Research

# The Carry Concept

FTSE Fixed Income Factor Research Series

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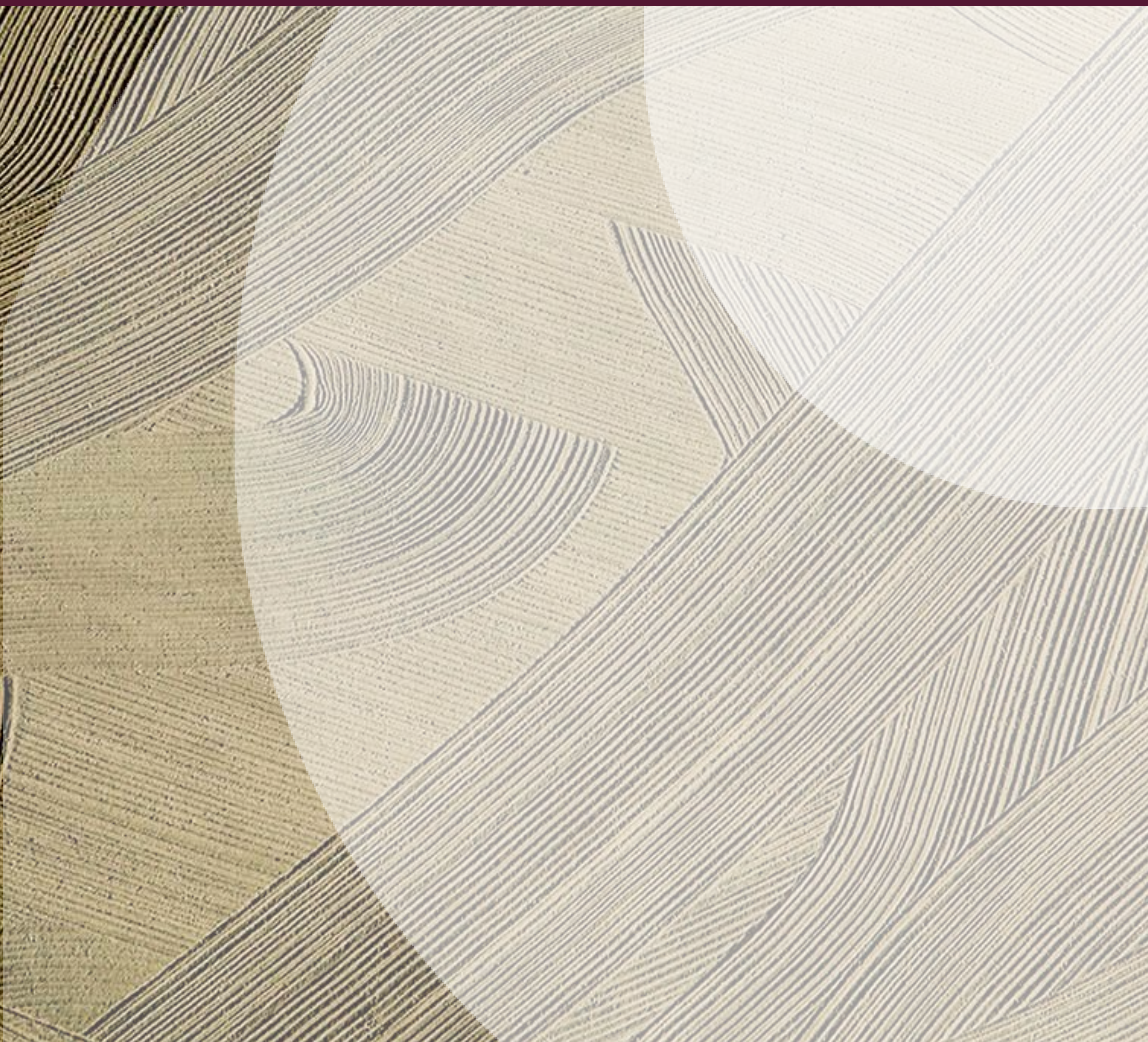


# FTSE Fixed Income Factor Research Series – The Carry Concept


## Executive summary: Uncover the carry premium behind the shape and curvature of the yield curve

As a well-known concept to practitioners and academics, carry has been leveraged in the currency markets for decades. With the understanding of such FX carry trades becoming established, recent academic publications have explored this concept cross-markets and showcased evidence of the carry premium across other asset classes.

This paper, which is the second in the series of Fixed Income Factor Research, provides an in-depth analysis of the carry concept in bond markets. Unlike in our previous paper on value[1], the carry factor discussed here has no direct equity counterpart, instead deriving from fixed income concepts only and more specifically the yield curve.

The paper will cover the following sections:

- **The carry concept**. The "carry and roll-down" concept in fixed income echoes the "hold and earn" carry trade in the FX market. When assessing the expected return from holding an asset, those two ideas share the same assumption that everything else stays relatively unchanged except for the passage of time. Within the fixed income space however, the concept has been expanded by featuring the additional expected capital gain from the term structure premium on top of the bond's yield.

- **Targeting carry in sovereign markets.** We explore various approaches that seek to maximise the carry exposure without taking additional interest rate risk. Favourable results were observed; and the expected return from carry was identified to be the primary source of the realized excess returns. Strong consistency of this approach was observed in a "reversed" simulation where the secular bond bull market was played backward in a synthetic bear market scenario.

- **Extending to corporate bonds.** The carry concept can be reproduced in the corporate space and tested against various global corporate bond markets. Despite unexpected return from yield and spread movements, excess return due to carry was still observed. However, in practice, the higher transaction costs in the corporate space may erode such excess return, which should be considered when implementing this approach into an investment strategy.

- **Real world utilization.** The performance of US active bond funds were examined and attributed to various market and factor return drivers. Our findings indicate that beyond the traditional market, duration and credit plays, the carry factor may be less utilized, especially in the US treasury space. We also discussed the FTSE Nomura Carry and Roll Down World Government Bond Index Series which captures targeted exposure to the carry factor using a transparent, rules-based index methodology.

We conclude that although the fixed income carry factor may not be as well-known to the wider investor group as the FX carry, evidence shows that it benefits from similar academic foundations and has delivered consistent outcomes across markets.


[1] For details, see https://www.ftserussell.com/sites/default/files/ftse-fixed-income-factor-research-series-the-value-effect.pdf

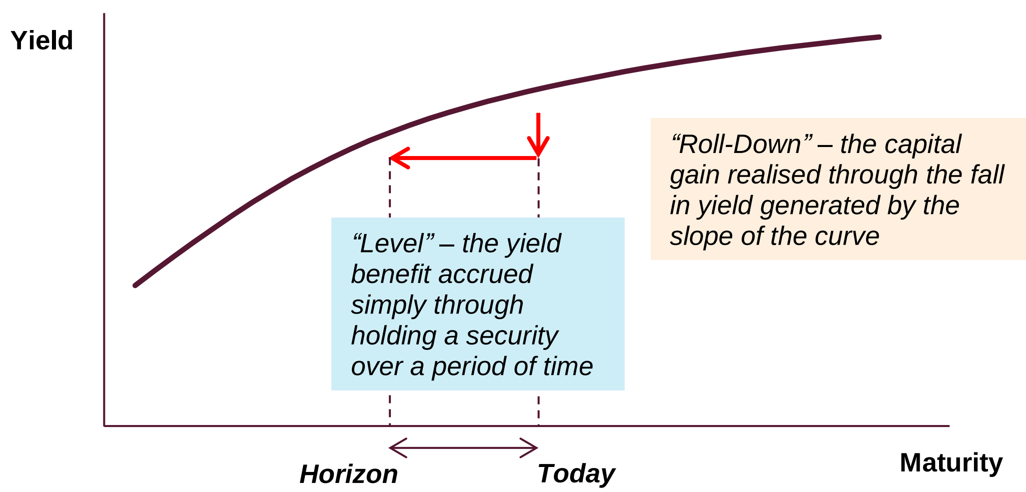
# Carry Factor: The expected return from holding an asset assuming nothing changes but only time elapses

## Introduction to the carry concept: from the FX market to fixed income

The “carry trade” originally gained its popularity in the foreign exchange market. Speculators would seek to generate alpha by borrowing money in a low interest-rate currency such as Yen or Swiss Francs, and invest it in a country where interest rates were higher. After a suitable period of time the funds from the higher-interest currency would be converted back into Yen or Swiss Francs and pay off the debt with some profit left over. Of course there has never been a way to lock in that profit: in order to eliminate the possibility of a risk-free arbitrage the theory of interest-rate parity dictates that today’s spot exchange rates will move towards an expected forward rate - the spot rate that will exist at the time the trade is unwound - such that the profit will disappear. What the currency speculator is banking on is that spot rates move more sluggishly than the market expects, and that the exchange rate when it comes time to unwind the trade will be closer to the spot value today than the forward value that is priced into the market to eliminate arbitrage. Often, this assumption would be borne out.

This “hold and earn” carry approach has a comparable concept in the fixed income market-place. It is known as the “carry and roll-down”, referring to the yield earned through investing in longer-term interest rates combined with the capital gain that can be realized through the fall in yield experienced by holding a shortening asset against a backdrop of a normally upward-sloping yield curve.

**Exhibit 1: Fixed Income Carry Combining the Level and Roll-Down Components**




Source: FTSE Russell

As with foreign exchange there is no guaranteed profit here: there is a forward yield curve which if it comes about means that nobody can beat the return that would be obtained just from holding a cash deposit whose term matches the life of the trade. Thus the idea behind the “carry and roll-down” factor is to target the most attractive part of the yield curve in the hope that when it comes time to unwind the trade the yield curve at that time more closely resembles the curve as it is today than it does the forward curve.

When it comes to terminology, the existing literature is not unified around the definitions of “carry” and “roll-down”. Some academics have referred to carry as incorporating not just the accrued yield benefit from holding an asset over time, but also the capital benefit that others refer to separately as the “roll-down” effect. This paper is concerned with understanding and targeting the aggregate “carry” and “roll-down” effects, which for simplicity in the rest of the paper we will refer to as the “carry” factor unless otherwise stated. In addition, the component that benefits from yield accrual is referred as “Level” to avoid confusion.

## Historical and current studies of carry investing in financial markets

Before we step into our own analysis of the fixed income carry factor, we first look at the carry concept overall and how it may have been studied historically via previous academic works.

As mentioned earlier, the carry concept is mostly known though the popular “carry trade” applied in the currency market. FX carry trades exploit the forward premium anomaly also known as the Fama puzzle [1984], which relates to the failure of the uncovered interest parity (UIP) to hold. The FX carry trade, which typically involves borrowing in a low interest rate currency to invest for a set horizon in a higher interest rate currency, leverages the fact that exchange rates do not adjust themselves enough to the interest rate differential between the two countries. While the UIP claims that in an efficient foreign exchange market, an investor should be indifferent between depositing his money in either of the countries since the value of the deposit should be equivalent at the end of his chosen investment period, in practice the UIP doesn’t hold well empirically as analyzed by Froot and Thaler [1990]. Accordingly, as the deviations from the UIP could be evidenced and exploited, FX carry trades became very popular and available studies of the carry factor were most frequent in the currency market.

Seminal work in the bond market however can be traced to Fama’s [1984] study that considered 10-year zero-coupon bonds and approximated their carry to the 1-year forward rate from year 9 to year 10. The early origin of the carry definition in fixed income can be traced back to the publication by Leibowitz and Homer of their book “Inside the Yield Book” in 1972. Since long-term bonds often have higher yield to maturity (YTM) than short-term bonds, if investors hold a long-term bond for a period shorter than its lifetime, the bond often generates a capital gain from the term structure premium, which is an extra return over the yield earned from the bond. Leibowitz and Homer [1972] defined “rolling yield return” as the combination of the bond’s periodic income earned and the additional price gain from the term structure premium. This expected total return is calculated under the scenario that the yield curve stays constant during the bond holding period. This idea is similar to the premise of the carry trade in the FX space where there is an expected premium from holding an asset over time assuming everything else stays relatively unchanged during such period.

As the concept of rolling yield return became well understood by bond investors, the concept of “riding the yield curve” emerged. In practice, with an upward-sloping yield curve, capital gain from the spread can be anticipated by investors when the longer bond becomes a shorter one with passage of time. Therefore, fixed income investors would not always invest in bonds with maturity matching their investment horizon but instead might consider longer tenor bonds. A number of studies covered this “riding the yield curve” concept, including Dyl and Joehnk [1981], Osteryoung, McCarty and Roberts [1981], and Grieves and Marcus [1992]. They concluded that such approach produces higher averaged return in the US Treasury market, compared to simply holding bonds with matching investment horizon. Ang, Alles and Allen [1998] also derived similar results from cross-country fixed income data.

As the understanding of carry trades in FX and rolling yield in fixed income become more established, a few recent academic publications have offered more cross-market evidence and in-depth analysis of the carry concept.

Koijen et al. [2018] offered a generalized definition of carry across various asset classes where a security’s expected return is decomposed into its carry and expected price appreciation. In fixed income a bond’s carry consists of the “slope“ (the bond’s yield spread to the risk-free rate) and the “roll down” (the price increase due to the bond rolling down the yield curve and as leveraged by the duration). This approach is in line with the yield plus rolling effect aggregate return defined by Leibowitz and Homer [1972]. For the credit market, a comparable definition is proposed based on the combination of the credit spread and the roll down along the credit spread curve. While details are not provided on how the credit curve is constructed, this is an approach for the credit space that we will revisit in this paper.

Koijen et al. [2018] also noted that compared with other asset classes, the fixed income carry factor was more strongly correlated to the traditional predictor for fixed income, namely the yield spread to the risk free-rate. In addition, the return predictability of the carry factor came primarily from the carry component compared to a lesser impact from the price change component.

Adopting a similar core concept as Koijen et al. [2018], Coche et al. [2018] chose to explore further by constructing yield curves with more maturity points and developing a curve-based carry. They utilized broader and longer historical data sets on ten developed economies spanning over 40 years, and showed higher carry bring greater return in cross-market and cross-curves results.

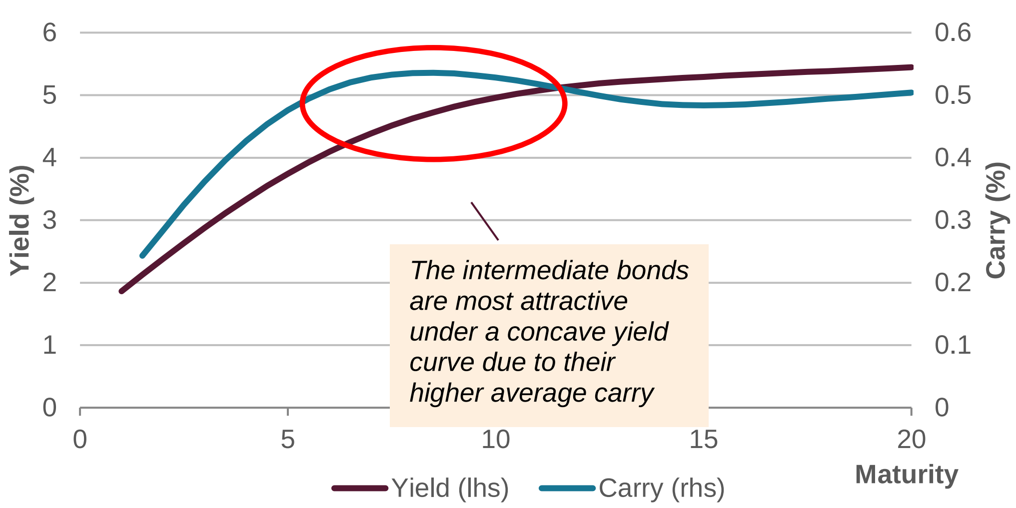
Another unique study by Kikugawa et al. [2017] focused on the application of fixed income carry to the Japanese government bond market. They introduced the term "CaRD", an acronym standing for "Carry" (the income gain generated from the bond's current yield) and "Roll-Down" (the capital gain coming from the bond rolling down the yield curve). The definition again echoed the approximation of Koijen et al. [2018] for global bonds: a combination of components of "slope" plus the "roll-down". This CaRD approach was explored as a long-short investment strategy with an interest risk matching constraint and tested on JGB portfolios. It was found to be an effective factor in delivering outperformance over comparable JGB funds. In this paper we will also touch on the outperformance observed with the application of such carry and roll-down concept, albeit on a long-only basis, with a similar duration constraint applied on a simulated global sovereign portfolio using the highly-recognized FTSE World Government Bond Index as the base universe.

## Selective allocation to the high carry segments of the yield curve

Typically yield curves are upward sloping as investors require higher interest for longer maturity bonds to compensate for the higher inflation and interest rate risks. These yield curves are referred as the "normal" yield curves. Without the roll-down component, carry would simply increase with the extension of maturities. However the addition of roll-down to target the broader carry factor changes the picture. The extra roll-down component reflects the impact of the slope and curvature of the yield curve.

For markets with a concave yield curve, some of the intermediate-term bonds can be more attractive from a carry factor perspective than the long tenor bonds. Exhibit 2 below illustrates how the steeper yield curve for the shorter to medium tenors leads to the intermediate-term bonds having a higher carry factor as they benefit from a higher expected price pick up from the faster roll-down.

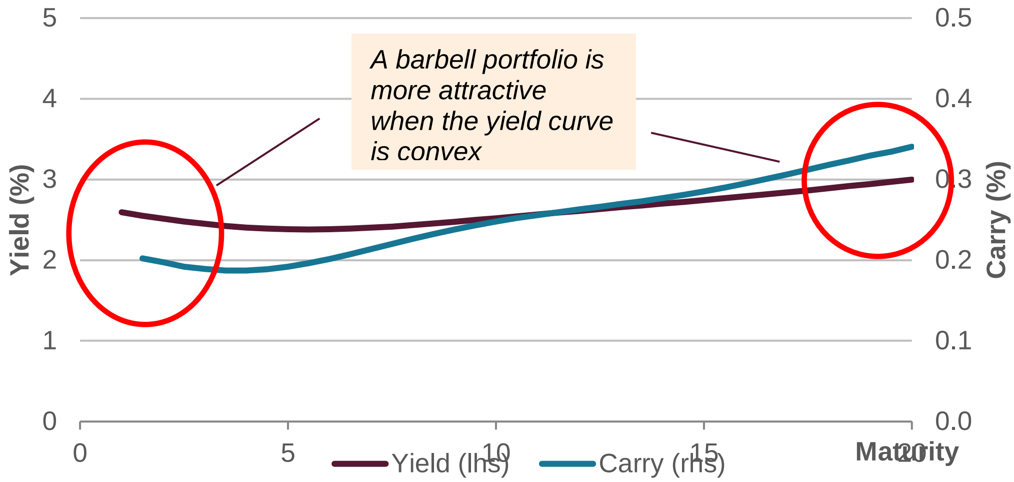
**Exhibit 2: Maximizing the Projected Carry under a Concave Yield Curve**




Source: FTSE Russell

Conversely, the yield curve can also have a convex curvature. In such instance the yield of the intermediate-term bonds is lower than the average yield of the short and long end of the curve. In the event of an upward-sloping yield curve that is convex from below the suitable carry factor strategy can be a very wide barbell investing in short-term bonds at one end of the curve and in long-term bonds at the other end that maintains a medium-term duration on average, as illustrated in Exhibit 3.

**Exhibit 3: Maximizing the Projected Carry under a Convex Yield Curve**




Source: FTSE Russell

Under certain market conditions, even when the yield curve is convex, the carry of the short end is higher than that of the intermediate bonds but lower than the long end. Nonetheless the short maturity bonds are still included into the barbell portfolio to balance the duration. Unless one seeks to express a directional view of the yield curve movement, typically bond investors look to stay relatively close to the duration of the benchmark to avoid excess interest rate risk.

In short the approach we are seeking is one that can increase the carry factor exposure while maintaining the same interest rate exposure. The most efficient way to achieve this goal is through an optimization process that will create a portfolio of bonds that maximizes the aggregate carry subject to a set of constraints where outright shorting is not allowed and the portfolio and the starting index durations are matched so that out-performances are not attributable to differences in interest rate exposures.

The portfolio is re-optimized and rebalanced on a monthly basis - in accordance with the index rebalance schedules - based on the prevailing yield curve at the time. This ensures that the duration of the portfolio remains close to that of the benchmark through time.

Before we evaluate the carry concept in various markets, it is worth clarifying our terminology between the "carry factor" and the "carry approach". As we introduced earlier, the carry factor defined by the combination of the yield carry and the curve roll-down effect is an attribute that can be used to explain some returns and risk of bonds in relation to the yield curve. While it may be less widely known and understood compared to the traditional factors introduced in the equity space, nevertheless the carry and roll-down has been known to bond market practitioners and recognized by the academic literature as a fixed income "factor" for some time. There can be many ways to capture and leverage this factor however. In the above, we stated our preference for one such manner whereby we would use an optimization process to maximize the targeted exposure to the carry factor while at the same time staying duration neutral. This is what we will refer to as our chosen carry approach in the sections to follow. It is one of many possible approaches to capture the carry factor.

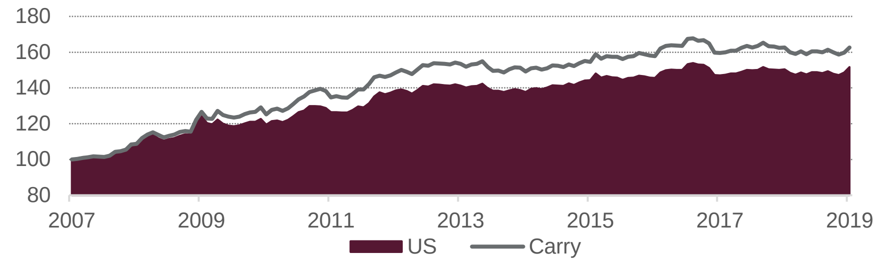
# Implementing a carry approach in the global sovereign space

## Issue-level optimization: Full security selection flexibility

The above mentioned approach is replicated in five government bond markets over a twelve-year historical period from the beginning of 2007 to the end of 2018 and as such the results cover the latest great financial crisis. The chosen markets are the US, Japan, Germany, Italy and the UK, which we've informally dubbed the "G5". No extra constraint is added to the optimization. In this variant the optimization is allowed to freely pick and reweight individual bonds in each country.

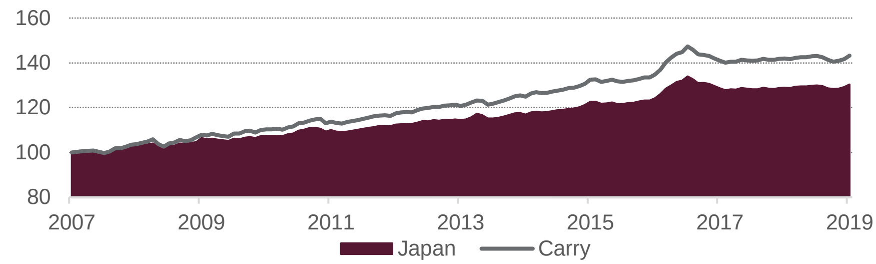
**Exhibit 4: G5 Government Bond Carry Optimization Performance – Issue Level Optimization**

## United States



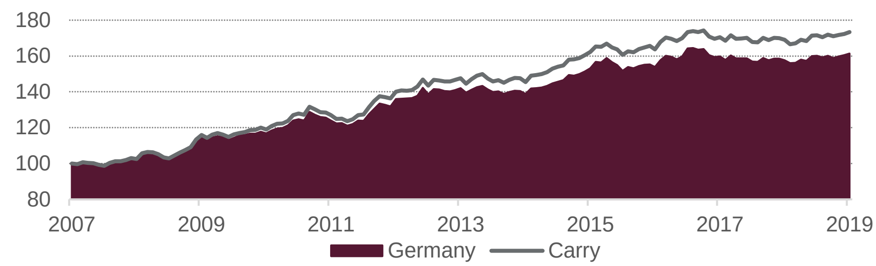

| | US | Carry |
|---|---|---|
| Ann Ret | 3.53% | 4.14% |
| Ann Vol | 4.07% | 4.48% |
| Ret/Vol | 0.87 | 0.92 |
| % Positive | 54.9% | 59.0% |
| Max DD | -4.4% | -5.5% |

## Japan



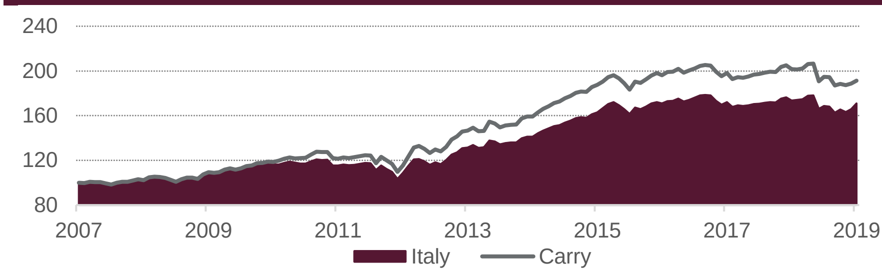

| | Japan | Carry |
|---|---|---|
| Ann Ret | 2.23% | 3.04% |
| Ann Vol | 2.02% | 2.32% |
| Ret/Vol | 1.10 | 1.31 |
| % Positive | 66.0% | 70.8% |
| Max DD | -4.6% | -4.9% |

## Germany



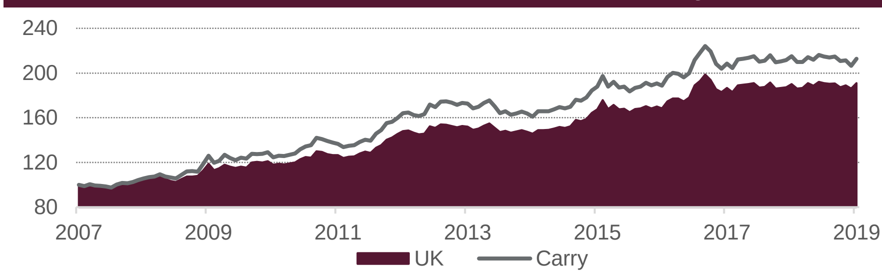

| | Germany | Carry |
|---|---|---|
| Ann Ret | 4.06% | 4.69% |
| Ann Vol | 4.22% | 4.28% |
| Ret/Vol | 0.96 | 1.09 |
| % Positive | 59.0% | 60.4% |
| Max DD | -5.9% | -6.0% |

## Italy




| | Italy | Carry |
|---|---|---|
| Ann Ret | 4.57% | 5.55% |
| Ann Vol | 6.48% | 7.28% |
| Ret/Vol | 0.71 | 0.76 |
| % Positive | 66.0% | 66.0% |
| Max DD | -14.4% | -14.2% |

## United Kingdom




| | UK | Carry |
|---|---|---|
| Ann Ret | 5.53% | 6.49% |
| Ann Vol | 6.70% | 7.60% |
| Ret/Vol | 0.83 | 0.85 |
| % Positive | 60.4% | 61.1% |
| Max DD | -7.9% | -9.0% |

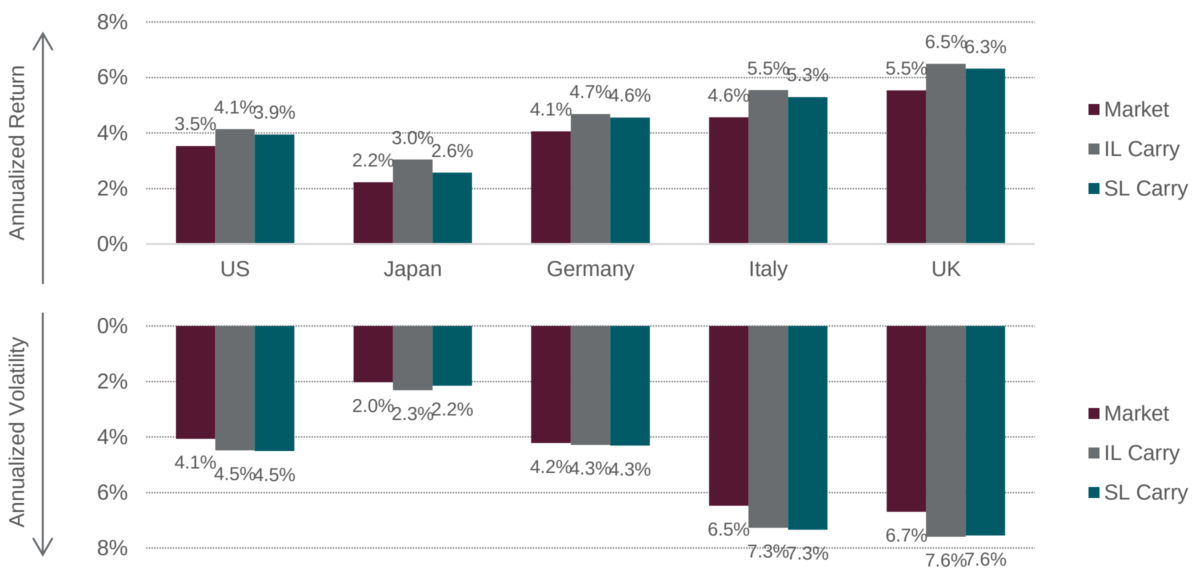
* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

In Exhibit 4 notable out-performance is observed in all 5 markets with improvements in both return and return-to-volatility ratio. However, this optimization variant, unconstrained in security selection, often ends up choosing just two bonds in each market – those bonds which in combination provide the highest carry while matching the duration of the underlying index. This may be uncomfortably radical for many bond investors who typically prefer to hold a larger and therefore more diversified portfolio of bonds. In order to avoid this concentration risk, we consider in the following section a variant that ensures the optimization is no longer performed at the individual issue level but at the sector level, meaning here by bond maturity buckets.

## Sector-level optimization: A less radical, more realistic implementation

Instead of allocating to individual bonds, the approach is now modified to allocate to maturity sub-sectors. The optimal portfolio is constrained to allocate between a defined set of maturity buckets: 1-3, 3-5, 5-7, 7-10, 10-15 and 15+ years. For example when the optimizer chooses to allocate to the 1-3 year bucket, it must buy all the bonds in the sector in amounts proportional to those in the underlying index.

**Exhibit 5: G5 Government Bond Carry Optimization Performance – Sector Level Optimization***




* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

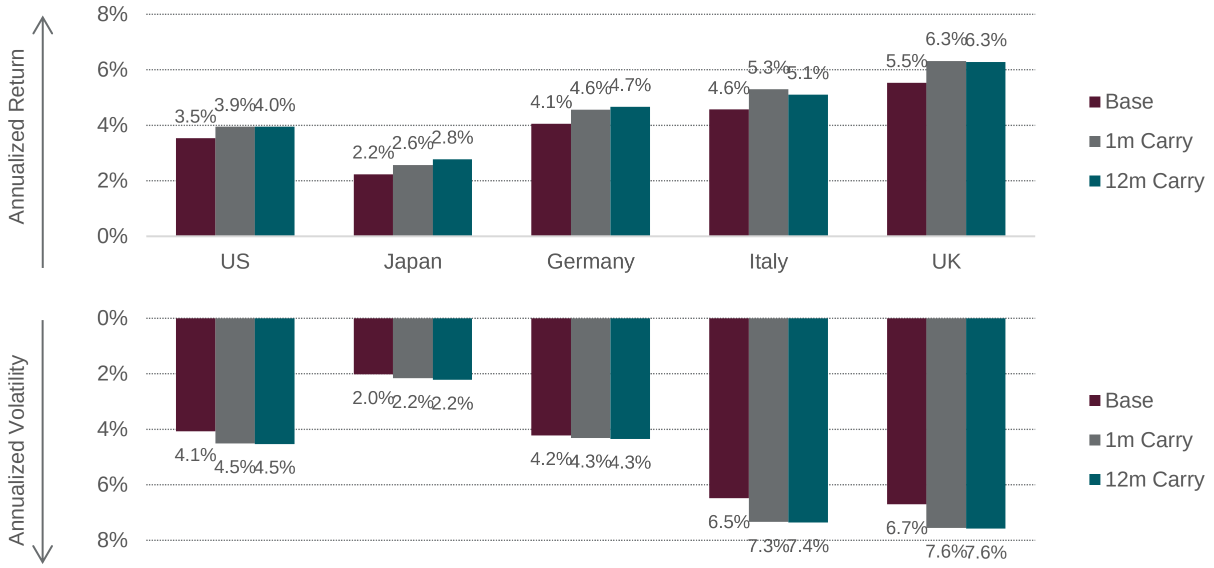
In Exhibit 5 the impact of applying the sector level constraints on return and volatility is observed. These approaches (SL Carry, for Sector Level optimisation) did not out-perform to the same extent as in the earlier variant (IL Carry, for Issue Level optimisation) when individual bonds could be purchased. This is unsurprising as the imposition of further constraints must result in a solution which is no more optimal than the less-constrained case and we would expect this to translate into an impact on performance. Nevertheless over the past twelve years the performance of the carry approach, even implemented at the sector level, can be observed. While returns of the sector constrained variants are slightly lower than that of the issue level optimizations, they are still showing out-performance over the base indexes and achieved via a less concentrated portfolio-based investments which most investors would prefer.

For the rest of our paper we adopt this sector level optimization as our preferred approach and we go through several technical variations to analyse the factor's sensitivity and robustness.

## Variation on the carry horizon – 12 month rolling yield

The first variation is on the choice of carry horizon. In the standard definition the carry factor is calculated under a one-month horizon to match the rebalance frequency of the benchmark index. However in cases where changes in yield curves on a month-to-month basis may not be significant, one may wish to consider a longer horizon. Though the portfolios are still re-optimized on a monthly basis so as to maintain duration close to the index, the allocations to the respective maturity buckets may prove to be more stable. Thus this approach could help reduce turnover levels. We therefore re-ran our historical back-test using an alternatively-defined carry factor based on a 12-month horizon.

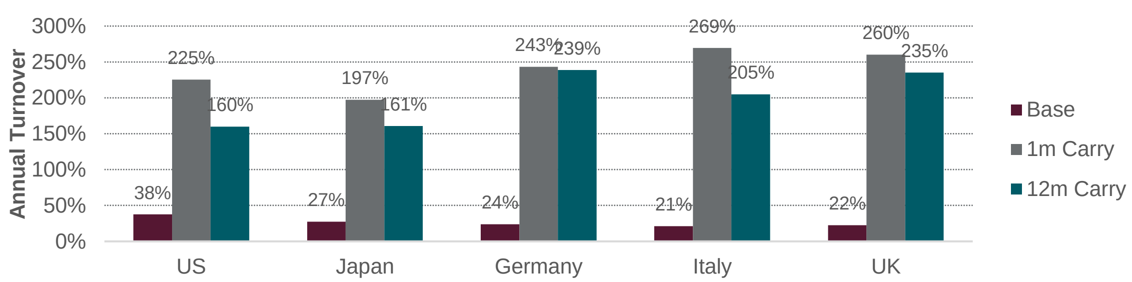
**Exhibit 6: G5 Government Bond Carry Optimization Performance – Carry with 12-Month Horizon***




* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

From a return perspective, the 12-month carry is generally in line with 1-month carry. Results in Exhibit 6 show similar performance in the US, Germany and the UK. Japan has better performance under 12-month carry while Italy has worse. On the volatility front, the choice of a 12-month versus 1-month carry horizon doesn't appear to lead to noticeable differences under a monthly duration matching approach.

**Exhibit 7: G5 Government Bond Carry Optimization Turnover**




Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

From the turnover perspective, while one would expect that the turnover of such optimisation-based alternatively-weighted approach would be clearly above that of the standard market cap weighted reference indexes (base), the benefit of using a 12-month carry horizon (12m Carry) instead of a 1-month horizon (1m Carry) is more pronounced than the impact that could be observed from a return or volatility perspective. As mentioned earlier, stability in the yield curves would translate into stability in the monthly re-composition of the optimal portfolio when using a longer carry horizon. In Exhibit 7, turnover is reduced noticeably for all G5 countries when the portfolio is optimized based on 12-month carry. This allows investors to target potential outperformance from an optimisation-based exposure to the carry factor, while realistically accounting for the turnover that would naturally be generated by such approaches. From an index perspective, this turnover consideration is included in the FTSE Nomura CaRD World Government Bond Index Series methodology which comprises indexes that aim to target exposure to the carry factor on a universe of global sovereign bonds.[2]

## Variation on the bond universe – long-end optimization

The second variation is on the base universe. The earlier analysis showed that the carry factor can be captured throughout the entire yield curve. Would our approach work when considering only a subset of the curve? In particular we wanted to investigate applying the carry approach at the long-end of the curve, as this is the part that is relevant for pension funds and life insurance companies who often seek longer assets to match the duration of their liabilities.

**Exhibit 8: G5 Government Bond Carry Optimization Performance – Long Maturity**

| Performance Statistics (5 year+) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | US | US-C** | JP | JP-C | DE | DE-C | IT | IT-C | UK | UK-C |
| Ann Ret* | 5.02% | 5.11% | 3.37% | 3.80% | 5.71% | 5.90% | 5.22% | 5.55% | 6.52% | 7.19% |
| Ann Vol | 7.56% | 7.87% | 3.18% | 3.26% | 6.81% | 6.94% | 8.54% | 9.08% | 8.80% | 9.33% |
| Ret/Vol | 0.66 | 0.65 | 1.06 | 1.16 | 0.84 | 0.85 | 0.61 | 0.61 | 0.74 | 0.77 |
| % Positive | 54.9% | 53.5% | 63.9% | 67.4% | 59.0% | 58.3% | 61.8% | 61.1% | 59.7% | 61.1% |
| Max DD | -9.1% | -9.8% | -6.5% | -6.1% | -9.5% | -9.4% | -19.0% | -19.4% | -10.6% | -11.1% |
| **Performance Statistics (10 year+)** | | | | | | | | | | |
| | US | US-C | JP | JP-C | DE | DE-C | IT | IT-C | UK | UK-C |
| Ann Ret* | 6.12% | 6.09% | 4.19% | 4.31% | 6.88% | 6.94% | 5.63% | 6.05% | 7.13% | 7.52% |
| Ann Vol | 11.56% | 11.55% | 4.47% | 4.44% | 10.18% | 10.08% | 10.20% | 10.24% | 10.66% | 10.73% |
| Ret/Vol | 0.53 | 0.53 | 0.94 | 0.97 | 0.68 | 0.69 | 0.55 | 0.59 | 0.67 | 0.70 |
| % Positive | 55.6% | 55.6% | 61.8% | 62.5% | 56.3% | 56.3% | 60.4% | 61.1% | 59.7% | 61.1% |
| Max DD | -16.2% | -16.2% | -8.5% | -8.3% | -13.6% | -13.5% | -21.7% | -20.8% | -12.7% | -12.7% |

* Transaction costs are not excluded from the annualized returns. ** '-C' represents the carry approach of the corresponding universe
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Exhibit 8 presents the results of the carry approach when applied to the 5 year+ and 10 year+ parts of the yield curves of the respective G5 countries. We observe lower consistency in the performances across markets. For example, the US didn't see much improvement as its curve is relatively flat in the long tenors. Japan demonstrated out-performance with a 5 year+ universe, but the marginal out-performance observed with the 10-year+ universe would hardly justify this narrower approach, especially when accounting for transaction costs. While a similar carry approach focused on a targeted sector of the yield curve can be applied to different universes with ease, its effectiveness across different markets is dependent on the patterns of those particular subsets of the yield curves.

[2] For details, see https://yieldbook.com/m/indices/single.shtml?ticker=NOMUCARD

## Variation on the optimization constraint – capping bucket weights

The third variation is on the optimization constraint. Currently the optimization only requires bucket weights to be non-negative. In other words when the average duration is matched certain buckets can take up the entire country with their weights allowed to fluctuate between 0% and 100% month to month.

While large turnover is less concerning in the sovereign market because of the typically tight bid-ask in this liquid space, in the below variation we explore curbing the turnover by capping the bucket weights at 200% of their natural market value weights and assess the impact on performance.

**Exhibit 9: G5 Government Bond Carry Optimization Performance – With Bucket Weight Caps**

| Performance Statistics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | US | US-C** | JP | JP-C | DE | DE-C | IT | IT-C | UK | UK-C |
| Ann Ret* | 3.53% | 3.89% | 2.23% | 2.58% | 4.06% | 4.41% | 4.57% | 5.01% | 5.53% | 5.97% |
| Ann Vol | 4.07% | 4.31% | 2.02% | 2.13% | 4.22% | 4.26% | 6.48% | 7.19% | 6.70% | 6.99% |
| Ret/Vol | 0.87 | 0.90 | 1.10 | 1.22 | 0.96 | 1.03 | 0.71 | 0.70 | 0.83 | 0.85 |
| % Positive | 54.9% | 58.3% | 66.0% | 68.1% | 59.0% | 61.8% | 66.0% | 65.3% | 60.4% | 61.8% |
| Max DD | -4.4% | -4.8% | -4.6% | -4.7% | -5.9% | -5.9% | -14.4% | -15.6% | -7.9% | -8.1% |
| Turnover | 37.5% | 66.1% | 27.4% | 101.7% | 23.9% | 85.9% | 21.2% | 70.5% | 22.4% | 51.3% |

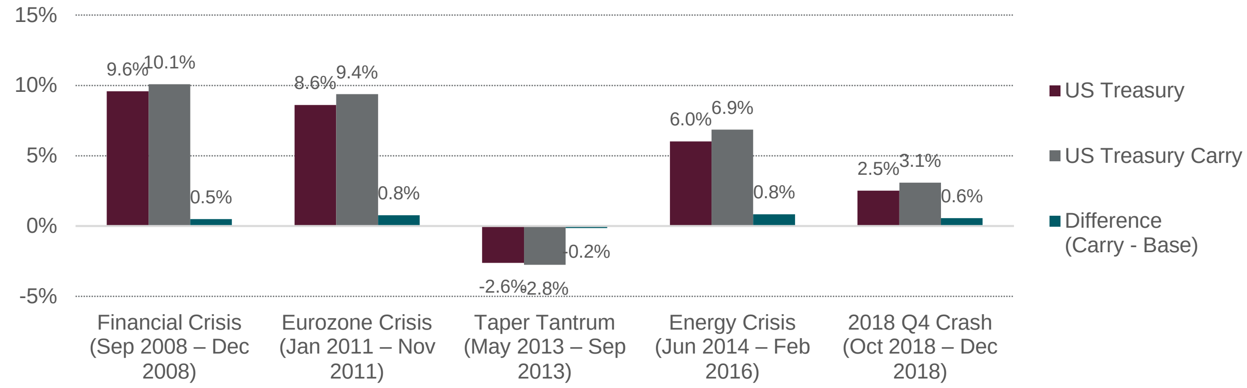
* Transaction costs are not excluded from the annualized returns. ** '-C' represents the carry approach of the corresponding universe
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Between Exhibit 7 and Exhibit 9 turnover is more than halved after the introduction of bucket caps in most countries. Japan is the only exception however its turnover still noticeably reduced from 197% to 102% per annum. Meanwhile compared with Exhibit 6 the performance is only affected marginally. UK had the largest drop in excess return by 35 bps; however at the same time its volatility also reduced by 57 bps, resulting in an improvement in its return-to-volatility ratio. In short adding bucket caps is a worthwhile feature to consider for practical implementation and to limit turnover.

## How does the carry approach behave during the crisis periods?

As we have shown, targeting carry would have generated attractive excess returns in several government bond markets. However, the period of our back-test from 2007 to 2018 is predominantly one of falling rates, due not least to quantitative easing and other central bank-led economic stimuli. When this picture was interrupted in the taper tantrum of 2013, for example,  the carry approach applied in the US experienced periods of underperformance. One might question whether with our chosen approach this factor is a pro-cyclical one similar to what we noted in our value factor paper - moving in accordance to the market direction with potentially larger exposure towards the downside. To evaluate this, in the below we focus on the US market and zoom into the recent crisis periods.

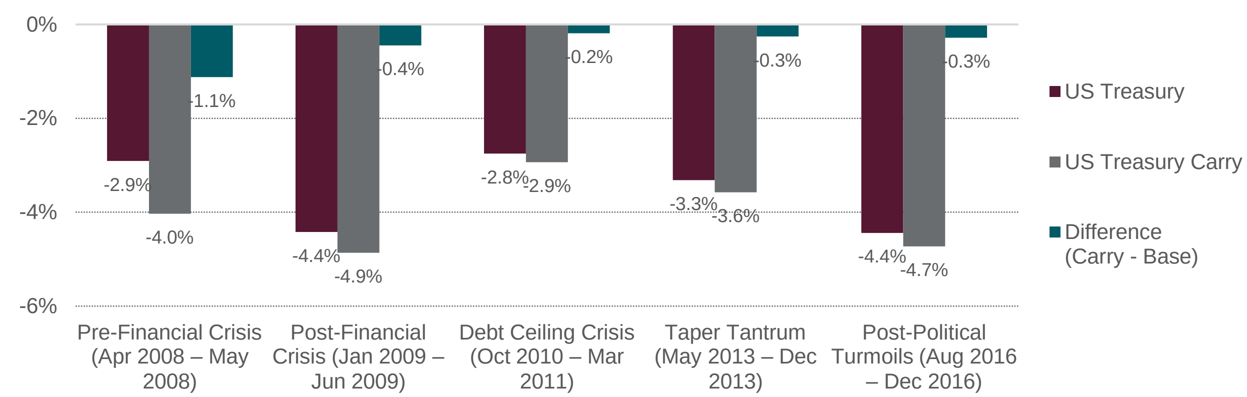
**Exhibit 10: US Carry Optimization Performance – Normal Crisis Periods**




Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Exhibit 10 analysed the recent five widely known crises for the risky assets such as equities. Four out of the five such broad market crisis periods turn out to be bull markets for the US treasuries. During those risk-off periods panicked investors increased their US treasury holdings in a flight to safety reaction. Against these backdrops the carry factor further out-performed the base US treasury universe. Amongst the five crises shown in Exhibit 10, US treasuries only suffered losses during the taper tantrum in 2013. Indeed during that period the disruption started from the treasury market itself and the carry factor also underperformed. Therefore instead of looking at the crises of the equity and credit markets, in the following we will focus on the treasury-specific bear markets only and see how the carry factor performed then comparatively.

**Exhibit 11: US Carry Optimization Performance – Treasury Crisis Periods**




Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

The treasury crisis periods usually take place either when there are substantial rate hikes at the back of strong economic growth, or after major market, economic or political events where uncertainties recede and investors switch to being risk-on again. Exhibit 11 includes the past five treasury crises. As expected there were declines in treasuries. However during the same period the carry factor performed worse.

When we put together our observations from the broad market crises vs. the US treasury specific ones, we conclude that the sovereign carry factor - as tested using our chosen approach - is a pro-cyclical factor to the sovereign market. The factor and the relate approach performed better when the government bonds performed well. However during the recent broad market crises, we observe the carry approach provided some diversification relative to allocations to risky assets.

## How does the carry approach fare when yields are rising?

The historical period we've used for back-testing begins soon before the crash of 2008, and rates have fallen secularly over much of the time since then. Has the historical out-performance of our approach been boosted by this effect? How would the same bond and sector-level approaches have performed if history were reversed?

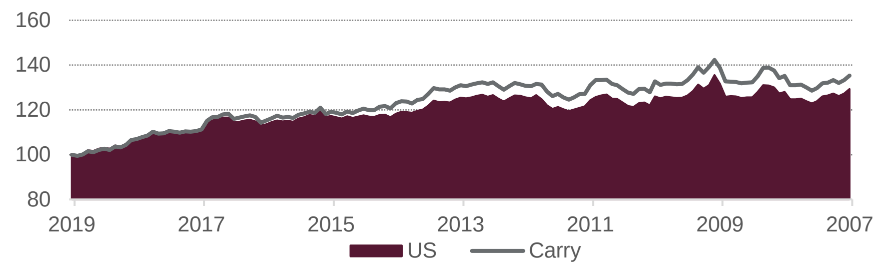
We investigated the performance of the same approaches as tested above in the situation that, over the course of each month, yields moved to where they were at the start of the preceding month. Such manufactured yield movements effectively exposed the optimal portfolios to a predominantly rate-rising environment. In this hypothetical analysis all the bonds in the index, and in our optimal portfolios, are at the end of each month therefore marked against the yield curve that in reality prevailed two months previously. In this way history is "reversed" a month at a time, with the starting yield curve each month the same as in the original analysis. This in turn means that the optimal portfolio for exposure to the carry factor is unchanged from the previous analysis and we are comparing "like with like".

In addition, note that the "end of month" yield curves would no longer match the "start of month" curves for the following month if the history is simulated in the normal sequence. Therefore we show the charts and monthly returns with a reversed calendar from the beginning of 2019 to the beginning of 2007. It achieves the desired effect that the portfolios and indexes are ultimately exposed to the full increase in rates over the reversed period.

Exhibit 12 below shows the results of how the simulated portfolios and indexes performed under this hypothetical situation.

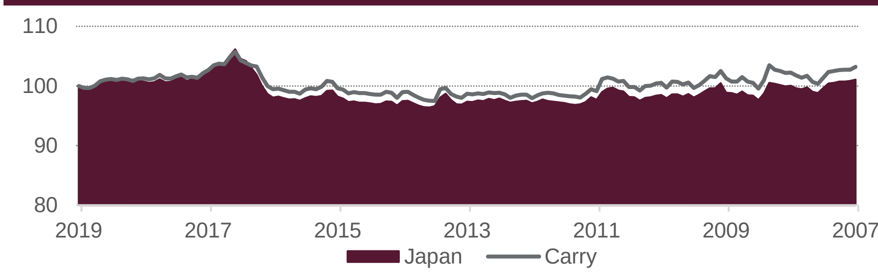
**Exhibit 12: G5 Government Bond Carry Optimization Performance – Backward Simulation**

## United States



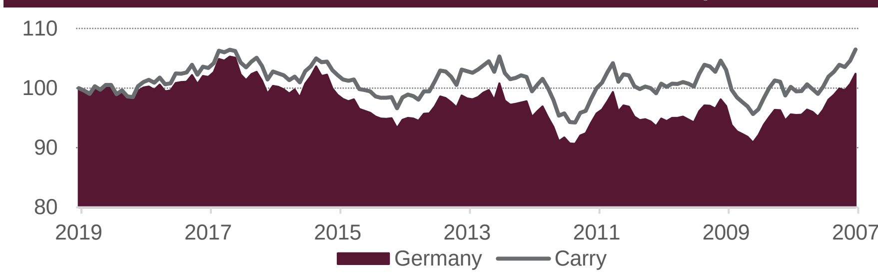

| | US | Carry |
|---|---|---|
| Ann Ret | 2.16% | 2.55% |
| Ann Vol | 3.95% | 4.30% |
| Ret/Vol | 0.55 | 0.59 |
| % Positive | 57.6% | 60.4% |
| Max DD | -9.4% | -9.6% |

## Japan



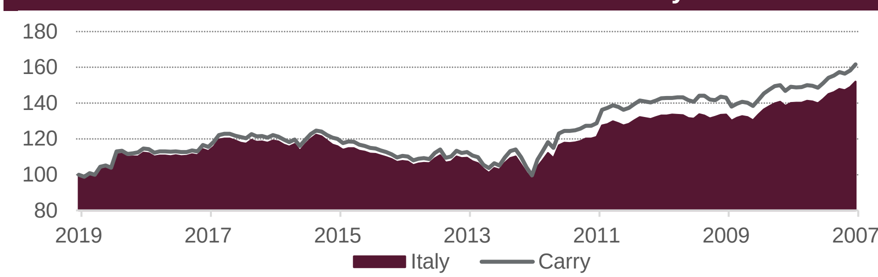

| | Japan | Carry |
|---|---|---|
| Ann Ret | 0.09% | 0.26% |
| Ann Vol | 1.99% | 2.18% |
| Ret/Vol | 0.04 | 0.12 |
| % Positive | 49.3% | 47.9% |
| Max DD | -9.2% | -7.8% |

## Germany



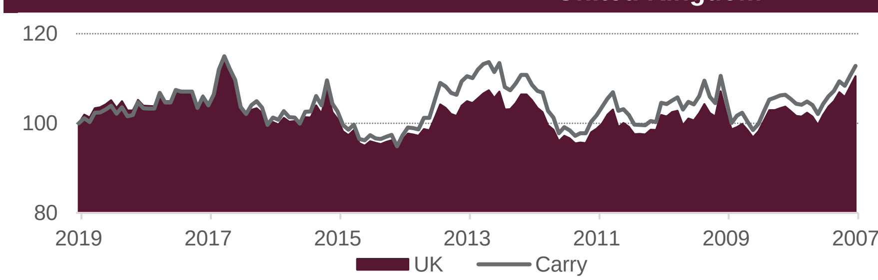

| | Germany | Carry |
|---|---|---|
| Ann Ret | 0.20% | 0.52% |
| Ann Vol | 4.18% | 4.27% |
| Ret/Vol | 0.05 | 0.12 |
| % Positive | 50.7% | 48.6% |
| Max DD | -13.9% | -11.5% |

## Italy




| | Italy | Carry |
|---|---|---|
| Ann Ret | 3.55% | 4.08% |
| Ann Vol | 6.60% | 7.32% |
| Ret/Vol | 0.54 | 0.56 |
| % Positive | 53.5% | 52.8% |
| Max DD | -20.5% | -20.1% |

## United Kingdom




| | UK | Carry |
|---|---|---|
| Ann Ret | 0.83% | 1.01% |
| Ann Vol | 6.53% | 7.42% |
| Ret/Vol | 0.13 | 0.14 |
| % Positive | 49.3% | 51.4% |
| Max DD | -17.1% | -17.5% |

* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Against the synthetic backdrop of rising rates the carry factor portfolios once again out-performed their indexes. In the cases of the US and Italy the out-performance were fairly close to the equivalent “normal time” sector-level optimization results. In the Japanese, German and UK cases, where yields have been less volatile, the out-performance decreased but nevertheless remained clear.

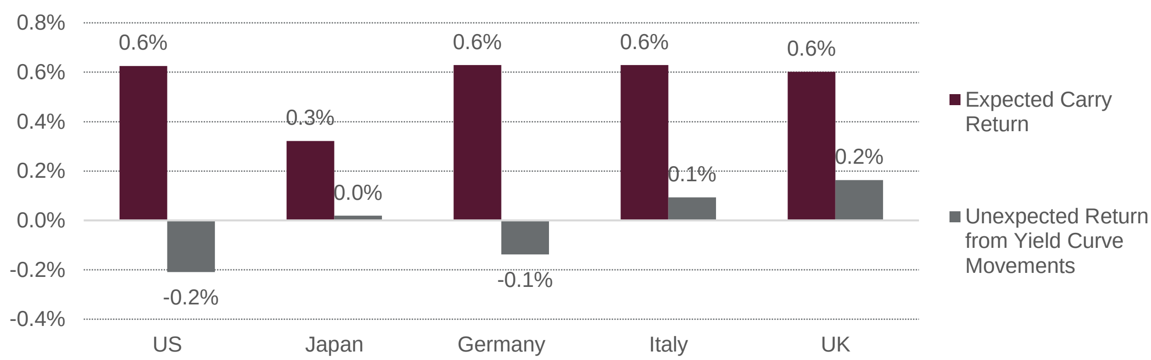
Recall that the optimal carry factor portfolio is often a barbell. Nevertheless the convexity of these portfolios is usually lower than that of the underlying index. Therefore it is not the case that the out-performance of the approach is simply due to convexity. Whether yields rise or fall, convexity always works to the benefit of the bond holder, so it might have been supposed that this would have explained the out-performance of the carry factor against back-drops of both falling and rising yields. In fact the reality is more subtle than that: as described above the carry factor allocations target specific parts of the yield curve and rely on some persistence in their shape over the investment horizon.

## Attribution of the excess return from a carry perspective

As the out-performance was only marginally affected in the backward simulation, there must be a significant and consistent source of additional return embedded in the carry factor portfolios. Here we switch back to the “normal time” sector-level optimizations. The analysis will focus on the base case where the carry factor is defined under a one-month investment horizon and bucket weights are not capped.

The traditional return attribution would have divided the realized returns into income return from accumulating the interest, and principal return from price movement. Under the concept of carry bond price has an expected movement due to rolling down the curve. Therefore we re-split the realized return into the expected carry return and the unexpected return from yield curve movements owing to deviations from the assumption of constant yield curve. The investment horizon of carry calculation is the same as the actual holding period of the optimal portfolios, making those factors reusable in the return attributions.

**Exhibit 13: Attribution of the Annualized Excess Return of the Carry Factor Portfolios**




* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in local currency. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

As demonstrated in Exhibit 13, the expected return from carry has been the dominating source of the excess returns. Those carry-based returns can be reliably assessed at the beginning of the holding periods with limited uncertainty. In contrast, regardless of whether being positive or negative in different countries, the remaining unexpected returns are small and volatile. They are the major source of volatilities in the excess returns. Recall that we applied the same optimal portfolios in the backward simulations. The same expected returns from carry also accounted for the majority of the out-performance in the reverse simulations.

# Extending the analysis of carry to corporate bonds

## Definition of corporate carry

The earlier part of the paper analysed the carry facto concept applied to the sovereign bond space. We now explore whether the same concept extends equally well to the corporate bond space. We maintain the same underlying principle whereby the carry factor is defined as the expected return one could earn by holding the fixed income asset assuming nothing changes but the passage of time. When applied to corporate bonds in a similar fashion as within the sovereign space such carry factor definition involves two components:

$$E[r_t] = \underbrace{y_t^{\tau}}_{Level} \times \Delta t - \underbrace{Dur_t \times (E[y_{t+\Delta t}^{\tau-\Delta t}] - y_t^{\tau})}_{Roll\ Down}$$

$$where$$

$$E[r_t]: expected\ carry\ factor\ return$$

$$y_t^{\tau}: level\ at\ time\ t\ with\ remaining\ tenor\ \tau$$

$$\Delta t: calculation\ horizon\ \ (one\ month\ in\ the\ context\ of\ this\ paper)$$

$$Dur_t: duration\ (effective\ duration\ in\ the\ context\ of\ corproate\ bonds)$$

$$E[y_{t+\Delta t}^{\tau-\Delta t}]: expected\ level\ at\ the\ end\ of\ the\ time\ horizon, which\ is\ assumed\ to\ be\ equal\ to\ y_t^{\tau-\Delta t}$$

$$y_t^{\tau-\Delta t}: current\ level\ of\ bond\ with\ remaining\ tenor\ \tau - \Delta t$$

In the earlier sovereign case the definition is clear that the "Level" is simply the yield to maturity while the "Roll-Down" is based on the treasury yield curve. However in the credit market both of them can have multiple interpretations:

- **Level:**

  1) Yield to maturity, inclusive of treasury rate and corporate spread, or

  2) Corporate spread only, i.e. the option-adjusted spread (OAS)

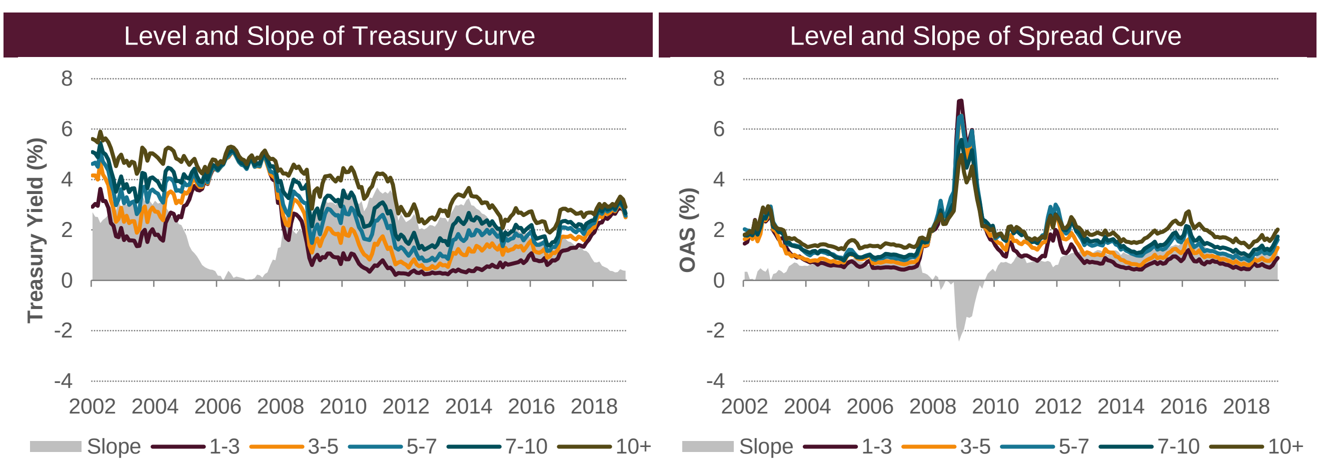
- **Roll Down:**

  1) Rolling down the treasury curve assuming constant OAS, or

  2) Spread rolling down the corporate spread curve as well

As we analysed in the sovereign space, the slope and curvature of the yield curve are the main drivers of the excess performance of the carry factor. The roll-down component is only meaningful when there is an appreciable slope in the yield curve, i.e. a noticeable difference between the short-end and long-end levels. However, in most cases the credit spread curve is much flatter than the treasury curve. In the below we discuss whether consideration to the roll-down component from the credit curve should be considered at all.

**Exhibit 14: Level and Slope of Treasury and Spread Curves**



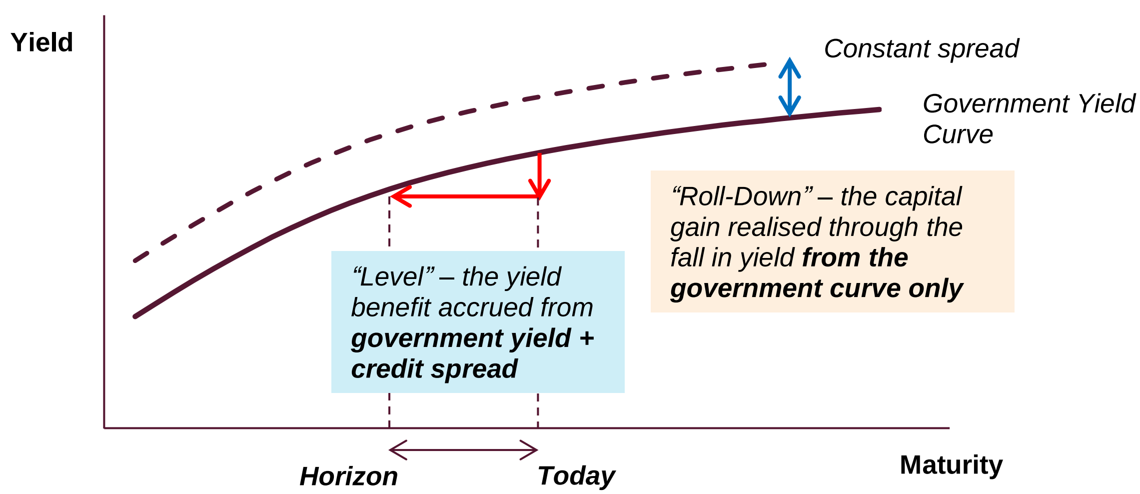

Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Exhibit 14 shows the level and slope of the treasury and spread curves corresponding to the US Investment-Grade corporate universe where the slope is calculated as the difference in treasury yield or spread between the 1-3 year and 10 year+ buckets for simplicity. From the charts one can observe that the slope of the treasury curve is more significant than the credit curve. Between 2002 and 2018, the slope ranged from -0.01% to 3.69% for the treasury curve, and from -2.43% to 1.54% for the spread curve. The average slope was 1.99% for rates and only 0.71% for credit. Therefore the impact of adding the roll-down from the credit curve to the corporate carry factor may be limited.

Furthermore, there is no clear or accepted approach to building credit curves that can effectively capture the credit roll down. This may be the reason why the availability of detailed information on how the credit curve is constructed and the model evaluated may have been limited in the paper of Koijen et al. [2018]. While the treasury curve has a single issuer with a single rating, building the credit curve is much more complicated – involving multiple issuers, multiple credit ratings and multiple industries. Using an issuer-based credit curve might be most relevant; however the curve can also be over-fitted and require extensive interpolations between outstanding issues. Conversely using an industry-wide curve has more available data points; however the curve will be constantly affected by the pattern of new issuance. With these considerations, in this paper we decide against having the spread varying down the credit curve to keep the analysis and the definition of the corporate carry factor simple.

Looking at the "Level" element of the carry factor definition, the question remains whether the corporate carry factor should be yield-based (inclusive of both the treasury rate and the OAS) or spread-based only. If one were to focus solely on the spread, the carry factor definition would essentially equate to OAS without the roll-down of the credit curve as per our earlier choice. However, the carry factor is arguably more suitable for long-only investors who don't hedge their rates exposures by shorting corresponding treasury futures. In this case the factor would embed more information when combining the rate and credit components in its definition; and it is in line with the total expected return from holding the bonds in the portfolio.

**Exhibit 15: Carry For Corporate Bonds**




Source: FTSE Russell

In conclusion, within the corporate sector we choose to define the carry factor by the combination of treasury rate and corporate spread with the addition of rolling down the treasury curve assuming constant OAS. This definition also has the benefit of maintaining consistency with the definition of carry factor in the sovereign space.

In the next section we will carry out a detailed study of applying the carry factor to the US investment-grade corporate universe and subsequently compare high-level results with other markets. Similar to the approach in the sovereign market, the corporate carry will be applied through an optimization process. Considering that the carry factor looks to exploit the shape of the entire yield curve, an approach based on inter maturity buckets comparison and optimization should in theory extract more premium from the term structure of the yield curves.

## Optimization approach with different degrees of freedom

As with our choice for the sovereign space, when it comes to our approach to corporate bonds we also choose to focus on sector-level optimizations to avoid overly concentrated portfolios of individual bonds. As discussed in the sovereign section, a sector level approach provides practical flexibility for investors to choose representative bonds in the bucket that they can source from the market. This rationale becomes even stronger in the corporate space as liquidity and price quality can vary significantly between individual issues.

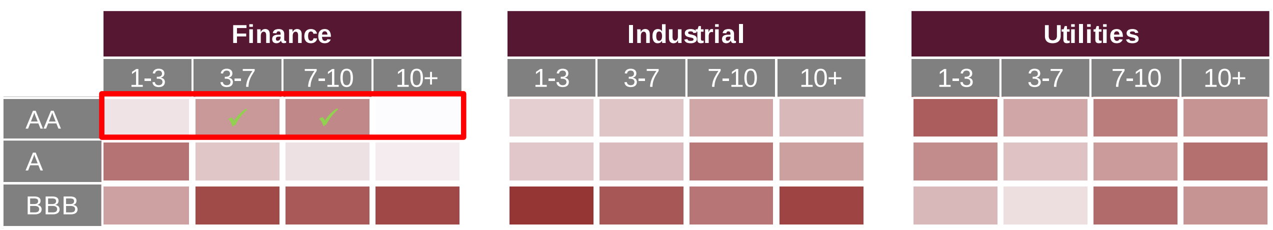
Unlike the one-dimensional optimization on different maturity buckets for the sovereign bonds, in the corporate space there can potentially be three dimensions: credit rating, maturity and industry. The exposure to all three dimensions should be maintained so as not to introduce additional noise from sector bias.

However there are multiple ways of implementing such optimizations with different degrees of freedom:

- **V1: Credit rating and industry neutral, duration matched**

  Divide the bond universe into credit rating x industry buckets. Run one-dimensional optimizations within each bucket ensuring that the average duration within the bucket is matched with the duration of the corresponding bucket in the starting universe. It is comparable to the earlier sovereign optimization where the individual countries are now replaced by rating x industry buckets.

**Exhibit 16: Illustration of one-dimensional optimization**

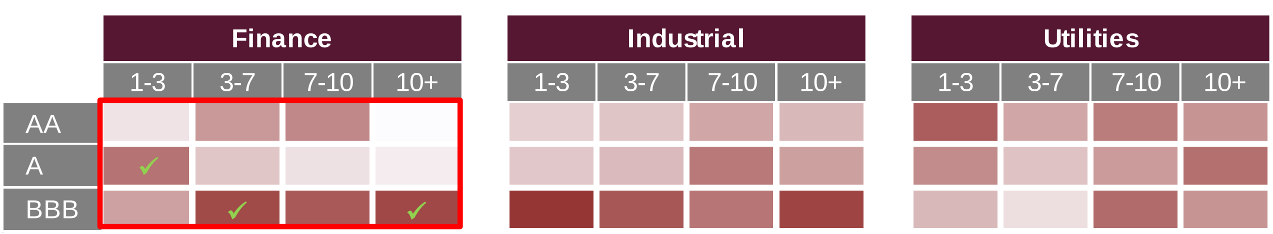



Source: FTSE Russell

- **V2: Industry neutral, average credit rating and duration matched**

  Divide the universe into individual industries. Run two-dimensional optimizations within each industry ensuring that the average rating and duration within the industry bucket are matched with those of the starting universe. The credit rating dimension is freed to allow numerical rating-based average matching only (using the simple scoring AAA=1, AA+=2, etc.). The duration-matching constraint is now only enforced at the wider industry level instead of the previous rating x industry bucket level. In this approach the curves across different credit ratings within the same industry are compared to determine the optimal selection of buckets.

**Exhibit 17: Illustration of two-dimensional optimization**

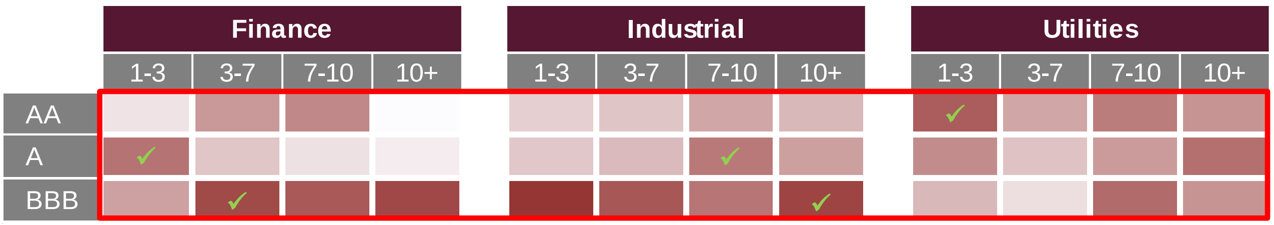



Source: FTSE Russell

**V3: Industry weight, average credit rating and duration matched**

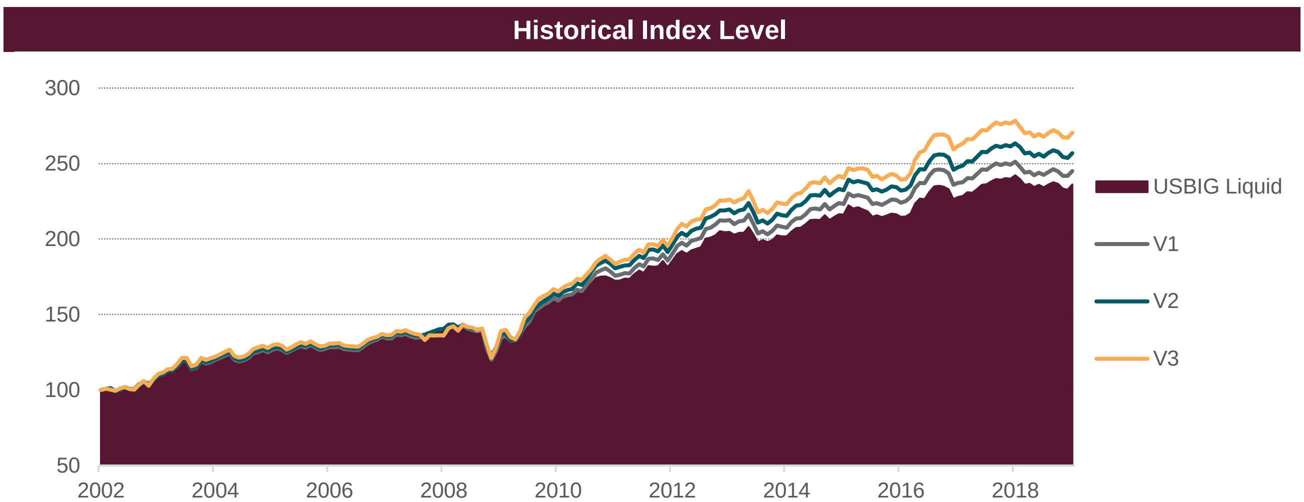
Run a single three-dimensional optimization within the entire universe ensuring that the industry weights, average rating and duration are all matched with the same measures in the starting universe. This variant further frees the industry dimension and allows comparisons of term structures across industries.

**Exhibit 18: Illustration of three-dimensional optimization**




Source: FTSE Russell

**Exhibit 19: US Investment-Grade Corporate Carry Optimization with Different Degrees of Freedom**




| Performance Statistics | | | | |
|---|---|---|---|---|
| | US BIG Liquid | V1 | V2 | V3 |
| **Annualized Return*** | 5.18% | 5.41% | 5.70% | 6.02% |
| **Annualized Volatility** | 5.53% | 5.81% | 5.84% | 6.39% |
| **Ret/Vol Ratio** | 0.94 | 0.93 | 0.98 | 0.94 |
| **% Positive Months** | 65.20% | 64.71% | 65.20% | 62.75% |
| **Max Drawdown** | -14.91% | -15.80% | -14.55% | -15.33% |
| **Annualized Turnover** | 25.7% | 135.7% | 217.6% | 383.7% |

* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

The impact of releasing the constraints and adding degrees of freedom is apparent from the results of Exhibit 19. For all three optimization implementations both realized returns and volatilities are higher than the base index universe. We can also observe that they further increase from V1 to V3 under the same sector-level optimization approach with increasingly flexible settings.

If we examine the details of the optimization performance from V1 to V2, the relaxation of credit rating improved the return by 29 bps annually at the cost of only 3 bps higher volatility. However from V2 to V3 the relaxation of industry added 32 bps in return and 55 bps in volatility. Therefore the return over volatility ratio increased from V1 to V2, but decreased from V2 to V3.

According to these results, allowing curve comparison across different ratings within the same industry can lead to more efficient sector allocation. However, further allowing curve comparison across different industries may introduce unproportioned uncertainties. Interestingly, this result supports our choice in our previous fixed income factor research paper of the value model as an industry-specific regression with parallel shifts on credit ratings intra-industry. With this observation, we choose to focus on the two-dimensional optimization in variant V2 and will give consideration to practical implementation considerations such as bucket concentration, turnover and transaction costs.

## Bucket concentration and bucket weight caps

The first consideration concerns bucket concentration. Note that under the current optimization settings, except for non-negativity bucket weights are not constrained and can potentially take up an entire industry. Moreover, if they can lead to an optimal carry while satisfying the duration-matching constraint, those bucket weights are allowed to range between 0% and 100% of their corresponding industry weights month to month. This scenario can easily raise concerns in the corporate space as it poses practical turnover issues. In the following we introduce caps on bucket weights into the optimization to mitigate this issue.

**Exhibit 20: US Investment-Grade Corporate Carry Optimization with Different Bucket Caps**

| Performance Statistics | | | | | |
|---|---|---|---|---|---|
| | US BIG Liquid | 1.5x | 2x | 3x | Uncapped |
| **Annualized Return*** | 5.18% | 5.45% | 5.50% | 5.48% | 5.70% |
| **Annualized Volatility** | 5.53% | 5.67% | 5.70% | 5.81% | 5.84% |
| **Ret/Vol Ratio** | 0.94 | 0.96 | 0.96 | 0.94 | 0.98 |
| **% Positive Months** | 65.20% | 64.71% | 64.71% | 63.73% | 65.20% |
| **Max Drawdown** | -14.91% | -15.29% | -15.17% | -15.56% | -14.55% |
| **Annualized Turnover** | 25.7% | 73.8% | 119.3% | 161.7% | 217.6% |

* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

In Exhibit 20 three weighting constraints are tested whereby the optimized bucket weights are capped at 150%, 200% and 300% of their corresponding natural market value weights. For comparison the unconstrained result is also included which is equivalent to the result of V2 in Exhibit 19.

Similar to the results in sovereigns, turnover is significantly reduced when tighter bucket weight caps are introduced. Interestingly the excess return didn’t follow a monotonic upward progression as flexibility in bucket weights was added to the optimization but actually fell slightly from 2x to 3x. The return-to-volatility ratio also slightly decreased from 0.96 to 0.94 before finally increasing to 0.98 in the uncapped version. On the other hand both the volatility and turnover consistently increased when bucket weights were allowed to fluctuate more freely.

The choice of appropriate bucket caps should be dependent on the level of additional risk and turnover that investors are willing to take. There is no economic rationale behind the pattern of risk-return profile between different caps, but rather whether those more extreme weights during certain months paid off.

## Turnover and transaction costs

The second test is on turnover and transaction costs. Similar to the observation in the sovereign space, here the turnover also increased significantly from the base universe after the optimization. This is an expected outcome whenever one decides to maximize one's return potential via an optimisation-based approach that should naturally lead to frequent changes in the portfolio as the optimiser seeks to maximize the carry exposure depending on the dynamics of the yield curve over time. The high turnover arising from such optimization-based approach might be acceptable for government bond investors as the securities are traded with tight bid/ask spreads. Some institutional investors managing large sovereign portfolio can often command sharper pricing and leverage efficient trading platforms. However, for corporate bonds all investors tend to face the same liquidity challenges and wider bid-offer spreads; the excessive turnover will bring practical difficulties to manage portfolios. Moreover, the typically higher transaction costs from rebalancing a portfolio of corporate bonds could reduce or even eliminate the carry approach's excess return.

The unconstrained V2, before adding bucket caps, had more than 200% annualized turnover. That is, the bond holdings in the portfolio changed completely twice within each year. Turnover naturally declined after bucket caps were introduced and bucket weights were only allowed to vary within a tight range. We therefore see the value in finding an approach to further curb turnover. One such method we explore below is to incorporate expected transaction costs into the optimization process itself.

**Exhibit 21: US Investment-Grade Corporate Carry Optimization with Transaction Cost and Different Bucket Caps**

| Performance Statistics | | | | | |
|---|---|---|---|---|---|
| | **US BIG Liquid** | **1.5x** | **2x** | **3x** | **Uncapped** |
| **Annualized Return*** | 5.18% | 5.43% | 5.49% | 5.54% | 5.60% |
| **Annualized Volatility** | 5.53% | 5.66% | 5.70% | 5.74% | 5.80% |
| **Ret/Vol Ratio** | 0.94 | 0.96 | 0.96 | 0.97 | 0.97 |
| **% Positive Months** | 65.20% | 65.20% | 65.20% | 65.69% | 65.20% |
| **Max Drawdown** | -14.91% | -15.29% | -15.30% | -15.35% | -15.67% |
| **Annualized Turnover** | 25.7% | 46.6% | 57.4% | 73.2% | 98.2% |

* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

In the above optimization we have assumed a hypothetical 30 bps bid/ask spread. The positive impact of featuring expected transaction costs now in the optimization is clear. The excess turnover over the base universe is more than halved from Exhibit 20 to Exhibit 21. When the expected transaction costs are reflected in the objective function the optimizer needs to make a trade-off between the additional gains in carry and the additional cost from the reweighting. In the case where only minimal benefit is available, the cost-enhanced optimization process determines it is not worthwhile to reshuffle the bucket allocations. Conversely, if the improvement in carry is sufficiently attractive, the optimizer will choose to reweight the buckets accordingly.

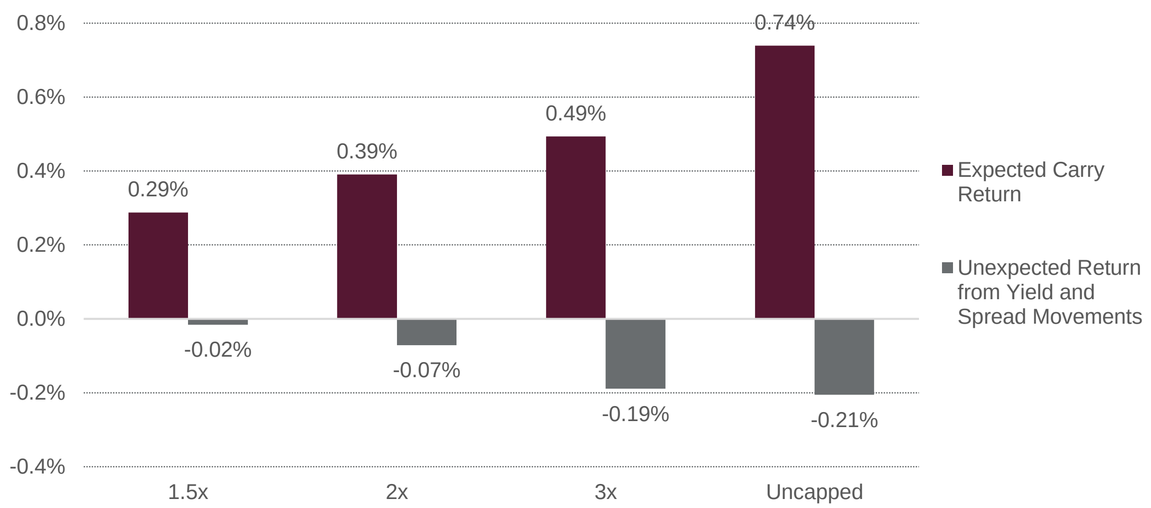
Compared with the reduction in turnover, the impact on performance is small. Adding transaction costs will tie the optimized weights closer to the existing portfolios. Such linkage is stronger during the periods when the difference in expected return from carry is small. In such cases out-performance is more uncertain, as the realized return will only be marginally attributed to the expected return at the beginning of the period. Therefore realized performance again is not the driver of the choice here.

It is worth noting that when expected transaction costs are reflected in the optimization, the simulated index becomes path-dependent: the profiles of the later months will be anchored to those of the earlier months. Therefore if the simulation starts at a different time, it could end up with a different trajectory. The results could also differ depending on the accuracy of the assumptions regarding the expected transaction costs.

## Return attribution for the corporate carry concept

To better understand the return characteristics of the corporate carry factor, here we conduct a similar return attribution as in the sovereign market based on expected return from carry and unexpected return from yield and spread movements. We switch back to the two-dimensional optimization V2 where various bucket caps are tested however the transaction cost is not incorporated into the optimizations.

**Exhibit 22: Attribution of the Annualized Excess Return of the Corporate Carry Factor Portfolios**




* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Exhibit 22 lists the breakdown of returns with the bucket caps applied in Exhibit 20, as well as the uncapped variant which is the original V2. Recall that the observation in the sovereign space is that the majority of the out-performance came from the extra expected return from carry. The same pattern holds in the corporate carry. In the US investment grade corporate market, the unexpected return is negative and erodes part of the gain from the higher carry. The short-term mean-reversion pattern in the value factor is not observed in the carry factor here.

However there are also other interesting findings. When testing different bucket constraints, it is logical to see an incremental expected return from carry with the loosening of bucket caps as there is more room for weight deviations. So too increases the loss from unexpected returns. However the additional gain and loss don't expand proportionally. From 2x to 3x for example, there were 10 bps gain from the expected but 12 bps loss from the unexpected. Hence in combination the out-performance reduced marginally from 2x to 3x. As we observed in the sovereigns, the unexpected return comes with great uncertainties and the direction and timing of it can't be predicted.

## Carry factor applied to various global corporate bond markets

The same two-dimension optimization is applied across regions and markets with the same bucket caps as well as the uncapped variants. This allows us to examine the carry factor against different fixed income asset classes and regional bond markets, as well as to run an out-of-sample validation test of the factor and our chosen definition. Exhibit 23 includes 4 sample markets from the global corporate space: US IG, US HY, European IG and European HY. The result of US IG is repeated here for comparison.

**Exhibit 23: Carry Factor Applied to Various Corporate Markets**

| US Broad Investment-Grade Corporate Sector (USD, Jan 2002 – Dec 2018) | | | | | |
|---|---|---|---|---|---|
| | US BIG Liquid | 1.5x | 2x | 3x | Uncapped |
| Annualized Return* | 5.18% | 5.45% | 5.50% | 5.48% | 5.70% |
| Annualized Volatility | 5.53% | 5.67% | 5.70% | 5.81% | 5.84% |
| Ret/Vol Ratio | 0.94 | 0.96 | 0.96 | 0.94 | 0.98 |
| **US High Yield Market Sector (USD, Jan 2002 – Apr 2018)** | | | | | |
| | US HY Liquid | 1.5x | 2x | 3x | Uncapped |
| Annualized Return* | 6.01% | 6.21% | 6.38% | 6.64% | 7.35% |
| Annualized Volatility | 9.75% | 10.05% | 10.11% | 10.22% | 11.07% |
| Ret/Vol Ratio | 0.62 | 0.62 | 0.63 | 0.65 | 0.66 |
| **EURO Broad Investment-Grade Corporate Sector (EUR, Jan 2002 – Dec 2018)** | | | | | |
| | EURO BIG Liquid | 1.5x | 2x | 3x | Uncapped |
| Annualized Return* | 4.52% | 4.63% | 4.68% | 4.67% | 4.90% |
| Annualized Volatility | 3.10% | 3.23% | 3.27% | 3.32% | 3.50% |
| Ret/Vol Ratio | 1.46 | 1.43 | 1.43 | 1.41 | 1.40 |
| **European High Yield Market Sector (EUR, Jan 2013 – Dec 2018)** | | | | | |
| | EU HY Liquid | 1.5x | 2x | 3x | Uncapped |
| Annualized Return* | 4.79% | 5.02% | 5.17% | 5.20% | 5.25% |
| Annualized Volatility | 4.47% | 4.64% | 4.66% | 4.76% | 4.94% |
| Ret/Vol Ratio | 1.07 | 1.08 | 1.11 | 1.09 | 1.06 |

* Transaction costs are not excluded from the annualized returns.
Source: FTSE Russell. Data from Jan 2002 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Overall the carry factor managed to deliver out-performance across these various fixed income asset classes and global markets. However it works less consistently than what has been observed in the value factor. The excess return from the standard approach is slim compared to the additional turnover it requires. This could be challenging for actual implementation, especially for high yield investors who face wider bid-ask spreads. For investment grade corporates however, while the transaction costs may be somehow lower on a relative basis, the limited excess returns from our simulations are not indicative of ample opportunities to leverage the carry factor in the investment grade universe either. As we summarized at the outset of the paper the carry concept has been well known with fixed income practitioners and documented since the early 70s. Therefore it would be expected that the fixed income carry trade has been a long standing investment strategy implemented in the corporate bond market to extract more outperformance from a sector where investors expect more returns for the credit risk they are taking. Our results indicate that the carry factor may have indeed been exploited enough in the investment grade universe that is seems to leave limited opportunity for further performance enhancement through building a strategy that gives specific exposure to such factor.

# Fixed income carry in the real world

Having covered extensively the concept of fixed income carry and offered simulated results on how it could be leveraged via carry-targeted approaches, we now discuss how this factor may already be utilized in the bond fund world using the well-established and sizeable US fixed income active fund universe as our analysis set. In the second part we look at how this factor has been captured in an actual fixed income index that can be used for global sovereign investors looking to gain a specific exposure to this factor.

## Utilization of the carry factor in US fixed income active funds

In their paper focusing on the Japanese bond market, Kikugawa et al. [2017] looked at actively-managed bond funds in Japan to evaluate their performance and attribute the source of any excess return to exposure to duration, credit and carry. They concluded that while credit was a significant driver of the excess return and that duration was not prevalent potentially by choice, the carry factor however was noticeably under-utilized in those Japanese active funds. In the following we want to examine whether the same observation can be found in the US market.

We apply a similar methodology as Kikugawa et al. [2017] to analyse the performance of active fixed income funds in the US. From the wide US fixed income funds universe we start by excluding passive funds, ETFs, ultra-short bonds, bank loans, munis and inflation linkers funds. The remaining funds cover US treasuries, US IG and HY corporates, which is a subset that matches the universe we used in our carry analysis. From there we selected the top 100 funds based on AUM. As of May 2019, the AUM of those 100 funds totalled approximately 1 trillion USD.

We examine the performance of these largest 100 funds in two ways. The first one calculates the weighted average returns from each of the 100 funds' monthly returns and their prevailing AUMs. In other words we are creating a synthetic "mega fund" that consists of the top 100 funds. Thereafter we regress this monthly return series against a number of market and factor returns. The second approach looks at the individual funds by running separate regressions based on each of them. The coefficients from those 100 discrete regressions are then averaged to look at the funds indiscriminately.

In the regressions we focus on three sets of market and factor returns. First we include the total market return of US treasury, IG and HY corporates. By featuring the total returns from those markets we can identify how much of performance can be attributed to the broad market movements. According to their specs almost all of the funds take blended positions in those three markets.

Thereafter we included two traditional fixed income factors: duration and credit, both of which can be traced back to Fama and French [1995] and widely used in fixed income. Fama and French [1995] has shown that a bond investor can enhance the performance (and take additional risk) of the portfolio by either extending the duration or reducing the credit quality. These factors are included in our regression analysis i) to identify whether fund managers are applying these technics to boost their performance and ii) isolate the additional returns from these common factors. For our purposes, the duration excess return is calculated as the return difference between the 10yr+ and 1-3yr buckets of the US treasuries. The credit excess return on the other hand is calculated as the return difference between the corporate bonds rated AA and above versus the BBBs.

Last we added the excess return of the carry factors corresponding to the respective US Treasury, US IG and HY corporates bond markets. They are calculated as the return difference between the standard optimization variant of our carry factor approach versus the base universe. The actual implementation, if any, of a carry factor approach into an investment strategy may vary across different fund managers; however the return characteristics should be along the same line.

**Exhibit 24: Regression of Active Fund Performance on Market and Factor Returns**

| | Combined Performance | | Average of Top 100 | |
|---|---|---|---|---|
| | Coefficients | t stat | Coefficients | t stat |
| Intercept | 0.047 | 1.86 | 0.072 | 1.82 |
| US Treasury Total Return | 0.278 | 3.95 | 0.263 | 3.71 |
| US IG Corp Total Return | 0.306 | 11.71 | 0.286 | 5.48 |
| US HY Corp Total Return | 0.304 | 16.93 | 0.293 | 7.63 |
| Duration Excess Return | -0.072 | -3.20 | -0.069 | -2.27 |
| Credit Excess Return | 0.155 | 4.90 | 0.201 | 3.94 |
| US GBI Carry Excess Return | -0.275 | -2.21 | -0.205 | -0.71 |
| US IG Carry Excess Return | 0.381 | 4.68 | 0.357 | 2.00 |
| US HY Carry Excess Return | -0.216 | -4.28 | -0.111 | -0.54 |
| R-square | 96.2% | | 86.6% | |

Source: Morningstar, FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in USD with currency unhedged. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Using our above approach, Exhibit 24 sheds some potential insight into the returns of US active fixed income funds. First of all, the 5 bps intercept (with a t-stat close to 2) indicates the skilfulness of the US portfolio managers. They appear to deliver close to 5 bps of monthly excess return on top of what can be explained by the market and common fixed income factors. The coefficients of the market total returns reveal that those funds on aggregate have an approximately equal allocation across US treasury, IG and HY corporates.

Secondly the top 100 funds on average have shorter duration and lower rating than the markets. The US active managers seem to favour short-term liquidity and flexibility over additional exposure to interest rate risk. However they also apparently try to gain extra performance by taking more credit risk.

Lastly, and most interestingly, we observe a negative exposure to the US Treasury carry, positive to the US IG carry and negative to the US HY carry. These results are all consistent with our earlier analysis. The US Treasury managers may be bounded by their mandated investment universe and therefore not allowed to freely place other bets. The results also show that the carry trade may already be heavily utilized in the IG space, while the high transaction costs in the HY space may have limited its widespread use.  The most noteworthy observation may be that US active funds may be still relatively under-exposed to the treasury carry. This is a similar observation to that reached by Kikugawa et al. [2017] for Japanese government bond active funds.

## Applying the carry factor systematically via a fixed income index

The understanding and acceptance of the potential benefit of factor-based investing in the equity space are now getting established. As we highlighted, the existence of similar factors in bond markets has been noted by academics and used over time by fixed income practitioners. When it comes to the carry factor our analysis corroborates Kikugawa et al. [2017] and seems to indicate that comparatively to the traditional duration and credit factors, carry may have been less widely exploited at least when it comes to the sovereign space. Additionally, when such factor is leveraged it is rarely done through an approach that specifically targets the carry factor but rather more often as part of a broad investment strategy. Considering that carry is a factor that has strong fixed income foundation, academics and practitioners' recognition and supported by empirical evidence as well as our own simulated results, one could wonder about trying to capture this exposure in a systematic and transparent approach.

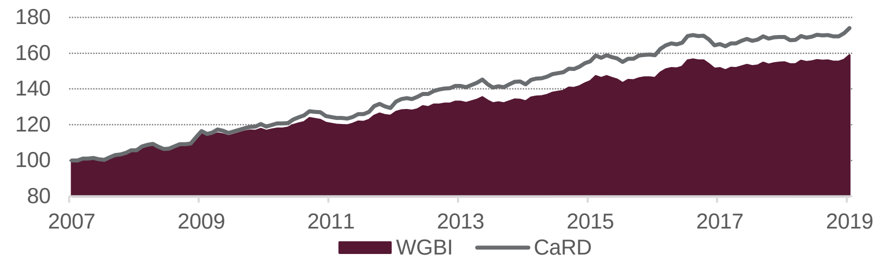
The FTSE Nomura Carry and Roll Down (CaRD) World Government Bond Index (WGBI) Series is a set of benchmarks offered in various investment currencies that look to provide such targeted exposure to the carry factor. It focuses on the sovereign bond space which is the universe where our research indicated the carry factor worked best and  still appeared to be under exploited. The base sovereign markets set that the indexes are built on is the FTSE Word Government Bond Index (WGBI), , currently consisting of 22 markets.

The CaRD WGBI indexes are built using a similar construction approach to the one discussed in our paper. They are alternatively-weighted using essentially the same optimization process as described in our paper that seeks to maximize carry factor exposure. Additionally the indexes ensure that investors maintain similar country exposure to the WGBI reference benchmark (or one of its chosen subset) and with no incremental interest risk. The indexes shown below are currency-hedged in USD, EUR, GBP, AUD and JPY to be relevant to various local investors and to reflect an exposure on the bond markets performances immunized against impacts from FX movements.

The indexes also apply some of the takeaways discussed in the earlier sections of the paper. They use an optimisation variant that is sector-based and leveraging inter maturity buckets opportunities to offer higher degrees of freedom for the optimisation process while avoiding concentration risk. Additionally, they use a 12-month carry horizon that helps reduce the expected higher turnover from such optimisation-based approach, while not impacting the return or volatility results when compared to a 1-month carry horizon approach.

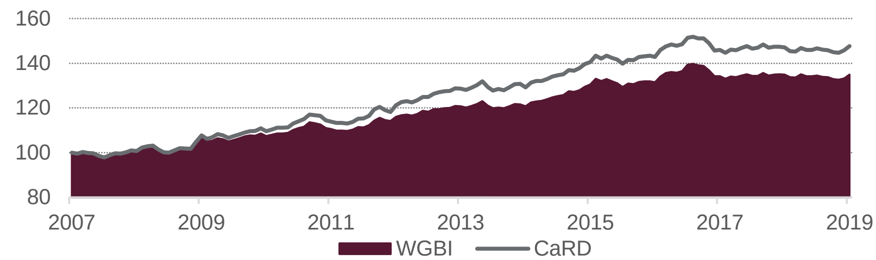
**Exhibit 25: FTSE Nomura Carry and Roll Down (CaRD) World Government Bond Index (WGBI) Series**

### WGBI and CaRD in USD Hedged



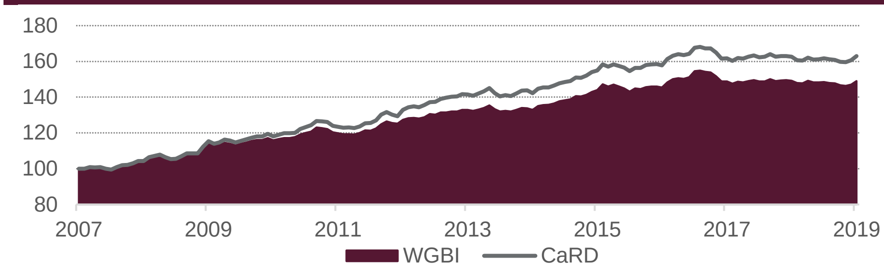

| | WGBI | CaRD |
|---|---|---|
| Ann Ret | 3.93% | 4.72% |
| Ann Vol | 2.94% | 3.29% |
| Ret/Vol | 1.34 | 1.44 |
| Exc Ret | | 0.79% |
| Max DD | -3.9% | -3.7% |

### WGBI and CaRD in JPY Hedged



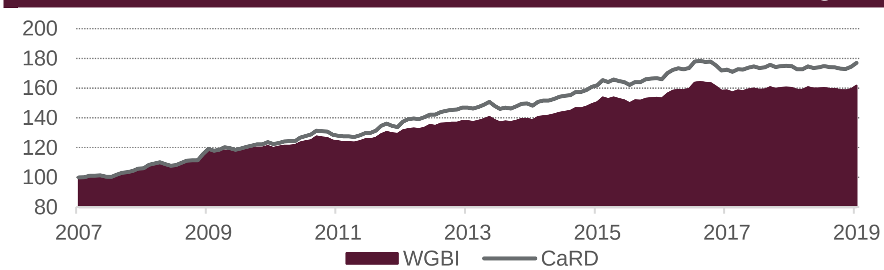

| | WGBI | CaRD |
|---|---|---|
| Ann Ret | 2.53% | 3.30% |
| Ann Vol | 2.93% | 3.29% |
| Ret/Vol | 0.86 | 1.00 |
| Exc Ret | | 0.77% |
| Max DD | -5.1% | -4.7% |

### WGBI and CaRD in EUR Hedged



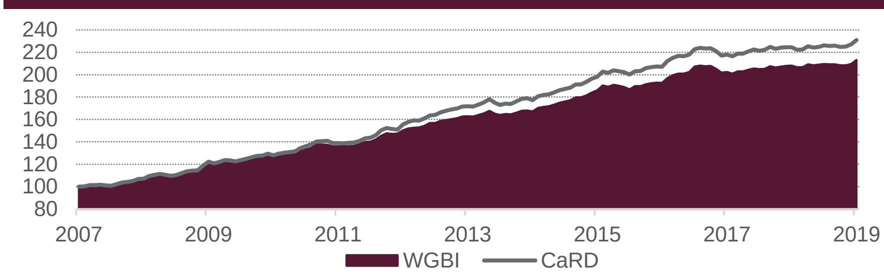

| | WGBI | CaRD |
|---|---|---|
| Ann Ret | 3.37% | 4.15% |
| Ann Vol | 3.00% | 3.35% |
| Ret/Vol | 1.13 | 1.24 |
| Exc Ret | | 0.77% |
| Max DD | -5.5% | -5.1% |

### WGBI and CaRD in GBP Hedged




| | WGBI | CaRD |
|---|---|---|
| Ann Ret | 4.09% | 4.87% |
| Ann Vol | 3.02% | 3.37% |
| Ret/Vol | 1.35 | 1.45 |
| Exc Ret | | 0.79% |
| Max DD | -4.3% | -4.2% |

### WGBI ex Australia and CaRD ex Australia in AUD Hedged




| | WGBI ex Aus | CaRD |
|---|---|---|
| Ann Ret | 6.51% | 7.22% |
| Ann Vol | 3.02% | 3.37% |
| Ret/Vol | 2.15 | 2.14 |
| Exc Ret | | 0.71% |
| Max DD | -3.4% | -3.3% |

Source: FTSE Russell. Data from Jan 2007 to Dec 2018. Return and risk in corresponding currencies with currency ***hedged***. Past performance is no guarantee of future results. Data shown reflects hypothetical, historical performance. Please see the end for important legal disclosures.

Exhibit 25 shows that the CaRD WGBI indexes delivered higher risk-adjusted returns than their respective reference benchmarks. Looking at the results across the 5 currency variations, the indexes all had close to 80bps excess returns and improved the return-to-volatility ratio 4 times out of 5.

# Conclusion

Unlike duration and credit, carry is a fixed income factor that is less talked about and potentially not as specifically targeted by investors. However, the potential return and diversification benefits of such factor have been well studied and shown empirically. The concept of fixed income carry is similar to that expressed in the FX carry trade whereby investors hold onto an asset hoping to capture an expected return upon passage of time assuming everything else constant. In the fixed income carry case the view is expressed on the shape and curvature of the yield curve and the bond delivering returns from its yield but also from change in the bond price.

Our research corroborates and furthers previous academic work that had highlighted the existence and robustness of the fixed income carry factor across markets. From our cross bond market analysis the carry factor appears to be more stable in the sovereign market compared to the corporate bond space. In particular, our observation is that the sovereign carry factor is a pro-cyclical factor to the treasury market and has performed better when the government bonds perform well. We also noted that it has historically offered diversification and counter-cyclical benefits versus the general risky assets.

In early 2019 the US curve flattened and experienced inversions amid fears of a possible recession. However, pursuing a carry approach in such environment if this were to become the new norm, could still potentially offer positive results. For example, Japanese yield curves have been close to flat over our testing period and the approach still managed to out-perform in JGBs. Carry factor-based approaches' effectiveness would depend on the market profile and how the yield curve subsequently evolved. Note that if a yield curve were to be completely flat then all portfolios would be equally optimal in terms of carry. From the term structure of the yield curve one can extract extra carry by allocating higher weights to the high carry segments of the yield curve.

As discussed earlier, certain sovereign portfolio managers may be bounded by the universe required by their mandate and not able to flexibly place their bets on the most attractive section of the yield curve. This may arguably explain our findings that US active bond funds generally appear to be under-exposed to the sovereign carry factor. This leads to the thought of trying to capture the carry factor in a systematic and transparent fashion via a fixed income index.

The FTSE Nomura Carry and Roll Down (CaRD) World Government Bond Index (WGBI) Series seeks to target the fixed income carry factor in such manner while keeping a similar interest rate exposure as the reference global sovereign benchmark. The results show that the CaRD WGBI indexes are able to capture exposure to the carry factor and had demonstrated similar performance characteristics as seen in the paper's prior carry factor analysis.

# References

Ang, S., L. Alles, and D. Allen, 1998, Riding the yield curve: an analysis of international evidence. *The Journal of Fixed Income*, 8(3), 57

Coche, J., M. Knezevic, and V. Sahakyan, 2018, Carry on? *Advances in the Practice of Public Investment Management*, 131–159, Springer

Dyl, E. A., and M. D. Joehnk, 1981, Riding the yield curve: does it work? *The Journal of Portfolio Management*, 7(3), 13-17

Fama, E. F., 1984, Forward and spot exchange rates*, Journal of Monetary Economics*, 14(3), 319-338

Fama, E. F. and K. R. French, 1993, Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Financial Economics*, 33 (1): 3–56

Froot, K. A., and R. H. Thaler, 1990, Anomalies: foreign exchange. *Journal of Economic Perspectives*, 4(3), 179-192

Grieves, R., and A. J. Marcus, 1992, Riding the yield curve: reprise, *Journal of Portfolio Management*, 18(4), 67

Kikugawa, T., T. Uchiyama, M. Motohiro, and S. Nishiuchi, 2017, Bond Fund Performance and a Smart Beta Strategy in Japan, Securities Analyst Journal, 55(2), 69-80

Koijen, R. S., T. J. Moskowitz, L. H. Pedersen, and E. B. Vrugt, 2018, Carry, *Journal of Financial Economics*, 127(2), 197-225

Leibowitz, M. L., and S. Homer, 1972, *Inside the Yield Book: New Tools for Bond Market Strategy,* Prentice Hall Direct

Osteryoung, J. S., D. E. McCarty, and G. S. Roberts, 1981, Riding the Yield Curve with Treasury Bills, *The Financial Review*, 16(3), 57-66

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