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AEGON Asset Management

LDI Deep Dive Series
Part 3: Positioning along the curve

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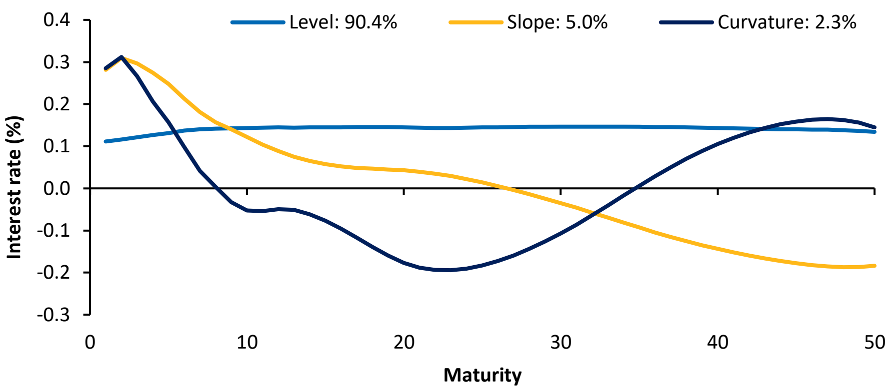
Investors with future liabilities are normally exposed to interest rate risk. A fall in interest rates will increase the value placed on future liabilities. By adopting a liability-driven investment (LDI) strategy, much of this interest rate risk can be mitigated. In this LDI Deep Dive Series, we will decompose interest rate risk into parallel interest rate risk, curve risk, and basis risk components, and finally we will deal with an efficient distribution for LDI strategies over these risk components. This third article looks at curve risk and positioning along the curve.

So far in this series, we have assumed that interest rate changes happen in parallel across the curve – that the entire interest rate term structure moves up and down to the same degree. However, this is normally not the case. Some parts of the interest rate curve will change more or less than others or even move in different directions. When the curve positioning of the interest rate hedge does not match that of the liabilities this will make the funding ratio sensitive to relative movements of the yield curve. It is therefore important to consider the interest rate hedge at different maturities and explicitly trade-off the benefits of a perfect hedge along the curve (minimizing interest rate risk) versus its costs (higher hedging costs and fewer opportunities to seek additional returns from the interest rate hedging strategy).

When we look at historical movements of the interest rate curve, we see some typical movements that explain a large part of the variation in the interest rate curve. These are presented in Figure 1. By far the most movements (90.4% of variance) can be explained by parallel changes of the yield curve. These are the changes that we have considered in the first two articles of this series. Nearly all the remaining 9.6% of variance is explained by changes in the slope of the yield curve (5.0%) or changes in the curvature of the yield curve (2.3%). Although they explain a minor part of the total variance, their impact on the funding level may be high given the greater sensitivity of many pension funds to longer maturity interest rates.

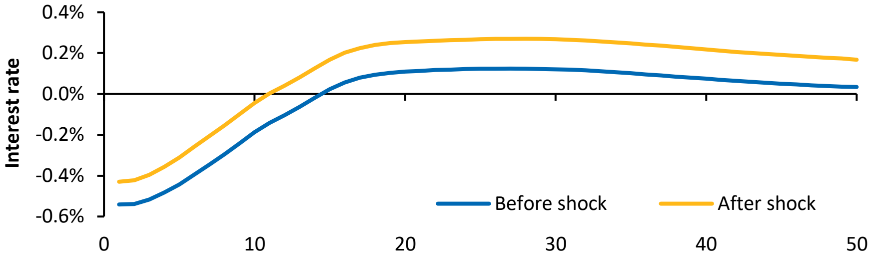
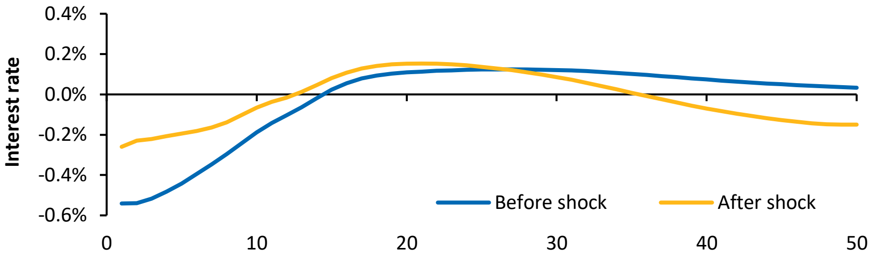
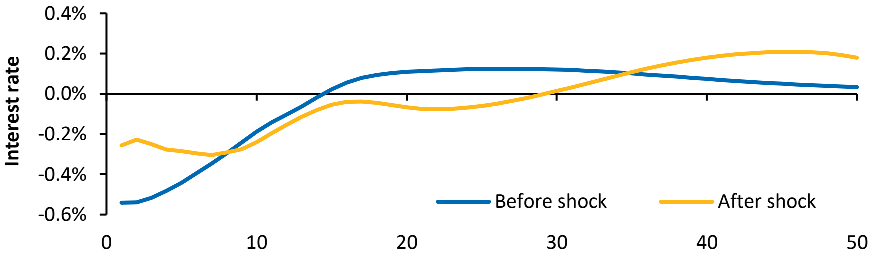
Figure 1: Most common changes in the interest rate curve



Source: Bloomberg, Aegon Asset Management. Results of Principal Component Analysis (PCA). Daily interest rates from January 2000 until March 2021.

When we look at the interest rate hedge positioning along the curve, these slope and curvature effects are therefore of most interest. Changes in the slope of the yield curve are relative increases (decreases) in the short end of the term structure with decreases (increases) for the longer maturities (for example maturities greater than 25 years). As pension funds normally have higher exposure to these longer maturities, and their impact on the valuation of liabilities is large due to the higher durations, changes in the slope might strongly impact the funding level. Changes in the curvature – increase (decrease) in middle-long maturities compared to shorter and longer maturities – have a more ambiguous impact on the funding level. Firstly, because such changes are less likely but also because the typical overhedge at the short end (from physical fixed income assets) will partly compensate for the typical underhedge at the long end.

Table 1: Interest rate curve changes

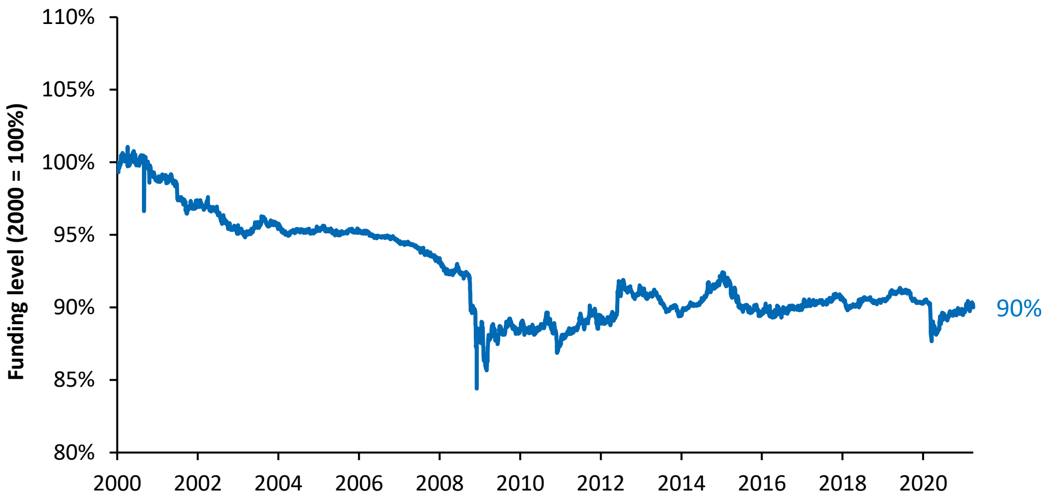
Factor description	Example typical interest rate shock
Factor 1: Description: **Level** (parallel) Proportion of variance: **90.4%**	
Factor 2: Description: **Slope** Proportion of variance: **5.0%** (cumulative: 95.3%)	
Factor 3: Description: **Curvature** Proportion of variance: **2.3%** (cumulative: 97.6%)	

Source: Aegon Asset Management. Daily interest rates from January 2000 until March 2021. Due to rounding, cumulative totals may not agree with the sum of the individual figures.

Impact on funding level risk

The impact of curve risk is illustrated in Figure 2. This shows the development of the funding level of a hypothetical pension fund that fully hedges its liabilities[1] using only 20-year interest rate swaps[2] – a so-called bullet strategy. Although this strategy can perfectly hedge parallel interest rate changes, it is sensitive to relative changes of the yield curve and therefore imperfectly matches the liabilities. Over the period since 2000, this leads to a tracking error from curve risk of 2.7%, compared to 0% with a perfect hedge and 11.2% with no hedge. This means that there is 32% probability that, in a given year, relative changes of the term structure will lead to a funding level which increases or decreases by 2.7% or more for this pension fund. Although the volatility caused by curve risk is smaller than that of parallel curve changes, it is still significant and therefore represents an important element of LDI strategies.

Figure 2: Funding level impact from curve risk



Source: Bloomberg, Aegon Asset Management. Funding level impact with 100% hedge using 20-years interest rate swaps from January 2000 until March 2021.

The analysis described above was based on a full (100%) hedge of parallel interest rate risk. In practice many pension funds choose not to fully hedge their parallel interest rate risk, either because they have an interest rate view or because they have a real (inflation-adjusted) target[3]. When parallel interest rate risk is not fully hedged the additional volatility caused by curve risks tends to decrease due to the diversification of risks. In the previous example, hedging 50% of the interest rate risk with only 20-year interest rate swaps would result in a tracking error of 5.8%, while this would be a mere 0.2% lower (5.6%) when the maturities of the 50% interest rate hedge would perfectly mirror those of the liabilities. The relevance of curve risks is therefore strongly dependent on the overall hedging level.

[1] Which are set equal to that of the average Dutch pension fund.
[2] With annual re-strikes, giving an average annual period to maturity of 19.5 years.
[3] The nominal interest rate consists of both the real interest rate and expected inflation. By fully hedging the nominal interest rate also expected inflation is hedged, with is not necessarily desirable from a real perspective.

Impact on expected returns

From a volatility perspective, less exposure to curve risk is better and the optimal strategy would be for a close match between the cash flows from the interest rate hedge and those of the liabilities. However, from an expected return perspective, there may be certain reasons to deviate from this thesis.

Costs: Operational complexity and transactions

Firstly, it is close to impossible for pensions funds to fully eliminate curve risk. As the membership profile changes – for example with new members, new contributions, or changes in mortality expectations – so the cash flows of the liabilities change. A perfect hedge would require regular rebalancing which adds to operational complexity and transaction costs. Furthermore, as most of these changes will only be known with a delay, even regular rebalancing would not completely eliminate curve risk.

In addition, a (near to) perfect hedge requires a very large number of cash flows (at least one for each year), which in turn would require a large number of instruments. Instruments with atypical maturities, for example an interest rate swap with 33 years to maturity, tend to be less liquid and therefore more expensive to trade. To prevent complexity and higher transaction costs most investors therefore choose to allow for some room for manoeuvre with their curve risk hedging strategy and limit the number of instruments, for example by focusing on a limited number of key maturity rates or maturity buckets.

Term premium

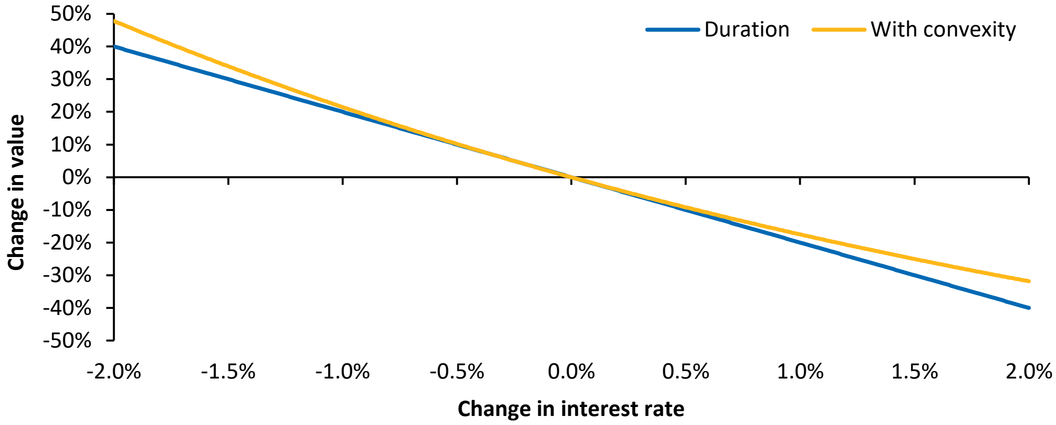
Another reason why some exposure to curve risk might be desirable is to optimally benefit from the term premium. As we show in more detail in article 1 of this series, interest rates tend to increase with maturity, so as to compensate for the higher interest rate risk (duration) and greater uncertainty that is associated with longer maturities. This is called the term premium.

The term premium can increase expected returns via both a higher interest rate (carry) and also the effect of the discount rate tending to decrease as the time to maturity comes closer (roll-down). Carry – compared to a fixed nominal value – is optimized by choosing the maturity with the highest interest rate, while roll-down is optimized by choosing the steepest part of the term structure. When the interest rate curve is expected to maintain its form, actively optimizing carry and roll-down will increase expected returns. However, this will also increase curve risk and therefore require a larger curve risk tolerance.

Convexity

Increasing convexity might be another reason to allow for curve risk in the funding level. Convexity describes the characteristic of fixed income assets to increase more in value from a drop in interest rates than to decrease in value from an equal rise in interest rates (illustrated in Figure 3), which thereby positively adds to the expected return when volatility is expected in the interest rate. The more convexity an asset exhibits, the higher the addition to expected return. As fixed income assets with longer maturities normally exhibit higher convexity, they also benefit more, on average, from volatility in the interest rate. This is also visible in Figure 4, which gives an estimation of expected return from convexity by showing the average return from either an increase or a decrease in the interest rate with one absolute deviation (approximately 0.5% between January 2000 and March 2021), while controlling for the nominal value.

Figure 3: Impact of convexity



Source: Aegon Asset Management. Impact of interest rate changes with and without convexity.

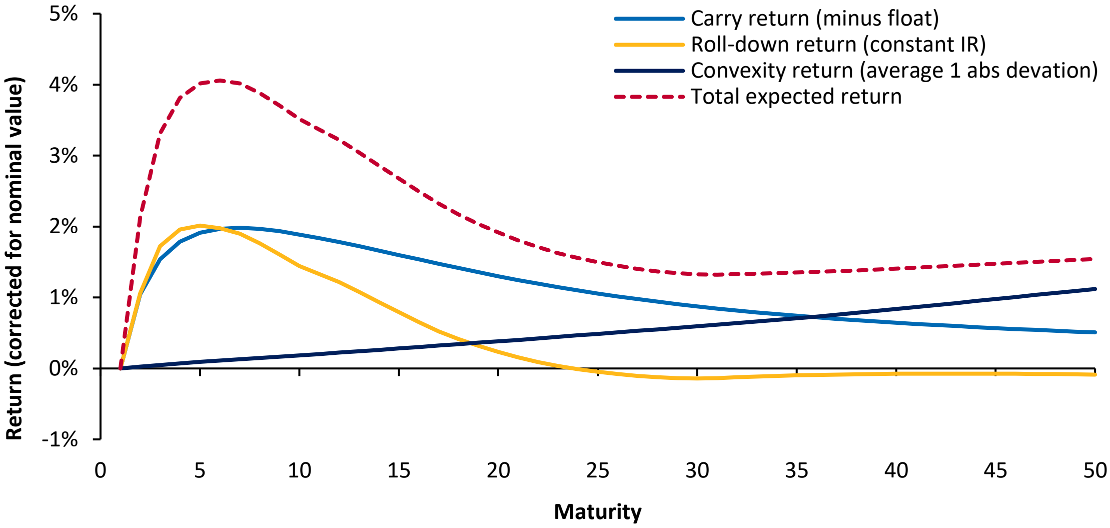
Increasing the convexity of the interest rate hedge might also provide protection against parallel interest rate shocks. When convexity of the assets is higher than that of the liabilities, the assets will increase relatively more than the liabilities when interest rates decline while they will decrease relatively less than the liabilities when interest rates rise. Convexity is therefore a valuable property of fixed income assets and derivatives and is as such valued in the interest rate for longer maturities, which normally tend to decrease – or at least become less steep – for very long maturities (thereby decreasing carry and roll-down return). Predicting volatility in interest rates might be as difficult as predicting the interest rate itself, therefore balancing expected returns from convexity with that from carry and roll-down is not straightforward. However, it is often assumed that interest rate volatility decreases when interest rates are lower. This in turn means the expected return from convexity might be lower in the current low-rate environment.

Nominal value

The expected returns from carry, roll-down and convexity are relative to the nominal value. However, when we want to hedge a certain level of interest rate sensitivity, using longer maturities means that the nominal value decreases to compensate for the higher duration. So even though return relative to nominal value might increase with longer maturities, total return might decrease because the nominal value of the interest rate hedge decreases. When interest rate swaps are used a lower nominal value also means that the floating leg becomes smaller which reduces the carry that needs to be paid (when short-term rates are positive) for the floating leg.

In Figure 4 we show the expected returns – based on the average interest rate level and volatility since 2000 – of the different components of the expected return from the interest rate hedge while correcting for the nominal value by scaling returns to a duration of 17.5 (average duration of the average pension fund). Expected returns in this analysis (based on average interest rates) are the highest for the seven year maturity but will be strongly dependent on the yield curve at the relevant point in time.

Figure 4: Expected return for different maturities, corrected for nominal value



Source: Aegon Asset Management, Bloomberg. Based on average interest rate from January 2000 until March 2021. Carry return (minus carry on floating leg) and roll-down return based on constant interest rates. Convexity return calculated using one annual absolute deviation in interest rates and maturity minus one year. All returns corrected for nominal value (rescaled to maturity 17.5).

Interest rate view

Finally, some investors may actively want to over-/underweight some maturities because they have a specific view about the term structure. For example, when an investor correctly anticipates that the term structure will steepen, underweighting longer maturities and overweighting shorter maturities will yield a higher return. However, as is the case for parallel interest rate movements, predicting the relative curve moments is very difficult, and it might take a long time before an expectation materializes. Therefore, whether an investor is willing to allocate curve risk budget to benefit from predictions in relative curve moments is dependent on the investment beliefs and skill of the investor.

Managing curve risks

As the previous analysis shows some exposure to curve risk is inevitable and possibly even desirable as a source of expected return from the interest rate hedge. However, this requires a careful balance of expected returns and volatility. It is therefore worthwhile defining a specific risk budget for curve risk. This risk budget can be either small to only allow for operational activities or larger, in order to also allow for return optimization along the yield curve. Figure 5 shows the maximum funding level volatility (tracking error) that is possible for different bandwidths of interest rate volatility for eight key rates (5, 10, 15, 20, 25, 30, 40 and 50 years). A bandwidth of 5% means that the interest rate hedge for each key rate is allowed to deviate with 5% (of total interest rate sensitivity) from that of the liabilities. We keep the total interest rate hedge unchanged (otherwise we get sensitivity to parallel shocks), therefore an overhedge on one key rate should be compensated by an underhedge on one or several other key rates. As the figure shows the maximum volatility that is possible within the bandwidths is a linear function of the size of the bandwidths. For the average pension fund, bandwidths of 5% can result in a maximum tracking error impact from curve risks of 1.1%, while doubling the bandwidths to 10% also doubles the maximum tracking error impact (2.2%).

Figure 6 shows that the impact of a mismatch is higher at the longer end of the yield curve – this is the result of higher interest rate volatility at longer maturities. However, the differences we find between maturities are relatively minor, suggesting that the additional complexity of varying the bandwidth per key rate might not be worthwhile.

What bandwidths are acceptable is again strongly dependent on the specific investor, whether curve risk is seen as a source of excess return and what additional level of operational complexity is acceptable.

Figure 5: Curve risk budget and maximum funding volatility

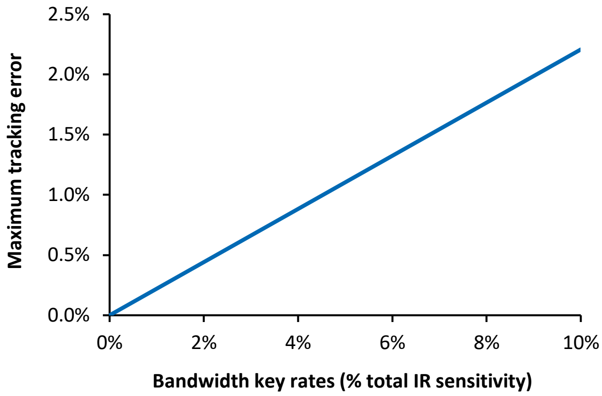
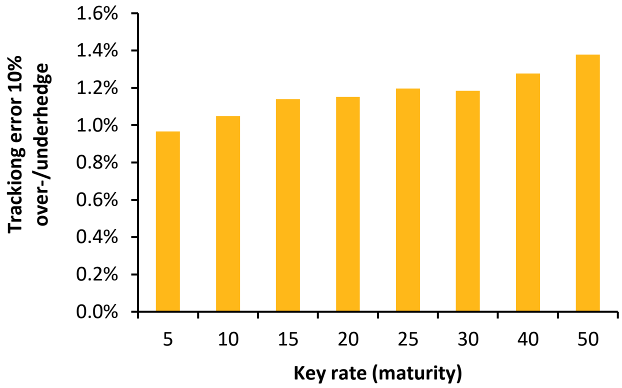


Figure 6: Tracking error impact over-/underhedge level specific key rates



Source: Aegon Asset Management, Bloomberg. Using daily interest rate movements from January 2000 until March 2021. Figure 5: Maximum tracking error possible given bandwidths for all eight key rates (5, 10, 15, 20, 25, 30, 40 and 50). Figure 6: Average impact of 10% over- and underhedge of key rate while under-/overweighting the other key rates pro rata.

Conclusions

A mismatch between the cash flows of a pension scheme's interest rate hedging assets and those of the liabilities will make the funding level sensitive to relative movements in the yield curve, such as a change in the slope or curvature. Funding level volatility will therefore normally increase when the liabilities are not perfectly hedged along the curve. The impact of curve risk can be considerable, although notably smaller in size than the impact from parallel movements. Furthermore, the incremental impact on volatility is strongly dependent on the overall level of interest rate hedging. While the impact is substantial with a 100% hedge, the incremental impact with lower overall levels of hedging decreases relatively quickly.

A perfect hedge is however not usually possible. Some curve risk might be necessary in order to restrict operational complexity and may also be used to increase expected returns by efficiently positioning along the curve. The risk budget that should be allocated to curve risk is strongly dependent on the investment beliefs of the investor, the cash flows of their liabilities, the acceptable level of operational complexity, and the overall risk attitude.

The fourth article of the series will look at various aspects of the fixed income assets that are typically used and eligible for LDI portfolios.

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