The Trustee toolkit downloadable

Investment in a DB scheme

Tutorial two: Changing asset and liability values

By the end of this tutorial you will better understand:

- how liability values are calculated
- what the present value of the liabilities are
- how liability and asset values change with changing market conditions
- what interest rate duration is
- how interest rate duration can be used to estimate changes in funding levels

This tutorial is part of Scenario one.

Glossary

A detailed glossary of technical terms can be downloaded from the Resources tab when you log in at www.trusteetoolkit.com

The Pensions Regulator

Introduction

In this tutorial we follow an example scheme and look at how changes in market conditions can impact the value of the scheme's assets and liabilities as the valuation assumptions are amended to reflect the changed market conditions. Throughout the tutorial these examples and calculations are simplified as much as possible. In reality they will be much more complex in your scheme.

Putting the asset and liability changes together will enable you to understand how your scheme's funding level would be different if market conditions changed. This is a first step in understanding the risks in your scheme's current investment strategy.

This tutorial assumes you have some existing knowledge or have completed some earlier modules in the Trustee toolkit.

Existing knowledge requirements

You should already be familiar with how changes in market conditions alter the value of pension scheme assets from the Module: 'An introduction to investment'. For example, if equity markets fall, then the value of the scheme's equity assets will fall. In bond yields rise, the value of the scheme's bond assets will fall (remember that bond yields and bond prices move in opposite directions).

In the Module: 'Funding your DB scheme' in the Tutorial: 'Calculating the liabilities' we looked at how liabilities are calculated for an individual member. In the Tutorial: 'Impact of assumptions' (in the same module) we also looked at how the value of the scheme's liabilities change depending on the assumptions used for the discount rate, salary increases, price inflation and length of retirement in the actuarial valuation calculations.

You will also need to understand the concept of 'compound interest' which we will explain next.

Compound interest

Imagine you have a loan of £10,000 which needs to be repaid in 10 years' time. You have a savings account paying a guaranteed rate of interest of 3.5% pa for 10 years.

How much money would you need to have in that savings account now to be able to repay the loan in 10 years' time?

The answer is: £7,089.19

In this simple example we have placed a 'present value' on the payment in 10 years time by 'discounting' it at an assumed rate of return, in this example the 3.5% pa savings account interest.

The present value can be worked out more quickly by understanding how much £1 would grow by over 10 years and then dividing the full loan repayment by that amount:

£1 x (1.035^10) = £1.4106

£10,000 / £1.4106 = £7,089.19 (rounded)

Alternatively if instead of a loan, you wanted to know how much £10,000 would have grown to in 10 years time in the savings account paying 3.5%pa interest, you would simply use multiplication in the final calculation instead of division:

£10,000 x £1.4106 = £14,106

You will see these calculations again throughout this tutorial.

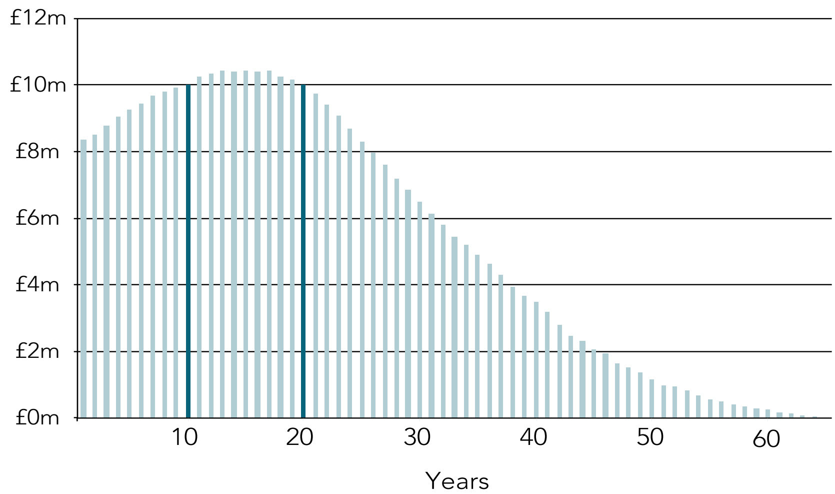
Reminder: How liability values are calculated

Before we look at how changes in market conditions alter the value placed on scheme liabilities, we will revisit how scheme liabilities are valued.

When the scheme actuary carries out a valuation of the scheme, they will estimate the benefits to be paid in each future year. The valuation output may include a chart or graph, often called a 'dinosaur chart', shows the estimated scheme liability value for each scheme year.

The graph shows the estimated scheme liability value for each scheme year. These are the estimated future benefit payments from the scheme, for each year until the last beneficiary is assumed to die.

These future benefit payments are called 'cash flows'.



The cash flows are estimates and:

- are based on the various assumptions made for the actuarial valuation
- relate only to benefits earned to the valuation date, known as 'accrued benefits' since the valuation is concerned with the liability position at that date
- are in current money terms (we will consider how to adjust them for inflation later)

Case study: Example scheme

The graph for our example scheme shows the estimated scheme liability value for each scheme year. These are the estimated future benefit payments from our example scheme, for each year until the last beneficiary is assumed to die.

The horizontal axis is scheme years from year zero to year 60. The vertical axis shows the scheme liabilities from zero to £12 million in £2 million stages. There is a line for each year showing the estimated liability to be paid. In year one this is £8.36 million, rising to £10 million in year 10, reaching a maximum of approximately £10.44 million in year 15, falling back to £10 million in year 20 and then slowly tailing off to zero in year 60.

We will focus on the cash flows required in year 10, year 20 and the total cash flow in this case study throughout this tutorial.

Before we look at how the present value of the liabilities is valued it is important that you understand how inflation impacts the liability values which we cover next.

Inflation

The future level of inflation will impact the expected future benefit payments as it is the basis for uplifting some occupational pension scheme benefits.

As a part of the valuation, the scheme actuary will make an assumption about the future level of inflation and use this in estimating the future years' cash flows.

In practice, many scheme benefits are only partially linked to inflation such as having an upper limit on each year's increase.

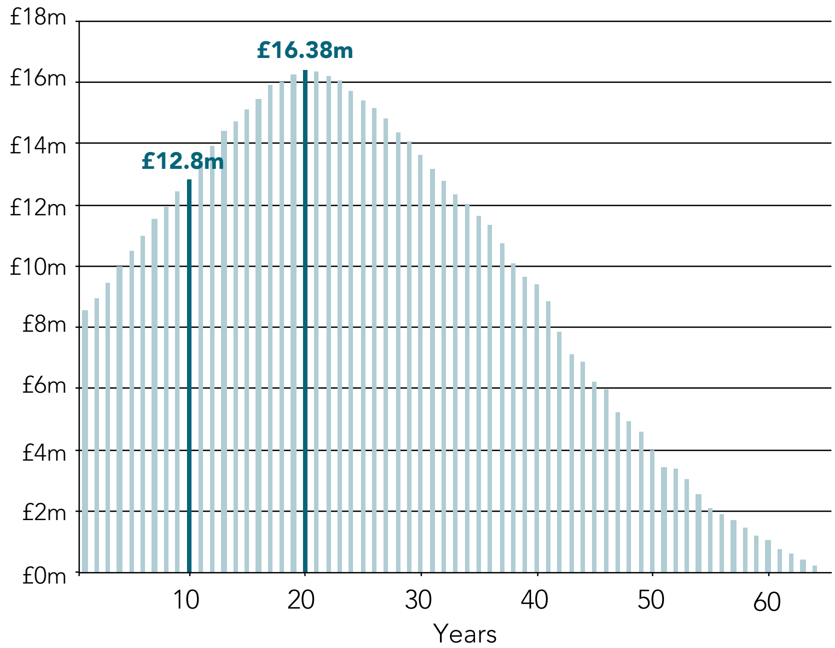
If you look at your scheme's documentation you will likely find that some benefits are linked to inflation using the Consumer Prices Index (CPI) and some are linked to inflation using the Retail Prices Index (RPI).

For simplicity, in our example scheme all benefits are fully linked to inflation both before and after retirement and we have assumed that our example scheme's benefits are linked to inflation using RPI.

Case study: Example scheme inflation

In both year 10 and year 20 our example scheme needs £10 million in current money terms to pay the benefits due in those years. But as these benefits are inflation linked*, we need to consider how much these liabilities would amount to when they become payable, after 10 and 20 years of inflation respectively.

In our example scheme the actuary has assumed that inflation will be 2.5% per year until the cash flows fall due.



Year 10 cash flow

Here is the calculation for year 10: £1 x (1.025^10) = £1.2801

£10m x 1.2801 = £12.8m

Year 20 cash flow

Here is the calculation for year 20: £1 x (1.025^20) = £1.6386

£10m x 1.6386 = £16.38m

We will use the figures of £12.8 million and £16.38 million in our calculations.

* Remember that for simplicity in our example scheme all benefits are fully linked to inflation, both before and after retirement, and we have assumed that our example scheme's benefits are linked to inflation using RPI.

Present value of liabilities

To ensure that the scheme can pay out the benefits shown (taking inflation into account) we need to understand how much money is needed now so that once it has grown at an assumed rate, allowing for any charges, it will meet the expected benefit payment.

This is known as the 'present value' of the payment and answers the same question from our simple compound interest example: 'How much money does the scheme need to have now, so it will grow at the assumed rate and meet the expected benefit payment?'

Next we will calculate the 'present values' of the year 10 and year 20 cash flows for our example scheme.

The scheme actuary will carry out very similar calculations in your scheme to place a 'present value' on each year's expected benefit payment by 'discounting' it at an assumed rate of return. In pension schemes this is known as the 'discount rate', or sometimes as the 'valuation discount rate' or 'valuation interest rate'. We will continue to use 'discount rate' in this module.

If you haven't already, you can learn more in the Module: 'An introduction to investment' in the Tutorials: 'Types of asset: Common assets' and 'Types of asset: Alternative assets'.

Discount rate

You may have seen the term 'discount rate' before in the Tutorial: 'Impact of assumptions' in the Module: 'Funding your DB scheme', where you were able to change various assumptions (including discount rate) to see how it affected the liabilities in the Forest Group and Hartington schemes. If you have not yet passed this module it may be worth doing so before continuing with this module.

Case study: Example scheme present value

Here we work out the present value of the liabilities in year 10 and year 20 for our example scheme. You can see the figures for the liabilities (including inflation) we calculated earlier for year 10 and 20, being £12.8 million and £16.38 million respectively. You should take time to work though these figures, as we will follow these examples throughout the tutorial.

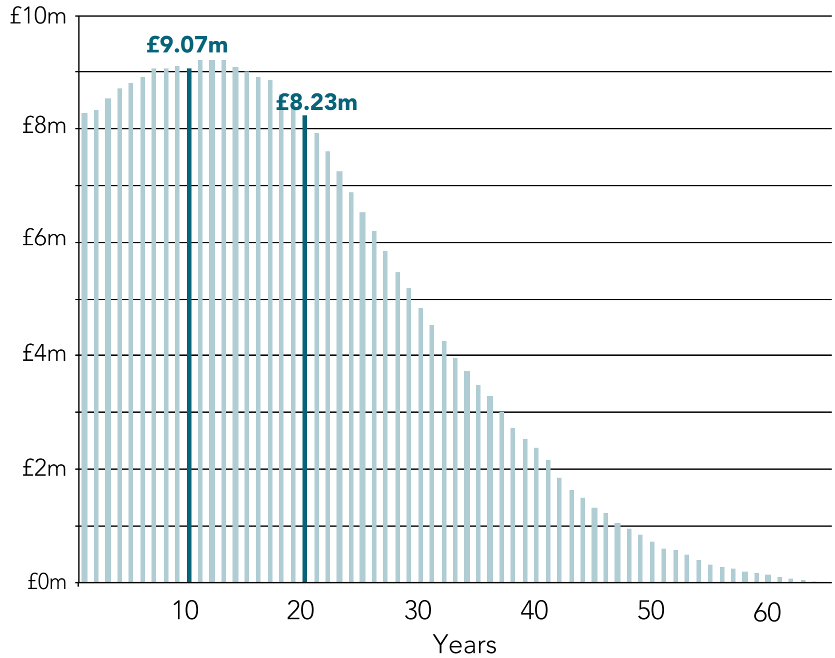
Year = N	10	20
Cash flow required in year = C (estimated using valuation assumptions, including inflation at 2.5%). Expected benefit payment in the particular year. We will refer to this as cash flow from now on.	£12.80m	£16.38m
Discount rate	3.5%	3.5%
Growth of £1 over (N) number of years = (G) This is the same calculation we saw in the simple loan example.	£1 x (1.035 ^ 10) = £1.4106	£1 x (1.035 ^ 20) = £1.9898
Present value of cash flow (C) / (G) Present value of expected benefit payment	£12.80m / 1.4106 = £9.07m	£16.38m / 1.9898 = £8.23m
Check your answer: what does this value grow to over (N) years? It should be the cash flow (C).	£9.07m x 1.4106 = £12.80m*	£8.23m x 1.9898 = £16.38m

* If you work through the figures yourself you may get £12.79m, a small rounding error.

Total present value of liabilities

We have now calculated the 'present value' (sometimes shortened to 'PV') of the year 10 and 20 cash flows for our example scheme. They were £9.07 million and £8.23 million respectively.

But we also need to understand the 'total present value' of the liabilities for the scheme as a whole.



The 'total present value' of the scheme's liabilities is calculated by adding up the PVs of all the future years' cash flows. For our example scheme, this is £300 million. The valuation output may include a chart like the one shown which includes the PV of each year's estimated cash flow.

As you can see, this chart looks a bit like the previous one. When you are looking at charts like these, it is important to be aware of whether it shows the estimated cash flows or their present value and whether they include allowance for inflation or not.

Changes in market conditions: Questions

Using the calculations from the example scheme we can now look at how liability values might change as market conditions change. We will focus on discount rate for this case study. There are two questions to consider:

1. Will the liability value fall or rise?
2. By how much?

The calculations and the answers to these questions follow.

Case study: Example scheme discount rate change

In this example we look at what happens when the assumed discount rate falls by 1% pa from 3.5% pa to 2.5% pa over the term of the year 10 and year 20 liabilities.

Year = (N)	10	20
Cash flow required in year = (C)	£12.80m	£16.38m
Value at discount rate 3.5%pa		
Growth of £1 over (N) years = (G)	£1 x (1.035 ^ 10) = £1.4106	£1 x (1.035 ^ 20) = £1.9898
Present value of cash flow (C) / (G)	£12.80m / 1.4106 = £9.07m	£16.38m / 1.9898 = £8.23m
Value at discount rate 2.5%pa		
Growth of £1 over (N) years = (G)	£1 x (1.025 ^ 10) = £1.2801	£1 x (1.025 ^ 20) = £1.6386
Present value of cash flow (C) / (G)	£12.80m / 1.2801 = £10m	£16.38m / 1.6386 = £10m
Change in liability value		
Increase in value	£0.93m	£1.77m
Percentage increase	0.93 / 9.07 = 10.3%	1.77 / 8.23 = 21.5%

Changes in discount rate: Answers

We can now answer our two questions. In our example scheme the liability value will rise if the discount rate falls for the term of the liabilities.

This is because the money invested now to meet the future payment will earn less return, so more will be needed up front to meet the payment. As you saw, the present value of the cash flow due in 10 years time will rise by 10.3% and the present value of the cash flow due in 20 years time will rise by 21.5%.

If instead the discount rate increases by 1% pa to 4.5% pa, the liability value will fall. The money invested now to meet the future benefit payment is now assumed to earn more return, so less will be needed up front to meet the payment.

If you work through the numbers, you will find that the present value of the cash flow due in 10 years' time will fall by 10.1% and the present value of the cash flow due in 20 years time will fall by 21.1%.

Interest rate duration

To enable trustees and advisers to keep track of estimated scheme funding levels it is helpful to know how the value placed on the scheme's liabilities will change as the assumed discount rate changes. If you know how the discount rate changes as market conditions change, you can then estimate how the liabilities will change as market conditions change.

What is interest rate duration?

One of the main 'rules of thumb' for estimating how liability values change when the discount rate changes uses a property of the liabilities known as their 'interest rate duration'. Interest rate duration is often in years because it is a way of measuring average term to payment of the liabilities.

The rule of thumb is that for a given percentage change in the discount rate, you multiply it by the interest rate duration to get the resulting percentage change in the liability value. It is not exact, but it is usually a reasonable approximation for small changes in the discount rate.

Interest rate duration for total liabilities

Working out the interest rate duration for the scheme's total liabilities is more complex as there are many years' cash flows and present values to consider which need to be weighted and averaged correctly.

Your scheme actuary or investment consultant will be able to provide the figure for your scheme and explain how it has been calculated.

Interest rate duration for assets

As well as the liabilities, some pension scheme assets also have interest rate duration. When they do, the same 'rule of thumb' applies.

Bond assets

For example, if the bond assets have interest rate duration of 10 years, they will rise in value by approximately 10% for a 1% fall in interest rates over the period.

Non-bond assets

The concept of interest rate duration is more difficult to apply to nonbond assets such as equities. Assumptions need to be made regarding how sensitive their values are to interest rate changes.

Frequently, the simplifying assumption is made that they have none, on the basis that their values do not respond immediately to changes in interest rates in the way that bonds do, although there may be longer-term relationships.

Total assets

Based on these assumptions your investment consultant or investment managers will be able to provide a figure for the overall interest rate duration of your scheme's assets.

Case study: Example scheme interest rate duration

As well as the liabilities, some pension scheme assets also have interest rate duration. When they do, the same 'rule of thumb' applies.

Earlier in this tutorial we calculated how the value of the liabilities to be paid in year 10 and year 20 would change for a 1% fall in the assumed discount rate.

Year 10

The value of the cash flow due in 10 years' time has risen or fallen by approximately 10% for a 1% change in the discount rate.

Year 20

Similarly, the value of the cash flow due in 20 years' time has risen or fallen by approximately 20%.

It is important to understand that we have only looked at one cash flow at year 10 and one at year 20 in this example. This means that these individual examples have durations of 10 years and 20 years respectively.

Total liabilities

The interest rate duration for our example scheme has been calculated to be 18.6 years. This means that the value of the liabilities will rise by approximately 18.6% if the interest rate goes down by 1%.

How can interest rate duration be used?

If you know the amount and duration of your scheme's liabilities, and the amount and duration of your scheme's assets, you will be able to estimate broadly the effect of changes to investment market conditions on the scheme's funding level. To do this, you need to understand how the discount rate used for calculating the technical provisions depends on investment market conditions. There are essentially two ways of doing this.

Basing the discount rate on bond market yields

One way of setting the discount rate used for calculating the technical provisions is to start from bond market yields. An addition is then made to reflect the (generally) higher expected return from scheme's actual investments. Under this method, there is a direct link between bond market yields and the discount rate.

Choosing bonds

The bonds concerned would be normally chosen having regard to the nature and duration of the scheme's liabilities. When this method is used, the reference bonds are typically gilts. Investment grade corporate bonds and swaps rates are also sometimes used.

Choosing the addition

The addition should prudently reflect the expected outperformance of the scheme's assets relative to the chosen bonds over the long term. Because of the focus on the medium to long term, the addition used would not normally change from valuation to valuation, unless for example economic conditions led to a justifiable change in the prudent expected long-term outperformance of the assets or there were amendments to the scheme's investment strategy that justified a change.

For example, the discount rate used might be 1% pa higher than the yield on fixed interest gilts of the same interest rate duration as the scheme's liabilities. This means that when this gilt yield is for example 4.2%, the valuation discount rate is 5.2%. When the gilt yield is 4.4%, the discount rate is 5.4%.

Basing the discount rate on expected return on scheme assets

Another way of setting the discount rate used for calculating the technical provisions is to base it on the expected return on the scheme assets. A prudent estimate is made of this based directly on market conditions for the asset classes concerned. Using this approach, to the extent that the scheme holds non-bond assets, there will not be a direct link between bond market yields and the discount rate.

For example, the return from any equities the scheme holds might be estimated based on current dividend yields and assumptions regarding future growth in dividends and the market conditions in which the equities will eventually be sold by the scheme.

Exercise: Check your scheme

It is important for you to know which approach is taken by your scheme for setting the technical provisions. You will find this in the scheme's Statement of Funding Principles (SFP) so check this now. Your scheme actuary will be able to explain these principles to you.

Case study: Example scheme

Bringing together the concepts we have covered so far, let's take a look at our example scheme again and work through these calculations to estimate how scheme funding may change if market conditions change.

Assets	Class	Target weight (%)	Value (£m)
Growth	Global equities	20	60
	Diversified growth strategy	20	60
Matching	Sterling bonds	60	180
	Total	**100**	**300**

Assumptions

These are the assumptions the calculations are based upon.

Technical provisions

The example scheme's trustees set their technical provisions based on gilt yields plus a prudent margin, the first of these two approaches covered on previously. The scheme is fully funded with £300 million of assets.

Target asset allocation

The scheme's target asset allocation is 60% in matching assets (sterling bonds £180 million) and 40% growth assets (global equities and diversified growth strategy £120 million).

Duration

Assets

For the purposes of this example we'll assume the bonds have a duration of 10 years and that the other assets (£120 million in global equities and diversified growth strategy) have no interest rate duration.

Liabilities

The duration has been previously worked out to be 18.6 years.

Change in market conditions

We will look at a 0.5% fall in interest rates, ie gilt yields in this calculation. Remember that:

- the fall in interest rates will directly increase the value of the scheme's bond assets
- as the discount rate is based on gilt yields, the discount rate will fall by 0.5% and the estimated value of the scheme's liabilities will also increase

Liabilities value

In our example scheme, we previously worked out the total present value of the liabilities and their duration as £300 million and 18.6 years respectively.

Calculation

0.5% (change in discount rate) x 18.6 (duration) = 9.3%

£300 million + 9.3% of £300 million = £ 327.9 million

Result: A 0.5% fall in interest rates would increase the liabilities by approximately 9.3% or approximately £28 million.

Assets value

Calculation

0.5% (change in interest rate) x 10 (duration) = 5%

£180 million + 5% of £180 million = £189 million

£189 million + £120 million = £309 million total assets

Result: A 0.5% fall in interest rates would increase the asset value by approximately 3% or approximately £9 million.

Interest rate duration for non-bond assets

The concept of interest rate duration is more difficult to apply to non-bond assets such as equities. Assumptions need to be made regarding how sensitive their values are to interest rate changes.

Frequently, the simplifying assumption is made that they have none, on the basis that their values do not respond immediately to changes in interest rates in the way that bonds do, although there may be longer-term relationships.

Scheme funding

Following a fall of 0.5% in interest rates, an estimated deficit of £19 million has emerged in the scheme, equivalent to a funding level of 94.2%.

Liabilities of £327.9 million – Assets of £309 million = £18.9 million deficit

Summary

Our example scheme has two characteristics in common with many UK pension schemes:

- it is less than 100% invested in bonds
- the bonds it holds are shorter in duration than the liabilities

Therefore, the overall interest rate duration of the assets is less than that of the liabilities and its funding level will worsen if interest rates fall. The effect would have been even greater if the scheme already had a deficit.

Earlier in this module we said that LDI portfolios are constructed to be a particularly good match for scheme liabilities. This is done by making the duration of the LDI portfolio close to the duration of the liabilities so that both assets and liabilities move more closely together, reducing potential impacts on deficits.

How inflation rate changes affect liabilities

So far we have looked at the effect of changes in interest rates on scheme liabilities. In order to understand a fuller picture of scheme funding and investment strategy risk we also need to consider the impact of changes in inflation.

There are many similarities in the way that inflation rates and interest rates affect liabilities but there are some important differences too.

Choosing the inflation rate assumption

As with the discount rate, there are different possible ways of deriving the inflation assumption.

One of the most common is to base it on 'market-implied inflation'. This is the bond market's expectation for future inflation, which can be worked out by comparing the yields on fixed interest and index-linked bonds of the same duration. It is the answer to 'how much does inflation have to be for the index-linked bond and the fixed interest bond to give me the same return?'

Gilts are the type of bond normally used under this method. The market-implied inflation figure may be used directly, or adjusted if the trustees believe that the market estimate is biased.

For simplicity, in this module we have assumed that our example scheme uses the inflation rate implied by the gilt market without adjustment.

The difference between inflation and interest rate changes

There is an important difference between how interest rates and inflation affect liability values.

1. Inflation affects the estimated amount of the cash flows (remember that this is the expected amount of benefits due to be paid in that year) and therefore it also affects their present value.
2. Interest rates just affect the present value leaving the cash flow amount unchanged.

Case study: Example scheme inflation increase

Let's take a look at our example scheme for a final time in this tutorial to see what happens to the cash flows in year 10 and year 20 if inflation is instead assumed to increase by 1% per annum from 2.5% per annum to 3.5% per annum.

Year 10 cash flow

£1 x (1.035^10) = £1.4106 £10 million x 1.4106 = £14.1 million

Year 20 cash flow

£1 x (1.035^20) = £1.9898 £10 million x 1.9898 = £19.9 million

In our example scheme the estimated cash flows become £14.1 million in year 10 and £19.9 million in year 20. These are 10.2% and 21.5% higher respectively.

This is an illustration of how 'inflation duration' works for inflation-linked liabilities. The same broad 'rule of thumb' applies as for interest rate duration. The cash flow in year 10 is approximately 10% higher and the one in year 20 is approximately 20% higher.

Benefits that are not fully inflation linked

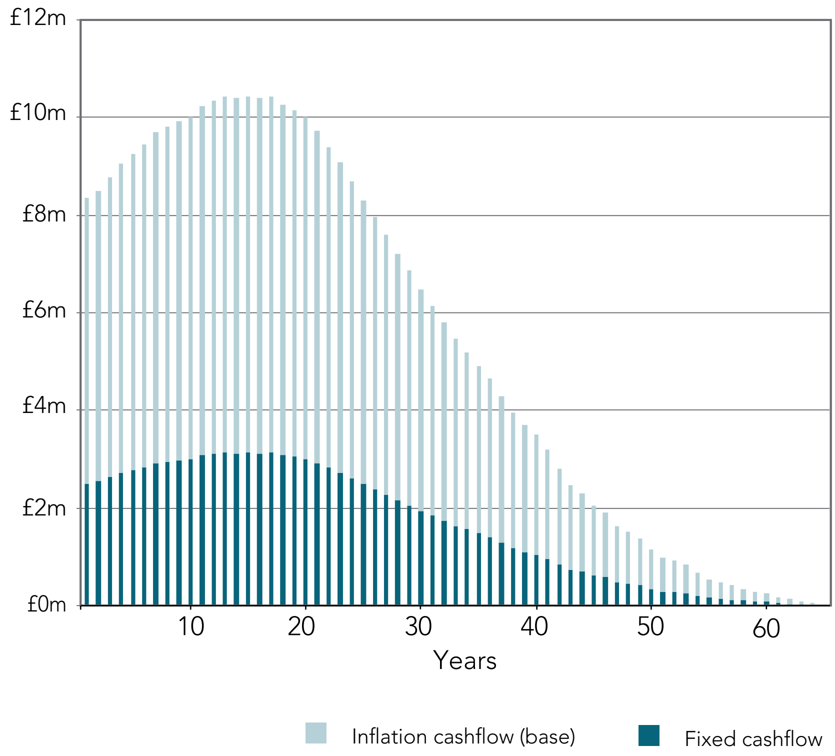
We said earlier in this tutorial that for simplicity we would assume all the scheme benefits were linked to inflation, but this is unlikely to be the case in your scheme.

If you look at your scheme's latest valuation report, you should find that there is information regarding how changes in key assumptions such as the assumed inflation rate alter the liability value. You will very likely see that the liabilities are not as sensitive to inflation as they are to interest rates. This is likely to be because your scheme has benefits that are:

- not index-linked eg they receive fixed annual increases or no increases at all
- partially index-linked eg there is an upper limit on the annual pension increase

If all your scheme's benefits are fully index-linked, like our simplified example, their value should be as sensitive to interest rates as it is to inflation.

As part of the strategy review process, it is normal for the investment consultant to work with the scheme actuary to assess the extent to which each future year's estimated cash flow is linked to inflation, based on suitable assumptions about the future behaviour of interest and inflation rates. The results might be presented in a chart like the one shown here.



There are several different ways to do this. The differences are mainly about how to deal with partially index-linked benefits, and they can sometimes be significant. Your advisers should be able to explain how they have been dealt with in your scheme, if applicable.

Putting it all together

Understanding these principles will help you understand the likely change in the scheme's funding level as economic conditions change in future. This is an important step in understanding the riskiness of your scheme's investment strategy.

If your scheme has undertaken an investment strategy review, you may find that the output includes a table summarising the liabilities in terms of the proportion index-linked and their duration like the one shown for our example scheme.

A table like this, together with an understanding of how the discount rate and valuation inflation assumption are set, provides a simple overview of how the value of the scheme liabilities changes as interest rates and inflation change.

Liability type	Percentage	Duration
Fixed	30	15.3
Index-linked	70	18.6
Total	**100**	**17.6**

For example:

- if future inflation rates rose by 0.5%, the value of the example scheme's liabilities would rise by approximately 6.3% (18 x 0.5% x 70%)
- if interest rates fell by 0.5%, the value of the example scheme’s liabilities would rise by approximately 7.5% (15 x 0.5%)

(Recall that for our example scheme, there is a direct link between market interest and inflation rates, and the valuation assumptions.)

If you have similar information regarding the scheme's assets, you can then estimate (like we did earlier) how their value would change if interest rates and inflation change.