacrificing potential performance. If a scheme has a funding deficit then making this sacrifice may not be possible because the shortfall cannot be met without the sponsor having to increase its contributions into the scheme. In other words, many schemes cannot afford to relinquish their growth asset holdings in favour of bonds.

Section two: Matching liabilities using swaps and other derivatives

Given the limitations of physical bonds, pension schemes have looked elsewhere for tools that are better placed to match assets to liabilities. Swaps have grown in prevalence thanks to their capital efficient ability to hedge inflation and interest rate risk.

Whilst they can be more operationally complex than bonds and require a little more understanding, swaps are considerably more flexible. For example, swaps are available over virtually any maturity of up to 50 years, making them an excellent match for long-term liabilities. They are also not restricted by physical supply determined by a government's financing requirements, as is the case with gilts.

What is a swap?

A swap is an agreement between two parties to exchange (or "swap") one flow of payments for another. In this case, the two parties are the pension scheme and their counterparty, an investment bank.

Swaps normally involve exchanging a variable rate of interest for a fixed rate of interest, both of which reference the same underlying notional (similar to a coupon being applied to the notional on a bond). This type of swap can be referred to as an interest rate swap, a fixed swap, or a nominal swap. For

example, the "price" of a 20 year interest rate swap might be quoted as 3.5%. This means that we could enter into a swap whereby we receive fixed interest of 3.5% for 20 years on the agreed notional (let's say this is £100). In return, we pay the counterparty variable interest on £100 for 20 years. There are a number of important features to note. Firstly, the underlying notional (the £100) does not change hands, this is simply the reference amount to which the interest is applied, and applies to both sides of the agreement. Secondly, the fixed rate (in this case 3.5%) is the market's expectation of what the variable rate will average over the life of the swap. This means that, all other things being equal, the market expects the sum of the fixed payments to be the same as the sum of the variable payments over the 20 years. Therefore neither side of the swap is more valuable than the other so the contract has zero value on day one.

Therefore, similarly to a bond, pension schemes can use interest rate swaps to match the future value of their liability cashflows.

How do swaps work?

As with bonds, the value of the swap will change if market interest rates change. For example, if 20 year interest rates rise to 4.0% the 3.5% 20 year swap we own in the previous example will fall in value. This can be explained as follows:

If long-term rates rise this is the market telling us that it now expects the short-term variable interest we are paying under the swap to average 4.0% rather than 3.5% over the 20 years. We still receive 3.5% fixed but will on average pay out variable interest that equates to 4.0%. The fact that we now expect to pay out more than we receive means that the swap has lost us money.

The opposite is true if rates fall in that the swap will make us money. Therefore, in this example, if interest rates rise the

swap falls in value and if interest rates fall, it rises in value.

The key consideration, however, is that this movement in value is exactly the same behaviour as exhibited by a pension scheme's liabilities and by bond prices so a swap can simply be thought of as an alternative to a bond and an effective risk management tool for matching pension scheme liabilities.

The big advantage of a swap is that it is capital efficient. It starts from a zero value and might rise in value to £10 or fall to -£10. A similar bond would move in the same way but require an upfront investment of £100 and thus rise to potentially £110 and fall to £90. The capital efficiency of a swap allows pension schemes to manage their liability risks without tying up significant amounts of capital.

What types of swaps do pension schemes use?

Interest rate swaps

Interest rate swaps can be used to manage a scheme's interest rate risk in the same way that conventional gilts might be used.

The pension scheme will typically receive fixed interest and pay variable interest. The variable interest is usually six or three month LIBOR (London Interbank Offered Rate), a short-term interbank lending rate.



Inflation swaps

Inflation swaps can be used to manage a scheme's inflation risk and, when combined with interest rate swaps, behave in the same way as index linked gilts.

The pension scheme will typically receive RPI (the variable rate) and pay a fixed rate. The fixed rate equates to what the market expects inflation will average over the life of the swap. If actual inflation ends up being higher or lower than this the scheme will receive more or less than the fixed rate they are paying. This creates certainty that whatever inflation ends up being the scheme will receive this via its swap portfolio.



Real rate swaps

Real rate swaps are available that combine the interest rate and inflation elements in one contract. The scheme would receive a fixed real rate of interest and pay a variable rate of interest such as three or six month LIBOR plus or minus a spread. The real rate of interest is essentially the difference between the two fixed interest amounts in the diagrams above.

Most investment managers transact separate interest rate and inflation swaps as it is usually more cost effective to do so, and provides for greater future flexibility.

Other types of derivatives and instruments

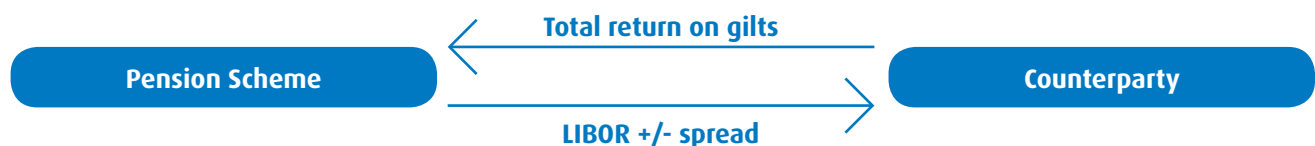
In addition to swaps, gilt based derivatives have become a popular way to achieve capital efficient liability hedging. A gilt-based derivative is simply a way of accessing the exposure to a gilt without purchasing the physical instrument, as a £100 investment in gilts requires the investment £100 of cash.

There have been three common structures that can be used to gain exposure to gilts in an unfunded manner. These structures are a) gilt total return swaps (TRS), b) gilt sale and repurchase agreements (repo) and c) gilt futures.

Gilt total return swaps (TRS)

A gilt TRS is an agreement to exchange the total return of a gilt for a floating rate (e.g. LIBOR plus or minus a spread) cashflow. Just like owning the physical gilt, the pension scheme will experience the changes in value of that gilt in the payments it receives, however instead of purchasing the bond with cash, the scheme pays a floating rate (much like the floating rate on a swap).

Typical maturity terms for TRS are between six months to five years, though liquidity, and hence pricing, may not be attractive for longer dated maturities.

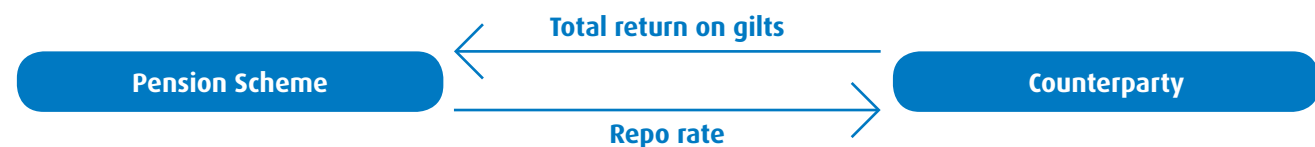


Gilt sale and repurchase agreement (repo)

A repo is when the pension scheme borrows money from an investment bank using a gilt they already own as security. The borrowed money can be used for anything but is usually used to buy more gilts. The interest rate applied to this "loan" is known as the repo rate.

In practice, the pension scheme sells a gilt to the bank but simultaneously agrees to buy it back on a particular date in the future and at a specified price. The time between the sale and repurchase point can vary from overnight to one year. Because the repurchase price is fixed at the outset the pension scheme retains economic exposure to the gilt. A rise or fall in the market value of the gilt still equates to a profit or loss to the pension scheme as the repurchase price does not move, so the pension scheme will experience the changes in value of that gilt as it would if it was not used in a repo.

The difference between the sale and repurchase price is the repo rate (i.e. the interest applied to the loan). A repo allows a pension scheme to create leveraged exposure to gilts, in turn helping them to manage their liability risks in a capital efficient manner.



Gilt future

A gilt future is an agreement (obligation) to buy or sell a given quantity of a particular government bond at a specified future date at a pre-agreed price. Bond futures can be bought on the stock market and are a highly liquid means of creating synthetic exposure to gilts. That said, there is only one regularly traded gilt contract known as the long gilt future, which provides exposure to 10 year maturity gilts, making gilt futures a relatively blunt hedging tool in isolation.



Jargon buster

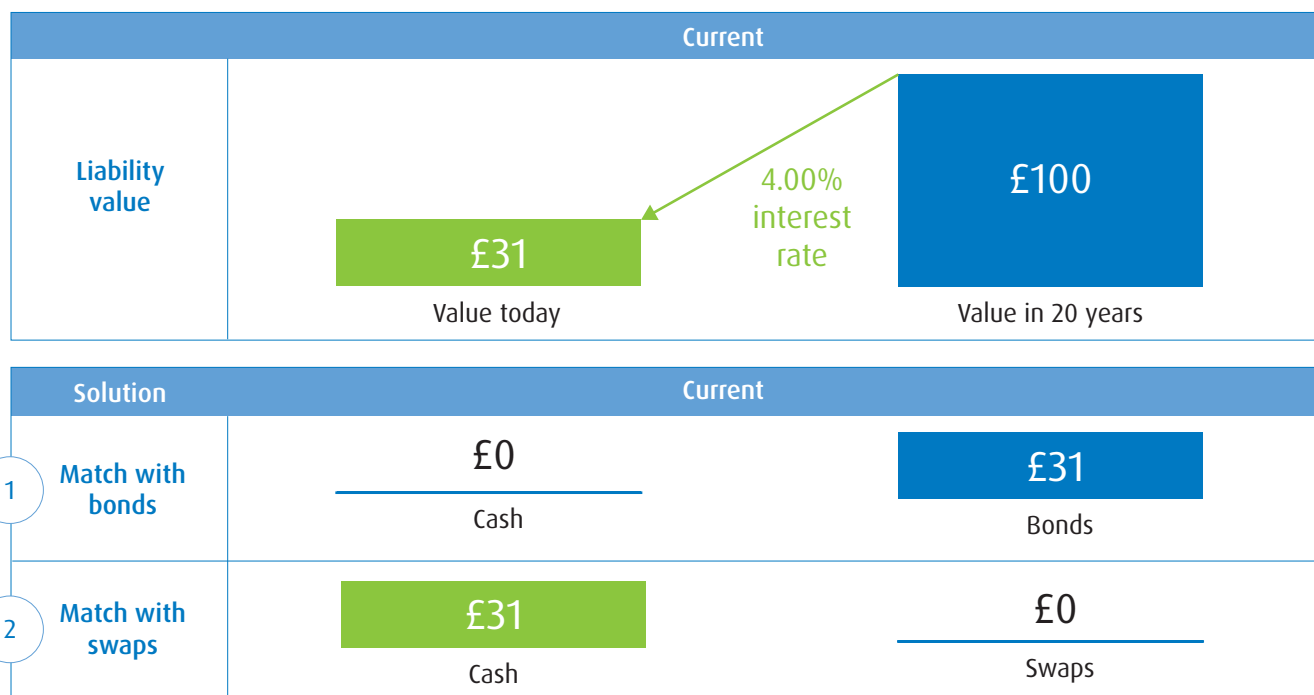
Par and zero coupon swaps

You may hear swaps referred to as par or zero coupon. Par swaps are simply swaps whereby coupon and interest payments are exchanged periodically (similar to a coupon paying bond). Zero coupon swaps accrue any profit or loss over the life of the swap whereby it is settled at maturity. Whilst zero coupon swaps used to be popular, the current market standard approach is to trade par swaps, which offer materially lower dealing costs.

Section three: How do bonds and swaps work in practice?

Bonds (both physical and bond derivatives) and swaps are all part of the ‘LDI toolkit’ – the assets used in an LDI strategy. This is because they experience the same changes in value as pension liabilities as interest rates and inflation change. The example below illustrates how bonds and swaps work in the context of hedging the interest rate risk of a liability cashflow.

Consider a fixed pension payment of £100 to be made in 30 years’ time. Interest rates are expected to be 4.00% per annum on average over this period, meaning the value today is £31. The scheme could invest £31 in a 30 year bond to hedge the interest rate risk of this cashflow. Alternatively the scheme could enter into a fixed interest rate swap with a counterparty bank, for 30 years, with a fixed rate of 4.00% and a notional of £31, this is shown in the chart below:

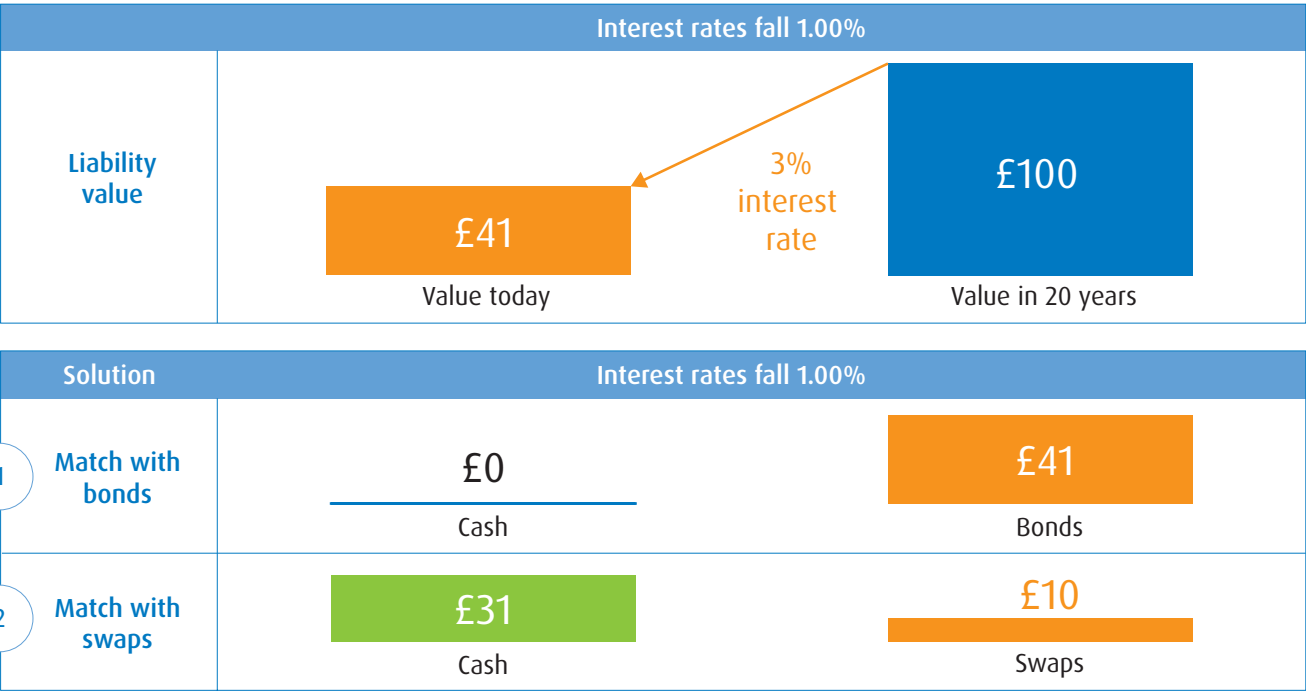


Source: BMO Global Asset Management, for illustrative purposes only

Now let's look at a scenario where the expected 30 year interest rate falls by 1%, i.e. to 3%. Our liability value will increase by £10, to £41. However, our bond will also increase in value.

With regards to our swap, the amount we're expected to pay will be lower, and the amount we're receiving will be the same, so overall the swap will now have a positive value (as we're receiving more than we're paying). Taking a look at this in more detail, we're now expecting to pay 3% on the £31 (so £75) and still receive 4% (which is the payment of £100). The difference is £25 - which is £10 in today's terms (discounting by 3%).

This is illustrated in the diagram below



In both cases, the scheme has £41 of total assets, matching the value of the future cashflow. By entering into a swap, however, the scheme has assets free to invest in growth asset classes, such as equity, diversified growth fund's (DGFs), etc. However, if interest rates were to rise, the liability value would fall, as would the value of the bond. In this scenario, the swap would have a negative value. So some of the £31 in cash in the example above would need to be held back in case interest rates did indeed fall.

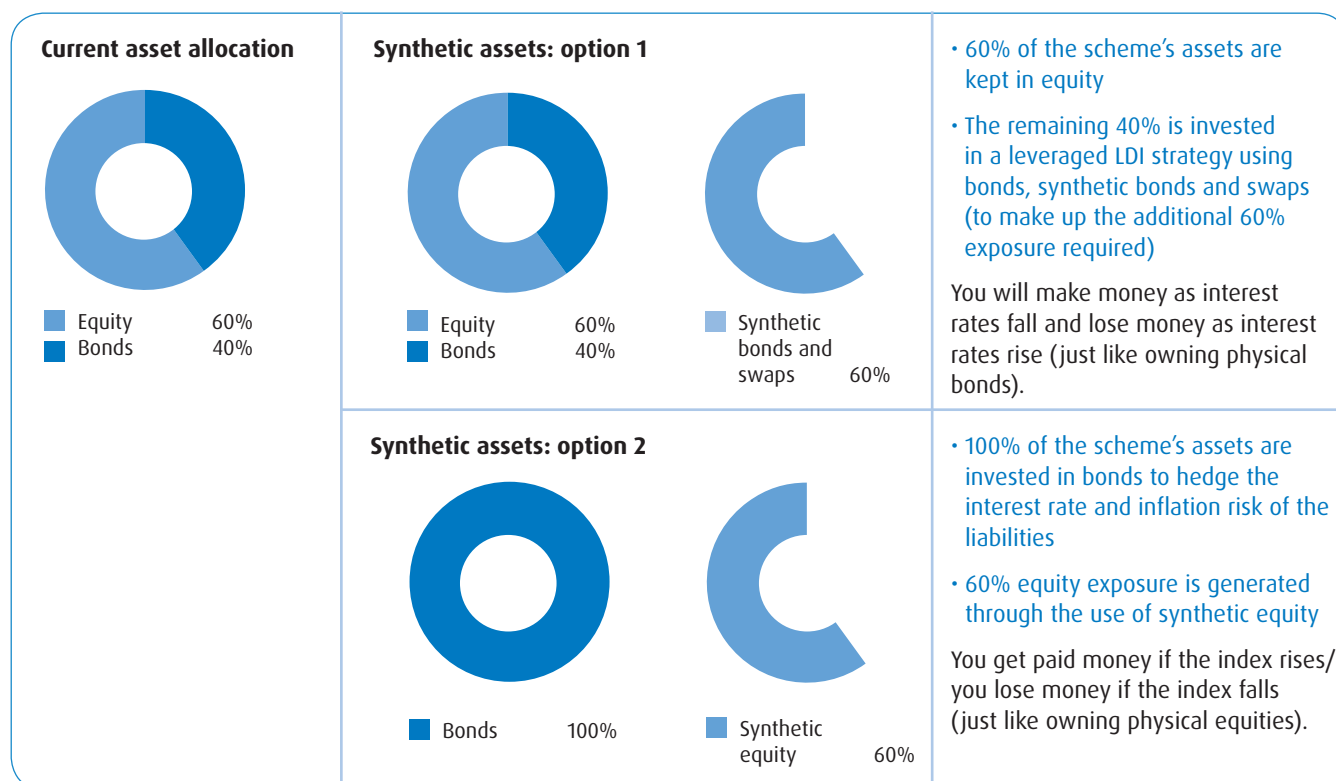
Section four: Combining hedging techniques with return strategies using equity futures

As we have just seen, a swap and synthetic bond based solution allows the scheme to retain investments in growth assets whilst hedging interest rate and inflation risks. A common way of funding an LDI allocation is from a traditional gilt portfolio. £100 of gilts can be moved into an LDI portfolio to hedge £300 of liabilities and to improve the accuracy of the matching portfolio. However, there are two instances where this may not be possible:

- 1) The scheme has very few or no gilts in the first place
- 2) The scheme has already switched its gilts to LDI but now wishes to increase its liability hedge further

In both these scenarios, the scheme may think that it needs to sell down some growth assets to fund its desired LDI allocation. This may not be desirable as it would result in a reduction in overall return expectation. It is however possible to replicate passive equity exposure using derivatives in order to free up cash to invest in LDI. In such a scenario the equities are sold for

cash and simultaneously replaced with equity derivatives. The cash raised by selling the equities is then invested in LDI which can either be a combination of swaps, gilts and synthetic gilts or could simply be a straightforward physical gilt investment. In each case, the equity exposure remains unchanged but liability hedging increases.



Both options provide 100% exposure to bonds using either entirely physical assets (option 2) or partly synthetic assets which are bond-like (option 1). Whilst option 2 provides exposure to equities synthetically, option 1 involves actual investment in physical equities.

Option 2 in more detail:

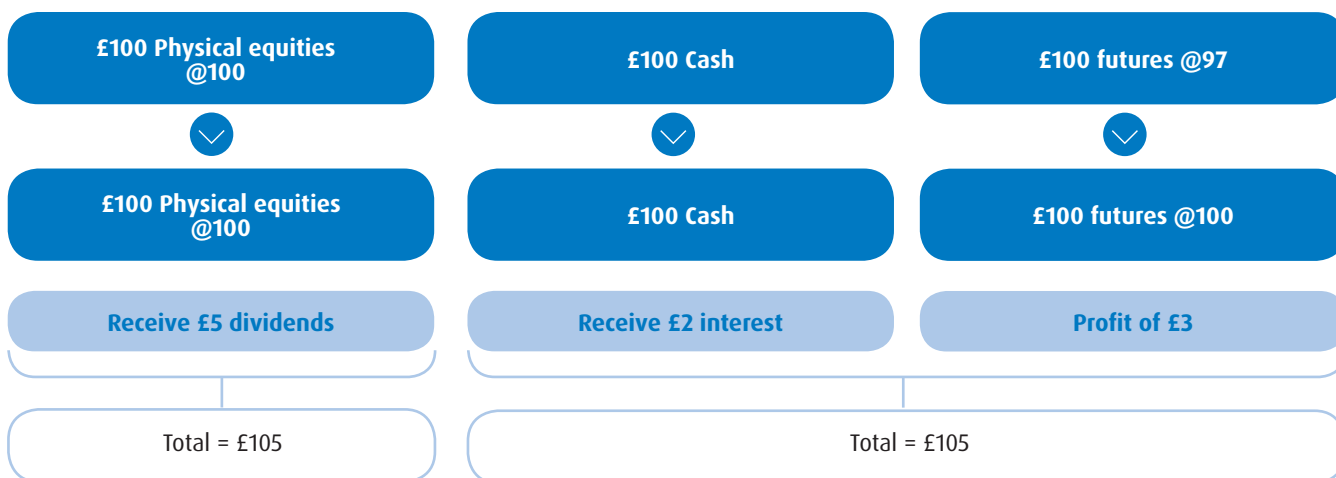
The main methods for gaining synthetic exposure to equity (and other growth assets) are set out below. Much like synthetic bonds, the following derivatives allow a scheme to gain exposure to equity, and other indices without purchasing the physical instruments.

Equity index futures

Stock market index futures are futures contracts used to replicate the performance of an underlying stock market index. A future is an agreement (obligation) to buy or sell a given quantity of a particular asset at a specified future date at a pre-agreed price. For example, a FTSE 100 Index future allows investors to gain exposure to the FTSE 100 Index which tracks the performance of the top 100 UK blue chip companies.

Assuming actual dividends on the FTSE 100 Index equal expected dividends, the example below shows how a cash plus futures position resembles a physical equity position, i.e. holding the FTSE 100 Index. On the right-hand-side a basket of the 100 blue chip companies which is worth £100 today is bought for £97 in the future.

Cash + future = physical equity



Equity index 100

$D = 5.00\%$ (Expected dividends)

$R = 2.00\%$ (Interest rate on cash)

Forward index $97 = 100 * (1 + 2.00\% - 5.00\%)$

When a future is purchased to track the FTSE 100 Index only a proportion of its total market exposure needs to be paid to open and maintain a position. This means positions can be taken in the underlying instrument by means of a relatively small cash outlay. The percentage of the total market exposure is called 'margin' and there are two types of margin payment.

Upfront, investors are obliged to put up what is referred to as 'initial margin'. The initial margin is set at an amount that reflects the maximum potential overnight change in the contract's value

and is returnable to the investor. If the price moves against the investor, additional funds will need to be put up in order to maintain appropriate backing for the positions. The daily amounts that are added to and subtracted from the margin over the life of a contract are known as 'variation margin'.

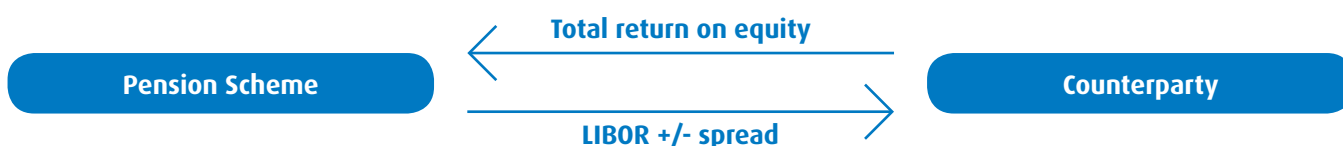
This process is called 'marking-to-market' and minimises the credit risk of investing in futures contracts, i.e. the risk that either counterparty to a futures contract reneges on the original deal.

Equity index total return swaps (TRS)

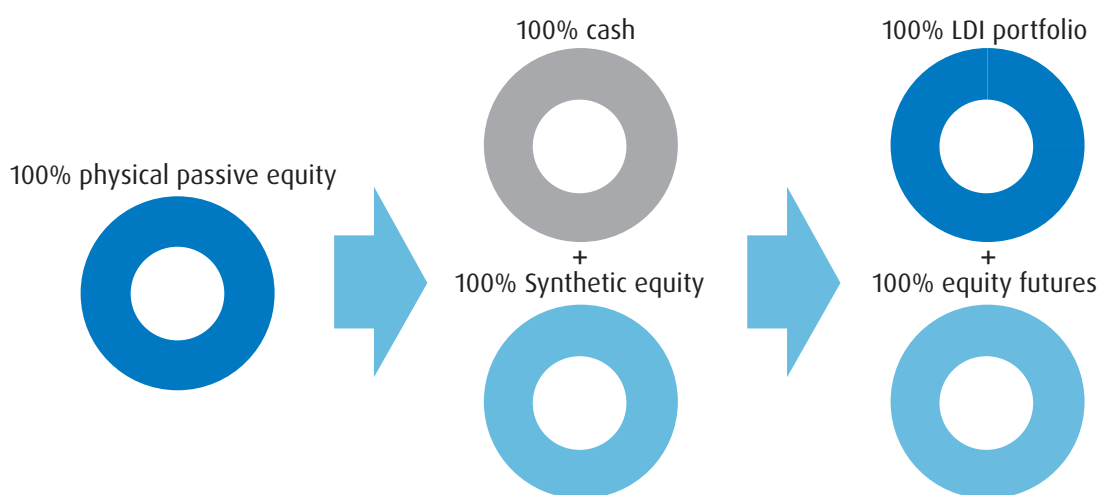
An equity TRS is an agreement to exchange the total return of an equity index for a fixed or floating rate (e.g. LIBOR plus or minus a spread) cashflow. Therefore the pension scheme will experience the changes in value on the index – just like owning a passive or index-tracking fund.

It is also possible to enter into TRS on other indices, such as property indices. However these are less common at present and therefore more expensive to enter into.

Typical maturity terms for TRS are between six months and three years.



Physical passive equity can be replaced by holding 'cash' and synthetic equity instruments



The cash can then be invested in an LDI strategy, either leveraged using bonds, swaps and gilt derivatives, or unleveraged, using just bonds. The resulting portfolio would provide a hedge of the interest rate and inflation risks and the pension scheme's liabilities, and also provide exposure to equity to give the scheme the additional return above the liabilities that it seeks to help improve the funding ratio.

Chapter 4

Practical considerations

This chapter takes a look at some of the practicalities associated with managing LDI portfolios. They are not typically things that clients need to provide input on as we will take care of them behind the scenes, but they are worth being aware of nonetheless.

It is important to understand how the market works, and how banks and other participants engage with the market and price trades. We also look at maintaining an appropriate level of leverage and managing counterparty risk.

Section one: Implementation of LDI strategies

How the market works

To understand some of the drivers of how we trade with banks, it may first be helpful to appreciate how the banks themselves operate.

Suppose we enter into a fixed swap to hedge a client's interest rate risk. If this transaction happened in isolation, the bank would then be exposed to the same risk that our client had just hedged away. So to avoid that situation the bank will simultaneously be looking to receive the fixed rate in a separate swap transaction with a third party. This means that the banks do not take the traded risk onto their own book over the long-term, they simply act as a middleman, matching buyers and sellers.

The dealing costs that a bank charges are dependent on how easy it will be for them to match off the trade. For example, if it is likely to take a week to find the opposite side of the trade they will be exposed to the underlying risk for a week and will apply a relatively high charge or not want to trade at all. Conversely, if they can find the opposite side of the trade in a matter of hours or better still have the opposite trade already lined up, then the cost will be much lower. This is where the specialist skills of an LDI manager come into play as we can structure the trade in a way that makes it easy for the bank to match off, therefore minimising costs. This can include focusing on market standard features and trade size as well as approaching banks we know have expertise in certain trade

types. Focussing on market standard features also makes it easy to adjust or unwind positions ahead of maturity if we want to.

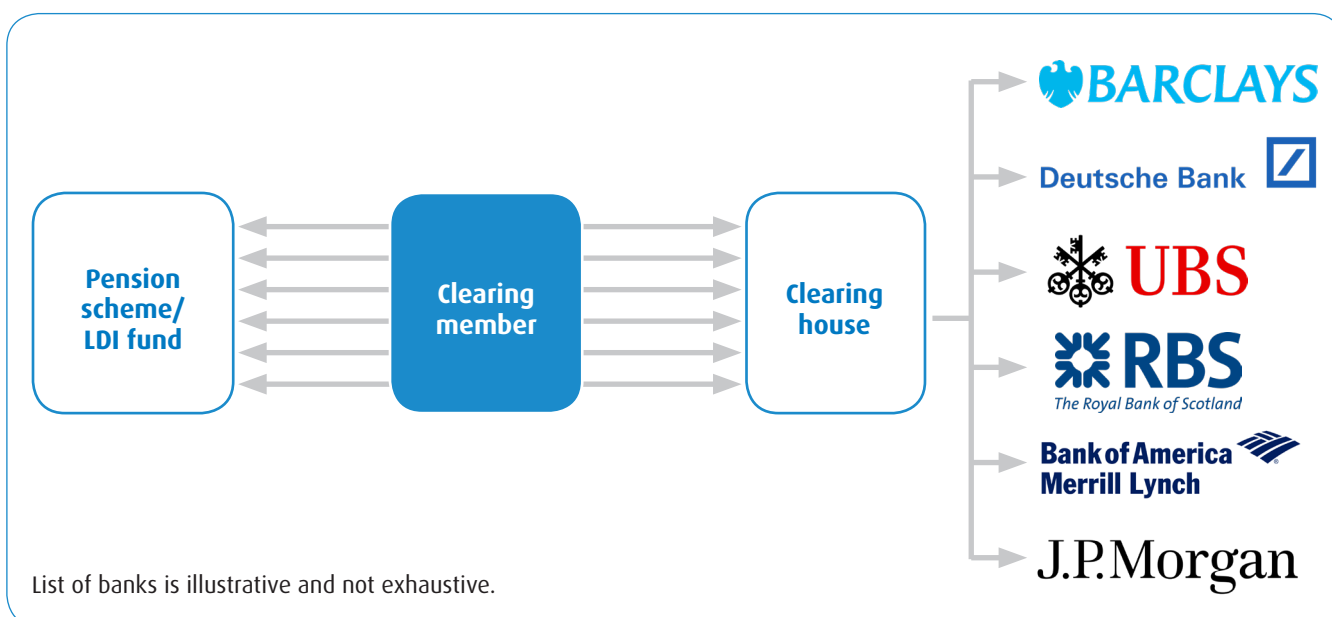
Dealing costs are usually quoted as basis points (bps) of risk so if someone quotes you a cost of 0.5bps for a swap this means that the pound cost is 0.5 multiplied by the amount of PV01 being traded. (See next jargon buster)

Once a trade is executed the portfolio has a direct contract with the bank in respect of the trade terms.

Central clearing

A recent development known as central clearing moves this model on a stage. Within central clearing, having negotiated the trade terms with the bank both the investment manager and the bank instantaneously give the trade up to a clearing house so that the clearing house becomes the counterparty to both sides of the trade. This removes the bank counterparty exposure altogether. Central clearing has come about through regulatory change and is becoming mandatory within investment markets. As a result, the majority of new swap positions that we trade are centrally cleared. However, some instruments remain outside the scope of central clearing including repo, total return swaps and swaptions. A portfolio's access to the clearing house is intermediated by a clearing member who provides an operational service to ensure the movement of margin (see counterparty risk section) amongst other things.

The diagram below illustrates the central clearing framework.



Counterparty risk

Counterparty risk is the risk that a bank defaults and is unable to settle any profit that has accrued within a swap contract. For trades that are not centrally cleared, there are three ways that we manage this risk.

- 1) The banks we trade with are carefully selected and monitored to ensure appropriate creditworthiness.
- 2) We diversify exposure across a number of banks.
- 3) All positions are collateralised daily which means that we call assets equal in value to any accrued profit from the bank each day. These assets are high quality and are typically cash for swap transactions and gilts for repo transactions.

For centrally cleared positions, we are not exposed to bank counterparty risk as we now face the clearing house. The clearing house is a well-capitalised and highly regulated entity thus ensuring a greater level of protection than if we faced a bank directly. Within central clearing all positions are collateralised daily using cash (referred to as margin) and all participants must post an additional margin buffer with the clearing house called initial margin. Initial margin can be bonds or cash.

Cash management

As the markets have moved towards today's centrally cleared model, it has also become necessary to carefully manage a liquidity buffer within our LDI portfolios, to meet the daily margin calls.

To facilitate this process, we employ a 'liquidity waterfall', whereby a small cash buffer is immediately available, and a further holding in our Liquidity Fund can be used to top this up from day to day. Additionally, we are able to access the gilt repo market in order to raise any further cash we may require.

Documentation

In order to provide access to the market, we need legal documents in place between the portfolio and a range of banks and/or clearing members. These documents set out the rules of engagement for any trading activity as well as specifying collateral terms such as minimum transfer amounts, collateral eligibility and any haircuts (often applied to bonds to account for the fact that their value may fluctuate from day to day). ISDA agreements (standing for International Swaps and Derivatives Association) are used to govern swap trading, GMRA's (Global Master Repo Agreements) are used to govern repo trading and clearing agreements are used to cover central clearing.

All this documentation is taken care of by the LDI manager within LDI funds. For segregated portfolios, LDI managers typically have 'umbrella' agreements which contain market best practice pre-agreed terms that all clients can use. Clients do not therefore need to set up their own documents but can use these umbrella agreements to expedite set-up times and minimise the governance burden. In fact, we would recommend that clients do not try to set up their own documents as it can be time consuming, expensive and burdensome. With market best practice and regulations constantly evolving, the LDI manager will own and update any umbrella agreements as required whereas this responsibility will sit with the investor if they have not used umbrella documents.



Jargon buster

PV01 (also known as DV01) is a measure of interest rate sensitivity, specifically the impact of a 0.01% change in interest rates. For example, if we say something has a PV01 of £10,000 we mean that if interest rates fell by 0.01% the asset or liability would rise in value by £10,000. A typical pension scheme with liabilities valued at £100m would have a PV01 of around £200,000.

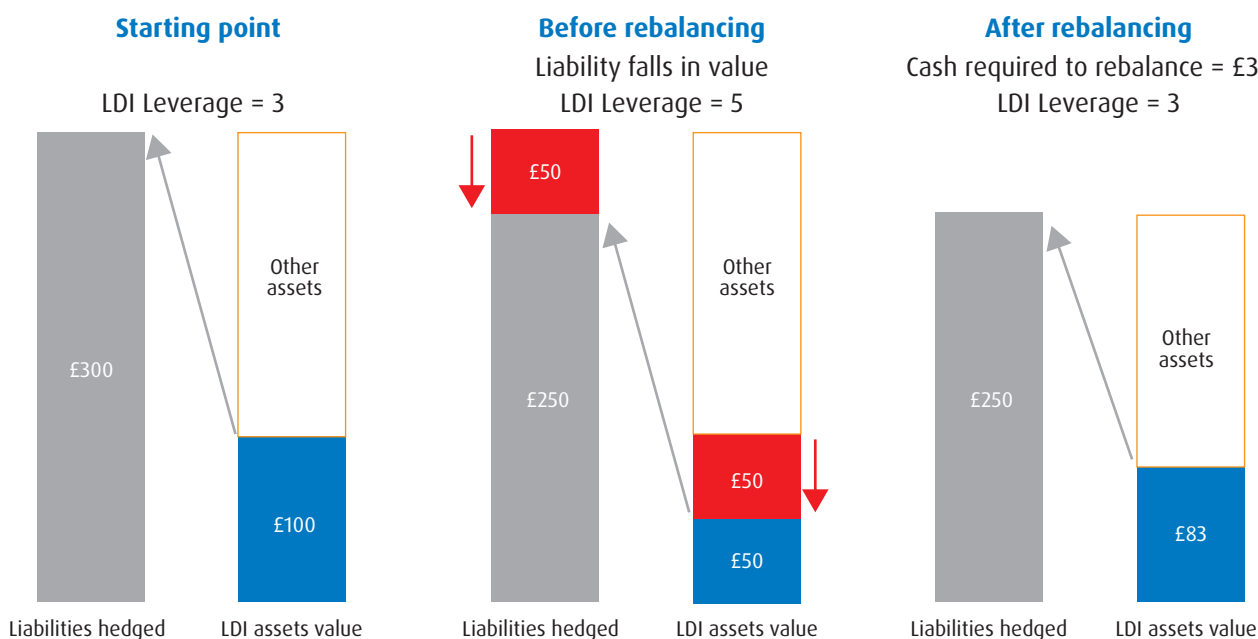
RPI01 (also known as INF01 or IE01) is a measure of inflation sensitivity, and is the impact of a 0.01% change in inflation expectations.

When designing an LDI portfolio we analyse the PV01 and RPI01 of a client's liabilities and then seek to build a portfolio with similar characteristics, both in aggregate and across all the key maturity points.

Leverage

Leverage is often a desirable feature of LDI portfolios as it allows clients to reduce liability risk without selling out of growth assets. However, leverage will vary as markets move and it is important to monitor this and to adjust the leverage as required. Leverage arises from the fact that the collateral pool may be a fraction of the liabilities being hedged. For example, if we hedge £300 of liabilities we may put £100 in the collateral pool and invest the remaining £200 in growth assets. In aggregate, we

are not leveraged because we have the full £300 to support the hedge it is just that we have chosen to keep some of it invested in growth assets. Viewed in isolation however, the LDI portfolio is three times leveraged. If the collateral pool becomes depleted leverage rises and it becomes necessary to top up the collateral pool. This means rebalancing between growth and matching assets. This scenario is illustrated below:



For illustrative purposes only

It is important that we monitor the leverage within a portfolio so as to be able to respond to any changes in a timely manner. We monitor leverage on a daily basis and if it reaches certain thresholds, we will call additional capital from clients. The process will differ slightly between pooled funds and segregated/bespoke accounts but the principles are the same.

Where we call capital into pooled funds we give clients 10 days-notice and there is no obligation to provide this. We are able to reduce leverage by reducing exposure albeit this results

in a reduction in hedging. We are also able to set the portfolio up so that rebalancing occurs automatically without any client involvement as we can automatically move money between the LDI fund and our liquidity fund or a growth fund. The process also works both ways in that we will return cash to clients if leverage becomes too low.

For segregated and bespoke portfolios, we are able to agree appropriate client-specific leverage limits, an example of which is shown below.

Example

Stop-loss leverage trigger 8X

Maximum leverage 5X

Target leverage c. 3X

Stop-loss trigger results in BMO Global Asset Management automatically reducing exposure

Maximum leverage triggers discussion with client and advisers about preferred course of action

- Supplement collateral pool
- Reduce exposure

No minimum leverage trigger

For illustrative purposes only

Chapter 5

Portfolio Structure

Having decided to reduce liability risk, scheme trustees are then faced with choices around portfolio structure and management approach. This choice can often be a hindrance rather than a help and can be a distraction from setting high level strategic objectives as it is all too easy to get caught searching for spurious accuracy.

Choosing the right portfolio structure

We have summarised the common portfolio structures below and provided some thoughts as to when each may be appropriate.

Pooled funds

Investors are co-mingled with other investors to benefit from economies of scale. LDI funds will typically invest in swaps and cash and are usually leveraged. Clients have flexibility to tailor their level of leverage up to that offered by the fund(s). For example if the funds are 3 times leveraged a client could have a 2 times leveraged portfolio by holding cash alongside the LDI fund(s) but they could not have more than 3 times leverage. It is a common myth that pooled funds are “one size fits all” and do not allow for any tailoring. Most providers offer real and nominal funds with a variety of different maturity profiles so that investors can cherry pick the funds that best match their unique liabilities. A custodian is not required for a pooled fund portfolio.

Segregated portfolio

Sometimes referred to as a separate account, the client’s investments are held separately to those of other investors via the client’s own custodian. The portfolio manager is then given the authority to manage the investments in accordance with pre-agreed guidelines. This structure allows for a high degree of tailoring, covering areas such as leverage, hedge design, asset-allocation and transition management. The portfolio can also accommodate other non-LDI derivative strategies such as FX hedging, equity protection and synthetic equity. This allows the collateral pool to be shared between strategies thus minimising the overall collateral requirements and creating a number of beneficial efficiencies. The investment parameters of

a segregated portfolio can be revised regularly and additional sub-portfolios added to meet changing client requirements.

With this flexibility and accuracy comes a higher governance burden. This includes monitoring the custodian as well as the investment portfolio. Any derivative trading documents (e.g. ISDAs, GMRA’s and central clearing agreements) will be in the name of the client, albeit most LDI managers will negotiate and maintain these documents for clients via umbrella agreements.

Bespoke fund

This is a fund wrapper set up for the exclusive use of a single client. As such, the single client can dictate all the investment parameters of the fund and it can be thought of as offering all the benefits of a segregated portfolio but with a number of additional governance advantages. Custody is provided within the fund and so a client does not need their own custodian. Additionally, derivative trading documents are in the name of the fund rather than the client. Most managers will maintain one or two dormant bespoke funds “on the shelf” which significantly expedites the portfolio set up process compared to a segregated portfolio.

The fund wrapper results in some additional administration and operational costs compared to a segregated portfolio. Excluding custody (which would need to be paid for anyway within a segregated portfolio) these costs are typically between 0.02% and 0.04% p.a. albeit the precise number will vary from portfolio to portfolio depending on size and complexity etc.

Pooled funds will generally provide sufficient accuracy for the large majority of investors and the economies of scale they offer make them extremely efficient for small and medium sized schemes.

A straightforward pooled fund solution will help minimise the governance burden for schemes of all sizes. It is worth noting that implementing a pooled fund solution does not preclude moving to one of the other structures at a later point. It is relatively easy to switch into a segregated or bespoke fund portfolio if the need arises and most LDI managers should be experienced in project managing such transitions so as to minimise costs and out of market risk.

Bespoke and segregated portfolios are worth considering where additional strategies are required over and above the core hedging portfolio, for example FX hedging, credit or equity derivative strategies. Another factor that might steer a scheme towards a bespoke or segregated portfolio would be a desire for a higher level of leverage.

Generally speaking, where a client wants a stand-alone portfolio and already has a custodian they will opt for a segregated portfolio in order to avoid the additional expenses of a bespoke fund. A desire to get the portfolio up and running quickly may on the other hand steer a client towards a bespoke fund.

At BMO Global Asset Management, we have been at the forefront of innovation in bringing efficient LDI solutions to the pooled fund market since 2006. We offer straightforward and effective hedging solutions to pension schemes of all sizes. Most recently, we have enhanced our range of funds to create the first integrated suite of liability profile LDI funds.

Our LDI fund range allows pension schemes and their advisers the flexibility to hedge interest rate risk, inflation risk or a combination of the two.

The fund range allows hedging portfolios to be tailored to each client's liabilities and leverage and asset allocation can also be adjusted to suit. We do this in a cost efficient manner, utilising both leveraged and unleveraged pooled LDI funds. Our fund range allows schemes and their advisers to choose between swap and gilt funds or to delegate this decision to us via our market leading Dynamic LDI funds. A summary of our range is outlined below:

Liability profile funds

Targets a hedge of the full liability profile of a UK defined benefit pension scheme. These comprise fully funded (i.e. unleveraged) gilts, leveraged gilts or leveraged swaps with long and short profile variations of each to ensure an accurate match for a wide range of client liabilities.

Dynamic LDI funds

Also target a full liability profile. Our 'Dynamic' process selects the cheaper of swaps or gilts across the full maturity spectrum at outset and systematically monitors this relationship through time, switching between equivalent hedging assets where opportunities arise to do so. Long and short profile variations are available.

Target maturity funds

Longer-dated funds utilising either gilts (nominal or index-linked) or swaps (inflation-only). Typically used by those schemes with very longer-dated liabilities or a significant allocation to credit.

Transition funds

Assists clients in a smooth transition into our LDI pooled funds, significantly reducing costs and out of market risk. These funds can also be used to reshape portfolios ahead of those assets moving to buyout, again minimising costs and out of market risk.

Our fund range supports all stages of the pension scheme's journey and facilitates easy, cost efficient switching between funds, thereby allowing the hedging solution to develop as a client's objectives evolve over time.

Equity-Linked LDI funds

In addition to our standard LDI funds, we recognise that some pension schemes want to improve the match of their liabilities without having to give up exposure to growth assets such as equities. At BMO Global Asset Management we have developed two fund types that allow investors to achieve exactly that.

Equity-Linked Dynamic LDI funds

Provide capital efficient exposure to hedging interest rates and inflation plus cost efficient access to global equities in a single pooled fund. The liability-hedging component employs the same process as our flagship Dynamic LDI funds whilst we use passive equity futures to deliver the equity exposure, maximising flexibility and minimising costs. Two funds are available to hedge either inflation-linked or fixed liabilities.

Equity-Linked Bond funds

Allow pension schemes to hedge their liabilities while still providing exposure to equity market returns. The liability-hedging component is unleveraged and available with either conventional or index-linked gilts. The equity component is delivered using equity futures, either UK or Global ex-UK.

Chapter 6

Implementing and managing LDI portfolios

This chapter looks at the practical and efficient ways that we can implement an LDI strategy as well as the different management approaches that can be adopted once the portfolio is up and running.

Having decided on a strategic hedging target the next item on the “to-do” list is to determine how best to reach this target. Before delving into the detail of this, it is worth setting the scene by highlighting a couple of market factors that we should be aware of when planning this implementation:

Investment markets can be volatile, meaning that the level achievable on any individual day can be better or worse than the prevailing average market level and whether it is better or worse is almost impossible to predict. This lends itself to pound cost averaging whereby the implementation is broken down into a number of trading days so that the aggregate traded level ends up being an average of the individual days as opposed to being entirely driven by the whims of the market on a particular day.

Above traditional minimum lot sizes, dealing costs within LDI tend to be higher in percentage terms for larger trades. This is in contrast to other markets such as equity markets where bulk discounts are often available for large trading programmes. The reason for this is that LDI trades can be thought of as risk transfer trades. When trading, the LDI manager is offloading risk that the pension scheme/portfolio does not want to a bank. In all honesty, the bank does not want the risk either! They simply act as a middleman and hedge their position by matching the

trade up with an equal and opposite trade. The harder the LDI manager makes it for the bank to match off the trade the more they will charge. Trading in large size and trading non-market-standard instruments are good examples of how we can make matching off the risk difficult, thus leading to elevated dealing costs.

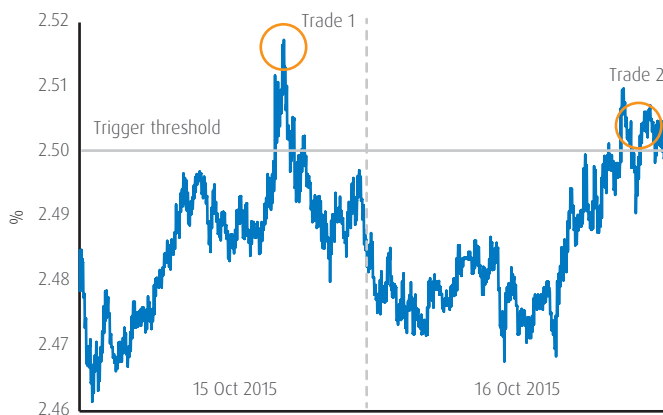
There is also one important scheme specific factor worth considering which is the scheme’s funding ratio. If a scheme is fully funded using a conservative valuation basis there is little benefit in running any significant investment risk, particularly unrewarded interest rate and inflation risk. In such a scenario it would typically hedge its liabilities to the fullest extent possible, as soon as possible. This may result in higher dealing costs than a more nuanced approach but these costs will be far outweighed by the benefits of locking into the strong funding position. The following section is therefore more relevant to underfunded schemes than fully funded schemes.

Implementation strategies

- 1 Single tranche implementation** – This is appropriate for modest hedge upsizes, schemes that are keen to reduce risk immediately or for schemes that have strong conviction about market levels or direction.
- 2 Phased implementation** – For larger implementations where there is less desire to de-risk immediately, a phased implementation can be sensible. This combines the benefits of pound cost averaging whilst keeping dealing costs down through the execution of numerous smaller trades as opposed to a single large transaction. This approach is best delegated to the LDI manager by issuing them with an upfront instruction that asks them to add a pre-agreed amount of hedging on a number of specified future dates (e.g. weekly, monthly or quarterly).
- 3 Trigger based implementation** – For schemes with specific buy thresholds in mind or that have a view on the future direction of markets, an efficient way of delegating LDI implementation is via triggers. This involves asking the manager to monitor a particular market metric (e.g. interest rates) and adding a pre-agreed amount of hedging if specified thresholds are reached. For example “increase the hedge by 10% if interest rates reach 3.0%”. Several thresholds can be set so that the hedge is gradually increased if the market trends in the direction anticipated. One word of caution on this approach is to remember that the setting of triggers does not equal any kind of risk reduction until the trigger is hit so the trigger threshold needs to be realistic. In turn, the probability of it being hit needs to be assessed alongside the scheme’s desire

for timely risk reduction. Additionally, as the market environment can change it is worth reassessing the validity of trigger structures and levels on a regular basis. Triggers can be specified net of anticipated transaction costs to ensure that the traded level is not eroded by trading costs on the day.

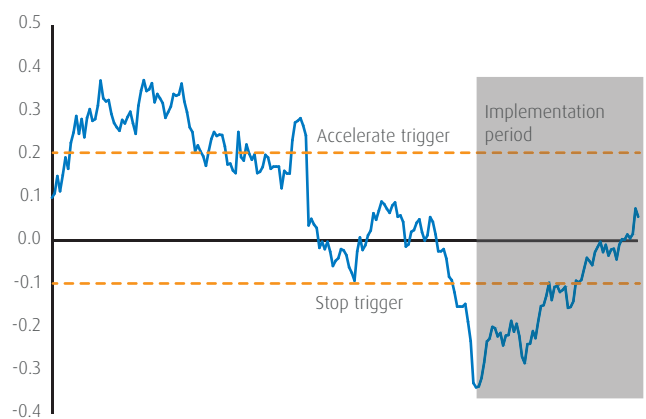
The chart below illustrates a trigger based trade. The client had asked us to trade if interest rates exceeded 2.5% which they did very briefly on 15 October 2015. We were able to respond straight away and trade half of the hedge upside before markets fell below the trigger level. We were then able to trade the remainder of the upside the following day. This example illustrates how triggers allow short lived opportunities to be captured, something that could not be achieved through a regular client trade instruction.



Source: Bloomberg

- 4 **Combined approach** – A popular implementation tactic is to combine a phased implementation with some triggers. For example “increase the hedge by 5% each week for the next two months but if interest rates fall below 2% then suspend the programme and if they rise above 3% accelerate the programme”. Clearly this statement is a slight oversimplification but the idea is that if market conditions remain stable then the implementation is simply phased in over time. The triggers then act as a stop-loss safety net in the case of the lower number and a catalyst for taking advantage of a market opportunity in the case of the higher number. All in all, this is a governance friendly approach which allows the manager to respond to changing market conditions without having to refer back to the trustees.

The chart below illustrates an implementation for a client which combines phased trading with triggers. We had a three month window in which to increase the hedge subject to the upper and lower triggers. Initially, the market was below the lower trigger and so no trading occurred during the first half of the period. This approach saved the client around £8m compared to averaging in over the whole period or transacting everything on day 1.



Source: Bloomberg

- 5 **Delegated implementation** – For larger implementations that need to be done relatively quickly it makes sense to delegate the process to the LDI manager. For example, by giving them discretion over 2 or 4 weeks to implement a pre agreed amount of hedging. This allows them to break the trading down into smaller tranches and to respond to supply and demand in the market in order to keep costs down. This approach is not just confined to segregated portfolios but can be employed in fund based portfolios using a “transition fund”.

Transition management

When planning an implementation it is important to consider the schemes existing assets. For example, if the scheme already has some gilts they should be moved into the LDI portfolio to minimise the amount of trading required. Even if the manager intends to hold swaps the gilts can be exchanged for swaps in a way that avoids out of market risk and is cheaper than selling the gilts and buying the swaps independently of one another.

Clients often ask about the possibility of crossing trades with other clients in order to minimise costs. Whilst possible, this should not be overplayed. Most pension schemes are trading in the same direction (i.e. buying LDI) and so crossing opportunities are not that abundant in practice.

Managing the LDI portfolio

There are four main categories of LDI management style as follows, noting that client specific variations will exist from time to time:

Buy and maintain – holdings are specified by the client/consultant and we will provide an execution and maintenance service. The portfolio will not be managed against or rebalanced to a benchmark although positions such as gilt repo will be automatically rolled to maintain the status-quo. This approach is generally used where the investment consultant or trustees wish to own the day to day decision making.

Passive – The portfolio will largely be static but designed to match a specific benchmark. We will monitor the portfolio relative to benchmark and will rebalance the portfolio to this benchmark periodically to ensure an ongoing match. This results in a straightforward and effective portfolio with day to day monitoring, oversight and rebalancing delegated to the LDI manager.

Dynamic – As per passive but with the addition of our Dynamic instrument selection strategy (other managers may call this passive plus or something similar). We build the portfolio from a blend of gilts and swaps and will switch between them on a discretionary basis where value can be added by doing so. This is the most common approach adopted by our clients.

The Dynamic strategy is entirely systematic and so does not introduce speculative or traditional active risk, even though it provides scope for outperformance of the liabilities.

Active – This comprises of a core Dynamic, passive, or buy and hold portfolio overlaid with our Active LDI strategy. As the name suggests, this introduces active position taking, similar to the sorts of positions found within an active government bond portfolio.

In each case, we may analyse the liabilities and provide advice and guidance around portfolio structure and the benchmark. Alternatively, there are occasions where this work is done by the client's consultant and we simply provide the investment management services described above.

In addition to the core LDI portfolio, some clients hold other derivative based strategies alongside the LDI positions. This is collateral efficient and makes full use of the derivatives expertise of the LDI manager. These other strategies might include FX hedging, equity derivatives, options, swaptions, credit derivatives etc. all of which are beyond the scope of this document.

A

Actuary – An actuary is a business professional who deals with the financial impact of risk and uncertainty. In a pension scheme, one of the key responsibilities of an actuary is to provide an estimate of the present value of the scheme's liabilities and the uncertainties around these liabilities.

B

Basis points (bps) – One hundredth of a percentage point = 0.01%.

Buy-in – The purchase of an annuity contract with an insurance company as an investment to match some or all of a pension scheme's liabilities, and therefore reduce risk.

Buy-out – The process whereby a pension scheme's liabilities are transferred to an insurance company and the obligation for the pension scheme to provide those benefits is ceased.

C

Central clearing – A set of regulations introduced by the European Markets Infrastructure Regulation (EMIR) after the global financial crisis. It is a framework designed to increase security in the OTC derivatives market. By both the investment bank and the investor simultaneously giving up their trade to a clearing house, this removes bank counterparty exposure from some OTC trades. All positions are collateralised daily using cash (referred to as margin) and all participants must post a further buffer with the clearing house known as initial margin. Central clearing was enacted in 2012 but implementation is still being phased in, though it will become mandatory within investment markets.

Clearing house – A well-capitalised and highly regulated entity that sits between an investment bank and investor for some OTC derivative transactions.

Collateral – An asset provided as security for a debt. In the example of a swap, collateral is normally provided in the form of cash or readily marketable securities.

Consumer Price Index (CPI) – This is a measure that examines the weighted average of prices of a basket of consumer goods and services. It is calculated by taking price changes for each item in the basket of goods and averaging them. Changes in CPI are used to assess price changes associated with cost of living and as such is one of the most frequently used statistics for identifying periods of inflation or deflation.

Counterparty – A participant in a derivative contract. Typically, the two participants in a swap contract are the pension scheme and a bank.

Credit Default Swap (CDS) – A CDS is a credit derivative between two counterparties, whereby one makes periodic payments to the other and receives the promise of a payoff if a third party defaults. The former party receives credit protection and is said to be the "buyer" while the other party provides credit protection and is said to be the "seller". The third party is known as the "reference entity".

Credit Support Annex (CSA) – A Credit Support Annex (CSA) is a document that provides details related to the collateral arrangements between two parties in privately negotiated over-the-counter (OTC) derivative instruments such as swaps. The CSA is an appendix to an industry standard derivative agreement called an ISDA master agreement.

D

Defined Benefit (DB) Scheme – A DB scheme is one whereby the benefit payable to the scheme member is defined in terms of factors relevant to the particular member. These factors include age at retirement, member's pay and years of employment.

Derivative – A derivative instrument or contract is one whose value is derived from the price movement of another asset or instrument. For example, interest rate swaps are derivatives which are dependent on interest rates.

Discount rate – The interest rate used to discount the liabilities (which are expected to happen in the future) so that a present value of these liabilities can be estimated today.

Duration – The weighted average timing of all of an instrument's cashflows, where the weightings are the present values of the cashflows at the current market yield. By formula: $\text{Duration} = (\text{Present Value} \times t) / \text{Sum}(\text{Present Value})$. Duration is widely used as a risk measure of a portfolio of assets or liabilities. It gives a general indication of the sensitivity of an instrument's or a portfolio's market price to small changes in interest rates.

E

Equity option – An option contract on a share or share index. The holder of an equity option has the options to buy or sell some number of stocks in a certain company at a given price known as the strike price on or before the expiration date.

Exchange-traded – Exchange trading is the alternative to OTC dealing. Exchange-traded financial instruments are standardised, and less flexible, but the interposition of the exchange reduces credit risk and increases transparency.

F

FRS17 – UK Financial Reporting Standard 17, dealing with retirement benefits. FRS 17 replaced – and widened the scope of – the earlier UK Statements of Standard Accounting Practice SSAP 24. The most significant impact of FRS 17 is in relation to DB pension schemes. FRS 17 requires any deficit in the pension scheme to be recognised in full in the sponsoring employer's balance sheet. FRS 17 also requires pension liabilities to be measured on a more conservative basis for accounting purposes, compared with the earlier accounting under SSAP 24. This generally resulted in significantly greater pension liabilities (for accounting purposes) under FRS 17, and a greater incidence of larger pension deficits for accounting purposes.

Funding level – The relationship at a specified date (often the valuation date) between the value of the assets and the value of the liabilities of a DB pension scheme, often expressed as a ratio (the 'funding ratio').

Future – A futures contract is a standardised contract traded on a futures exchange, to buy or sell a certain underlying instrument at a certain date in the future, at a specified price.

Forward price – The predetermined delivery price for an asset to be paid at predetermined date in the future.

G

Gilt TRS – A gilt TRS (total return swap) is an agreement to exchange the total returns of a gilt or gilts in exchange for a floating rate (e.g. LIBOR plus or minus a spread) cashflow. Typically, maturity terms for TRS are between six months to three years.

Gilt repo – A gilt sale and repurchase agreement (known as gilt repo for short) is an agreement to sell gilts to a bank and simultaneously agreeing to buy back these gilts on a particular date in the future and at a specified price. The time between the sale and purchase point can vary from overnight to one year.

Global Master Repo Agreements (GMRA) – A standard legal document used to outline the relationship between counterparties to a gilt repo contract.

H

Haircut – A percentage that is subtracted from the par value of the assets that are being used as collateral. The size of the haircut reflects the perceived risk associated with holding the assets.

I

Inflation swap – This is an agreement between two parties to exchange a series of inflation-linked cashflows for fixed cashflows. Pension schemes typically hedge their inflation-linked liabilities by receiving inflation-linked cashflows in exchange for fixed cashflows.

Initial margin – Collateral or security that must be lodged upfront in the case of an exchange traded derivative position or some OTC derivatives traded via central clearing.

Interest rate swap (IRS) – An IRS is an agreement between two parties to exchange a series of cashflows. Typically a pension scheme would hedge its fixed liabilities by paying floating cashflows (usually linked to LIBOR) in exchange for fixed cashflows.

International Swaps & Derivatives Association (ISDA) – An ISDA Master Agreement is a standard document developed by the International Swaps & Derivatives Association which is used to document the legal relationship between counterparties to an OTC derivative contract.

L

Leveraged fund – A fund which invests in swaps or in gilt derivatives and other assets (such as bonds, cash etc.) whereby the fund value is smaller than the total liabilities which are hedged using the underlying assets and derivatives in the fund.

Liabilities – These are future payouts resulting from pension commitments made by a pension scheme's sponsoring employer.

Liability cashflow – A schedule of aggregated future payouts that the pension scheme is expected to make over its lifetime.

Limited Price Indexation (LPI) – UK PRI but subject to a specified cap and floor.

London Inter Bank Bid rate (LIBID) – Interest rate at which banks are willing to borrow from one another in the inter-bank market.

London Inter Bank Offered Rate (LIBOR) – An interest rate at which banks offer to lend funds, in marketable size, to other banks in the London interbank market. It is set each day by the British Bankers Association, which calculates it by averaging short-term, inter-bank and deposit interest rates among the most creditworthy banks.

Longevity – A measure of the life expectancy of current and future pensioners and other beneficiaries of a pension scheme. From the perspective of the pensions provider, there is therefore a related 'longevity risk'. Longevity risk refers to the increased cost of providing pensions, resulting from improvements in health and increases in average life expectancy.

M

Margin – (in the futures markets) – Margin is a refundable cash deposit payable by market participants to protect other participants in the market against the risk of a default.

Mark-to-market – To record a change in the value of an asset or fund to reflect its current fair market value. For swaps, it leads to an adjustment of the amount of collateral required by the swap parties to reflect the current market value.

N

Nominal interest rate – It is often known as "interest rate" and is the charge applied by the lender of money to the borrower as a recompense for lending money. Normally, it is calculated as a percentage of the total amount loaned.

Notional amount – In the context of an interest rate swap, the notional amount is the specified amount on which the exchanged interest payments are based. Each period's rates are multiplied by the notional amount to determine the value of each counterparty's payment.

O

Over the counter (OTC) trading – The trading of a security directly between two parties instead of on a formal exchange such as the London Stock Exchange.

P

Par swap – This is a swap whereby fixed cashflows are exchanged for floating rate cashflows on a regular basis. In the UK, the cashflows are normally paid semi-annually. At the outset the present value (PV) of fixed rate cashflows equals the present value of the floating rate cashflows.

Pension Protection Fund (PPF) – A UK body which takes on responsibility for undefined pension schemes in the event of the sponsoring employers insolvency (subject to certain eligibility criteria).

Pooled LDI fund – A fund where individual investors with the same investment objective bring their monies together in a single investment vehicle portfolio. In exchange for the monies brought in, the investor receives a proportional share in the underlying assets which in this case pursue an LDI strategy.

Present value (PV) – Today's value of a future liability, calculated by discounting the future liability at an appropriate rate of interest.

PV01 – PV01 is the change in the present value of a liability or asset as a result of a 0.01% change in interest rates.

R

Real interest rate – This rate strips out the effect of inflation and is estimated as follows: nominal interest rate less inflation rate.

Real rate swap – A real rate swap is an agreement between two parties to exchange a series of inflation linked cashflows in exchange for floating (usually LIBOR) cashflows.

Retail Price Index (RPI) – This index measures the average change from month to month in the prices of goods and services purchased by households in the UK. RPI is the main domestic measure of inflation in the UK.

Rewarded risk – A rewarded risk is one which is associated with an expected benefit for the party accepting the risk. For pension schemes, investment in equities is expected to provide a reward i.e. higher return for the extra investment risk undertaken.

Risk premium – The extra return expected by an investor above the risk free rate to compensate them for the risk(s) they are exposing themselves to.

RPI01 – RPI01 is the change in the present value of a liability or asset as a result of a 0.01% change in RPI.

S

Segregated LDI solution – A solution whereby the LDI strategy followed by a single investor is tailored to the investor's specific requirements.

Spot price – The spot price or spot rate of an asset is the price that is quoted for immediate (spot) settlement (payment and delivery). Spot settlement is normally one or two business days from trade date. This is in contrast with the forward price established in a forward contract or futures contract, where contract terms (price) are set now, but delivery and payment will occur at a future date.

SSAP – Statement of Standard Accounting Practice is an older mandatory statement of accounting practice for the UK, issued by the Accounting Standards Board. It has been replaced by Financial Reporting Standards (FRS).

Sterling Over Night Index Average (SONIA) – The Sterling Over Night Index Average tracks actual average market sterling funding rates each day for settlement that day where repayment is made on the following business day.

Swap – A derivative instrument whereby two parties enter an agreement to exchange a series of cashflows at pre-determined future dates, usually settled for the difference. Examples of capital market swaps typically used by pension schemes to hedge interest rate and inflation risks include interest rate swaps, inflation swaps and real interest rate swaps.

Swaption – An option on a swap where the buyer of the option has the right, but not the obligation, to enter into a specified swap on a specific future date (or on one of a number of specified dates) set out in the terms of the swaption.

T

Technical provisions – Technical provisions is the name given to an actuarial valuation of the scheme's benefits earned to date using a method and assumptions chosen prudently by the trustees after taking actuarial advice and with the agreement of the employer.

Total return swaps – A swap agreement in which one party makes payments based on a set rate, either fixed or variable, while the other party makes payments based on the return of an underlying asset, which includes both the income it generates and any capital gains. (For example, the dividends plus capital appreciation from a share (equity)).

U

Unleveraged fund – A fund which invests in swaps or gilt derivatives and other assets (such as bonds, cash etc.) whereby the fund value is equal to the total liabilities which are hedged using the underlying assets and derivatives in the fund.

Unrewarded risk – An unrewarded risk is one which is not associated with an obvious benefit for the party accepting the risk. For pension schemes, interest rate and inflation risks are often considered as unrewarded risks.

V

Variation margin – A payment that is made by the participants to the relevant clearing house based upon day-to-day price movements of the contracts that these participants hold. Utilised in the futures market and for some centrally cleared OTC derivatives.

Z

Zero coupon interest rate swap – This is a swap whereby fixed cashflows are exchanged for floating rate cashflows at maturity. It is effectively accumulating the interest payments on a par swap on a compound rate and exchanged at maturity. At the outset the present value of fixed rate cashflows equals the present value of the floating rate cashflows.

Important information

Transactions of the sort described in this document contain complex characteristics and risk factors. Past performance should not be seen as an indication of future performance. The value of investments and the income derived from them can go down as well as up as a result of market or currency movements and investors may not get back the original amount invested. The information, opinions estimates or forecasts contained in this document were obtained from sources reasonably believed to be reliable and are subject to change at any time. BMO Global Asset Management may from time to time deal in investments mentioned herein on behalf of their clients. The source of information in all graphs is BMO Global Asset Management unless otherwise stated.

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LDI Provider of the Year 2017, 2016,
2015, 2014, 2013 and 2012



LDI Manager of the Year 2016



Risk Management
Provider of the Year 2015



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2012 and 2011

