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The Age of Peak LDI

April 2018

Executive summary

Liability Driven Investment (LDI) has been one of the dominant trends in UK Defined Benefit (DB) pension scheme investment during the past 15 years. But this trend may be coming to an end: the current pace of increasing hedging levels can only continue for at most three more years.

This paper explores three key interrelated aspects:

- Our survey of key market participants suggests that notional interest rate and inflation hedging exceeded 75% of private sector DB assets by March 2017. It is clear that, since its emergence around 15-20 years ago, LDI has grown incredibly rapidly.
- Concurrently, over the last 20 years, UK real yields have dropped by over 5%. While some of this reflects global trends, UK real yields have fallen by almost 2% more than global real yields. In part this will have been due to LDI activity by DB pension funds. This drop in yields has meant LDI asset portfolios have delivered very strong returns.
- Pension funds have been adding in the order of £100bn of notional interest rate exposure a year for the past couple of years. Given the high level of hedging that is already in place, we conclude that the current pace of rate hedging can only continue for at most another three years. We are approaching Peak LDI, as detailed below.

Section 2 of this paper provides a brief history of DB pension scheme investment. The second half of the 20th century could be characterised as the Age of the Equity Risk Premium. The early 21st century has been the Age of Unrewarded Risk – when increasingly interest rate and inflation risk was seen as unwelcome and schemes sought to hedge it. Our view is that we are now close to a transition in the UK where DB schemes will only increase rate hedging at the margin, in an opportunistic manner. We call this the **Age of Peak LDI.**

Having looked at drivers of global real yields in Section 3, and UK specific factors in Section 4, Section 5 sets out the analysis that shows we will reach the Age of Peak LDI by 2021 at the latest. In short, we believe that: c£1.2tn of notional interest rate risk is hedged today; in the past couple of years schemes have added around £100bn of notional hedging a year; and schemes will not materially hedge above assets levels of c£1.5tn. Our conclusion is not materially changed by most factors that affect pension scheme funding and investment: deficit payments, accrual, equity returns or even payments of substantial levels of transfer values. The main factor that could delay the peak is if there is a rapid slowing of hedging, although one could argue that this implies the peak has already occurred.

Given the scale of the flows of pension scheme money into hedging assets, an abrupt change to those flows will likely have a material impact on yields (both nominal and real) and consequently on DB scheme funding levels. Buying will be affected by sentiment, and sentiment will be affected by the pace of buying as well as broader asset price and yield moves.

We have not attempted to predict how the transition will play out, but do believe it has meaningful consequences for both schemes and gilt markets. Our analysis builds on previous work, see for example Schroders (2016), and extends it by considering: leverage; non-gilt sources of hedging assets; rate hedging rather than inflation hedging; and when hedging might peak and slow dramatically, rather than when it will actually stop.

We examined a number of economic research papers that seek to assess why the global real yield is at the levels seen today, and where it might go in future. Our summary is in Section 3. While the approaches differ, the main points of consensus are that:

1. We should not look to real GDP growth as an indicator for where real yields might end up.
2. The central expectation, globally at least, is for modest yield rises (<1%).
3. There is a great deal of uncertainty around the central expectation, and real yields could shift very materially up or down. This would be an argument in favour of LDI to reduce this risk, unless one had a strong directional view.

Having explored the global outlook, in Section 4 we then focus on supply and demand issues in the UK. We can think of UK yields as having a global real yield component and an idiosyncratic UK component:

- global real yields have dropped due to factors economists can largely explain, in hindsight; and
- the UK idiosyncratic component appears to have been stretched considerably due to the weight of UK pension scheme demand.

We examine some time series of real yields in the UK vs the US (where we utilise the US as a global proxy) which demonstrates evidence of this distortion in the UK.

This present over-valuation (high price) of index-linked gilts is in no small part due to perceived and actual UK DB demand. Though we do not forecast a large move in global real yields over the medium-term, there is room for considerable cheapening in the UK as a result of the following related forces which could come into play:

- Any softening in the LDI "unrewarded risk" philosophy prevalent in the UK pension fund industry.
- A move from the Age of Unrewarded Risk to the Age of Peak LDI whereby UK pension funds' demand for gilts is largely satiated and becomes marginal to yield levels.
- Market sentiment recognises that we are close to the Age of Peak LDI, and that this transition could happen soon.

While we are chastened by the fact that commentators have been saying 'yields will rise faster than predicted by markets' for the past decade, when in practice yields have continued to fall further, at some point this will play out. However, the key question is how the combination of global and UK components will move in aggregate over the medium-term.

In writing this paper we have relied, in part, on a proprietary survey of key market participants and also extrapolated from known data. The reason for this is that key data simply does not exist. In particular, despite the wealth of data captured on DB schemes, there is no definitive measure of the degree of aggregate hedging undertaken to date, or the pace at which those hedging levels are altering. Given the importance of yields and yield risk to pension schemes and capital markets, in our view this gap in data could and should be closed. Our thoughts on further work are set out in Section 6.

UK DB pension schemes promise pensions to over 10 million people, underwritten by thousands of UK companies. Collectively they invest c£1.5tn of assets, hundreds of billions of which supports the UK Government bond market. Our work suggests that a fundamental shift will occur in the next few years. That is important to other market participants both UK and overseas based; the "buyers of last resort" are soon to become more price sensitive. The ramifications of this shift are important to understand, given the consequences for all involved.

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1. Introduction

The UK private sector Defined Benefit (DB) pensions industry has had a troubled start to the 21st century, with scheme closures, sponsor failures and record deficits. This is despite sponsors paying hundreds of billions of pounds to schemes; £27.7bn in special contributions in the two years to 31 March 2017 alone [PPF (2017), Hymans Robertson (2017)].

Few aspects of the management of these DB schemes cause as much heated debate as the appropriate way to measure the value of the promised benefits, and invest to meet them. For example, see Exley et al (1997), Hatchett et al (2013), and Hilton (2016). Experts fundamentally disagree on the best approach, albeit for the most part that seems to us because they are seeking to answer subtly different questions. For example, is the focus on meeting cashflows over the very long-term as they fall due, or the short-term hedging of mark-to-market sensitivities? Is a deficit a cashflow issue or is it an unsecured corporate loan?

Two interlinked trends in DB measurement and investment have occurred concurrently with a massive change in capital market conditions over the past generation. Those two trends are the move from predominantly equity based investment to bond based investment, together with a measurement approach related to the market yields on long-dated bonds.

Given that a significant majority of DB liabilities have some linkage to inflation, it is worth noting that often the most relevant benchmark is predominantly based on index-linked gilts. The yield on index-linked gilts is often referred to as the "real yield".

Real yields on UK Government index-linked gilts have dropped by over 5% over the period 1997-2018. Given a 1% drop in yields increases the value typically placed on DB liabilities by around 20%, this has massively increased the perceived cost of meeting these pension promises.

Moreover, since the financial crisis of 2008, people have been questioning the market pricing of long-dated yields. For many commentators, it has seemed a one way bet, that yields will almost certainly rise faster than the market implies. Yet, in reality, the opposite has occurred, with yields dropping again and again, with the last major lurch downwards in the UK following the vote for Brexit on 23 June 2016. Some have described this overall trend in real yields, which is more than a UK phenomenon, as financial repression [Fulcher et al (2014)].

The purpose of this paper is to take a fresh look at these investment trends, and in particular the use of Liability Driven Investing (LDI), which has been the dominant theme in the UK of the past 15 years. Given the rapid rise in hedge ratios for schemes, we question whether we are in fact reaching the point of "Peak LDI", and speculate as to what some of the consequences might be if indeed we are.

2. DB investment past, present, and near future

Private sector DB buy-out liabilities currently stand at £2,277bn with assets valued at £1,541bn per the PPF Purple Book [PPF (2017)], a deficit on this basis of £736bn.

The 5,588 schemes making up the PPF aggregate are varied in terms of, among other things, liability maturity profiles, funding levels, asset mixes and, crucially, approaches to "de-risking".

A "de-risking" approach typically seeks to increase:

- the proportion of interest rate and inflation sensitive assets owned by the scheme; and
- the stability of the funding position calculated on an actuarial basis which reflects the yields on those interest rate and inflation sensitive assets.

Over time, schemes' typical objective is to raise the proportion of yield sensitive assets as the funding position improves. This increasingly stabilises the actuarial funding position.

This de-risking approach often focuses on one of two possible end positions.

1. Self-sufficiency

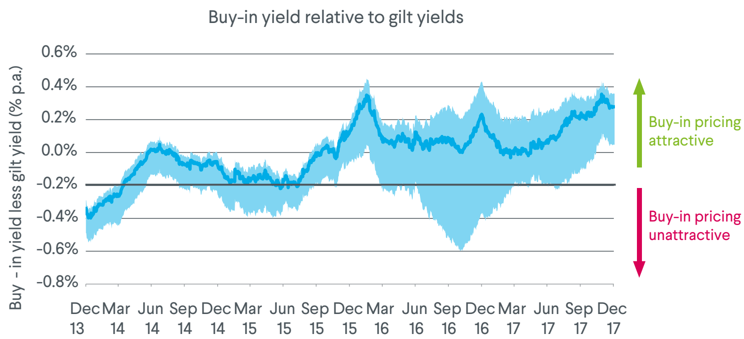
The scheme will meet all the promised benefits with the aim of no recourse to the sponsor. This typically requires interest rate, inflation and longevity risks to be largely protected against and minimal investment risk – suggesting liabilities should be valued at close to gilt or swap yields.

2. Buy-out

All the risk and responsibility of paying the pensions is fully transferred to an insurance company.

Insurance regulations, in the form of Solvency II, link reserving to swap yields plus a "matching adjustment". However, for the purposes of most pension schemes, insurance pricing is generally thought of relative to the yields on long-dated gilts, and has indeed tracked this relatively closely over recent years.

The chart below (taken from Hymans Robertson (2018)) shows the yield locked in based on typical buy-in pricing. This analysis varies between schemes depending on particular views over members' life expectancies. The dark blue line shows the central estimate for pricing, while the light blue area shows a typical range for different schemes depending on their specific circumstances.



Whether the target is self-sufficiency or buy-out, the idea is to secure the scheme's pensioner and non-pensioner liabilities through to run-off. This also breaks the reliance on the continued solvency of a private sector sponsor over many decades.

When we consider the history of pension funds over the last 50-60 years we see two key phases – the Age of the Equity Risk Premium and the Age of Unrewarded Risk. We believe that there is another Age fast approaching, which is the focus of this paper – the Age of Peak LDI.

The Age of the Equity Risk Premium

Allocating an increasing proportion of scheme assets to hedge yields is a relatively novel idea if one considers the full post World War II history of DB investment.

Pre-war schemes largely invested, to the extent that assets had been allocated by corporate sponsors, in UK consols (bonds) with some allocation to non-interest rate sensitive assets.

In the post-war period schemes grew rapidly. This was both in terms of liabilities as membership grew, and in terms of assets as contributions increased commensurately.

Typical asset strategies became increasingly dominated by allocations to equities. This was partially on the basis of high dividend yields. It was also connected with the thesis that real GDP growth, contributing to corporate profitability growth, would lead to high returns in the long-term.

This strategy is perhaps most strongly associated with George Ross Goobey, fund manager at the Imperial Tobacco Pension Fund. In 1954, Mr Goobey recommended the fund move towards 100% equities (see Avrahampour and Young). Interestingly, given later developments described below, his justification included references to the lack, at that time, of any market-based regulatory and accounting standards for pension funds, in contrast to life insurers, and to the very strong sponsor covenant.

We might refer to the second half of the 20th century as the Age of the Equity Risk Premium for DB schemes.

The Age of Unrewarded Risk

Twenty years ago, in April 1997 a seminal paper entitled The Financial Theory of Defined Benefit Pension Schemes [Exley et al (1997)] was presented to the Institute of Actuaries. Arguably this paper, more than any other, signified a radical break from the prevailing approach of the previous decades.

The paper argued for the application of financial economics principles to the valuation and investment strategy of UK pension funds. It argued that deficits, in essence, constituted unsecured loans to the corporate sponsor.

It also argued for a market consistent valuation and a switch to a discount rate for liabilities based upon market observable risk free rates (gilts and index-linked gilts). This was in contrast to the equity dividend / equity risk premium approach that was the prevailing actuarial approach at the time.

Linked to this, yield sensitive assets, essentially gilts, would be the de facto ultimate asset allocation for a fully funded scheme. Investing going forward would, and indeed should, be driven by the nature of the liabilities.

Part of the rationale for the change in actuarial approach was a change in the nature of the liabilities, which was hardened by the UK Government in the interest of protecting scheme members. What was once a best endeavours and significantly discretionary promise, became a ‘guaranteed’ non-discretionary payment stream.

As pointed out in Fulcher et al (2014), while equities may be a good long-term match for real liabilities, they are equally a very poor short-term mark-to-market match for explicitly inflation linked liabilities valued at market yields. Experience in the early 2000s demonstrated this very powerfully.

One of the first schemes to publicly embrace the new approach was the Boots Pension Scheme in 2001, as documented in Alexander (2002).

A further key actuarial paper, Speed et al (2003), popularised the terminology of the "liability benchmark portfolio" and the concept of liability led, or liability driven investment (LDI) was born.

Over the course of the early 21st century the concepts of LDI developed further in other areas of the financial services industry. This included asset management, investment consulting, actuarial consulting, investment banking and markets, as documented in Fulcher et al (2007).

For the past 15 years, key principles of LDI have become increasingly familiar:

- Rate and inflation sensitive assets should be held by a fully funded scheme seeking to buy-out its liabilities with an insurer, or in long-term "self-sufficient" run off.
- The present value of scheme liabilities is calculated with a discount rate based on gilt (or swap) yields. The discount rate is only marginally sensitive to any additional risk premium that might be expected to be harvested based on the actual asset allocation. Connected with this, the valuation of liabilities does not depend on the asset mix of the scheme. Some schemes have reached the end point of this journey, while many others are on a path towards this destination for scheme funding.
- A deficit is a (generally) unsecured loan to the corporate sponsor.
- Investment in any asset strategy which did not match that of the liability interest rate sensitivity would lead to an increase in funding risk.
- Funding risks can be measured using banking risk management concepts such as Value at Risk (VaR) or Tail Value at Risk (TVaR). These techniques can quantify the amount of asset-liability "mis-match".

If liabilities are discounted at gilt yields, and given that gilts can be purchased in financial markets, then investing away from gilts creates funding level volatility. If one does not take account of any risk premium, this volatility is created without any accounting for a corresponding reward. Yield risk consequently became known as an unrewarded risk, in the absence of strong market views.

Nevertheless, many schemes and sponsors over the past decade felt there was a reward to be had from running interest rate risk. A common narrative was that yields were "too low" and would rise faster than priced into markets. As most schemes would benefit on a mark-to-market basis as yields rise, delaying yield hedging was done with a view to investing at higher yields in future. Indeed, much time and effort was spent in setting triggers to hedge at higher yields than those prevailing in current markets.

Given the actual continued downward trend in yields over the past decade, it is easy, with the benefit of 20:20 hindsight, to say that schemes collectively made the wrong call.

UK DB schemes are so large that their investment is limited by the supply of gilts. For example, see Schroders (2016), which highlights some of the practical supply and demand issues which a simple financial economics analysis of a perfect market can easily overlook. This has led to some describing the current investment philosophy of schemes as a tragedy of the commons. While the matching asset for each scheme might be gilts, if there are not enough gilts to go around then gilt prices simply keep rising. In turn this raises aggregate scheme liabilities and deficits. A response to this challenge is one aim of this paper.

Index-linked gilts were first issued in 1981 and were only originally sold to UK pension schemes. This restriction was lifted within a year and index-linked gilts are now widely held. However, UK pension schemes still own the majority.

Twenty years ago, at the time that Exley et al (1997) was presented, long-dated index-linked gilts yielded 3.8% (looking at the 2.5% July 2024 index-linked gilt). Today the yield with a similar term to maturity has fallen to -1.6% (looking at the 0.75% November 2047 index-linked gilt), a very sizeable drop of 5.4% in real interest rates. Over the same period global real interest rates have fallen 3.5% as measured by Borio et al (2017), from 3.5% to 0%.

As UK and indeed global real rates have fallen, LDI strategies have delivered strong returns. However, given a starting point of asset yield sensitivity being well below liability yield sensitivity, schemes in the UK have been chasing un-remitting benchmark moves for years. This is a key driver behind the aggregate solvency deficit of £736bn. We characterise this period of falling real rates, a time when in the UK the debate swung firmly around to the mind set of LDI and of hedging, as the Age of Unrewarded Risk.

The coming Age of Peak LDI

DB schemes have been rapidly increasing their bond holdings and their degree of yield hedging [PPF (2017), KPMG (2017)]. Indeed, the latest KMPG survey was titled "No end to growth in sight: The UK LDI Market". In contrast, we believe that there is an end in sight, and it is at most a few years away.

Our view is that the time will soon come when the emphasis on pension schemes to close perceived asset-liability rate mismatches will dissipate. Here, there would be sufficiently higher hedging levels such that schemes would only marginally or opportunistically close such gaps. We call this the Age of Peak LDI.

3. A long-term look at real yields

In this section we survey a number of long-term economic research papers that seek to assess why the real yield is at the levels seen today, and where it might go in future.

While the approaches differ, several of the papers are able to quantitatively assess the causes for the drop in real yields that fit either the global or UK data rather well.

The main points of consensus are that:

1. We should not look to real GDP growth as an indicator for where real yields might end up. The role of growth in setting long-term real yields is somewhere between modest and non-existent; the two are weakly linked at best.
2. We are in a "new normal" regime, and despite low yields today relative to recent history, the central expectation, globally at least, is for only modest rises from here (<1%).
3. There is a great deal of uncertainty around the central view, and sentiment as much as macroeconomics could lead to major shifts in real yields – which of itself would be an argument for LDI to reduce this risk in the absence of a strong market view.

Secular drivers of the global real interest rate, Rachel and Smith (2015)

This paper looks at global data on real yields and identifies a fall in long-term government real interest rates of around 450bps (more than 500bps in the UK) over the last 30 years, noting variation across countries. They argue that as inflation has been low and stable, this signifies a fall in the global neutral rate. They then look at a range of global data to try and find quantifiable causes for this drop, which allows them to speculate as to future movements:

- They argue that around 100bps of the fall in real rates recently could be due to the downward revision in growth expectations following the global financial crisis in 2008.
- They suggest that for various reasons the desire for savings has increased, which has lowered real rates by:
  - 90bps due to demographic forces (a hump in working age people who are saving more);
  - 45bps due to higher inequality within countries (with those who are richest saving more); and
  - 25bps due to higher savings by emerging market governments following the Asian crisis in the late 90's.
- They also suggest that desired investment levels have also fallen (with the global investment and savings ratio staying relatively stable), which has lowered real yields by:
  - 50bps due to falls in the relative price of capital goods;
  - 20bps due to a shift away from public investment projects; and
  - 70bps due to a rising spread between returns on capital and risk-free rates.

Collectively their analysis accounts for 400bps of the 450bps fall in observed real yields. They then project the above drivers forward and suggest that over the coming 15 years we might expect to see modest (<1%) increases to global real rates.

Demographics will reverse three multi-decade global trends, Goodhart and Pradhan (2017)

This paper argues that it is the positive supply shock of Chinese and Eastern European labour entering the global workforce that has driven falling real interest rates (among other macroeconomic indicators). As this one-off shock is largely complete, and the world population is aging, it further argues that this will likely unwind in the years ahead.

Their primary reason for uncertainty over the outlook for rates is the sheer levels of debt in the financial system, which will weigh on growth and repress rates for longer.

Their macroeconomic conclusions are that:

1. Ageing will raise, not lower, inflation.
2. Rising inequality within countries will reverse.
3. There will be a political battle around the cost of delivering pension obligations and the social safety net.

While they do not quantify it, they argue that the aggregate effect will be a rise in long term rates.

Real interest rates and risk, Vlieghe (2017)

This speech argues that it is a fallacy to think of the equilibrium medium-term interest rate as a constant; rather rates move a lot (as we have seen in recent decades) and those changes can be persistent. In particular, interest rates today are neither at emergency nor unprecedented levels. Showing a measure of UK real yields dating back to 1800, it highlights that real yields have varied between +/- 20% p.a.

It then derives a theory for real interest rates (and critiques the standard approach of simply linking them to expectations of long run growth), based on the distribution of levels of growth. Given it is a relationship relying on the distribution, the level of real yields depends on the riskiness of growth, i.e. the variance, skewness and excess kurtosis of the distribution. This model fits the UK data rather well.

In the short term it suggests there is economic evidence that deleveraging in the UK economy (post the financial crisis) is slowing, and so this will be positive for growth and modestly increase expectations for medium term real yields. However, these rising expectations are in the context of the current low real yield regime being the new normal. The 1980s yields were the outlier, arguably due to the efforts to lower both inflation and inflation expectations in that decade following the inflation shocks and collapse of Bretton Woods in the 1970s.

Eight centuries of the risk-free rate: bond markets reversals from the Venetians to the "VaR shock", Schmelzing (2017)

This paper produces a (global) dataset for annual nominal and real yields dating back to the 13th century. It allows it to put the current bond bull market into a broad historical context. It also considers several examples for the causes and magnitudes of bond market reversals.

Two points of note were that an inflation driven reversal in the 1960s left investors facing losses of a cumulative 36%. In the other direction it notes that the current bull market is the second most intense bull bond market (in the history of bonds), but at the current trajectory it would require another 11 years at this continued rate of compression levels to be the biggest.

Without commenting on what the future holds, it highlights that there are historical precedents for further very large changes in the real yield (both up and down) from here. As with Vlieghe (2017), this would be an argument for LDI to reduce the risk of this uncertainty, unless investors had sufficiently strong views that one scenario was much more likely from here.

Conclusion

Global real yields have fallen significantly over the last 30 years due to various macroeconomic effects. This itself cannot be materially attributed to UK pension scheme activity or indeed to LDI generally.

As set out above, while there is some consensus that global real yields are likely to gently rise over the medium-term, there is still significant uncertainty as to their outlook.

4. The UK real yield curve: theory and practice

Having considered the global context for real yields, in this section we focus on the UK. The UK real yield curve is clearly a function of both global and “local” factors, including the influence of LDI.

We first summarise some relevant theoretical analysis. The key conclusion of this analysis, which is perhaps unsurprising, is that supply and demand are key drivers of UK real yields.

We then move on to compare UK bond market behaviour with that of the US in practice. What we are able to show is that there is a variety of “local” factors suppressing UK real yields. We postulate that LDI has been a key suppressant, and conclude by suggesting certain forces which could lead to a relative cheapening of index-linked gilts.

Inflation: the long-end of the UK real curve, Duval-Kieffer and Garg (2015), Nomura International plc

In two research pieces published in 2015, Nomura’s inflation strategists looked at drivers of the long-end of the UK real curve, focusing on:

- supply & demand interactions;
- “preferred habitat” theories;
- correcting for the RPI/CPI wedge; and,
- duration and convexity issues when real yields are very low.

In particular this research tried to measure the extent to which index-linked gilt yields were suppressed by looking at forward real yields and by comparing the UK and US curves. We produce a simplified version of this analysis below.

Preferred Habitat Theory

Traditional theories on the term structure of interest rate curves include:

- pure expectations theory – that long-term rates reflect expectations of future short-term rates; and
- liquidity preference theory – that investors in longer-dated bonds would require compensation for uncertainty.

These theories are both difficult to reconcile with UK Government bond nominal and real curves during the last 15 years which have shown long-end inversion.

Culbertson (1957) developed the alternative market segmentation theory, suggesting different investors would have strict maturity preferences. For example, pension schemes would often prefer ultra-long-dated inflation-linked bonds.

This was extended by Modigliani and Sutch (1966) to the “preferred habitat” theory. This suggests that investors could deviate from their maturity preference but only if they were sufficiently well compensated by higher expected returns.

Vayanos and Vila (2009) formalised this and subsequent work applied this to the UK index-linked gilt market and to the influence of UK pension schemes on this sector.

Price Pressure in the Government Bond Market, Greenwood and Vayanos (2010), American Economic Review P&P 100

This paper specifically focuses, in the UK, on the aftermath of the Pension Act 2004. This Act created the Pension Protection Fund (PPF) and introduced a risk-based levy on schemes. The risk-based levy paid by schemes, or their sponsors, is based on the deficit calculated in a prescribed way. This calculation is based on an estimate of the buy-out cost of the liabilities the PPF would pay in compensation (i.e. cut back from the full scheme benefits).

The paper shows that pension schemes in 2005-6 proceeded to buy £11bn of long-dated nominal and index-linked bonds. However, it also suggests that the true impact on markets was much higher as, including swap markets, pension schemes may have swapped c£50bn of rates/inflation exposure in the period. This figure compares to £73bn of total issuance of long-dated fixed and index-linked gilts in the period April 2005 - March 2007.

In market terms, this manifested as both a reduction in real yields generally, but also an inversion of the term structure. The spread between the real yield on 30-year (maturing in 2035) and 10-year (maturing in 2016) index-linked gilts moved from flat to an all-time low of -0.68% by the end of 2006 (30-year yields below 10-year yields).

One response was for the Debt Management Office to shift the pattern of issuance including bonds with maturities up to 50 years i.e. altering supply to fit changing preferences in demand.

Price pressures in the UK index-linked market: an empirical investigation, Zinna (2014), Banca d'Italia Working Papers Number 968

This paper extends the work of Greenwood and Vayanos (2010) to look at a longer time period.

It finds that during 1990-2012, the impact of pension scheme demand on real yields ranged from -70bps at 2 years to -165 bps at 20 years. In other words, long-dated real yields were 165bps lower than they might have been without pension scheme demand, with life insurers having an impact of around half this amount.

However, it also found that the impact of pension schemes was at its peak around the time of the 1995 Pensions Act, and the introduction of the Minimum Funding Requirement. In part, this was because the supply of index-linked and long-dated bonds at that time was so limited.

It actually attributes falling real yields since 2000 primarily to life insurers and foreign investors.

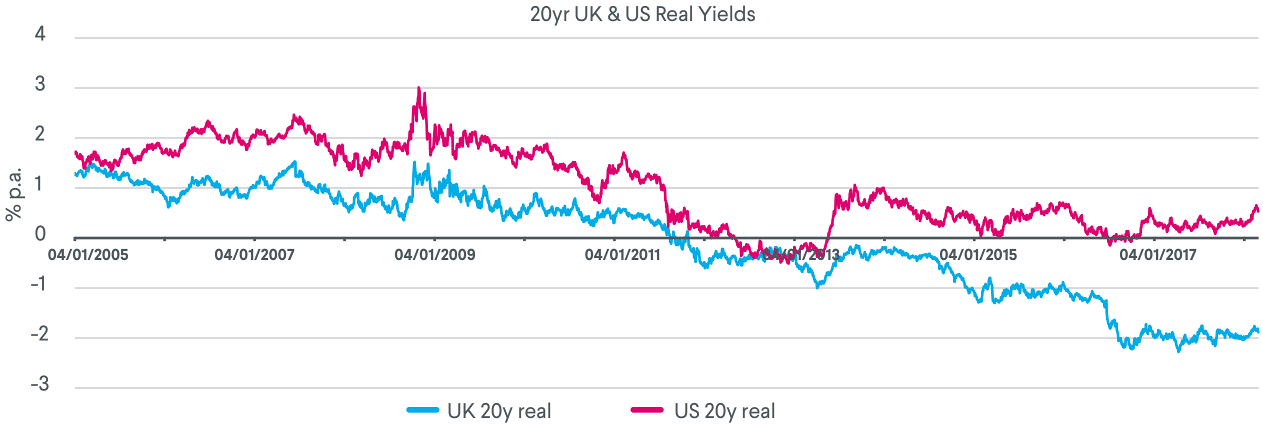
However, the paper acknowledges that its measure of demand reflects only direct purchases of physical bonds and hence does not factor in activity in derivative markets (which we note have been key to LDI activity), and the consequent knock-on effect on the demand for cash bonds and on real yields.

Market data

In order to illustrate some of the "local" impacts, including LDI, on UK real yield curves, we look at a brief history of UK gilts and index-linked gilts both in absolute terms and relative to the US.

Where data permits, we have begun our analysis in 2003. This is around the time LDI began to take off in the UK (the Age of Unrewarded Risk). Additionally, UK markets immediately prior to this period were somewhat distorted by, among other things, the paying down of the deficit following the 3G mobile phone network auctions in 2000, which raised proceeds equal to c2.5% of GDP.

We can also compare UK real yields to corresponding US real yields from Treasury Inflation Protected Securities (TIPS). The latter serves as a simple proxy for global real yields, noting that LDI has historically been much less significant in the US markets. It should be borne in mind that whilst TIPS compensate investors for changes in the Consumer Prices Index (CPI) in the US, index-linked gilts compensate investors for changes in the Retail Prices Index (RPI) in the UK. These two measures and their respective computations are very different measures of inflation. However, given that during the relevant history, the past 15 years, both have consistently been applied, we are comfortable that the relative changes in these yields sends a clear message. Going forward, the Bank of England may well make significant changes to the inflation compensation component of index-linked gilts, but we do not believe this has much relevance to our historical analysis or conclusions.



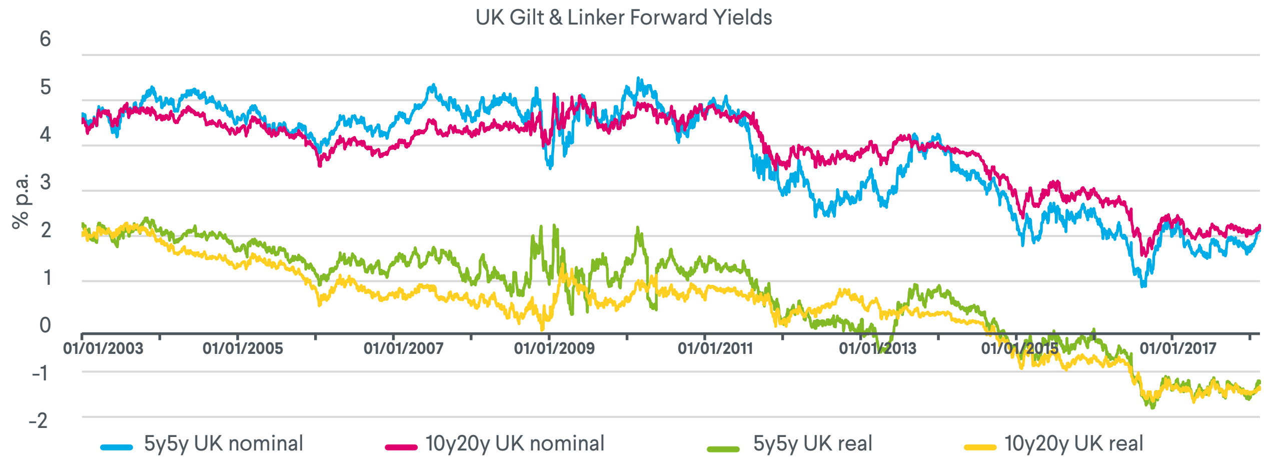
Source: Bloomberg and Nomura

The first graph above simply shows the real yield on the generic 20-year inflation-linked bonds in the UK and the US. While US yields have fallen in the last 15 years, the downward trend has been much more pronounced in the UK, and there is currently a real yield difference of over 200bps, compared to less than 50bps at the start of the time series. In other words, over the period shown, both US and UK inflation-linked bonds have become more expensive, but UK bonds have increased in price by significantly more.

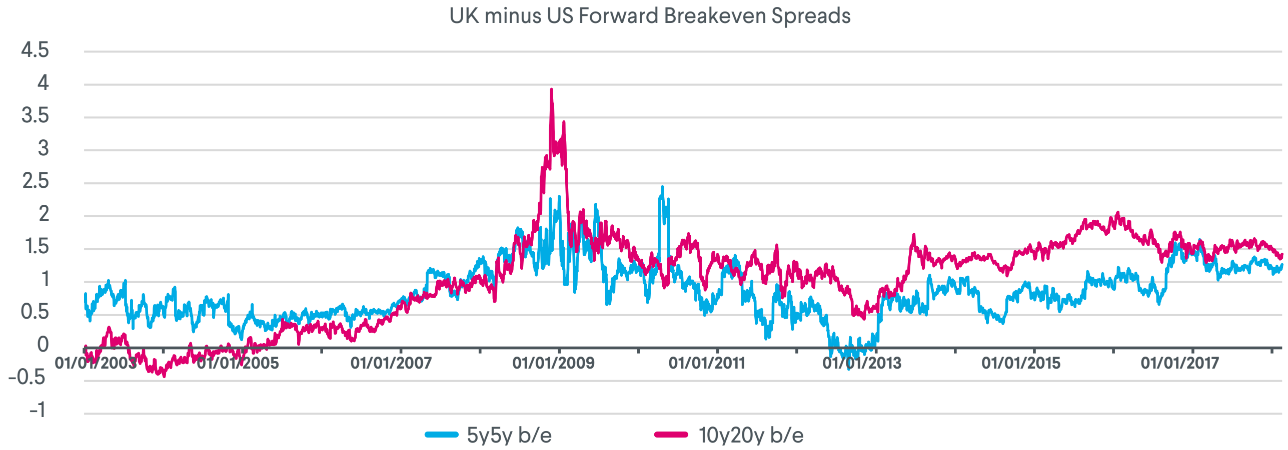
The one exception to the widening spread between US and UK yields was in 2012. This was due to the Consumer Prices Advisory Committee consultation on changes to the RPI index in the UK. During that period the market attempted to price in the potential impact of altering the measure of inflation away from the traditional RPI measurement.

To take this simple analysis further we look at forward rates. Forward rates observe the market implied level for interest rates for a given period, starting from a future period from today. Forward rates help because they remove any “noise” and “distortion” from what is happening in market pricing for the short-term. This short-term pricing can be based on views on near term monetary policy and market participants trading on those views. In this way, forward rates provide a clearer view of what interest rate markets are telling us about medium-term economics. Specifically we consider 5 year rates 5 years forward (so called, 5y5y) and 20 year rates 10 years forward (so called, 10y20y).

We can clearly see the stark decline in yields during the Age of Unrewarded Risk. The traffic is one way, but on the other hand, this is more or less in line with the global trend. In other words, while it is suggestive, the picture does not prove to what extent these yield reductions are due to DB scheme LDI.



Source: Bloomberg and Nomura



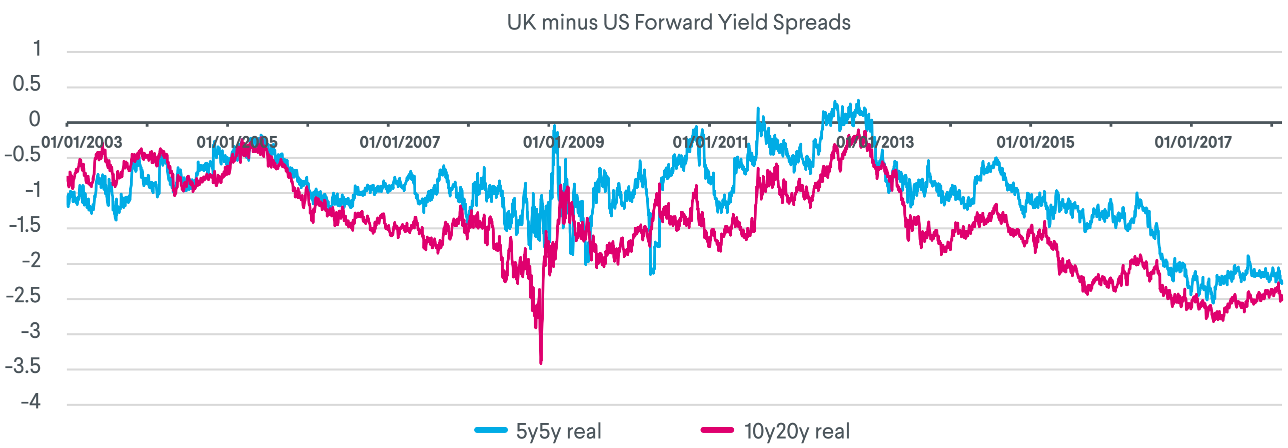
Source: Bloomberg and Nomura

In order to try to remove, at least to first order, more global trends, we can compare UK real rates to those in the US markets. In order to do this, we have split our analysis into two areas. Firstly we compare so called "breakevens". Breakevens are the rate of inflation that, were it to occur in future, would mean an investor in an index-linked bond would obtain exactly the same return as an investor in a nominal bond.

In 2003, UK and US breakevens were similar. The gap between them steadily increased to around 150bps as shown in the chart above. Notwithstanding some distortions around the 2008 financial crisis, breakevens have remained around this level ever since. This may suggest evidence of a premium being paid to buy inflation protection in the UK today relative to the price of protection in 2003.

Next, we compare real yields in the chart below and these show a similar picture. UK real yields – the price paid for buying government cashflows which guarantee compensation from inflation effects – are over 200bps lower than the corresponding US yields. It's important to note that 15 years ago, before the Age of Unrewarded Risk and the start of LDI activity in the UK, there was a much smaller difference between the UK and the US.

It is also striking that the long-dated forwards (10y20y) are actually more distorted than the medium-dated ones (5y5y). In the absence of supply-demand imbalances, such as that caused by LDI, we might naturally expect the opposite. This is because macroeconomic differences between countries are more likely to occur in the short to medium term, but one would expect convergence over the medium to longer term. This is illustrated by the impact of Brexit in 2016, which, as can be seen from the chart below, had a much larger effect on the 5y5y rates than the 10y20y rates.



Source: Bloomberg and Nomura

Upcoming supply

Looking specifically at gilt supply, it is worth noting that the Debt Management Office have been able to successfully raise £165bn through selling index-linked gilts and £500bn through selling nominal gilts in the last five years. Peering ahead into the future, we also note that the Government Treasury's own forecast from the 2018 Spring Statement is for an average gross financing requirement of £131.6bn per year over the next five years, which roughly translates into an average gilt supply of £118bn per year (after National Savings & Investments, and T-bill issuance).

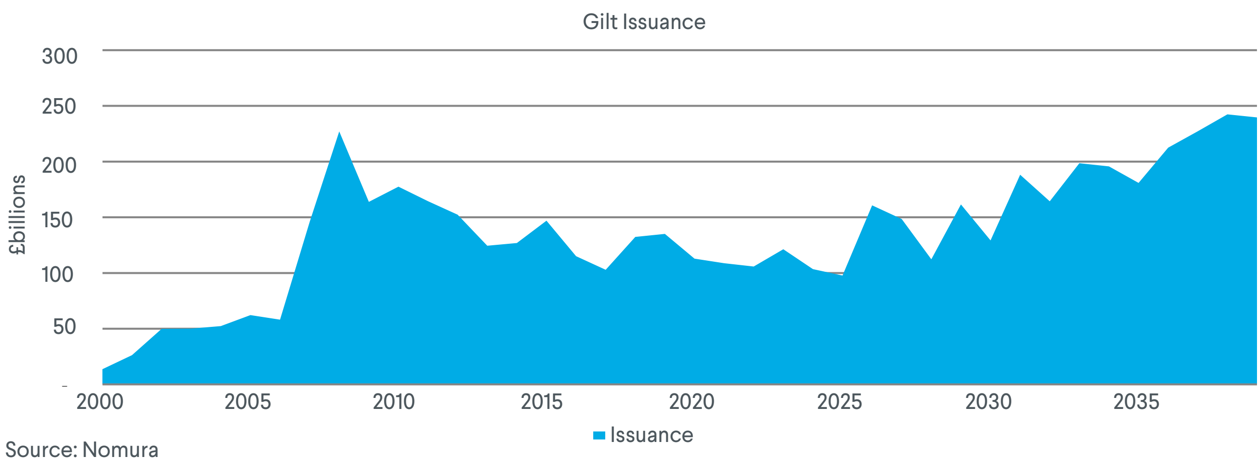
The Treasury forecast ends in 2022-23 but we estimate a fairly flat profile for the following four years before a rapid doubling of issuance over the proceeding ten years as the gilt redemption profile grows. This is based on the broad expectation of Central Government Net Cash Requirement excluding financial interventions (CGNCR ex) being around 3% of GDP, with nominal GDP growth of 3.5%. This assumption is founded on our perception that the focus of the current Government is to bring debt to GDP ratios gradually lower over time; clearly either the Government or its focus could change with a material impact on our estimates.

Conclusion

We see evidence of a distortion in the UK relative to the US, even for long-dated forward yields, suggesting this is due to supply-demand factors.

We conclude that the present over-valuation (richness) of index-linked gilts, is in no small part due to perceived and actual UK pension scheme demand. Though we do not forecast a large move in global real yields over the medium term, there is room for considerable cheapening in the UK as a result of the following related forces which could come into play:

- Any loosening in the LDI philosophy amongst the UK pension fund industry;
- A move from the Age of Unrewarded Risk to the Age of Peak LDI whereby UK pension funds' demand for gilts is largely satiated; and
- Market sentiment recognises we will transition to the Age of Peak LDI, and this transition could happen soon.



Source: Nomura

5. When will we hit Peak LDI in the UK?

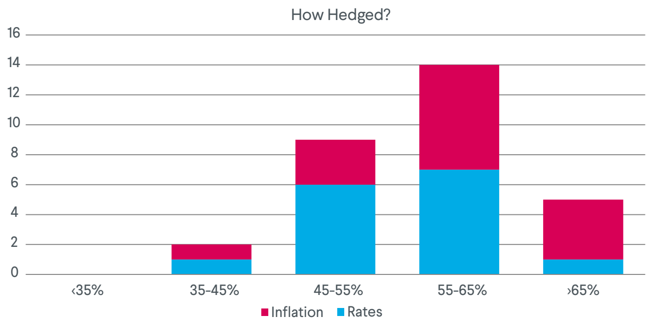
In this section we seek to answer when we will reach the Age of Peak LDI. Given the high level of hedging that is already in place, we believe that the current pace of rate hedging can only continue for at most another three years.

Taken as a point in time, “Peak LDI” means the last year of large flows into interest rate and inflation sensitive assets, before the flows have slowed to a trickle. After this point, schemes would only be closing remaining hedging gaps marginally or opportunistically.

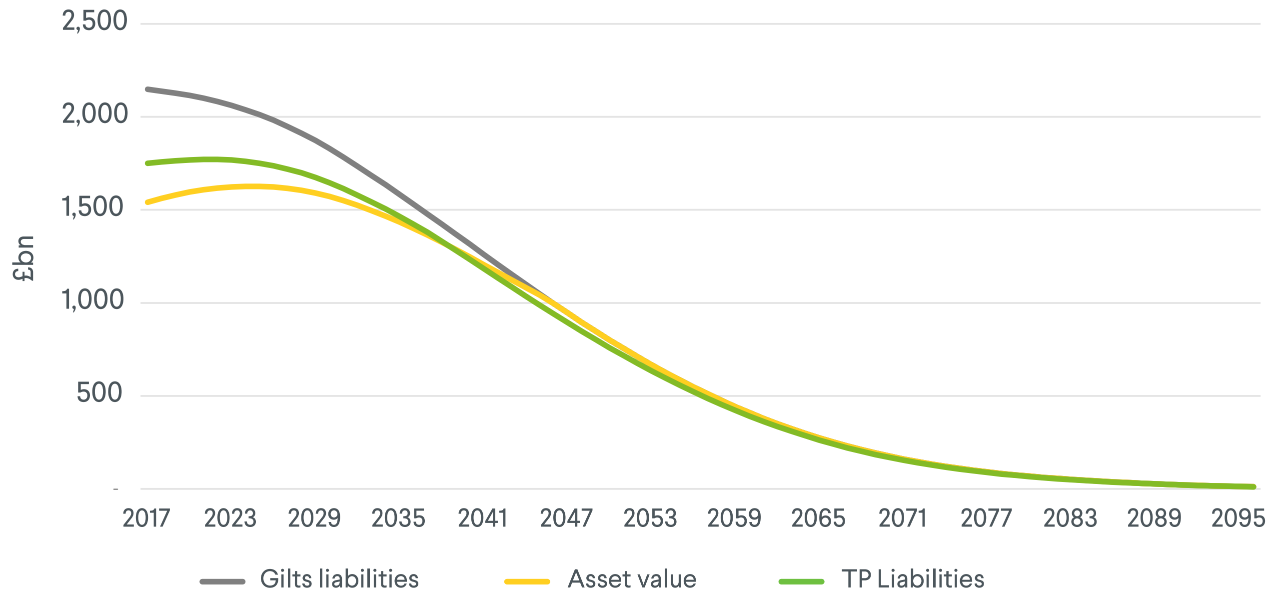
To work out when this might happen, we have built a simplified aggregate model of UK private sector DB schemes. The model is described in Appendix A. Interestingly, the model is surprisingly insensitive to many potential variables. Perhaps, on reflection, this should not be remarkable, but the key variables are:

1. The proportion of liabilities (or assets) that are hedged today. There does not seem to be a definitive picture of the extent to which UK private sector DB liabilities are already hedged. While the Purple Book [PPF (2017)] notes that 55.7% of assets were invested in bonds as at 31 March 2017, it does not provide any account of the use of derivatives which materially increase the asset sensitivity to nominal and real yields.

Based on our own survey of leading LDI managers, of some of the largest UK DB schemes and insurers, we use a working assumption that 55% of gilt liabilities are hedged as at 31 March 2017, i.e. the total notional exposure is a little shy of £1.2tn. 55% of gilt liabilities represents over 75% of DB assets. This is higher than set out in KPMG (2017), although we note that survey covered c1,800 schemes rather than the entirety of the UK private sector. More details on our survey are set out in Appendix B, and a summary of responses is set out in the chart above right.



2. How quickly schemes increase their hedging before we hit the peak. Our central assumption for modelling purposes is that schemes continue to purchase exposure at the same rate as they have for the past two years, i.e. they purchase c£100bn a year of hedging exposure. Of course, this may turn out to be different, but if it is because schemes slow their hedging materially it means we are already past the peak. More detail on our rationale for this assumption is set out in Appendix A.



3. When schemes stop hedging further. For simplicity, we assume schemes will hedge up to the level of their assets. In practice very few schemes currently hedge much above their asset level, and some schemes continue to resist hedging even to these levels. Therefore, the peak may be somewhat sooner than set out in what follows.

Under these central assumptions we will hit the peak in only three years, i.e. 2021. In other words, the longest we could possibly see schemes continue to move money into LDI at current rates is another three years.

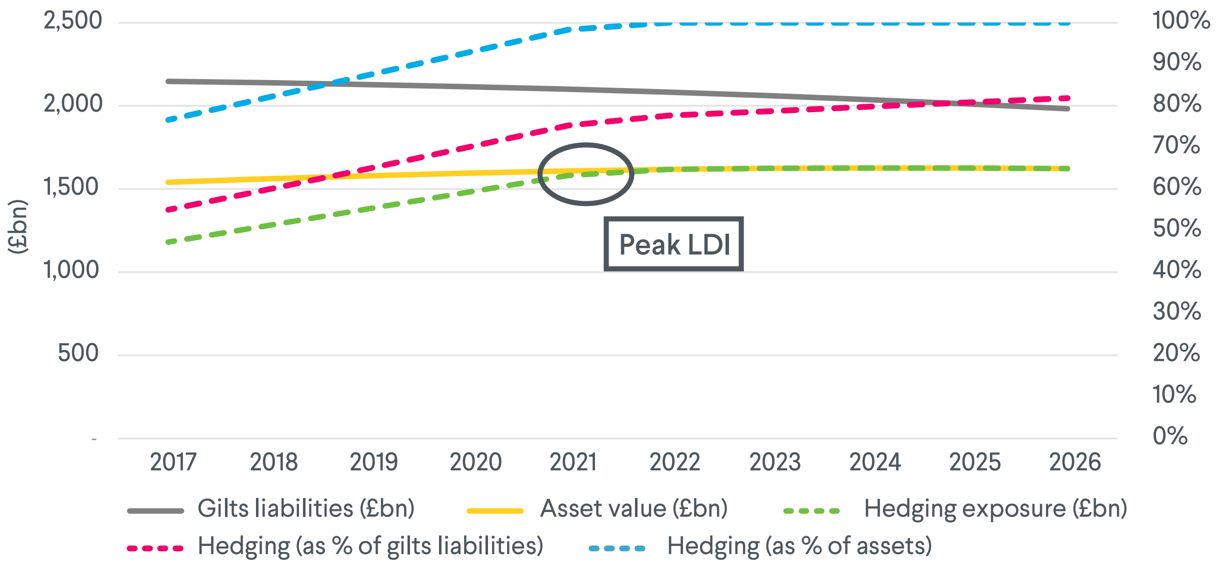
In addition to the assumptions above, data limitations mean we have not split out interest rate from inflation hedging. This would add further depth and detail to our analysis and would be worthy of further investigation.

Modelling results

The chart above shows how total liabilities and assets develop under our model, reflecting the run-off of DB schemes.

Naturally, the extrapolation will become less reliable over time. Having said that, a few noteworthy aspects of the model are:

- **DB liabilities have already peaked on a gilts basis:** payments to members (pensions, lump sums and transfer values) exceed new accrual and interest; so total liabilities fall in every year of the model.
- **Assets are still increasing:** this is due to the payment of contributions and investment outperformance relative to gilts. Schemes reach full funding on their technical provisions basis (where the yellow line meets the green line) in around 2040 and no further deficit contributions are paid from this point.
- Investment returns bring schemes up to **full funding on a gilts basis** by about 2050 (where the yellow line meets the grey line).
- **Total assets in schemes** have halved by 2050 and reach very low levels from around 2070 onwards. For simplicity we have ignored the transfer of liabilities to insurance companies within our modelling. This is on the grounds that insurers will typically hedge around 100% of the yield sensitivity of the insured liabilities (so it would not change our conclusions).



Identifying Peak LDI

The above chart shows in more detail the first 10 years of the model, where we have also added dashed lines which identify hedging ratios.

Sensitivity to assumptions

One key driver of when we hit the peak is the rate of purchase of interest rate exposure. The table to the right shows when Peak LDI might be reached as we vary the rate of purchase for rates exposure. Again, we point out that if the rate of new exposure dropped to £50bn p.a. this would already mean a substantial reduction of future demand immediately compared to what we've witnessed in the past couple of years.

Rate of exposure purchased	Peak LDI year
£50bn p.a.	2026
£100bn p.a.	2021
£150bn p.a.	2019

Assumption	Change	Peak LDI year
Starting hedging exposure	Decreased from 55% to 50% of gilt liabilties	2022
Deficit contributions	Decifits paid off in four years rather than 24	2022
Ongoing accrual	Accrual ceases completely after three years rather than 14	2021 (no change)
Transfer values	Making no allowance for any transfer values to be paid	2021 (no change)
Growth asset outperformance relative to gilts	Doubling (halving) the asset outperformance	2022 (2020)
Interest rate shock	+/-50bps p.a. at all durations, with nil assumed impact on 'growth' asset values	2021 (no change)

The other assumptions we have made in our modelling have a very limited effect on this peak, as shown above. As a reminder, the base case is a peak in 2021. To provide some intuition behind these results, recall that the peak is determined by the starting amount of notional hedging, the extra amount hedged each year, and the final asset value.

So, for example, higher asset outperformance leads to higher assets in future years, so it takes longer for the amount hedged to catch up with the asset value. As a different example, while faster payment of deficit contributions would increase the asset base and so lead to the hedging stopping at a later point, the scale means that even a dramatic shortening of recovery plans only pushes out the peak by around a year.

Finally, the impact of the interest rate shock might seem counterintuitive at first glance. However, this is because we are targeting hedging up to asset value and we make the simplifying assumption that growth asset values remain unchanged by the shock. The table below shows a simplified example to illustrate this.

Behavioural aspects and conclusions

It is clear that the pace of buying will be affected by sentiment. In turn, sentiment will be affected by the pace of buying, and broader asset price and yield moves. Sentiment could also be affected by the recognition that there is a peak, if schemes believe that hitting the peak would affect the prices of hedging assets. We have not attempted to tackle this challenge in this paper, as the level of speculative assumptions required would be substantially broader than those we have already made.

So perhaps a reasonable way to interpret our results is the following. If schemes did continue to buy at the pace they have over the past couple of years, they would be broadly fully hedged against yield movements up to the level of their assets in around 2021. It seems quite likely that the pace of purchase by DB schemes would drop dramatically at that point. Given 2021 is so soon, it appears that the pace of buying must also slow substantially very soon, if it has not done so already. This appears to us to be a strong and relatively robust conclusion from our work.

Pre Interest Rate Shock	
Growth assets	50
LDI assets	50
Liabilities	125
Notional hedge	75
Target hedge remaining	25 (100 – 75, as we are targeting hedging up to asset value)

Post Interest Rate Shock (higher rates)	
Growth assets	50 (no change assumed)
LDI assets	35 (falls by same monetary amount as notional hedge)
Liabilities	100 (20% fall)
Notional hedge	60 (20% fall)
Target hedge remaining	25 (85-60, as we are targeting hedging up to asset value)

6. Conclusions

In writing this paper we have relied in part on a proprietary survey of key market participants and also extrapolated from known data. The reason for this is that key data simply does not exist.

In particular, despite the wealth of data captured on DB schemes, there is no definitive measure of the degree of aggregate hedging undertaken to date, or the pace at which those hedging levels are altering. Given the importance of yields and yield risk to pension schemes and capital markets, in our view this gap in data could and should be closed.

Real and nominal rate exposure is one of the biggest sources of mark-to-market risk for DB liabilities. Given the data captured already on schemes, we feel more information could be put into the public domain on the sensitivity of scheme assets to yields, and how this is evolving over time. This would allow a more informed debate as to the health of the DB sector, and how best to build on the hedging decisions that have driven UK yields to fundamentally expensive levels.

We can think of UK yields as having a global real yield component and an idiosyncratic UK component:

- Global real yields have dropped due to factors economists can largely explain in hindsight, and they are predicting modest increases over the medium-term, although with a wide degree of uncertainty.
- The idiosyncratic component appears to have been stretched considerably due to the weight of UK pension scheme demand, which in our view will materially decrease over the next few years relative to the last few years.

While we are chastened by the fact that commentators have been saying 'yields will rise faster than predicted by markets' for the past decade, at some point this must be true. However, the key question is how the combination of the two components will move in aggregate over the medium-term.

With this in mind, holders of long-dated gilts and index-linked gilts (that do not have a liability to hedge) should be wary: the investment strategy of hoping someone else will buy their gilts at ever more expensive levels has a limited lifespan.

UK DB pension schemes promise pensions to over 10 million people, underwritten by thousands of UK companies. Collectively they invest c£1.5tn of assets, hundreds of billions of which supports the UK Government bond market. Our work suggests that their approach to investment is going to undergo a fundamental shift in the next few years. The ramifications of this shift are important to understand, given the consequences for all involved.

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Appendix A: Summary of our DB model

Description of model

Overview	The model is intended to represent the universe of UK private sector occupational defined benefit schemes. In practice, we have based it on data from PPF (2017). This covers 5,588 schemes which are virtually all the PPF-eligible schemes. The model treats all schemes as a single fund. It projects the total assets and liabilities year by year, for 100 years, starting from 31 March 2017. Our main focus is on the next 10 years or so.
Projection of liabilities	The projection allows for interest, benefit payments (including an allowance for transfers out), and future accrual for a limited period.
Projection of assets	The projection allows for investment returns, benefit payments (consistent with the liability projection), ongoing contributions and deficit reduction contributions. Total assets are capped at the level of the total gilts liabilities. This is on the presumption that schemes would purchase insurance if that was affordable from scheme assets, at or around that level of funding.
Asset allocation and rebalancing	Assets are split into 'liability-matching' and 'return-seeking'. The liability-matching assets are assumed to provide the stated interest rate exposure. Return-seeking assets are assumed to have zero interest rate exposure. Net cashflows over a year are first met out of the coupon on the liability-matching assets, and the remainder met from return-seeking assets. This appears to us to be a reasonable approximation in the short to medium term, which is our main focus.

Data

Gilts basis liabilities as at 31 March 2017	£2,148.2bn Based on 'full buy-out' liabilities in PPF (2017) of £2,277.3bn, approximately adjusted onto a gilts discount rate.
Total assets as at 31 March 2017	£1,541.1bn [PPF (2017)]
Interest rate exposure as at 31 March 2017	55% of gilts liabilities – equivalent to £1,181.5bn KPMG (2017) states £908bn of liabilities are hedged in LDI mandates across 1,808 schemes, a subset of the 5,588 schemes covered by PPF (2017). The balance of hedging exposure is based on the survey set out in Appendix B.

Central assumptions

Rate of adding to interest rate exposure of assets	Initially £100bn a year. See below for more details. However exposure is capped at the total asset value, so schemes are never more than 100% hedged by asset value.
Discount rate (gilts basis)	1.65% p.a. flat assumption Over 15 year FI gilt yield as at 31 March 2017
Return on assets	Liability-matching: no outperformance Return-seeking: 2.5% p.a. outperformance over discount rate
Benefit payment cash flows	Based on a typical cash flow profile of a UK DB scheme, scaled to give specified liabilities as at 31 March 2017. Includes allowance for transfers-out of £20bn in year 1, reducing linearly to zero after 20 years. Duration of cashflows is 20.6 years on the gilts discount rate as at 31 March 2017.
Future accrual	£22bn additional liabilities (gilts basis) accrue in year 1, reducing linearly to zero after 14 years (i.e. schemes are materially closed to accrual in 14 years).
Ongoing contributions	In line with future accrual, but paid on the technical provisions basis (see below), i.e. lower than cost of accrual on gilts basis.
Deficit reduction contributions	Set each year such that technical provisions deficit would be paid off over half of duration of liabilities at that point. Under the central assumptions this results in c£20bn in deficit contribution payments in the year from 31 March 2017, reducing to zero over the subsequent 24 years.
Technical provisions discount rate (used only to derive contributions)	Gilts + 1.0% p.a. in year 1, reducing to gilts + 0.5% p.a. over the subsequent 20 years.

How quickly will schemes add to their interest rate exposure in the future?

To estimate purchasing in the future, we have looked at the trend of purchasing gilts in the last few years. In the following, 'bonds' has the meaning used in PPF (2017) and we approximate government bonds as the sum of FI govt bonds and IL bonds.

Year to 31 March	Net purchases – FI govt bonds (£bn)	Net purchases – IL bonds (£bn)	Total net purchases (£bn)
2014	4	10	14
2015	7	11	18
2016	20	41	61
2017	38	9	47

Source: PPF (2017) approximately adjusted for year on year changes due to market movements by author calculations

Estimate of exposure added based on past purchases:

- Average purchases of government bonds over the past couple of years are (£47bn + £61bn)/2 = £54bn.
- Physical government bonds held at 31 March 2017 = £589bn
- Interest rate exposure at 31 March 2017 = £1,182bn
- Leverage ratio of notional exposure to physical government bonds held = £1,182bn / £589bn = 2.0

Therefore the implied exposure purchased over past couple of years = £54bn x 2.0 = £108bn, which we have rounded to £100bn.

Estimate of exposure added based on KPMG (2017)

This survey estimated that in 2016, the 1,808 schemes covered added £77bn of hedging exposure through new or expanded LDI mandates and in the previous year their figure was £108bn. I.e. over the past couple of years, the 1,808 schemes have hedged £92.5bn p.a. on average. Given this is a subset of schemes, it provides further justification (and indeed a hard lower bound) for our working assumption of £100bn.

Appendix B: Survey

To better understand how much LDI (de-risking) has been undertaken in the UK DB pension scheme sector, we conducted a survey. We reached out to a wide number of UK asset managers in the LDI market, to several self-administered pension schemes and to UK life insurers. We posed the following two questions:

Question 1:
If you were to consider the GBP swap discounted dv01 interest rate sensitivity of the total liability in the UK private sector Defined Benefit pension scheme sector, what proportion of this would you conclude has been hedged by dv01 sensitive assets?

a. Less than 35%
b. Between 35% and 45%
c. Between 45% and 55%
d. Between 55% and 65%
e. Greater than 65%

Question 2:
If you were to consider the GBP RPI swap discounted dv01 inflation rate sensitivity of the total liability in the UK private sector Defined Benefit pension scheme sector, what proportion of this would you conclude has been hedged by RPI dv01 sensitive assets?

a. Less than 35%
b. Between 35% and 45%
c. Between 45% and 55%
d. Between 55% and 65%
e. Greater than 65%

For simplicity for respondents, and comparability between assets and liabilities, we posed our question in terms of swap yields rather than gilt yields. We do not believe this will have introduced any material distortion into the results of this survey.

What we found is that the mean response was almost exactly halfway between "c" and "d" for Question 1 and was "d" for Question 2. It was with this survey result in mind that we set our base modelling assumptions to a 55% "hedge ratio" position for our analysis. It is worth noting that both answers have a standard deviation of 0.8, rounded to 1 decimal place, meaning there was some variation (within + or –10%) in order to capture more than two-thirds of the responses.

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