BARCLAYS

Quantitative Portfolio Strategy

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Introducing GRACE: the Global Rates Adjusted Carry (GRACE) Scorecard

- We introduce GRACE (Global Rates Adjusted Carry) scorecard, a framework designed to quantify carry across eleven government bond markets.
- The framework is based on our previous research, *Carry Strategies in Global Rates Markets*, Barclays Research, 14 June 2017.
- Carry is calculated by re-pricing individual government bonds while keeping the yield curve constant and calculating total returns on a one-month horizon.
- We use a statistical model to estimate expected changes in rates in different markets and adjust carry signals accordingly. GRACE calculates *adjusted* net carry of individual government bonds per unit of duration.
- We find that GRACE scores have been positively related to subsequent bond returns across different government bond markets.
- A long/short strategy that systematically invests in markets with top GRACE scores and sells markets with bottom scores has delivered average returns of 1.85%/yr between February 2001 and December 2017, with an information ratio of 0.93.

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Introduction

In our empirical study *Carry Strategies in Global Rates Markets*, we found evidence that cross-market carry strategies can be profitable and exhibit attractive risk-adjusted returns, whether implemented with swaps or with government bonds. To assist investors implementing and monitoring carry strategies in rates markets, we now start publishing bond-level scores called GRACE (Global Rates-Adjusted Carry) for a set of eleven global government bond markets.

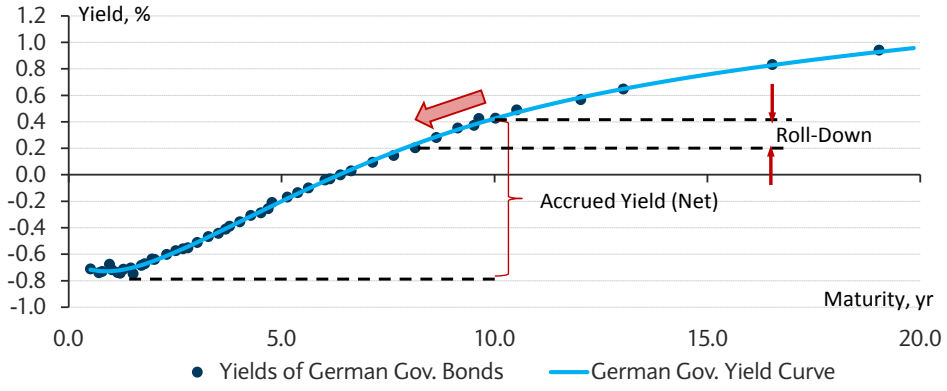
The GRACE scorecard includes two components: a pure carry calculation which is consistent with typical bond market conventions; and a macro adjustment that includes a projection of rates according to the current macro environment and market conditions.

The carry of a government bond is commonly defined as its projected return calculated under the assumption that the underlying yield curve remains unchanged. Carry return includes two components: *accrued yield* and *roll-down*.

Figure 1 shows an example German Government bond curve and illustrates the two carry components. Accrued yield is the interest accrued over time. It depends on the length of the holding period and includes paid or accrued coupon and price change due to *pull to par*. The *pull to par* effect can be either positive or negative, depending on whether a bond trades below or above par. Roll-down return is earned due to a change in yield (usually decrease), according to the shape of the curve, as the remaining maturity of a bond declines. Roll-down return is higher for markets with a steeper yield curve or bonds with longer duration. It also increases with the length of the holding period.

FIGURE 1

Carry Components: German Government Curve, 29 December 2017



Source: Barclays Research

In addition to this traditional measure of bond carry, as illustrated in the first section of this report, we explain how a macro adjustment inspired from the Taylor rule can be designed to augment a pure carry signal. Adjusting carry for expected changes in the yield curve is explained in the second section. Finally, the third section illustrates the performance of a cross-market carry strategy based on GRACE.

Measuring Carry of Individual Bonds

In order to calculate carry, we re-price individual bonds at a one-month horizon, assuming that underlying yield curves remain unchanged. To do this, we calibrate the yield curves of our universe of G11 markets[1] using observed bond prices. We then shift the calculation date

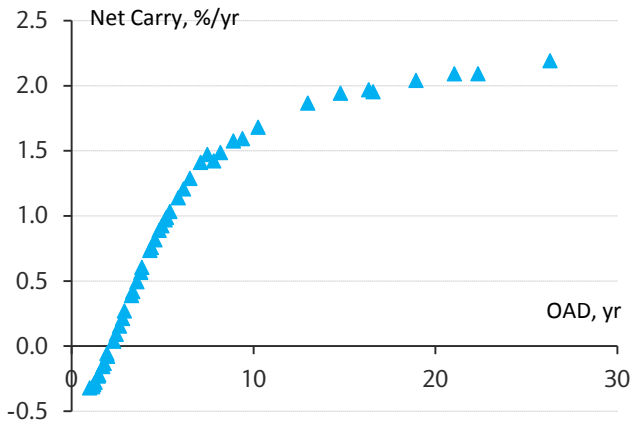
[1] We consider the following 11 government bond markets: United States (US); Germany (DE); Japan (JP); United Kingdom (GB); Canada (CA); Australia (AU); Sweden (SE); Denmark (DK); Norway (NO); Switzerland (CH); and Singapore (SG)

one month forward so that remaining maturity decreases by one month and use the same curves to re-price all bonds. Carry is then calculated as the annualised total return of a bond net of its funding rate.[2] We also account for paid coupons and accrued interest accumulated over the period.

Figure 2 plots net carry of bonds issued by Germany and the UK as a function of duration. The relationship between net carry and duration can be monotonic, as for Germany, with higher carry return associated with long-maturity bonds or bell-shaped, as for the UK, with carry gradually declining with duration for long-maturity bonds. The latter occurs when the yield curve is flatter at longer maturities.

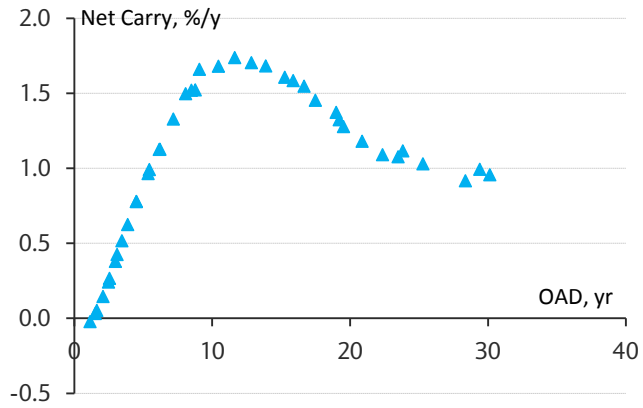
FIGURE 2
Bond Carry (GB, DE) as function of duration, 29 December 2017

PANEL A
German Government Bonds



Source: Barclays Research

PANEL B
UK Government Bonds (GILTS)



Source: Barclays Research

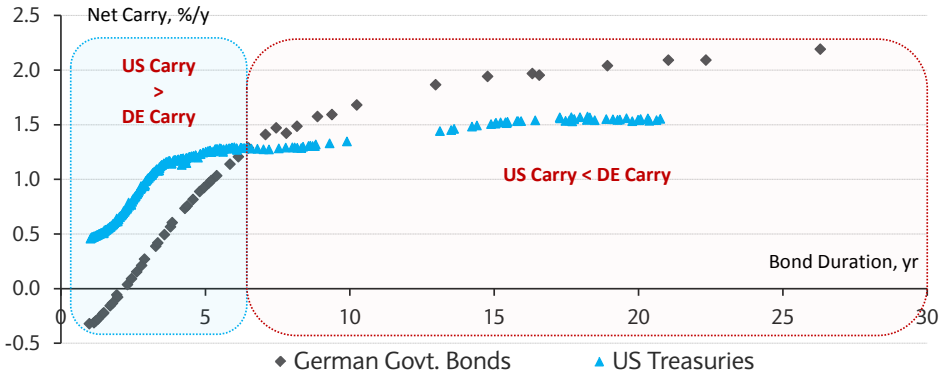
Panel B of Figure 2 illustrates that there can be a "sweet spot" where bond carry reaches a maximum. Indeed, the longer end of the curve can sometimes be flat and exhibit lower carry than intermediate or short maturities. This can result from investor preferences for long maturity securities, for example in the context of long-dated liabilities.

The rankings of individual countries by carry can vary across different duration segments of the curve. As a result, countries selected into "high carry portfolios" can vary according to different maturity buckets. Figure 3 illustrates this by plotting net carry measures for US treasuries and German government bonds as a function of duration. In this example, US Treasury bonds have higher carry than German government bonds for durations below seven years, while the opposite is true for durations above seven years.

[2] We use one-month interbank rates as funding rates. When not available, one-month deposit rates are used instead.

FIGURE 3

Net carry of US Treasuries and German government bonds, 29 December 2017



Source: Barclays Research

Figure 3 implies that a portfolio with carry tilt could allocate to both US and German bonds, overweighting US Treasuries in the short maturity segment and favouring German government bonds for long maturities.

Comparing two bonds of different maturities based on their absolute carry is not always desirable because market risk also increases with duration. Therefore, we report carry per unit of duration (Net Carry per OAD) to facilitate the comparison of bonds of different maturities.

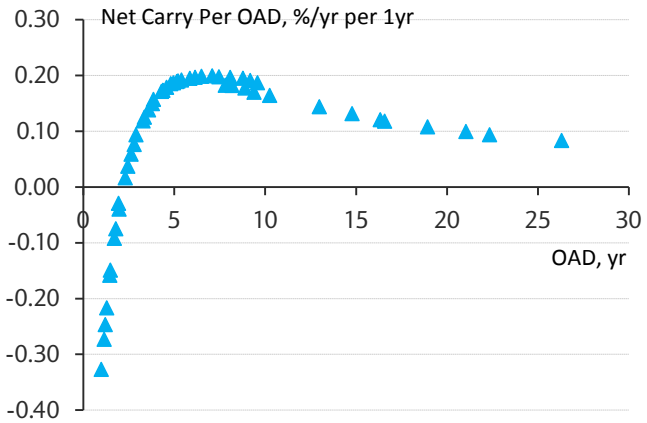
Carry per unit of duration depends on the shape of the yield curve. We often find that carry per OAD is bell-shaped, reaching a maximum for intermediate duration range and declining for longer-maturity bonds. Panels A and B of Figure 4 plot net carry per OAD for German and UK government bonds. Both curves peak around seven years, offering about 20bp/yr of net carry per year of duration exposure.

FIGURE 4

Bond net carry per unit of duration (OAD) , 29 December 2017

PANEL A

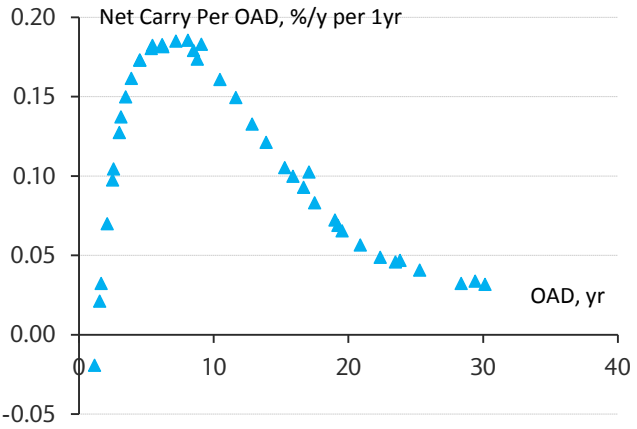
German Government Bonds



Source: Barclays Research

PANEL B

UK Government Bonds (Gilts)

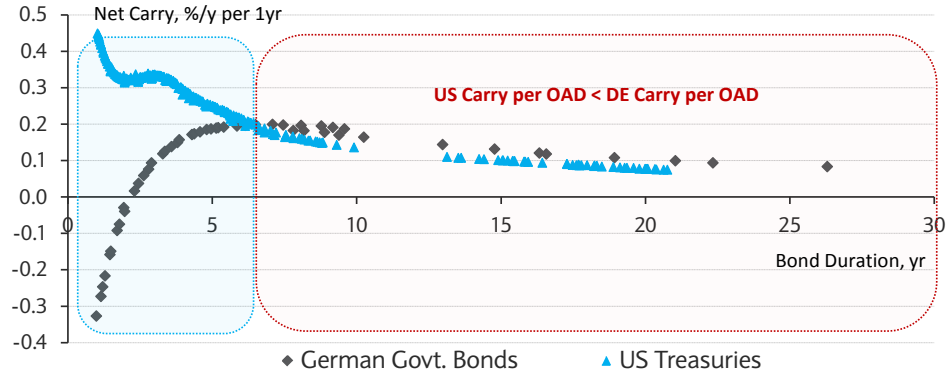


Source: Barclays Research

Market ranking using net carry per unit of duration can also change with bond maturity. Figure 5 plots net carry per OAD for US Treasuries and German government bonds. For bonds with durations below seven years, US Treasuries have higher net carry per OAD than German bonds. However, for durations above seven years, German government bonds have higher carry per OAD than US ones. The difference between the two markets is more pronounced for bonds with shorter maturities.

FIGURE 5

Net carry per OAD of US Treasuries and German Government Bonds, 29 December 2017



Source: Barclays Research

We can extend this analysis by ranking all G11 markets by carry within five different maturity buckets: 1-3; 3-5; 5-7; 7-10; and 10+ years. Results are shown in Figure 6. Panel A shows rankings of individual markets by net carry, while panel B shows an equivalent ranking by net carry per unit of duration. Higher rank means lower carry, so that countries with ranks 1, 2 and 3 are the top-three carry markets.

As discussed earlier, country rankings vary across maturity buckets. For example, Germany and the UK have rank 11 and 9 respectively in the 1-3 year maturity bucket as per Panel A of Figure 6. However, they rank close to the top in the 7-10 year maturity bucket.

FIGURE 6

Country Carry Ranks Across Different Maturity Buckets , 29 December 2017

PANEL A

Ranks by Net Carry

Net Carry Ranks	1-3	3-5	5-7	7-10	10+
Top (Rank=1)	AU	US	US	DE	DE
2	US	AU	AU	AU	DK
3	SG	SE	SE	GB	AU
4	CA	SG	DE	DK	SE
5	SE	CA	GB	SE	US
6	NO	DE	SG	US	GB
7	DK	GB	DK	SG	SG
8	CH	DK	CA	CH	CH
9	GB	NO	CH	CA	JP
10	JP	CH	NO	NO	CA
Btm (Rank=11)	DE	JP	JP	JP	-

Source: Barclays Research

PANEL B

Ranks by Net Carry per OAD

Net Carry Per OAD Ranks	1-3	3-5	5-7	7-10	10+
Top (Rank=1)	AU	US	AU	AU	AU
2	US	AU	US	DE	DE
3	SG	SG	DE	GB	SE
4	CA	SE	SE	US	DK
5	NO	CA	GB	SE	SG
6	SE	NO	SG	DK	US
7	CH	GB	DK	SG	GB
8	DK	DE	CA	CA	CH
9	GB	DK	CH	CH	CA
10	JP	CH	NO	NO	JP
Btm (Rank=11)	DE	JP	JP	JP	-

Source: Barclays Research

Panel B shows qualitatively similar results. This implies that a portfolio of high carry bonds can- in principle- be well diversified across markets. For example, an all-maturity portfolio that includes the top three carry markets (by net carry) within each maturity bucket would allocate into seven markets in total: Australia; Sweden; Singapore; Germany; the UK; the US; and Denmark. If based on net carry per unit of duration, the portfolio would allocate into six markets instead. Country-specific risk could be addressed in portfolio construction, for example by balancing duration contributions.

Adjusting Carry for Expected Changes in Rates

Typically, a steep curve signals market expectations of increasing short-term rates. For example, if the market expects a central bank to tighten monetary conditions by increasing policy rates, the yield curve becomes steeper. Similarly, if the market anticipates monetary policy to ease, the yield curve becomes flatter.

Monetary authorities, in turn, often try to convey information to the market and be transparent regarding factors affecting their policy. In many cases, they are guiding expectations and looking to make the future path of rates predictable.

Our bond-level carry returns calculated so far ignore the link between curve slope and future changes in rates. Therefore, we introduce a simple adjustment to accommodate for anticipated changes in rates. We call the resulting bond-level measure Global Rates *Adjusted* Carry (GRACE) score which shows the return per unit of duration, after accounting for the anticipated rate change, that an investor could receive from investing into a particular bond.

When building the model for anticipated changes in rates, we take inspiration from the Taylor's rule[3] which sets the target policy rate of a Central Bank as a function of economic growth and inflation. Most central banks in developed countries conduct their monetary policy by setting short-term interest rates to influence the cost of capital in the economy. Inflation and economic growth are known to be important factors in those decisions. The Taylor rule describes how growth and inflation deviations from their equilibrium values are translated into target policy rates:

Target Rate = Real Rate + CPI + a x Inflation Gap + b x Output Gap

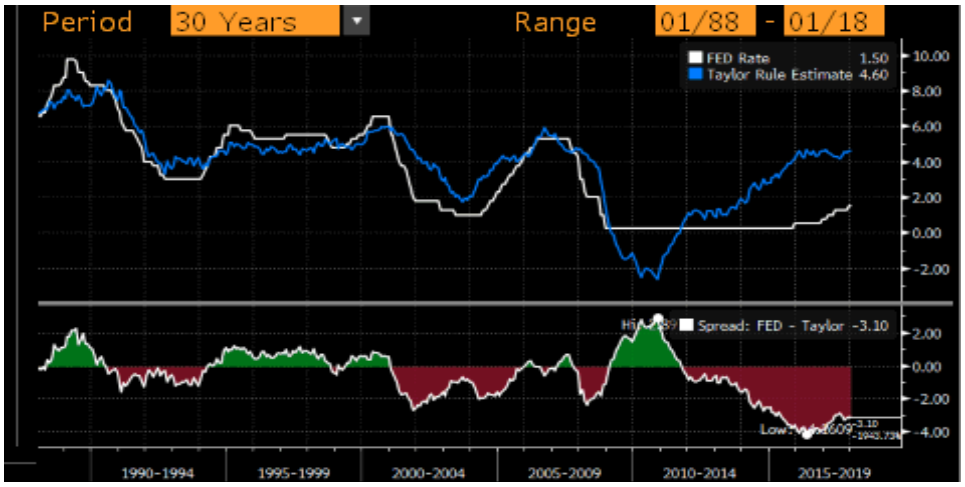
Here, Real Rate and CPI are the equilibrium real rate and inflation, respectively, while Inflation and Output Gaps are deviations of inflation and economic growths from their equilibrium values. Other things being equal, a stronger economy and higher inflation warrant higher policy rates.

Figure 7 shows target policy rates for the US market derived using the Taylor model along with actual policy rates. According to this framework, the Federal Reserve is more likely to increase rates when the target rate implied by the Taylor model is higher than the actual short-term policy rate.

[3] Please see Taylor, John B., *A Historical Analysis of Monetary Policy Rules*, 1999

FIGURE 7

FED Rate vs Taylor Rule Estimate



Source: Bloomberg

In actual implementation, however, using inflation and growth statistics produced by government agencies is problematic because the publication cycle significantly lags the market. Markets learn the state of the economy much earlier than it is reflected in published, official statistics.

In our model for expected changes in rates, we use more timely indicators of economic growth, such as equity market performance (inverse wealth indices)[4] and purchasing managers indicators (PMIs) published by Markit Economics.

We then calibrate models for target government par rates in the eleven markets using rolling regression of realised rates on inverse wealth, PMI, and inflation. The calibrated models are used to produce expected rates which are compared to market rates. We assume that market rates converge to the target rates over time, so that the adjustment applied to bond carry return is derived as:

Carry Adjustment = - Rho x (Target Rate – Market Rate) x Bond OAD

where Rho stands for the adjustment inertia.

The Global Rate Adjusted Carry (GRACE) score is defined as the net carry of a bond adjusted for anticipated changes in rates and normalised by duration.

Evaluating GRACE Performance

In order to demonstrate that GRACE signal can be used to identify carry opportunities across global rates markets, we aggregate bond-level GRACE signals by maturity and by country.[5] Then, we sort markets by GRACE score within each maturity segment and select the top and bottom three markets to form *Top* and *Bottom* Carry maturity-specific portfolios.[6] The top and bottom maturity-specific portfolios are then combined across

[4] Inverse wealth is defined as a normalized trend of an equity market. Please see A. Ilmanen, Expected Returns: An Investor's Guide to Harvesting Market Rewards, 14 March 2011.
[5] As before, we use 1-3, 3-5, 5-7, 7-10, and 10+ year maturity buckets for each market.
[6] Countries are equally weighted in the top and bottom carry portfolios.

maturities by applying market weights of individual maturity buckets in the Global Treasury G11 index.[7] Portfolios are rebalanced monthly.

Figure 8 reports the performance of consolidated Top and Bottom GRACE portfolios over different time periods. The left-side panel includes the results based on the carry signal without adjusting for anticipated rate changes, while the right-side panel includes the results with the adjustment.

FIGURE 8

Performance of USD-hedged GRACE portfolios in different periods

	No Adjustment			With Adjustment		
	Top 3	Btm 3	GRACE: Top - Btm	Top 3	Btm 3	GRACE: Top - Btm
From Feb 2001 to Dec 2017						
Avg. Return, %/yr	4.82	3.03	1.79	5.03	3.18	1.85
Volatility, %/yr	3.64	3.19	2.00	3.52	3.23	1.98
Sharpe / Inf Ratio	0.87	0.44	0.89	0.96	0.48	0.93
Market Beta	1.20	0.96	0.24	1.15	0.98	0.17
From Feb 2001 to Jun 2007						
Avg. Return, %/yr	5.20	2.64	2.56	5.26	2.85	2.42
Volatility, %/yr	3.34	2.95	1.69	3.34	2.96	1.68
Sharpe / Inf Ratio	0.67	-0.11	1.52	0.68	-0.05	1.43
Market Beta	1.15	0.94	0.21	1.15	0.95	0.20
From Jul 2007 to Dec 2017						
Avg. Return, %/yr	4.59	3.27	1.31	4.96	3.50	1.46
Volatility, %/yr	3.82	3.31	2.17	3.61	3.36	2.14
Sharpe / Inf Ratio	0.99	0.74	0.61	1.14	0.79	0.68
Market Beta	1.22	0.97	0.25	1.15	1.00	0.15

Source: Barclays Research

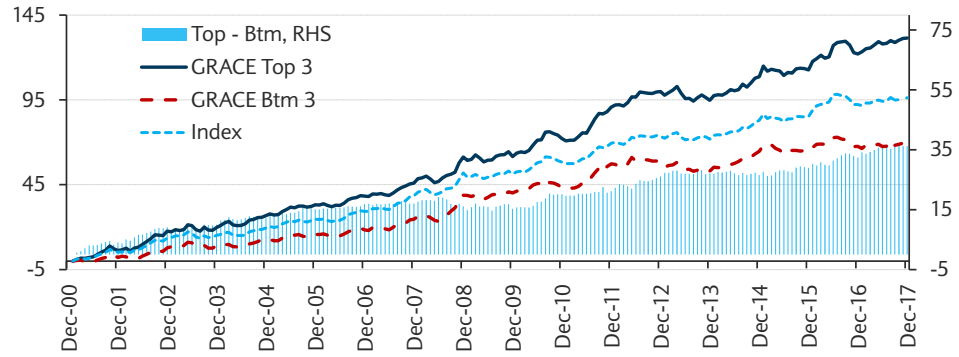
We find that Top carry portfolios tends to outperform Bottom carry portfolios both in absolute and risk-adjusted terms. The outperformance was stronger in the early period between 2001 and 2007, when the top GRACE portfolio outperformed the bottom one by 2.42%/year with information ratio of 1.43. The outperformance in the recent period between 2007 and 2017 was weaker: the top GRACE portfolio outperformed the bottom one by 1.46%/year with information ratio of 0.68. The performance of the GRACE strategy (Top over Bottom carry portfolios) has been slightly directional on the performance of the global treasury market.

Figure 9 reports cumulative returns of Top and Bottom GRACE portfolios, as well as that of the market-weighted Global Treasury G11 index. Top GRACE portfolios have consistently outperformed Bottom ones and the index.

[7] This index is a customized version of the Bloomberg Barclays Global Treasury index that includes only the G11 markets selected for our study: United States (US), Germany (DE), Japan (JP), United Kingdom (GB), Canada (CA), Australia (AU), Sweden (SE), Denmark (DK), Norway (NO), Switzerland (CH), and Singapore (SG).

FIGURE 9

Cumulative returns of USD-hedged GRACE portfolios and the index



Source: Bloomberg Barclays Indices, Barclays Research

Figure 10 reports the performance of the GRACE strategy (Top over Bottom carry portfolios) within individual maturity buckets. The cross-market strategy has performed well across all maturities, both in absolute and risk-adjusted terms.

FIGURE 10

Performance of USD-hedged GRACE portfolios by maturity bucket, February 2001 – December 2017

	Avg. Retun, %/yr	Volatility, %/yr	Information Ratio	Market Beta to Index Buckets
1-3	0.54	0.87	0.62	-0.04
3-5	1.48	1.81	0.82	0.34
5-7	1.63	2.21	0.74	0.28
7-10	1.86	2.85	0.65	0.26
10+	3.67	4.40	0.84	0.15
Combined	**1.85**	**1.98**	**0.93**	**0.17**

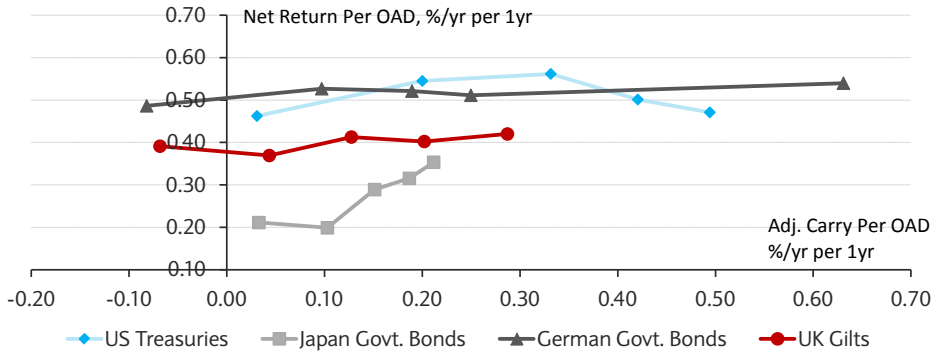
Source: Barclays Research

These results suggest that GRACE scores help differentiate bonds by subsequent performance. Does GRACE work equally well within as well as across individual markets? To answer this question, we sort bonds by their GRACE scores into quintile portfolios within each one of the G4 markets[8]. For each quintile portfolio, we then calculate net return per unit of duration in the subsequent month. Figure 11 shows average returns per OAD for the quintile GRACE portfolios in each market. Japan seems to be the only market, where GRACE scores have exhibited a positive relationship with subsequent risk-adjusted returns.

[8] We looked at individual bonds in G4 markets: US; Japan; Germany; and the UK.

FIGURE 11

GRACE measure vs returns per OAD across maturities, February 2001 – December 2017

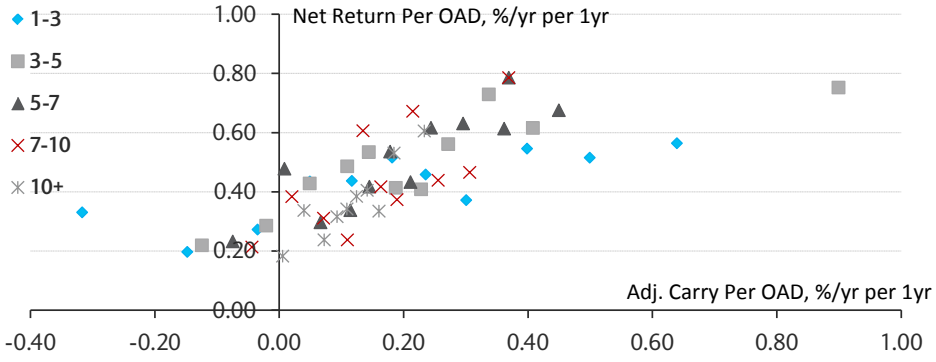


Source: Barclays Research

To continue this analysis, we aggregate bond-level GRACE scores within each maturity bucket of each market for all eleven markets in our universe (a maximum of 55 cells: 11 markets x 5 maturity buckets). Then, within each maturity segment, the eleven markets are ranked by GRACE score every month. Net return per unit of OAD is measured for all eleven ranked portfolios, in each maturity bucket. Figure 11 plots average returns per unit of duration for the ranked portfolios against their average GRACE scores for each maturity bucket. Average normalised returns generally increase with GRACE score, showing that GRACE provides a useful signal for cross-market allocation in global rates markets, for all maturity sectors considered.

FIGURE 12

GRACE measure vs returns per OAD across countries, February 2001 – December 2017



Source: Barclays Research

GRACE scores seem to have a stronger predictive power when applied across markets than when applied within individual markets.

Conclusion

We introduce Global Rate Adjusted Carry (GRACE) scorecard, a quantitative framework designed to measure carry returns of individual government bonds across global markets. GRACE calculates net carry per unit of duration adjusted for anticipated changes in rates.

Countries with higher GRACE measures have generally performed better historically than those with low GRACE measures in both absolute and risk-adjusted terms.

We present a GRACE validation strategy that goes long the top-three markets based on GRACE and shorts the bottom-three markets. This cross-market strategy has attractive risk-return characteristics. The strategy is moderately directional on returns of the global treasury market.

Practical applications of GRACE include filtering the global treasury investment universe to monitor carry. GRACE can also be used for advanced beta strategies in government bonds, potentially in combination with other rates signals.

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