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Carry Strategies in Global Rates Markets

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- **Carry is a popular strategy that has been used for many years by global bond investors. A rates carry strategy overweighs bonds that have high returns under the assumption that the yield curve remains unchanged.**
- **We analyse the performance and properties of carry strategies implemented with swaps in developed markets or with bonds in both developed and emerging markets. We find that cross-market carry strategies have been performing well and better than cross-curve strategies.**
- **Carry signals can be adjusted to account for expected changes in interest rates resulting from central bank monetary policy. We propose a simple model for adjusting signals according to the Taylor rule and find it has improved performance and made the strategy less correlated with treasury index returns in the past 22 years.**
- **The returns of carry strategies can be correlated with treasury index returns but this correlation changes over time according to the strength of the signal and can depend on the way the strategy is constructed.**
- **Cross-market rates carry strategies perform well in emerging markets. Carry signals have often been more dispersed in EM than in developed markets, giving scope for performance enhancement in addition to diversification benefits.**

Introduction

We study the performance and properties of carry strategies in global rates markets, and consider both long-short strategies investing in swaps and long-only bond portfolios from developed and emerging markets. Carry strategies have been popular with investors in rates markets; for example, those benchmarked against global bond indices, such as Bloomberg Barclays Global Treasury Index. Several studies have documented their effectiveness and broad properties[1].

In rates markets, the carry return of a bond is the return earned if the underlying yield curve remains unchanged. It comprises two parts: yield accretion in excess of financing cost and the roll-down return due to re-pricing the bond on the unchanged yield curve at the horizon yield of the analysis. Carry return is high when the yield curve is steep and low when it is flat. It is deterministic and can be calculated *ex ante*. A rate carry strategy that overweighs high carry bonds and underweight low carry ones will perform well if the carry signal is related to subsequent performance.

Two distinct strategies can be considered: cross-curve within a given market and cross market for a given tenor. Cross-curve strategies overweight bonds in the steepest maturity sector of a yield curve while cross-market strategies overweight markets with steeper yield curves and underweight those with flatter curves. In that context, carry can help actively manage exposure to individual markets in a global bond portfolio. In this report, we document differences in performance between cross-curve and cross-market strategies but otherwise focus mostly on cross-market carry which performs better. We investigate the robustness of cross-market carry strategies under different specifications and discuss their properties, including their correlation with treasury market indices.

Carry return is a simple analytical measure of performance that only depends on the shape of the yield curve. But a yield increase when the curve is steep, or a drop in yield when it is flat or inverted, can make realised returns lower than expected. Therefore, additional information on expected changes in rates and related to macro-economic indicators, such as growth and inflation, can make an adjusted carry signal more informative. We use a model similar the Taylor rule to adjust carry signal for the macro environment and discuss changes in the corresponding performance and risk properties.

We expand the investment universe to emerging markets bonds included in the Bloomberg Barclays Global Treasury Index and contrast the performance of cross-market carry in developed and emerging markets. While many investors consider local currency emerging market investing to be essentially a play on currency carry, we focus on currency-hedged performance which depends on relative dynamics of the yield curve. We address the question of whether a carry signal has a similar value in EM as in developed markets.

This report is organised as follows: the first section describes long-short swap portfolios that use carry signals updated on a monthly basis and documents their performance. The next section explains how a carry signal can be adjusted according to macro indicators consistent with the framework of the Taylor rule. Then, we investigate how rates carry strategies perform over time and discuss their directionality on various market regimes. Finally, we study the performance of carry strategies that invest in bonds rather than swaps and discuss two practical implications: how to construct long-only bond portfolios that are anchored to a baseline bond index and what is the value of expanding the carry strategy investment universe to emerging markets.

[1] See in particular Koijen, Ralph et al. *Carry*, NBER (2013) and Coche et al *Carry on?*, BIS working papers (2016)

Designing a rates carry strategy

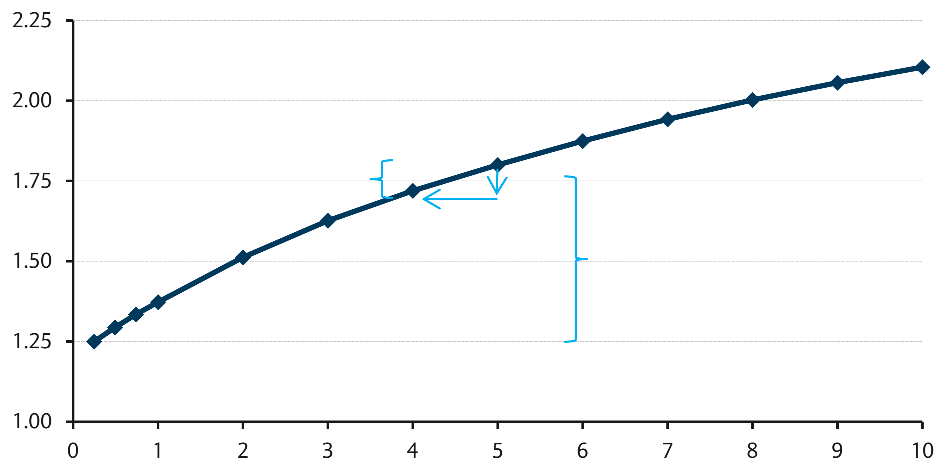
The first step in designing a carry strategy is to define a carry signal for each instrument considered. We calculate carry return for interest rate swaps or for bonds, assuming that the yield curve remains unchanged on a one-month horizon. This is illustrated in Figure 1 which plots the USD swap curve and schematically outlines the two main components of carry return: yield accretion (the yield in excess of the cost of funding) and roll-down return, (the change in price from re-pricing a bond at a shorter maturity yield assuming the yield curve remains unchanged). This is also summarised in the following expression where carry return is projected on a one-month horizon for a bond of maturity T:

$$CarryReturn_t = \frac{1}{12}(Yield_t^T - 1MRate_t) - Duration\left(Yield_t^{T-1month} - Yield_t^T\right)$$

Carry return is therefore high when the yield curve is steep and low when the yield curve is flat or inverted.

FIGURE 1

Example USD swap curve (2 June 2017)



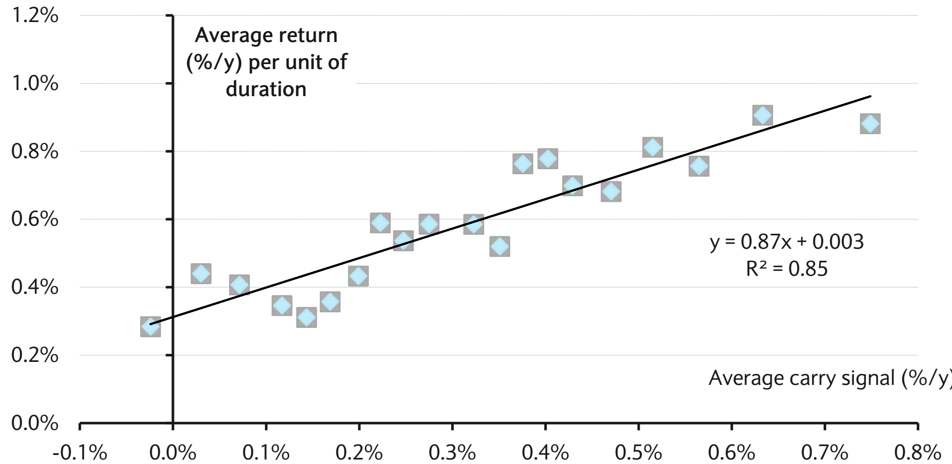
Source: Barclays Research

We study the relationship between carry signal – the carry return per unit of risk – and subsequent return in the swap market. Swaps have some advantages, including consistency between funding and investment rates and availability of a variety of tenors across a broad maturity spectrum. Figure 2 shows a positive relationship between average carry signal and subsequent swap return. Each month since the end of 1994, expected carry returns are calculated for 21 swaps[2] (seven markets multiplied by three tenors) and these 21 swaps are sorted by beginning-of-month carry signal (expected carry return per unit of duration) to form 21 carry cells. So, the rightmost point of the diagram represents a strategy that switches every month to the highest carry asset amongst the 21 swaps in our universe. The corresponding realised return per unit of duration is observed every month-end. Each dot in Figure 2 represents the average carry signal of a cell (horizontal axis) and its average realised return over the 22-year period considered (vertical axis). The positive slope indicates that a high carry signal generally anticipates a positive performance. So, a portfolio that is long duration in high carry swaps and short duration in low carry swaps should over time display a positive performance if the relationship shown in Figure 2 is stable.

[2] We consider 3 tenors (3, 5 and 10y) across seven markets (USD, JPY, GBP, CAD, AUD, CHF and SEK)

FIGURE 2

Carry and subsequent return per unit of duration for swap buckets sorted by carry signal (1995 to 2017)

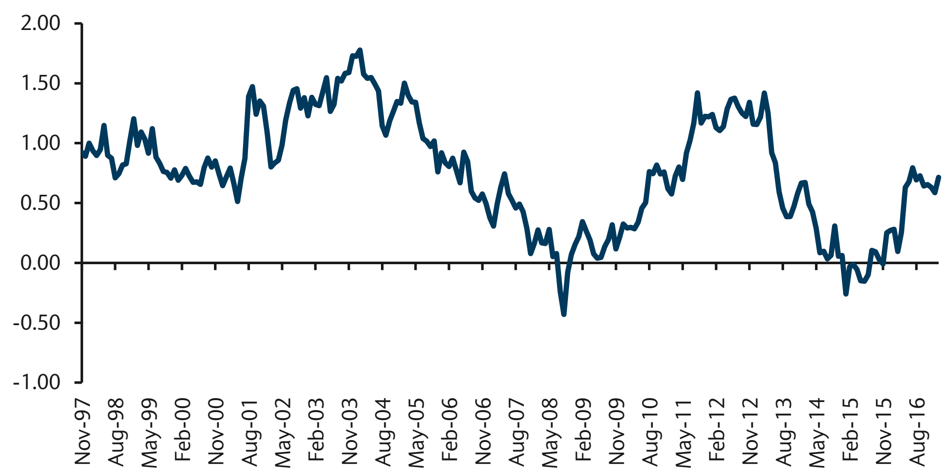


Source: Barclays Research

In Figure 2, the slope of the relationship between average signal (expected return per unit of duration) and average return per unit of duration is 0.87, meaning that 87% of carry increase has translated into realised return. Carry strategies should perform well when the relationship between signal and subsequent return is strong, and therefore when the slope of that relationship is high, and poorly when the slope is flat or inverted. This slope fluctuates over time as shown in Figure 3 but remains positive most of the time. The two periods when it was negative correspond to the high volatility experienced during the financial crisis, when all seven rates markets rallied together irrespective of the shape of their curve prior to the crisis, and in a longer, more recent, period from in 2013 and 2014 when global rates converged in the face of persistently accommodative policies by major central banks.

FIGURE 3

Slope of the relationship between carry signal and return estimated from a 36 month rolling window in swap markets

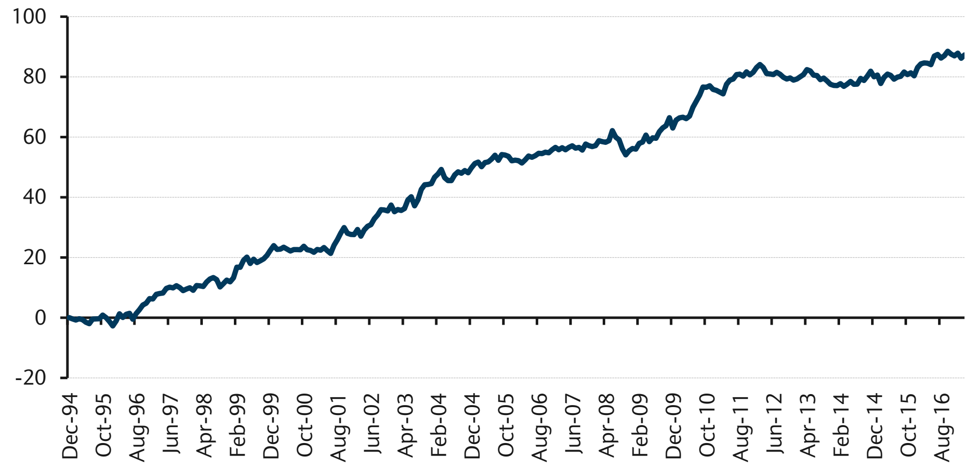


Source: Barclays Research

Once carry signals are calculated for a suitable investment universe, portfolios can be constructed in many different ways. Let us consider a cross-market strategy that invests in 5-year swaps across a universe of seven markets (USD, JPY, GBP, CAD, AUD, CHF and SEK). It is long duration in the top three markets (out of seven) and short the bottom three markets sorted by carry signal and is rebalanced every month. Swap positions are sized to have equal-duration contributions and the total duration of each (long or short) leg of the swap is arbitrarily set to be a constant seven years[3]. The cumulative return of this strategy is shown in Figure 4. Performance has been attractive with two volatile episodes that correspond to the times when the signal performance relationship was weaker, as shown in Figure 3: the end of 2008 and a more recent period from the end 2012 to 2014.

FIGURE 4

Cumulative return of cross-market strategy investing in 5-year swaps (duration-weighted)



Source: Barclays Research

In addition to weighting positions to target a specific duration contribution, we consider a weighting scheme where each position has the same isolated return volatility. The motivation for this is the realisation that the risk of the long and short legs of duration-weighted portfolios may not offset if there are significant differences in volatility across markets. If this is the case, a duration-weighted portfolio may remain somewhat correlated with global rates markets. In fact, the average volatility (estimated from a rolling 3-year window) of a 5-year JPY swap return has been half of the volatility of the corresponding maturity USD swap since 1994, and only 27% for the three years ending in March 2017. This leads us to introduce a weighting scheme based on volatility alongside the equal duration contribution logic just discussed.

When swaps are weighted to have identical duration contributions, the total duration of the long and short legs of the strategy is set to a constant seven years. On the other hand, when return volatility is used to size positions, the target volatility is 1%/year for each individual position, but there is no volatility target for the entire long or short leg of the strategy. So, the realised risk of duration and volatility-weighted strategies may not be comparable and performance should be assessed in terms of information ratio rather than return. When using volatility weighting, the carry signal is the projected carry return of a swap on a one-month horizon divided by the trailing 36 month return volatility of that swap.

Example details for both duration and volatility-weighted portfolios are shown in Figure 5. As expected, the absolute weight of Japan increases relative to other markets (from 0.468 which is in line to 1.148 which is roughly three times as large as other markets[4]) when positions are sized to a target a specific volatility. The example provided in Figure 5 is long duration in the top three markets in terms of carry signal and short duration in the bottom three out of a universe of seven markets. So the weight of the middle market, Canada in this example, is zero.

[3] Given the relatively short duration of 5-year swaps, this 7-year duration target implies that the sum of absolute weights is larger than 100%.

[4] Position units are swap notional per unit of the strategy. So, if a USD 1MM is invested in the duration-weighted strategy, the notional exposure to the JPY 5-yr swap is USD 0.468 MM equivalent.

FIGURE 5

Portfolio construction details for duration-weighted and volatility-weighted cross-market portfolios investing in 5-year swaps (weights as of end February and returns for March 2017)

	SEK	USD	AUD	CAD	CHF	GBP	JPY
Floating swap rate (end February 2017)	-0.47%	1.06%	1.99%	0.95%	-0.68%	0.51%	0.03%
Fixed swap rate (end February 2017)	0.23%	2.05%	2.60%	1.43%	-0.46%	0.78%	0.09%
Yield accretion (%/m)	0.058%	0.082%	0.051%	0.040%	0.018%	0.022%	0.005%
Roll-down return (%/m)	0.076%	0.043%	0.048%	0.037%	0.042%	0.032%	0.010%
Duration	4.97	4.71	4.63	4.79	5.07	4.89	4.99
Carry signal (per unit of duration, %/m)	0.027%	0.027%	0.021%	0.016%	0.012%	0.011%	0.003%
Weight (equal duration contribution)	*0.470*	*0.496*	*0.504*	*0.000*	*-0.460*	*-0.478*	***-0.468***
Volatility (%/y)	0.70%	0.95%	0.73%	0.74%	0.71%	0.93%	0.25%
Carry signal (per unit of volatility, %/m)	0.056%	0.038%	0.040%	0.030%	0.025%	0.017%	0.017%
Weight (equal volatility)	*0.413*	*0.305*	*0.397*	*0.000*	*-0.405*	*-0.309*	***-1.148***
Return (March 2017)	-0.253%	0.110%	0.468%	-0.095%	-0.523%	-0.313%	-0.071%
Return of the duration-weighted portfolio				0.595%			
Return of the volatility-weighted portfolio				0.505%			

Source: Barclays Research

Let us now compare the performances that correspond to different weightings schemes and periods. Carry strategies are evaluated over the period from January 1995 to March 2017 as well as for a more recent period that starts in January 2002. The dataset is broadened in 1999 with the inclusion of EUR-denominated swaps. This allows for a second set of simulations that start in 2002 as we require 36 months of historical data to estimate volatility in risk-based portfolio allocations. In each market, the tenors considered are 3, 5, and 10y with the 15y tenor added only for the analysis that starts in 2002.

Figure 6 reports the performance of historical simulations for equal duration contribution and equal volatility strategies. For all cross-market historical simulations starting at the end of 1994 and that relate to a single tenor, the strategy is long the top three and short the bottom three markets sorted by carry signal. For the single-tenor strategies that start in 2002, the universe is expanded to eight markets and the strategy is long the top four and short the bottom four markets in terms of carry signal.

The bottom four rows of Figure 6 report the results of pooled strategies where the investment universe includes 21 assets (seven markets multiplied by three maturities). These pooled strategies are more diversified (either long top five vs. short bottom five markets in terms of signal strength, or long the top 10 vs. the bottom 10) than single-tenor strategies. For duration-weighted strategies, the total duration budget of seven years for each leg of the portfolio is spread equally across all positions. For volatility-weighted strategies, the isolated risk attached to each position is the same as before (one percent of return volatility). So, given positive correlations, the more diversified pooled strategies tend to exhibit higher realised volatility than single-tenor strategies.

FIGURE 6

Summary performances of rates carry strategies investing in swaps

Period	Weighting	Tenor	Avg Ret (%/y)	Vol (%/y)	Skewness	Excess Kurtosis	Max. Drawdown (%)	I.R.	Correl w Global Tsy Index
Jan 1995 - Mar 2017	Equal Durt Contrib	3y (3 vs. 3)	2.4%	3.6%	0.5	1.2	-6.2%	**0.67**	0.19
		5y	2.9%	3.2%	-0.1	0.1	-5.0%	**0.90**	0.15
		10y	2.4%	3.0%	0.0	1.2	-5.0%	**0.80**	0.18
	Equal Vol	3y (3 vs. 3)	1.1%	2.0%	0.1	0.0	-3.7%	**0.54**	0.04
		5y	1.2%	1.9%	-0.3	1.0	-4.0%	**0.65**	-0.02
		10y	1.2%	1.7%	0.1	2.6	-3.6%	**0.69**	-0.02
Dec 2002 - Mar 2017	Equal Durt Contrib	3y (4 vs. 4)	1.3%	2.5%	-0.1	1.4	-5.2%	**0.53**	0.29
		5y	2.1%	2.4%	-0.5	0.7	-4.7%	**0.87**	0.31
		10y	1.7%	2.1%	-0.2	0.4	-4.1%	**0.83**	0.36
		15y	1.5%	2.1%	0.2	0.9	-4.1%	**0.71**	0.25
	Equal Vol	3y (4 vs. 4)	1.2%	2.2%	0.1	1.1	-4.1%	**0.55**	0.07
		5y	1.5%	1.9%	-0.2	1.2	-3.8%	**0.75**	0.14
		10y	1.3%	1.7%	0.1	1.2	-3.6%	**0.78**	0.07
		15y	1.7%	1.8%	0.4	3.2	-3.6%	**0.99**	0.09
Jan 1995 - Mar 2017	Equal Durt Contrib	3Y 5y 10y (5 vs. 5)	3.2%	3.8%	-0.1	1.0	-6.8%	**0.84**	0.28
		3Y 5y 10y (10 vs. 10)	2.2%	2.7%	0.0	0.8	-5.0%	**0.81**	0.17
	Equal Vol	3Y 5y 10y (5 vs. 5)	2.7%	3.3%	0.0	0.4	-5.5%	**0.81**	0.02
		3Y 5y 10y (10 vs. 10)	3.9%	4.9%	-0.2	0.9	-11.1%	**0.79**	-0.02

Source: Barclays Research

Figure 6 shows that information ratios are relatively similar (between 0.5 and 1), irrespective of the strategy specifications. Most carry strategy performances are also directional on global rates as indicated by the positive correlations with the returns of Bloomberg Barclays Global Treasury Bond Index. The volatility-weighted strategies have generally not delivered higher information ratios that duration-weighted ones, but their correlation with the Global Treasury Index are lower, and close to zero. Throughout the whole period of the analysis, the largest difference between the two weighting schemes has been the weight of Japan, as shown in Figure 5.

While pooled strategies are more diversified that single tenor ones, their information ratios are not higher. This indicates that most of the strategy value lies in cross-market rather than in cross-curve allocation. Figure 7 confirms this point as it provides information ratios for two sets of long-short strategies: cross-curve (investing across a universe of four tenors in each individual country) in the first two columns and cross-market (investing across a universe of eight markets for a given tenors) in the two rightmost columns. Cross-market information ratios range from 0.53 to 0.87 while cross-curve IRs range from -0.02 (Canada) to +0.55 (Japan). A reason for cross market to perform better than cross-curve strategies is the segmentation that exists between different monetary policies, and hence between yield curve dynamics across different markets, as opposed to the strong relationship that links different rates from the same curve to each others.

FIGURE 7

Information ratio of duration-weighted cross-market and cross-curve carry strategies (2002-17)

By Market	Cross-Curve	By Maturity	Cross-Market
USD	0.00	3Y	0.53
GBP	0.10		
EUR	0.41	5Y	0.87
JPY	0.55		
CAD	-0.02	10Y	0.83
AUD	0.24		
CHF	0.45	15Y	0.71
SEK	0.12		

Source: Barclays Research

The strategies considered in this article rebalance on a monthly basis with no considerations for turnover and performances ignore transaction costs. However, we estimate that including transaction costs would not qualitatively change the performance pattern observed in these historical simulations. For example, we calculate that the cross-markets strategy that invests in 5-year swaps and is weighted according to equal duration contributions would have entailed 16bp/y of transaction cost from 1995 to 2017. This estimate is based on average bid-ask of 0.5bp of yield. Accordingly, the effect of transaction costs is to reduce return from 2.86 to 2.70%/y and information ratio from 0.90 to 0.85.

Adjusting the carry signal for expected changes in rates

The results presented in the previous section rest on a simple definition of rates carry, directly associated with yield curve slope. However, this effectively ignores that a steep curve is a predictor of rising rates. Rather, a rates carry strategy implicitly assumes that the yield curve tends to remain unchanged rather than converge to the forward. Can a carry signal be adjusted according to macro considerations and deviate from the assumption that the yield curve persists in its current shape?

Answering this requires an analytical framework which can be provided by the Taylor[5] rule, a well-known framework that relates central bank policy to the macroeconomic environment. It models the relationships between inflation and economic growth to policy rates. Inflation is assessed relative to a target, real economic growth against potential growth and the equilibrium level of rates.

While the Taylor rule has been well publicised, its practical application to assess the level of interest rates offers a broad range of implementation choices. In addition, using standard economic indicators such as inflation and growth can be challenging as they are often published with time lags and can be subject to revision. Nonetheless, this framework can help us identify important variables which we retain in a simple model.

We take inspiration from the Taylor rule to identify relevant macroeconomic variables but adopt a simple model that we can apply across all markets in our swap universe to assess whether current yield levels deviate from macro fundamentals. To capture inflation pressure and growth dynamics, we consider indicators such as unemployment, real GDP growth, industrial production or leading indicators, such as Purchasing Manager Index (PMI). In addition, recent equity market performance may capture both a wealth effect and a

[5] **See** Taylor, John B. (1993). "Discretion versus Policy Rules in Practice" Carnegie-Rochester Conference Series on Public Policy"

forward-looking indication of economic activity. During periods of strong economic activity, a steep yield curve points to an expectation of rising rates. However, a low inflation environment corresponds to a lower probability of an increase in rates even in a steep curve environment. Finally, the level of local and US Libor rates, taken in combination with the macro variables mentioned above, are informative of overall yield curve level.

There are many ways of modelling rates with exogenous factors. We use linear regression analysis on a rolling basis to determine whether a spot interest rate significantly deviates from "predicted value". If it is the case, we adjust the carry signal of the strategy for this discrepancy. A short look-back period (the regression is run on a 30 month rolling window) allows capturing changes in markets regimes in a timely manner. Technically, the model is specified as follows:

$$r_t = \alpha + \beta_1 \times Inflation_t + \beta_2 \times Unemployment_t + \beta_3 \times Wealth_t + \beta_4 \times EconomicActivIndicator_t + \beta_5 \times ShortRate_t + \beta_6 \times USShortRate_t + e_t$$

For simplicity and consistency, we use the same model specifications for all markets, one rate at a time, and do not explicitly factor global interest rates markets correlations. We perform the analysis on strategy rebalancing dates using monthly frequency data.

Fundamental data are incorporated in the strategy carry portfolio at the level of signal definition. The residuals of the regression model outlined above are expressed in the same units (expected return per unit of duration) as the original carry signal and so can be added to the original definition of the duration-normalised carry signal as shown below. A scaling factor is applied to the adjustment (residual of the above regression) to reflect the time horizon (in this case 12 months) at which the gap between actual and modelled yield is expected to close.

$$CarrySignal_t = \frac{1}{12}\frac{(Yield_t^T - 1MRate_t)}{Duration} - \left(Yield_t^{T-1month} - Yield_t^T\right) + \frac{1}{12}\, e_t$$

In practice, we find that the size of the macro adjustment has been less than half the size of the unadjusted carry signal on average in the period and set of markets covered by our analysis.

We also find that the macro adjustment has delivered positive performance on a stand-alone basis[6]. Indeed, similarly constructed long-short portfolios based solely on the fundamental signal described above have delivered modestly positive information ratios in the time period of our analysis.

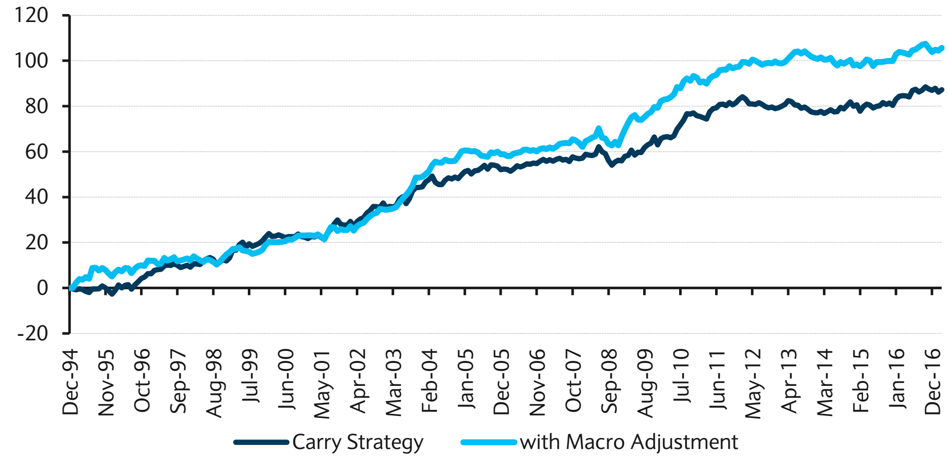
This modelling exercise does not represent a sophisticated effort at explaining interest rates. It should be seen as a simple attempt to adjust a carry signal in order to study changes in performance and in risk properties. The performance of strategies that incorporate this macro adjustment illustrates potential advantages of such an approach, but there likely is plenty of room for improvement.

Does adjusting a carry signal for expected changes in rates improve performance? Figure 8 shows that his has been the case for a cross-market 5-year swap strategy where positions are sized to have equal duration contributions.

[6] We must however be very cautious with this claim as the macro indicators used in our analysis are final, revised indicators as opposed to the ones published and available at the time of portfolio rebalancing.

FIGURE 8

Cumulative Return of 5-year cross-market swap strategy (duration-weighted)



Source: Barclays Research

Figure 9 follows the same template as Figure 6 for a number of different strategy specifications and time periods. Information ratios are generally higher and correlations with the global treasury index are generally lower than was the case when using simple carry signals. This is observed for single maturity cross-market strategies as well as for the more diversified pooled strategies shown in the bottom four rows of Figure 9. As was the case for the pure carry strategies shown in Figure 6, volatility is generally higher and information ratios are lower for the 3-year maturity strategies than for the longer maturity ones.

FIGURE 9

Summary performances of swap-based strategies that exploit macro-adjusted carry signals

Period	Weighting	Tenor	Avg Ret (%/y)	Vol (%/y)	Skewness	Excess Kurtosis	Max. Drawdown (%)	I.R.	Correl w Global Tsy Index
Jan 1995 - Mar 2017	Equal Durt Contrib	3y (3 vs. 3)	3.3%	3.4%	0.5	1.6	-5.5%	**0.97**	0.12
		5y	3.3%	3.1%	0.5	1.8	-4.4%	**1.07**	-0.04
		10y	3.3%	2.9%	0.4	1.8	-5.1%	**1.14**	0.01
	Equal Vol	3y (3 vs. 3)	1.4%	2.0%	1.2	7.8	-3.3%	**0.69**	0.00
		5y	1.5%	1.6%	0.0	0.4	-3.2%	**0.94**	-0.13
		10y	1.8%	1.6%	0.5	2.4	-3.5%	**1.12**	-0.09
Dec 2002 - Mar 2017	Equal Durt Contrib	3y (4 vs. 4)	1.9%	2.4%	0.0	1.1	-4.5%	**0.82**	0.09
		5y	2.0%	2.1%	0.0	0.9	-3.6%	**0.95**	-0.07
		10y	2.5%	2.1%	0.3	0.9	-3.0%	**1.19**	0.04
		15y	1.8%	2.2%	0.5	3.6	-4.8%	**0.84**	0.01
	Equal Vol	3y (4 vs. 4)	1.2%	2.2%	1.0	5.9	-3.8%	**0.54**	-0.02
		5y	1.4%	1.8%	0.0	0.3	-4.7%	**0.74**	-0.15
		10y	1.8%	1.8%	0.2	0.8	-4.7%	**1.00**	-0.05
		15y	1.4%	1.9%	0.8	4.3	-3.9%	**0.74**	0.10
Jan 1995 - Mar 2017	Equal Durt Contrib	3Y 5y 10y (5 vs. 5)	4.2%	3.6%	0.3	2.0	-6.4%	**1.18**	0.10
		3Y 5y 10y (10 vs. 10)	3.1%	2.5%	0.5	1.7	-3.6%	**1.25**	0.03
	Equal Vol	3Y 5y 10y (5 vs. 5)	3.8%	3.3%	0.3	1.3	-6.0%	**1.14**	-0.03
		3Y 5y 10y (10 vs. 10)	4.7%	4.5%	0.3	0.5	-7.9%	**1.05**	-0.10

Source: Barclays Research

Figure 10 relates to pooled strategies that invest in three maturities across seven markets (21 assets considered), and reports differences between "macro-adjusted" and pure carry strategies. These strategies are reported at the bottom of Figures 6 and 9 and a selection of their performance characteristics is repeated in Figure 10. Information ratios increase by 0.3 to 0.4 and correlations with bond indices are reduced when signals are adjusted for the macro environment. The directionality of rates carry strategies is discussed in more detailed in the following section.

FIGURE 10

Differences between macro-adjusted and pure carry performances (1995-2017)

	Equal Duration Contribution		Equal Volatility	
	3, 5 and 10y (5 vs 5)	3, 5 and 10y (10 vs 10)	3, 5 and 10y (5 vs 5)	3, 5 and 10y (10 vs 10)
Difference in Return (%/y)	1.1	0.9	1.2	0.8
Difference in I.R.	0.34	0.44	0.32	0.26
Difference in Correlation w Global Tsy Index	-0.18	-0.14	-0.06	-0.09
Difference in Correlation w US Tsy Index	-0.23	-0.18	-0.12	-0.13

Source: Barclays Research

Although cross-market rates strategies have performed well over the period of our analysis, performance may not always be very stable and can be directional on various market factors. Figure 3 showed that the relationship between carry signal and return does fluctuate over time and Figure 10 shows that correlations with the market index depend on the weighting scheme used in defining the strategy. The next section investigates in more details how carry strategies perform over time.

How do rates carry strategies perform over time?

In the previous sections, we have documented a positive correlation between carry strategies and treasury bond indices. Let us now investigate how rates carry performances vary under different market regimes. For this, we focus on the pooled carry (long 10 and short 10 swaps out of 21 instruments from seven markets and three tenors).

As expected, we find that the strength of the carry signal is related to strategy performance. Figure 11 shows strategy information ratio for different definitions of the carry signal and different weighting schemes. For all four combinations considered, information ratios are higher following above-median than following below-median signal strength. The same pattern was also observed for average returns. This is a very intuitive finding as the signal is a measure of expected return and, as Figure 2 already established, a significant relationship between signal strength and performance at the level of individual assets.

FIGURE 11

Information ratios following below or above median carry signals (1995 to 2017)

	Strategy Specifications			
Beginning of month signal	Duration-weighted	Volatility-weighted	Macro-adjusted duration weighted	Macro-adjusted volatility weighted
Below median	0.59	0.66	1.03	0.90
Above median	1.01	0.95	1.45	1.18

Source: Barclays Research

Figure 12 displays risk-adjusted performance under different market regimes for duration and volatility-weighted strategies. We find that the duration-weighted strategy is much more directional on overall rates market performance than the volatility-weighted one. This results from the fact that the risk of the long and short legs of the portfolio does not always not cancel out as a unit of duration in one market is not always equivalent to a unit of duration in another market in terms of volatility. Indeed, we observe that the long leg of duration-weighted strategies has a higher volatility than the short leg while this is not the case for volatility-weighted strategies.

Rates carry is also directional on credit excess return, with substantially higher information ratios observed when US credit excess returns over Treasuries are in the top half of our sample, for all strategy specifications. This finding is consistent with Koijen [2013] who document a commonality between carry strategies across different asset classes. The directionality on yield curve slope[7] is not significant and is mostly a feature of duration-weighted portfolios. It tends to disappear when considering a volatility-weighting scheme.

FIGURE 12

Strategy information ratios under various market regimes (1995 to 2017)

Market regime (above or below median)		Duration-weighted	Volatility-weighted
Global treasury index return	high	1.29	0.79
	low	0.33	0.78
Return of a duration-neutral slope flattener	high	0.90	0.72
	low	0.76	0.85
US corporate index excess return	high	1.00	1.21
	low	0.64	0.42

Source: Barclays Research

We also find that the relationship between carry strategy performance and the direction of the rates market depends on the strength of the carry signal. Figure 13 reports strategy returns sorted according two dimensions: strength of the carry signal and return of the Global Treasury Index (above/below median in both cases). Carry performance is the highest when signal strength is high and treasury markets rally. But this pattern is not observed across all four definitions of our pooled carry strategy. In fact, while signal strength always helps discriminate performance regimes, it is only the duration-weighted pure carry strategy that is strongly directional on treasury market regimes.

FIGURE 13

Average return of duration-weighted strategy in signal and treasury market regimes (1995-2017)

			Treasury index return	
			Low	High
			0.8%/y	3.5%/y
Signal Strength	Low	1.5%/y	1.2	1.9
	High	2.9%/y	0.4	4.7

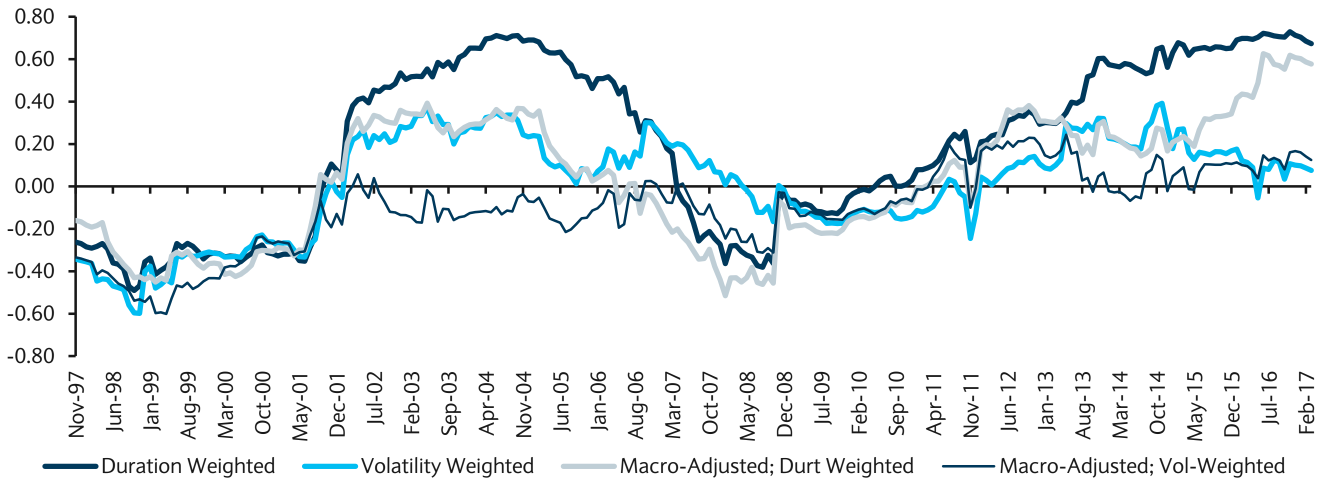
Source: Barclays Research

[7] The yield curve slope factor is a global duration neutral flattener that is long duration in the 10y swap and short the 3y swap in each the seven markets in the universe.

Indeed, we have seen in the previous section and in particular in Figure 10 that adjusting carry signals according to macro variables has the effect of reducing correlations with rates markets. As documented by Coche et al [2016], these correlations change over time, as shown in Figure 14, in a pattern loosely related to the strength of the carry signal.

FIGURE 14

Rolling 3-year correlation of four different carry strategies with global treasury index returns



Source: Barclays Research

For all definitions of the strategy, we find that a strong carry signal comes with a higher correlation with treasury index returns. This is illustrated in Figure 15 where for different signals (pure or with macro-adjustment) and different portfolio construction approaches (equal duration contribution or equal volatility) we observe that correlation between strategy performance and treasury market returns increase according to the strength of the carry signal.

FIGURE 15

Correlations between strategy performance and global rates market by quartile of carry signal (1995 to 2017)

	Strategy Specifications			
Quartile of carry signal	Duration Weighted	Volatility Weighted	Macro-Adj. Duration Weighted	Macro-Adj. Volatility Weighted
Quartile 1 (low carry signal)	14%	-11%	-11%	-19%
Quartile 2	21%	-10%	6%	-15%
Quartile 3	22%	14%	0%	-7%
Quartile 4 (high carry signal)	25%	13%	15%	0%

Source: Barclays Research

We have found that the performance of cross-market carry strategies in swap markets has been relatively robust to alternatives specifications. Risk properties are intuitive but adjusting a carry signal according to macroeconomic variables, can change these properties. We now turn to bond portfolios which are subject to long-only constraints and cover different universes of markets, developed and emerging.

Rates carry in long-only bond portfolios

Many investors in rates markets run long-only bond portfolios as they must comply with funding constraints. In this context, our investment universe becomes the Bloomberg Barclays Global Treasury Bond Index. Some of the markets included in this index are developed markets with long time series of returns while others are emerging markets and only have a shorter history. We study various market subsets: G4, a selection of eight developed markets (G8), the entire global treasury index universe (up to 27 markets), and a subset of 15 emerging markets included in the index[8]. For each one of these subsets, we construct long-only carry bond portfolios relative to either equal-weighted or to market-weighted benchmark indices. For each one of four maturity buckets (1-3, 3-7, 7-10 and 10+yr), the carry portfolios are free to allocate across markets but we require that the total weight of a maturity bucket to match the benchmark index weight in that maturity to avoid large differences in duration that could result in very unstable risk profiles. All performances are currency-hedged into USD. In order to compare results of developed and emerging market portfolios, this analysis covers a more recent time period and starts only in 2002. In this section, carry signals are not adjusted for economic variables but taken as pure carry and roll-down per unit of duration.

Carry can be used for comparing bonds across various markets as the short-term rate used as a local currency funding rate is reflected in the forward exchange rates of the corresponding tenor. Indeed, a USD-based investor holding a foreign bond in combination with a one-month currency forward meant to hedge away foreign currency exposure is effectively receiving the yield of the foreign bond, paying a one-month foreign rate and receiving a domestic USD one-month rate. These two exposures to short-term rates are embedded in the currency forward transaction[9]. Therefore, comparing bonds across markets based on their respective carry boils down to comparing the steepness of different yield curves.

In the context of a long-only portfolio, the allocation within each maturity bucket must contain non-negative weights to all markets. Thus, instead of going long high-carry markets and short low-carry markets as we did with portfolios of swaps, we need to overweight high-carry markets and underweight the low-carry ones, taking care that no weights are negative and all weights sum to 100%. Furthermore, to keep our portfolio anchored to the market-weighted benchmark, our portfolio construction considers the benchmark weight of each asset as well as the carry signal.

To achieve these goals, portfolio weights are determined in three steps. First, we calculate the signal as measured by a sum of carry and rolldown per unit of duration for each country-maturity cell of the index[10]. Then, signals are transformed into scores to ensure that stronger signals lead to larger weight allocations. Finally, scores are combined with benchmark weights to produce portfolio weights while ensuring the portfolio is fully invested. The reference to benchmark weight is relevant to investors concerned about market capacity and who want to anchor portfolio weights to relative market-capitalisations. The appendix explains this weighting scheme in greater details.

A reference to market capitalisation weights can be very useful in ensuring that the portfolio allocation recognises market capacity. However, it implies that large markets can be over or

[8] In the context of this study, G4 markets include USD, JPY, EUR and GBP, G8 markets include AUD, CAD, CHF, EUR, GBP, JPY, SEK, and USD while the EM country group includes CLP, CZK, HKD, HUF, ILS, KRW, MXN, MYR, PLN, RUB, SGD, THB, TRY, TWD and ZAR

[9] Note that this description ignores the cross-currency basis swap which can be large and volatile.

[10] We use local one-month deposit rates to measure carry in each market and measure performance in USD terms, with currency-hedging implemented using 1-month forward exchange rates. We could have used (and in fact did use) the 1-month deposit rate implied by FX forward points instead of local deposit rates but found that implied rates have been highly unstable at times, as a result of the high volatility in cross-currency basis swap. Strategy performance and characteristics were not qualitatively different when using implied 1M rates but turnover was much higher, as was portfolio concentration in some months.

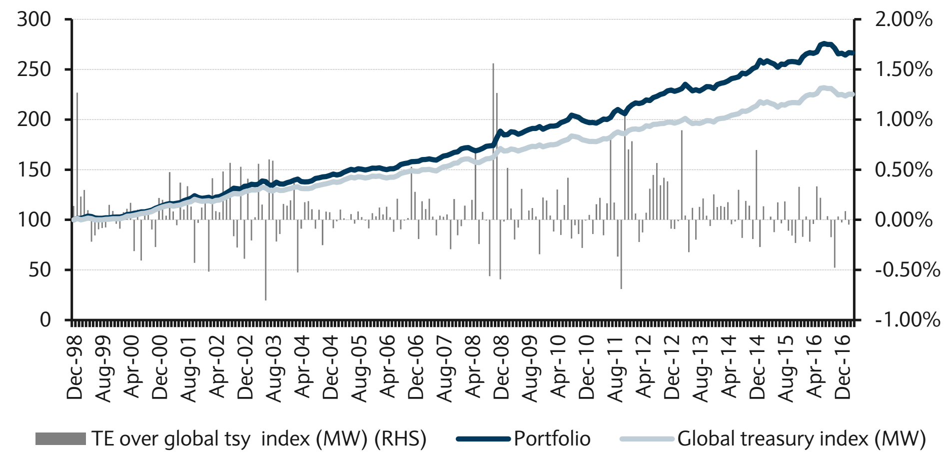
underweight much more aggressively than smaller markets. In that case, there may not be much diversification of the strategy across markets and signals. This is why, in the examples that follow, we present results related to both market-capitalisation and equal-weighted bond indices.

The portfolio construction approach described above has several practical advantages but it is not the only one that investors can consider when assembling active portfolios. For example, portfolios could be assembled using mean-variance techniques, taking market correlations into account to maximise portfolio return per unit of risk, or setting weights as a function of the expected carry Sharpe ratio of individual assets.

Figure 16 plots the cumulative performance and monthly tracking errors of a global treasury "carry-weighted" bond portfolio relative to the market capitalisation-weighted Bloomberg Barclays Global Treasury Index.

FIGURE 16

Performance of global treasury carry portfolio relative to market index (hedged into USD)



Source: Bloomberg, Barclays Research

Figure 17 and 18 summarise bond portfolio performances for various subsets of the bond market. For G4 and G8 portfolios, excess returns over benchmark (from 0.88 to 0.93%/y) and information ratios (from 0.84 to 0.88) are very similar irrespective of whether the baseline is market or equal-weighted but, for EM and global treasury portfolios, higher returns and IR are obtained when starting from an equal-weighted baseline than from a market-weighted one. As expected, global treasury portfolios deliver the highest return and IR in their respective peer group as they benefit from the broadest spread of carry signal and also of the broadest diversification. Indeed, the global treasury universe includes up to 27 markets while our EM universe covers only 15.

FIGURE 17

Performance of carry-based bond portfolios that take equal weights as baseline (2002-2017)

	Avg Ret (%/y)	Vol (%/y)	Skewness	Excess Kurtosis	Max Drawdown (%)	S.R. / I.R.	Correlation with Benchmark
G4 EW benchmark	4.50%	3.46%	0.02	0.18	-3.6%	0.86	
G4 Carry Portfolio	5.43%	4.09%	0.08	1.10	-4.2%	0.95	0.97
G4 Portfolio over EW	0.93%	1.10%	0.31	1.86	-1.1%	0.84	0.47
G8 EW benchmark	4.31%	3.48%	0.12	0.07	-3.6%	0.80	
G8 Carry Portfolio	5.20%	3.89%	0.12	0.74	-3.9%	0.95	0.97
G8 Portfolio over EW	0.88%	1.00%	0.12	3.13	-1.6%	0.88	0.29
Gl Tsy EW benchmark	4.31%	3.10%	0.16	1.10	-4.0%	0.90	
Gl Tsy Carry Portfolio	5.65%	3.55%	0.33	2.15	-4.0%	1.16	0.96
Gl Tsy Portfolio over EW	1.34%	1.03%	0.79	3.72	-1.2%	1.31	0.31
EM EW benchmark	4.62%	3.53%	-0.12	1.29	-6.3%	0.88	
EM Carry Portfolio	5.76%	4.00%	0.41	3.08	-7.3%	1.06	0.94
EM Carry over EW	1.14%	1.34%	1.76	9.11	-3.8%	0.85	0.18

Source: Barclays Research

FIGURE 18

Performance of carry-based bond portfolios that take market weights as a baseline (2002-2017)

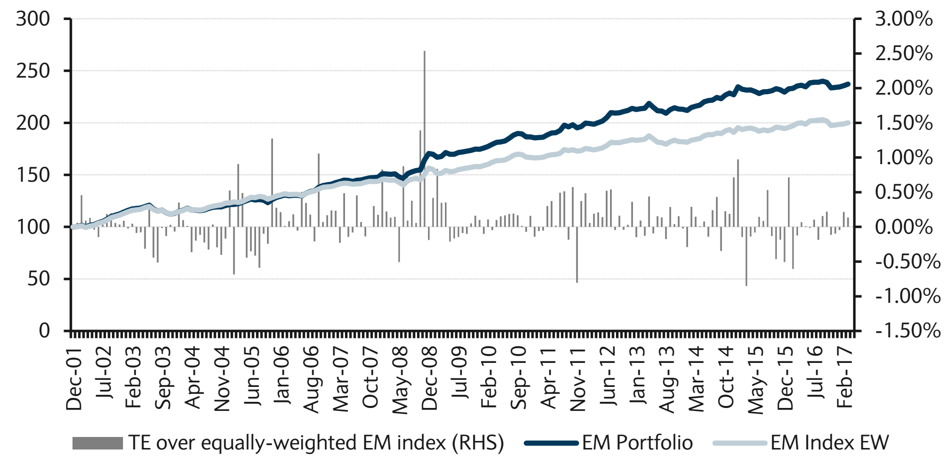
	Avg Ret (%/y)	Vol (%/y)	Skewness	Excess Kurtosis	Max Drawdown (%)	S.R. /I.R.	Correl with Benchmark
G4 MV benchmark	4.26%	2.94%	-0.04	-0.07	-3.6%	0.93	
G4 Carry Portfolio	5.15%	3.61%	0.03	0.63	-4.4%	1.01	0.97
G4 Portfolio over MV	0.89%	1.06%	0.47	1.27	-1.1%	0.84	0.52
G8 MV benchmark	4.26%	2.94%	-0.03	-0.08	-3.6%	0.93	
G8 Carry Portfolio	5.14%	3.60%	0.03	0.62	-4.4%	1.01	0.97
G8 Portfolio over MV	0.88%	1.05%	0.47	1.33	-1.1%	0.84	0.52
Gl Tsy MV benchmark	4.26%	2.90%	-0.02	0.01	-3.6%	0.95	
Gl Tsy Carry Portfolio	5.23%	3.60%	0.24	1.31	-4.2%	1.03	0.97
Gl Tsy Portfolio over MV	0.97%	1.09%	1.05	3.82	-1.1%	0.89	0.53
EM MV benchmark	4.72%	2.87%	0.05	2.46	-4.3%	1.11	
EM Carry Portfolio	5.33%	3.29%	0.80	4.35	-4.5%	1.16	0.94
EM Portfolio over MV	0.62%	1.16%	2.11	15.68	-4.1%	0.53	0.18

Source: Barclays Research

The EM portfolio that refer to an equal-weighted baseline performance has a higher excess return than G4 and G8 portfolios (1.14%/y vs. 0.93 and 0.88%/y) but only a comparable information ratio (0.85 vs. 0.84 and 0.88) as EM have been volatile and portfolio tracking errors relative to the index have exhibited significant kurtosis. The positive skewness and excess kurtosis of EM portfolio returns can be attributed to a very large return observed in November 2008, as shown in Figure 19. Excluding that month would have the effect of reducing average excess return over the EW index from 1.14 to 0.98%/y, volatility (from 1.34 to 1.18%y), IR (from 0.85 to 0.83), skewness (from 1.8 to 0.6) and excess kurtosis (from 9.1 to 2.0).

FIGURE 19

Performance of EM carry portfolio relative to equal-weighted EM index



Source: Barclays Research

While the bond portfolios shown so far invest across all maturities, we also study cross-market carry portfolios that are concentrated in just one maturity sector at a time. Information ratios are shown in Figure 20. Predictably, we find that information ratios are higher when all maturities are available rather than just one particular bucket. It also appears that information ratios are lower in the 1-3y maturity sector than in longer maturities. We found that these lower IRs can mostly be attributed to lower returns (tracking error volatilities are also lower for 1-3y portfolios than for longer maturity ones, but to a smaller extent than returns). This is because carry signals have generally been lower, and often negative, for short-maturity bonds than for longer ones. Two sub-periods are of particular interest, the run up to the financial crisis in 2008 when negative signals (some inverted yield curves) were followed by steep drop in rates in the aftermath of the crisis, and a more recent period of very accommodative central bank policy during which the short end of the curve has been persistently flat or even inverted in major markets.

FIGURE 20

Strategy information ratio by asset class and maturity sector, relative to equal-weighted benchmarks (2002-2017)

	All	1-3y	3-7y	7-10y
G4	0.84	0.36	0.81	0.79
G8	0.88	0.39	0.80	0.86
Global Tsy	1.31	0.64	0.95	1.14
EM	0.85	0.49	0.51	0.73

Source: Barclays Research

As is the case for swap portfolios, we find that carry-based bond portfolios are market directional. This is illustrated in Figure 21 where information ratios are provided for a subset of our historical sample split according to various market regimes. The first section distinguishes between high (above median) and low returns of the Global Treasury Index. The second section of Figure 21 relates to yield curve slope regimes and the third one to credit excess return regimes.

While all portfolios are highly sensitive to global treasury market performance, carry-based emerging market portfolios appear to be less directional on credit market regimes than G4 and G8 portfolios while the directionality on yield curve reshaping is not stable across universes.

FIGURE 21

Information ratios under different market regimes (carry portfolios relative to EW indices – 2002 to 2017)

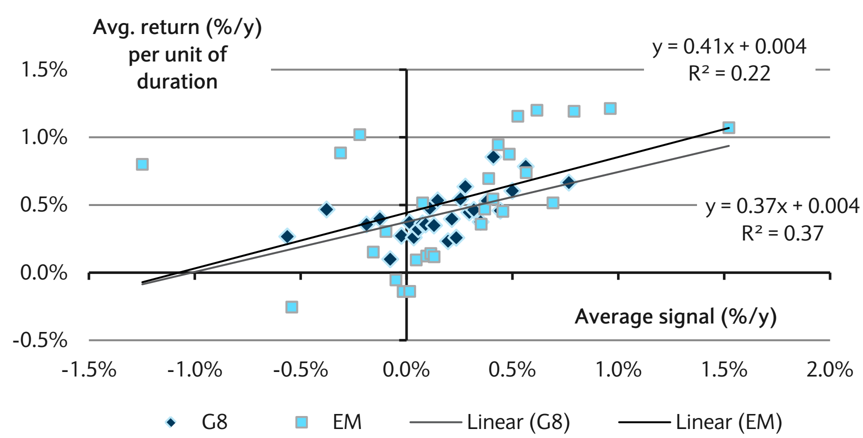
Market Regime (above/below median)		G8	Global treasury	EM
Global treasury index return	high	1.71	1.67	1.22
	low	0.23	0.84	0.39
Duration-neutral slope flattener	high	1.20	1.01	0.82
	low	0.65	1.47	0.86
US corporate index excess return	high	1.49	1.64	0.80
	low	0.45	0.89	0.87

Source: Barclays Research

Most published studies so far have investigated rates carry strategies in developed markets but the question remains of whether carry signals are a better predictor of subsequent performance in developed or in emerging markets. Figure 22 reproduces the analysis shown in Figure 2 but covers both developed and emerging market bonds identified as separate groups. Each dot represents a cell based on signal strength. It is obtained from the ranking of individual assets by strength of carry signal (carry return divided by duration) at the beginning of each month. The corresponding returns are observed at month-end and Figure 22 plots average signals and returns for the entire period of the study, starting in 2002. We observe that the relationship is weaker than shown in Figure 2 in terms of both R-squared and slope but this is largely period-specific[11]. The slope of the relationship between signal and return is almost the same for emerging as for developed markets, but R-squared is lower. Signal dispersion is also larger in EM, where strongly inverted curves have produced negative carry signals which were not always followed by poor returns, as shown by the leftmost dot on Figure 22. One reason for this outlier is that EM have, on some occasions, experienced sharp increases in central bank policy rates that were intended to protect the currency exchange rate, but at the same time had the effect of slowing economic growth and therefore were followed by a drop in long-term yields.

FIGURE 22

Relationship between carry signal and realised return for developed and emerging markets (2002 to 2017)

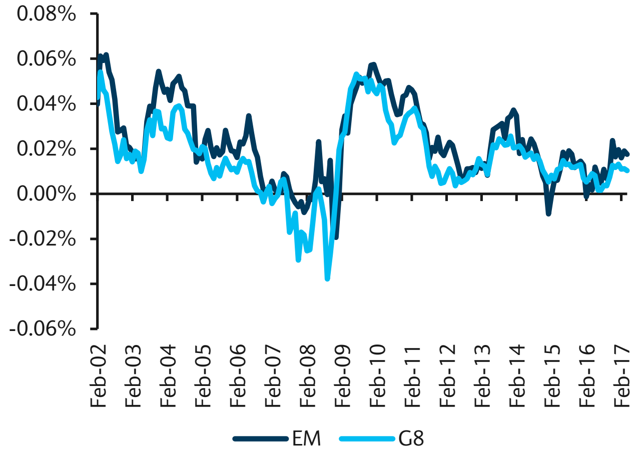


Source: Barclays Research

[11] In swap markets, the R-squared between signals and returns is 85% for the sample that starts at the end of 1994 and 56% for the one starting in 2002. This is consistent with the evolution of the relationship between signal and return shown in Figure 2.

FIGURE 23

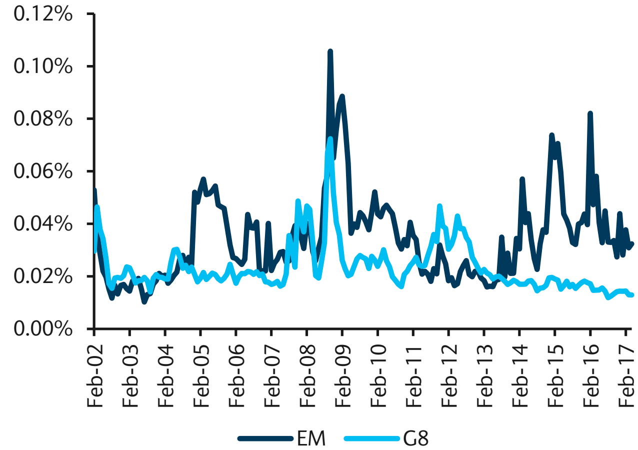
Average rates carry signal (in %/month per unit of duration) has been similar across developed and emerging markets



Source: Barclays Research

FIGURE 24

Carry signal dispersion (cross-sectional standard deviation) has been much larger in emerging than in developed markets



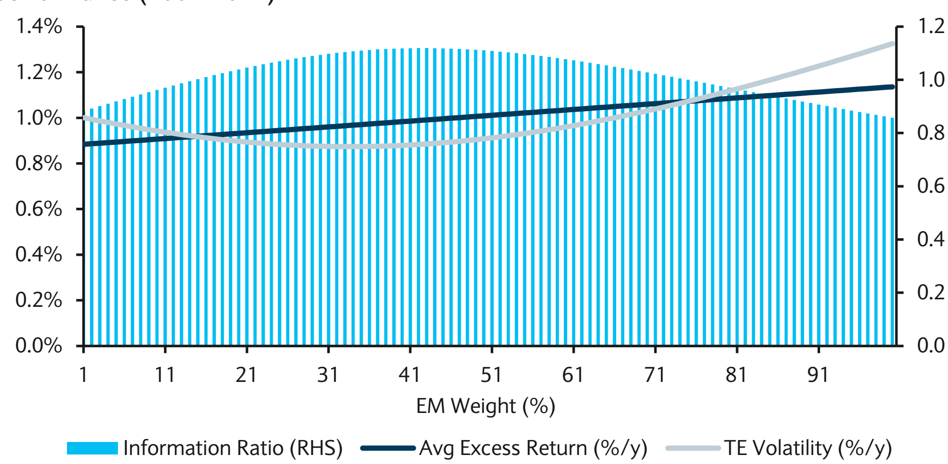
Source: Barclays Research

Figure 23 and 24 compare carry signals in our sets of emerging and developed markets over time: average signals have been very similar over the past 15 years, consistent with similar yield curve slopes, on average, across the two universes. However, the dispersion (cross-sectional standard deviation) of signals has recently been larger in emerging than in developed markets, potentially giving scope for more substantial alpha generation.

Finally, Figure 25 illustrates the benefit of diversifying a carry portfolio across both G8 and emerging markets and expands on the results shown in Figure 17 (performance relative to equal-weighted benchmarks). The leftmost part of the diagram represents a carry portfolio invested only in developed markets. For that point, return, volatility and information ratios are shown in excess of the DM equal-weighted benchmark index. Moving to the right, excess return, tracking error volatility and information ratio are plotted for portfolios that include an increasingly larger allocation to EM bonds. The rightmost portfolio is fully invested in EM and is benchmarked against an equally-weighted EM index. The highest information ratio is obtained for a 41% allocation to EM. For that portfolio mix, the benchmark is 59% DM and 41%. So, the performance and information ratio presented in Figure 25 relate to the strategy alpha rather that the total return of a portfolio with a varying allocation to EM. Active returns and information ratio do indeed benefit from a broadening of the strategy universe beyond developed markets.

FIGURE 25

Combining developed and emerging market carry portfolios can enhance risk-adjusted performance (2002-2017)



Source: Barclays Research

Conclusion

Carry has been a popular strategy that has been used for many years by global bond investors. We find a strong relationship between carry signal and performance which has supported attractive information ratios for both long-short and long-only portfolios that exploit cross-market carry signals.

The strength of the carry signal is informative of subsequent performance and of correlations with market factors. The returns of carry strategies can be correlated with treasury index returns but this correlation changes over time according to the strength of the signal and to the way the strategy is constructed. Cross-market strategies have also been correlated with credit market excess returns.

Carry signals can be adjusted according to the macroeconomic environment in a way that is consistent with the Taylor rule. We propose a simple model for adjusting signals and find it improves performance and makes the strategy less correlated with treasury index returns.

Cross-market rates strategies also perform well in emerging markets. Carry signals have often been more dispersed in EM than in developed markets, giving scope for performance enhancement in addition to diversification benefits.

References

Coche, Joachim, Mark Knezevic and Vahe Sahakyan (2017), 'Carry on?', forthcoming in *Proceedings of the 6th BIS/WB/BoC Public Investors' Conference, Palgrave Macmillan*.

Koijen, Ralph SJ, et al. *Carry*. No. w19325. National Bureau of Economic Research, 2013

Leibowitz M., L. Bader and S Kogelman, *Global Fixed Income Investments: The Persistence Effect*, Financial Analysts Journal, 1995

Ilmanen, Antti. *Expected Returns,* Wiley Finance, 2011

Taylor, John B. (1993). Discretion versus Policy Rules in Practice, Carnegie-Rochester Conference Series on Public Policy. 39: 195–214

Appendix – Transforming carry signals into portfolio weights

We transform carry signals into portfolio weights in two steps. First, signals are normalised and transformed into a weighting score and then portfolio weights are obtained by combining scores with benchmark weights.

We use a logistic function to transform signals into scores as it meets three essential requirements: scores must be positive, strictly monotonic according to signal and bonds that have similar signals should have similar scores. Signals are normalised using parameters μ and σ . Normalisation ensures that the strategy is more conservative, with smaller net deviations from the benchmark, when all carry signals are similar to each other and more aggressive when we observe large differences in carry signal across the different assets in the portfolio universe.

$$X_{i,t} = \frac{CarrySignal_{i,t} - \mu}{\sigma}$$

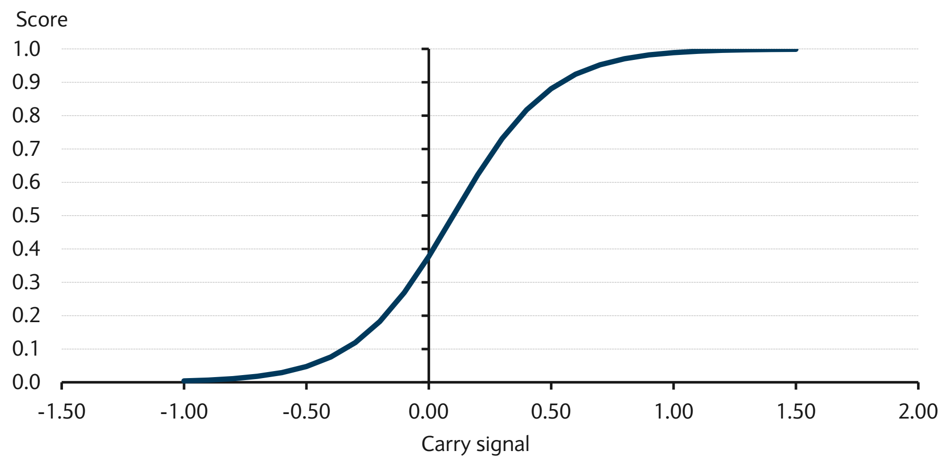
Then the score is calculated from a logistic function with a parameter κ that regulates the "aggressiveness" of the function.

$$\text{Score}(x_{i,t}) = \frac{1}{1 + e^{-\kappa \; x_{i,t}}}$$

The normalisation (μ and σ) and aggressiveness (κ) parameters[12] are fixed and kept constant for the whole analysis and informed by long history of carry signal distributions across a large sample of markets. As a result, when signals are similar and exhibit clustering across many markets, scores are similar as well. Scores that do not exhibit much cross-sectional variation do not contribute much to weight adjustments. The diagram in Figure 17 illustrates the transformation from carry signal to weighting score.

FIGURE 26

Example transformation of a carry signal into a weighting score



Source: Barclays Research

The final step is to multiply benchmark weights with the score and to obtain portfolio weights.

$$\omega_{i,t} = \frac{Score_{i,t} \times BW_{i,t}}{\sum_i Score_{i,t} \times BW_{i,t}}, where\ BW_{i,t}\ is\ a\ weight\ in\ the\ benchmark$$

[12] The values used in this study are set arbitrarily as follows: μ=0.1, σ=0.2 and κ=1- and correspond to signals (expected return per unit of risk) calculated on a one month horizon.

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