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DON'T GET CARRIED AWAY: UNCOVERING MACRO CHARACTERISTICS IN CARRY PORTFOLIOS

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Investors are increasingly showing interest in risk premia strategies across asset classes. Carry is one of the most studied premia. To successfully execute a risk premia strategy, it is important to have a detailed understanding of how individual premia returns are affected by macroeconomic conditions. The literature reports that carry strategies are commonly exposed to business cycle, liquidity, and volatility risks; however, evidence of direct links has never been clearly established. We build on this research by directly measuring the macroeconomic characteristics of carry factor portfolios, namely real economic growth and inflation exposures. By pairing methodologies commonly used to derive fundamental characteristics of equity portfolios, we are able to identify macro linkages that have not been previously made evident. Our holdings-based and factor-mimicking portfolio analyses provide insights into the behavior of carry strategies across various asset classes. This approach can help investors build multi-asset carry portfolios that are better aligned with their goals.

1 Introduction

Recent trends in asset management[1] point to a shift from strategies based on asset class selection to those defined by risk premia: the excess return earned by targeting specific types of risk factors that compensate investors for taking on different forms of market risk. In this paper, we focus on carry premia across asset classes. Recent literature[2] updated the historical research on currency carry (Hansen and Hodrick, 1980; Engel, 1996; Brunnermeier *et al.*, 2008) to include asset classes such as equity country selection, commodities and fixed income country selection. These studies define carry as the return that an investor earns from the relative differences between higher- and lower-yielding assets if all other market conditions, including the asset price, remain the same.

Koijen *et al.* (2018) and Ahmerkamp and Grant (2013) found that multi-asset carry portfolios' drawdowns, along with most individual asset class-specific carry portfolios' drawdowns, are

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related to recession and expansion periods, confirming that carry strategies provide compensation for time-varying risk premia. However, formal analysis of the link between carry portfolio payoff and global inflation and growth is weak. For instance, Kolanovic and Wei (2013) regress carry payoff to global growth and global inflation, and report insignificant beta attributable to either macro variable.

We extend this literature by identifying the typical macroeconomic characteristics of multi-asset carry portfolios by using holdings-based and factor-mimicking portfolio analyses. Our approach leads to several significant empirical contributions. First, taking advantage of the cross-country inflation and growth expectations implicit in every carry portfolio, we multiply countries' weights in the portfolio by their forecasted rates of inflation and real GDP to derive the net inflation and real growth characteristic embedded in each asset class carry portfolio at each point in time. This approach allows us to derive a time series of the macro characteristics of the carry portfolios that we can then use to estimate the average macro characteristic over our full analysis period. While a similar approach is commonly used to derive characteristics of equity portfolios such as size and valuation, to the best of our knowledge ours is the first paper to explore this approach for multi-asset macroeconomic factors.

Secondly, while the net embedded inflation and growth characteristics are time-varying, we find that payoffs to carry portfolios are only weakly related to this time variation. Finally, using factor-mimicking portfolio performance attribution methodology also common to the equity space, we find that payoffs to carry portfolios in various asset classes are strongly linked to relative growth and inflation expectations across countries.

Our approach belies a shortcoming of the standard equally weighted carry portfolio. Equally weighting carry exposure across developed and emerging currencies, country equities and developed bonds essentially buys assets of countries with relatively high inflation and lower growth, especially in emerging markets. These findings are relevant for investors, and can be used to build multi-asset carry portfolios that are better aligned with the investors' goals. For example, investors might want to neutralize undesired macro characteristics embedded in the portfolio, or modify such characteristics by tilting the portfolio composition toward individual carry strategies. Our results also provide a link between the well-known macroeconomic exposures of traditional asset classes and those of carry risk premium.

The remainder of this paper is organized as follows. Section 1 defines and reviews carry strategies across asset classes. Section 2 describes data and the portfolio construction method. Section 3 replicates stylized carry results. Section 4 introduces our novel holdings-based and factor-mimicking portfolio analyses of the macro characteristics and describes our new results. Section 5 provides our conclusion.

2 Carry strategies across asset classes

Carry strategies seek to capture the differences in expected returns between two assets by investing in higher-yielding securities while shorting lower-yielding securities. This assumes that the yield is the primary component of return and that price moves will not offset this yield advantage.

A classic application of carry is found in currency markets. The currency carry trade involves buying currencies from countries with higher interest rates and selling currencies from countries with lower interest rates. This spread between interest rates represents the carry risk premium. While the uncovered interest rate parity hypothesis states that carry gain due to the interest rate differential will be offset by commensurate depreciation of the investment currency, empirically the reverse holds true (Hansen and Hodrick, 1980; Engel, 1996; Brunnermeier *et al.*, 2008). The historical positive return to currency carry, coupled with its potential for significant losses in periods of capital market stress, has been associated with a risk premium that investors expect as a reward for holding systemic risk in their portfolio. The academic literature has proposed several different explanations for the risk factors embedded in carry portfolios, ranging from macroeconomic risk (Lustig and Verdelhan, 2007; Koijen *et al.*, 2018) to crash, volatility and liquidity risk (Brunnermeier *et al.*, 2008; Menkhoff *et al.*, 2012; Melvin and Shand, 2017).

Likewise, profitable carry strategies in fixed income are constructed by ranking countries by the slope of their yield curves (Asness *et al.*, 2015). Yield curves are typically upward-sloping in order to compensate long-term bond investors for illiquidity risk, tightening monetary policy and inflation risk. Thus, the slope of each country's curve becomes a standard predictor of bond returns in the time series (Fama and Bliss, 1987; Campbell and Shiller, 1991) and in the cross-section (Baz *et al.*, 2015; Brooks and Moskowitz, 2017; Koijen *et al.*, 2018).

Finally, carry strategies have been extended to equities using dividend yield as a factor (Mesomeris *et al.*, 2012).[3] In this case, dividend yield represents the income an investor would get if the stock prices remained the same. While we follow the practitioner's literature and use this measure for our analysis, we acknowledge that dividend yield is not widely accepted as a carry measure in the stock or country equity selection literature. Dividends represent only a small portion of a stock's total return; moreover, dividends represent just one of the ways (along with stock repurchases) a firm can return capital to investors. More typically, dividend yield is considered a value or quality factor due to the defensive nature of high-dividend-paying firms (Kolanovic and Wei, 2013; Mesomeris *et al.*, 2012). Indeed, even in the carry literature, some papers (e.g. Asness *et al.*, 2015) have refrained from calling dividend yield carry, because it is so highly correlated with value.

3 Data collection and portfolio construction

This section describes the return sources, carry measures, and approach to portfolio construction used in our empirical analysis.

3.1 Investment universe and data sources

In our empirical analysis, we sought to use only liquid, investable assets a global macro investor could trade. Our data extends back to 1990, since most of the assets in our study were uninvestable before 1990 due to regulatory or liquidity restraints. Our analysis does not include commodities since they are a global asset and therefore do not naturally map into the economic characteristics of individual countries.

Currencies: We focused on the most liquid currencies traded by active currency investors. The developed market currency portfolio consists of Australian dollar, Canadian dollar, Euro, Japanese yen, Norwegian krone, Swedish krona, New Zealand dollar, British pound sterling and Swiss franc. For the time period prior to 1999, we excluded legacy euro currencies, and approximated euro with the Deutsche Mark. Our emerging markets universe consists of Brazilian real, Mexican peso, Polish zloty, Turkish lira, South African rand and South Korean won. We obtained spot and forward exchange rates from WMR, Bloomberg and various brokers. We computed returns for one-month currency forwards from the perspective of a US-based investor.

In developed markets, we approximated returns using spot exchange rates and the one-month LIBOR/deposit rate. In emerging markets, we computed the returns from currency forwards. The developed markets data sample covers January 1990–December 2017, while the emerging markets sample ranges from January 2001 to December 2017. The shorter emerging markets sample is necessitated by the historical existence of fixed exchange rates and illiquidity.

Country Equities: We used the local returns of MSCI[4] country indices in the following 20 developed and emerging countries: US, UK, Canada, Australia, Japan, France, Germany, Italy, Spain, Sweden, Switzerland, Brazil, Mexico, Turkey, Poland, South Africa, China, India, Taiwan and South Korea. Returns and dividend yields were sourced from MSCI.

Bonds: We used 10-year bond futures indices hedged to USD from Bloomberg for the following countries: US, UK, Canada, Australia, Japan and Germany. For time periods prior to the introduction of the Bloomberg futures indices, we backfilled the returns with synthetic bond futures returns similar to Koijen *et al.* (2018). Ten- and two-year yields on the bonds were sourced from Bloomberg.

3.2 Carry measures

We closely followed the existing literature in each asset class for our carry measures. The purpose of this paper is to shed light on macroeconomic characteristics of carry, so we did not focus on how to improve the factor measurement.

Currencies: We measured carry using the one-month deposit rate in the domicile of the currency.

Country Equities: We used the trailing 12-month dividend yield from MSCI country indices to measure carry for country equities.

Bonds: We measured bond carry as the relative differences in the spreads between ten- and two-year yields for ten-year maturity bonds from one major developed market to another.

3.3 Macroeconomic measures

We built real GDP and inflation constant one-year forecasts from Consensus Economics to approximate real growth and inflation expectations for the set of countries of interest. Consensus Economics surveys over 250 prominent financial and economic forecasters for their estimates of a range of variables, including future growth and inflation. More than 20 countries are covered and the data goes back to 1990. One advantage of using forecasts instead of realized macroeconomic data is that such forecasts are not revised and are not subject to forward-looking bias. Participants provide current- and next-year forecasts for the measures of interest typically released in the middle of the month. Incoming survey responses are then processed and checked for accuracy, completeness and integrity, and aggregated into a consensus average. We created constant one-year forecasts by time-weighting the forward year-one and year-two forecasts for inflation (*Infl1YFcst*) and real GDP growth (*GDP1YFcst*) in each country of interest. We also created global inflation (*GlobalInfl1YFcst*) and real GDP growth (*GlobalGDP1YFcst*) by aggregating country-specific forecasts using GDP weights.[5,6]

3.4 Portfolio construction

We built portfolios of assets to implement our strategies in line with current industry and research practices. At the end of each month, we sorted the assets according to the carry measure specific to each asset class (as described in the previous section), and formed zero-cost long–short portfolios, taking long positions in the highest-yielding assets and shorting the lowest-yielding.

We rebalanced the portfolios on a monthly basis over the sample time frame, from January 1990 to December 2017, ignoring transaction costs.

Following Asness *et al.* (2013) for any security $i = l, \ldots, N$ in asset class j at time t with carry measure $F(i, j, t)$, we weighted securities in a linear fashion according to the following scheme:

$$w(i, j, t) = c(j) \times \left[rank(F(i, j, t)) - \frac{1}{N} \times \sum_{i=1}^{N} rank(F(i, j, t)) \right].$$

The weights across all securities sum to zero, representing a dollar-neutral long–short portfolio where $c(j)$ is an asset class-specific scalar such that the *ex post* annualized volatility of each portfolio is comparable and equal to 5% over entire sample period.

We also built a reference diversified multi-asset carry portfolio by taking an equal volatility-weighted average of the five individual carry portfolios (developed and emerging country equities, developed and emerging currencies, developed bonds). We then rescaled the resulting combined portfolio to 5% *ex post* annualized volatility. This procedure is similar to that used by Asness *et al.* (2013) and Koijen *et al.* (2018).

4 Stylized empirical results

Table 1 shows the historical performance statistics for the diversified multi-asset carry portfolio, as well as the asset class-specific carry portfolios from 1990 through 2017. Broadly speaking, all carry strategies generate positive excess returns with attractive information ratios ranging from 0.37 in emerging country equities to 0.57 in emerging currencies. The diversified multi-asset carry portfolio has an information ratio of 1.04, confirming the significant diversification benefits of applying carry trades across asset classes as found in Asness *et al.* (2015), Baz *et al.* (2015), and Koijen *et al.* (2018). Table 1 also shows that the multi-asset carry portfolio has little negative skewness and is weakly positively correlated to global equities, and bonds. While our carry factor portfolios are constructed from a USD investor perspective, we find very small correlation (−0.13) with the US dollar index (DXY). These properties are less consistent when we look at the asset class-specific carry portfolios. For the developed currency carry portfolio, we observe a strong negative skewness and high correlation with equities in large down months (5% percentile move of −4.5%). Moreover, while the performance of carry in developed and emerging currencies is positively correlated with global equity returns, carry portfolios in developed and emerging country equities and bonds have a low negative or positive correlation with global equity returns. Even in large negative equity market return periods, the conditional correlation of the multi-asset carry portfolio with equities is still muted at (0.43).

Furthermore, Table 2 shows that the correlations of individual carry portfolios across various asset classes are quite weak when measured at monthly frequency.

Carry portfolios in emerging markets have become investable since the 2000s as these markets opened up to global investors. We show the performance statistics and correlations among payoffs for all market segments from January 2001 to December 2017 in Tables 3 and 4, respectively. The equal-weighted carry portfolio has a somewhat lower, but still very attractive information ratio of 0.83 in this recent time period. Developed and emerging market country equity carry portfolios earned significantly lower

Table 1 Performance of carry across asset classes (1/1990–12/2017).

Performance statistics (1/1990–12/2017)						
	Carry					Equal risk carry
	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**	
Obs	336	204	336	275	312	336
GeoRet	2.1%	2.8%	2.2%	1.7%	2.6%	5.2%
Vol	5.0%	5.0%	5.0%	5.0%	5.0%	5.0%
IR 1990–2017	0.43	0.57	0.47	0.37	0.54	1.04
Corr (MSCI ACWI)	0.39	0.09	(0.02)	(0.01)	0.04	0.16
Corr (Fixed Income)	(0.12)	(0.08)	0.11	0.15	0.15	0.08
Corr (DXY)	(0.18)	0.17	(0.01)	(0.12)	(0.11)	(0.13)
Corr (MSCI ACWI, MSCI ACWI $<-4.5\%$]	0.68	0.02	(0.07)	0.17	0.28	0.43
Skew	(0.92)	0.09	(0.00)	0.78	0.08	(0.12)
Excess Kurtosis	2.42	2.70	1.29	5.54	1.77	0.95

Source: QMA, MSCI, WMR, Bloomberg.
Performance statistics are reported for carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity), developed country bonds (FI6) and diversified multi-asset portfolio (Equal Risk Carry). Statistics are computed from monthly return series over the sample time period: January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly. Weights are scaled so that the *ex post* volatility of each strategy is set to 5% over the entire backtest period for comparison purposes. Reported returns do not include transaction costs.

Table 2 Correlations of carry portfolios across asset classes (1/1995–12/2017).

	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**
G10FX	1.00	0.21	−0.17	0.03	0.14
EM6FX		1.00	−0.06	−0.23	0.11
DevEquity			1.00	0.03	−0.12
EMEquity				1.00	0.10
FI6					1.00

Source: QMA, MSCI, WMR, Bloomberg.
Average correlations are reported among carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). Statistics are computed from monthly return series over the sample time period: January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For developed country bonds, sample is January 1992–December 2017. For emerging markets equities the sample is January 1995–December 2017. Portfolios are rebalanced monthly.

Table 3 Performance of carry across asset classes (1/2001–12/2017).

Performance statistics, 2001–2017	Carry					Equal Risk Carry
	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**	
Obs	204	204	204	204	204	204
GeoRet	2.1%	2.8%	0.6%	0.4%	2.9%	3.7%
Vol	5.0%	5.0%	5.0%	5.0%	5.0%	4.5%
IR 2001–2017	0.45	0.57	0.15	0.11	0.60	0.83
Corr (MSCI ACWI)	0.59	0.09	0.14	−0.13	0.03	0.31
Corr (Fixed income)	−0.21	−0.08	0.07	0.13	0.28	0.09
Corr (DXY)	(0.31)	0.17	(0.14)	(0.18)	(0.06)	(0.23)
Corr (MSCI ACWI, MSCI ACWI $\leq -4.5\%$]	0.70	0.02	(0.06)	0.11	0.38	0.54
Skew	(0.95)	0.09	(0.12)	0.47	(0.26)	(0.21)
Excess kurtosis	3.35	2.70	2.11	2.06	0.54	(0.29)

Source: QMA, MSCI, WMR, Bloomberg.
Performance statistics are reported for carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity), developed country bonds (FI6) and diversified multi-asset portfolio (Equal Risk Carry). Statistics are computed from monthly return series over the sample time period: January 2001–December 2017. Portfolios are rebalanced monthly. Weights are scaled so that the *ex post* volatility of each strategy is set to 5% over the entire backtest period for comparison purposes. Reported returns do not include transaction costs.

Table 4 Correlations of carry portfolios across asset classes (1/2001–12/2017).

	Correlation (1/2001–12/2017)				
	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**
G10FX	1.00	0.21	−0.06	0.00	0.14
EM6FX		1.00	−0.06	−0.23	0.11
DevEquity			1.00	0.03	−0.05
EMEquity				1.00	−0.02
FI6					1.00

Source: QMA, MSCI, WMR, Bloomberg.
Performance statistics are reported for carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). Statistics are computed from monthly return series over the sample time period: January 2001–December 2017. Portfolios are rebalanced monthly.

returns than in the earlier period. However, general characteristics of carry portfolios over the recent sample period are similar to the full-period backtest.

Carry drawdowns have occurred during global recessions (e.g. Koijen *et al.*, 2018; Melvin and Shand, 2017), but formal regression analysis has shown no significant link between carry payoff

Table 5 Carry portfolio payoff regression on expected global inflation or growth (1/1995–12/2017).

	Developed			Emerging	
	FI6	G10FX	DevEquity	EM6FX	EMEquity
cGInfl	***0.184***	0.349	−0.278	***0.448***	0.050
BetaGInfl	−0.036	−0.078	***0.210***	−0.100	0.039
R2	0.00	0.00	0.02	0.00	0.00
cGGDP	0.051	0.279	0.311	0.538	−0.293
BetaGGDP	0.027	−0.045	−0.069	−0.133	***0.201***
R2	0.00	0.00	0.00	0.01	0.01

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
The table reports linear regression of expected global inflation or real growth onto returns of carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). For developed markets equities and currencies the sample is January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly. Significance at the 1% level is denoted in bold, while significance at the 10% level is denoted in bold and italics.

and global growth and inflation (Kolanovic and Wei, 2013[7]). It is common to estimate the exposure of carry portfolios payoffs to global macro variables. This is based on the empirical observation that the assets of lower- (and higher) yielding countries tend to move as a block as part of the general risk-on and risk-off patterns associated with shifts in global growth or inflation expectations.

We performed a similar analysis by regressing the payoff of asset-class-specific carry portfolios on our measures of expected global inflation or real growth:

$$
\begin{aligned}
ReturnCarry(j,t) &= cGInfl(j) \\
&\quad + BetaGInfl(j) * GlobalInfl1YFcst(t) \\
&\quad + eGInfl(j,t) \\
ReturnCarry(j,t) &= cGGDP(j) \\
&\quad + BetaGGDP(j) * GlobalGDPlYFcst(t) \\
&\quad + eGGDP(j,t)
\end{aligned}
$$

where $ReturnCarry(j,t)$ is the return of carry portfolio in asset class j at time t and $GlobalInfl1YFcst(t)$ and $GlobalGDP1YFcst(t)$ are the global inflation and real GDP growth forecasts at time t.

Table 5 shows that expected global inflation or real growth does not explain carry payoff in a statistically significant way. All the betas are statistically insignificant, except for inflation in developed country equity and growth in emerging country equity, from 1990 to 2017. Even in those cases, economic significance is very weak.

5 Revealing the macro characteristics of carry portfolios

While the traditional stylized approach has sought to link the carry payoff to global inflation and real growth, we can measure the net inflation and real growth characteristics directly from the holdings of the carry portfolio. To do so, we borrow the framework for equity risk factor models introduced by Zangari (2003), in which a portfolio's net factor exposure is simply determined by multiplying the book-to-market value (or earnings per share revisions, etc.) of each stock in the portfolio by its portfolio weight and summing the totals. Similar to fundamental equity factors, there is always a one-to-one mapping between an asset and the macroeconomic fundamental variable of interest in our investment universe. Consider a simplified currency carry portfolio that is long Australian dollar and short Japanese yen. This portfolio is mapped to: (1) long Australian inflation expectation and short Japanese inflation expectation; and (2) long Australian real growth expectation and short Japanese real growth expectation. If Australian inflation (or real growth) expectation ends up being higher than Japanese inflation (or real growth) expectation, then the currency carry portfolio will show net positive inflation (or real growth) characteristics. In this example, we observe the portfolio's exposure to each country's growth and inflation expectations, but we do not yet know the payoff of the growth or inflation factor. This is the opposite of the stylized analysis described in the previous section, where we started with portfolio returns and global growth and inflation but not the specific exposure of the carry portfolio to global growth or inflation.

The remainder of this section is organized as follows. First, we estimate the average net growth and inflation exposures embedded in each carry portfolio and study the time series behavior of such exposures. Next, we examine whether the time-varying macroeconomic exposures embedded in the carry portfolios can explain the returns to carry strategies. Finally, we use a closely related but different methodology to show that payoffs to carry portfolios in various asset classes are linked to relative growth and inflation expectations across countries.

5.1 Net growth and inflation characteristics in carry portfolios

We define the real GDP growth exposures of the carry portfolio j at time t as:

$$GrowthExposure(j, t) = \sum_{i=1}^{N} w(i, j, t) \times GDP1YFcst(i, t)$$

where $w(i, j, t)$ is the weight of asset i in asset class j at time t and $GDP1YFcst(i, t)$ is the real GDP forecast for country i at time t. Note that there is a one-to-one mapping between asset i and country i for each asset class j. For example, Australian dollar, government bond and country equity index are all linked to Australian inflation and real growth expectations. The weight of Australia in currency, bond or equity carry portfolio depends on how attractive it is relative to other countries in that universe based on the carry factor used. A similar exercise using inflation forecasts allows us to define the inflation characteristic of a given carry portfolio.

Figure 1 shows that developed currency carry portfolios' inflation and real growth characteristics have been fairly stable over time. The correlation between inflation and real growth in the portfolio was only -0.22. The only exception is the negative exposure to real growth during the early 1990s. The 1992–1995 period was one of the worst for developed market currency carry (see Melvin and Shand, 2017), as it entailed the Exchange Rate Mechanism (ERM) crisis in Europe as well as spillover effects of the Mexican Peso crisis.

Figure 2 shows that inflation and real growth characteristics of carry portfolios in developed fixed income markets were stable in earlier periods, but have behaved somewhat differently since the global financial crisis of 2008. Post-crisis, many central banks in developed countries

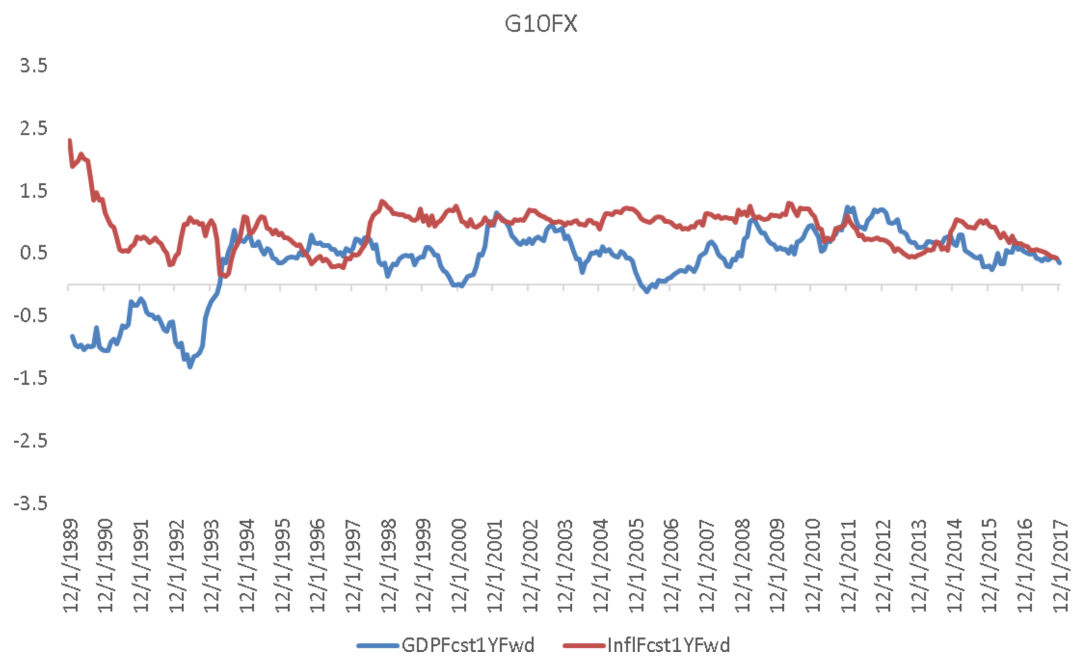

Figure 1 Macroeconomic characteristics of developed currency carry.
The figure shows inflation and real growth exposures of developed currency carry portfolios (G10FX). Statistics are computed from monthly series over the sample time period: January 1990–December 2017. Portfolios are rebalanced monthly.
Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.

engaged in quantitative easing, negative policy interest rates and other non-conventional monetary policy tools to create inflation and avoid deflation. This unprecedented policy environment seems to have shifted the inflation expectations associated with fixed income carry premia away from decades worth of negative expectations to positive expectations today.

While the time series variation in the characteristics of carry portfolios is interesting, we first want to estimate the *average* expected growth and the inflation exposure of carry portfolios. Table 6 shows that the average inflation and real growth expectations (in percentages) of carry portfolios in currencies, bonds and equities in developed and emerging countries are statistically significant. Developed currency carry has, on average, positive loading on real growth and inflation expectations. This finding further supports earlier evidence that currency carry has exposure to business cycle risk (Lustig and Verdelhan, 2007; Koijen *et al.*, 2018).

On average, emerging markets currency carry has a positive loading on inflation and a small negative exposure to growth. The differences between developed and emerging markets currency carry presumably reflect the underlying differences between the two groups of countries. Historically, emerging markets countries experienced higher and more variable rates of inflation as well as greater vulnerability to inflationary monetization of government debt (see IMF, 2001). One cost of inflation, which is particularly relevant in developing countries, relates to its effects on the poor. Evidence suggests that inflation tends to hurt the poor to a greater extent

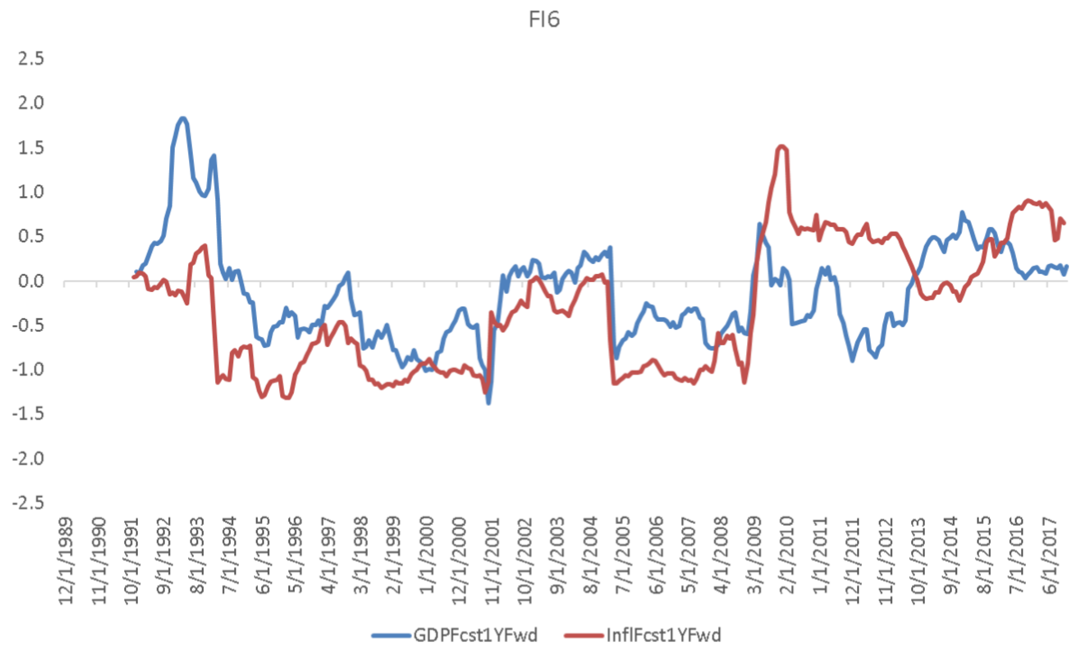

Figure 2 Macroeconomic characteristics of developed fixed income carry.
The figure shows inflation and real growth exposures of developed fixed income carry portfolios (FI6). Statistics are computed from monthly series over the sample time period: January 1992–December 2017. Portfolios are rebalanced monthly.
Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.

than it hurts the rich (Easterly and Fischer, 2001). As a consequence, in the early 2000s, several EM countries (Brazil, Mexico, South Korea, South Africa) adopted full-fledged inflation-targeting frameworks. The more formal inflation-targeting frameworks in emerging markets compared to their developed counterparts likely translated into a temporary negative impact on economic growth in order to achieve price stability.

Developed and emerging markets equity carry portfolios have economic characteristics similar to their currency carry counterparts. In equities, dividend policy is influenced by many considerations, and, as noted earlier, dividend yield can also be viewed as a value factor (Kolanovic and Wei, 2013; Mesomeris *et al.*, 2012).[8] On average, either carry or value would support the positive growth and inflation characteristics we find in the developed country equity universe. Emerging country equity carry has weak positive loading on inflation and negative exposure to growth. As mentioned above, emerging countries stabilized their inflation and experienced significant repricing over our backtest period, so our results may be influenced by this transition. We find this to be a puzzling result that requires further analysis.

Cross-country fixed income carry portfolios have, on average, negative growth and inflation characteristics.[9] This finding is in line with the positive correlation of fixed income carry with the fixed income benchmarks reported in Table 1. Therefore, fixed income carry has similar macroeconomic characteristics to nominal fixed income assets (at least those with no material credit risk). Unexpected high inflation hurts nominal bonds as

Table 6 Average macroeconomic characteristics of carry portfolios.

6. A. Exposure to real GDP Expectations

	GDPFcst1YFwd					
	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**	**Equal Risk Carry**
Avg.	0.36	−0.13	0.10	−0.33	−0.22	−0.08
***t*-stat.**	13.84	−7.82	4.52	−19.84	−3.82	−3.72
5th Perc.	−0.95	−0.81	−0.72	−0.90	−1.69	−0.62
95th Perc.	1.00	0.24	0.69	0.00	1.66	0.59

6. B. Exposure to inflation expectations

	InflFcst1YFwd					
	G10FX	**EM6FX**	**DevEquity**	**EMEquity**	**FI6**	**Equal Risk Carry**
Avg.	0.89	1.59	0.57	0.24	−0.54	1.08
***t*-stat.**	63.49	11.98	43.73	2.15	−7.45	20.49
5th Perc.	0.40	0.00	0.04	−2.53	−2.24	−0.44
95th Perc.	1.23	7.57	0.88	5.38	1.61	2.81

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
Exposure statistics for expected real growth and inflation (in percentages) are reported among carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). Statistics are computed from monthly return series over the sample time period: January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly.

the expected inflation becomes priced in. Higher growth also hurts bonds via expected interest rate hikes or loss of capital to competing assets. These parallels help us better understand the reasons for the low correlation in the payoffs between fixed income and developed currency carry portfolios shown in Table 2.

5.2 *Can the carry payoff be explained by macro exposures?*

While we discussed the average macroeconomic characteristics in the previous section, 5% and 95% percentiles of real growth and inflation characteristics in Table 5 as well as in Figures 1 and 2 showed that macroeconomic characteristics of carry portfolios may be different in various economic and policy environments over time. In this section, now that we have a more precise way of determining the macro characteristics of the portfolio, we explore the time-varying macro exposures, and if they can explain the time-varying payoff to carry portfolios. For each asset, we regressed the carry payoff on the net real growth and inflation exposures derived in the prior section:

$$ReturnCarry(j,t) = cInfl(j) + BetaInfl(j) * InflExposure(j,t) + eInfl(j,t)$$

Table 7 Carry portfolio payoff regression on net expected inflation or growth in the portfolio.

	Developed			Emerging	
	FI6	G10FX	DevEquity	EM6FX	EMEquity
cInfl	***0.095***	0.086	−0.132	−0.030	0.140
BetaInfl	−0.049	0.109	***0.612***	**0.101**	***0.071***
R2	0.00	0.00	0.00	0.01	0.00
cGDP	**0.113**	0.109	***0.167***	***0.309***	***0.337***
BetaGDP	0.033	0.204	−0.027	0.132	0.418
R2	0.00	0.01	0.01	0.01	0.03

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
The table reports linear regression of net expected inflation or real growth onto returns of carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). For developed markets equities and currencies the sample is January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities, the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly. Significance at the 1% level is denoted in bold, while significance at the 10% level is denoted in bold and italics.

$$
\begin{aligned}
ReturnCarry(j,t) &= cGDP(j) \\
&\quad + BetaGDP(j) * GrowthExposure(j,t) \\
&\quad + eGDP(j,t)
\end{aligned}
$$

while time-varying macro exposures are compelling, we find that the carry payoff is only weakly related to the net growth or inflation expectations embedded in the portfolio. Table 7 shows the estimated constant and beta of carry portfolio payoff regressed on inflation and growth expectations embedded in the portfolio in various asset classes. In country equities and currencies, higher net growth and inflation spread tends to be weakly related to higher payoff. Even in these asset classes, weak statistical significance comes with very small economic significance. Therefore, we do not find evidence for explaining or timing carry portfolios using their time-varying exposures to expected real economic growth and inflation.

5.3 *Carry portfolios are proxies for ranking on country inflation*

However, Zangari (2003) showed that there is an alternative way to perform return attribution when asset-specific exposure to the variable of interest is available, as in our case. First, we construct factor-mimicking portfolios for growth and inflation, then we calculate the return on these portfolios. Once the factor payoff is observable, we can estimate the exposure of individual carry portfolio to the factor-mimicking portfolio. Using the same portfolio construction approach discussed in Section 4.4, at each point in time we rank each country's equity, currency or bond market based on its inflation and real growth, and build dollar-neutral long–short portfolios by weighting securities in a linear fashion.

Figure 3 shows an example for developed currencies. In December 2017, the United Kingdom, Australia and Canada would have been the countries with the highest inflation, while Switzerland,

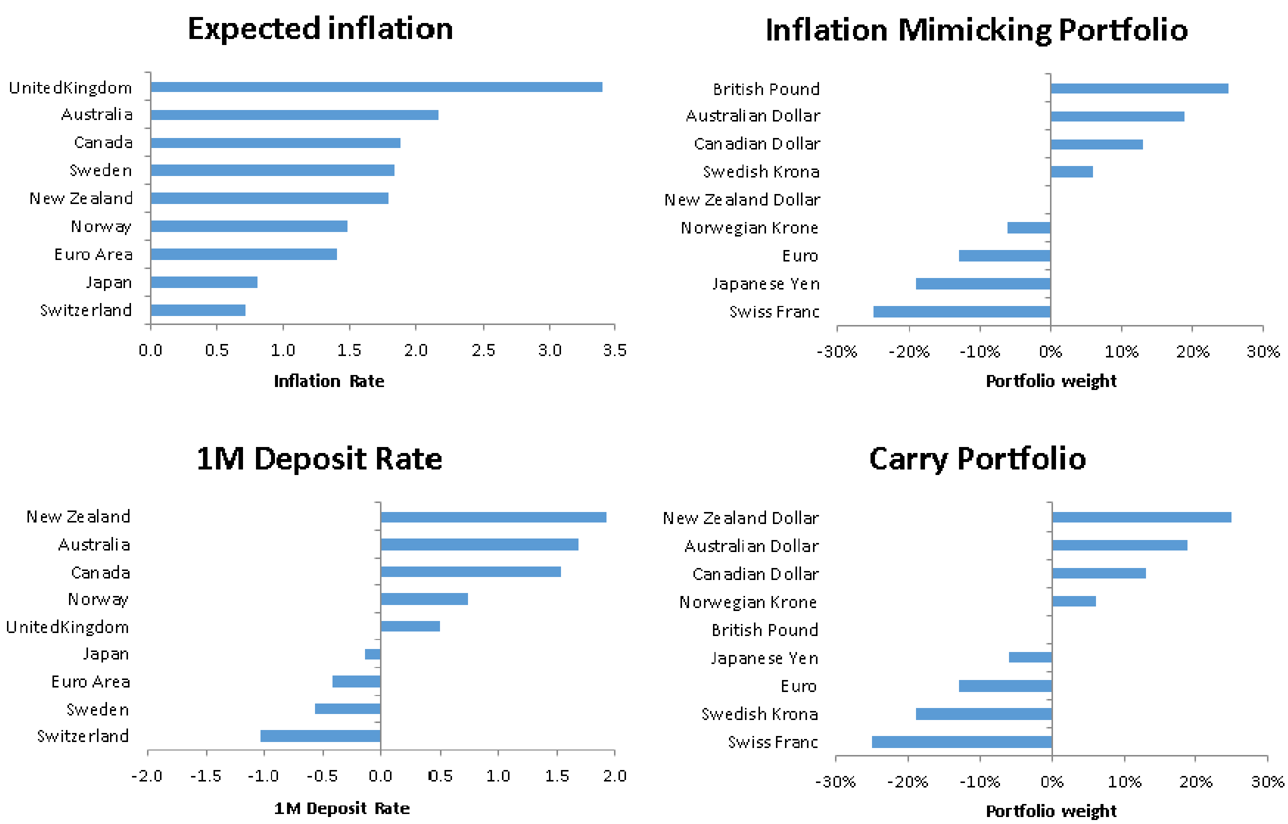

Figure 3 Inflation factor-mimicking portfolio vs carry portfolio for developed currencies.
The chart shows inflation factor-mimicking portfolios and carry portfolios for developed currencies in December 2017.
Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.

Japan and the Eurozone were the ones with the lowest expected inflation. Therefore, the inflation factor-mimicking portfolio would have been long British pounds sterling, Australian dollars, Canadian dollars and short Swiss francs, yen and euros. Using the same portfolio construction methodology, we know that a carry portfolio formed at the same time would have been long New Zealand dollar, Australian dollar, Canadian dollar and short Swiss franc, yen and euro. There is clearly a large overlap between the carry portfolio and the inflation factor-mimicking portfolio.[10]

We performed the following regression analysis to explain the payoff of asset class-specific carry portfolios using asset class-specific inflation or growth factor-mimicking portfolios:

$$ReturnCarry(j,t) = cFInfl(j) + BetaInfl(j) * ReturnInfl(j,t) + eFInfl(j,t)$$

$$ReturnCarry(j,t) = cFGDP(j) + BetaGDP(j) * ReturnGDP(j,t) + eFGDP(j,t)$$

where $ReturnCarry(j,t)$ is the return of carry factor portfolio in asset class j at time t; $ReturnInfl(j,t)$ is the return of inflation factor-mimicking portfolio in asset class j at time t; and $ReturnGDP(j,t)$ is the return of real growth

Table 8 Carry portfolio payoff regression on inflation or growth factor-mimicking portfolio payoff.

	Developed			Emerging	
	FI6	G10FX	DevEquity	EM6FX	EMEquity
cFInfl	**0.001**	0.000	***0.001***	0.000	***0.001***
BetaInfl	−0.240	**0.880**	**0.390**	**0.940**	0.020
R2	0.08	0.71	0.16	0.72	0.00
cFGDP	**0.001**	0.001	***0.002***	***0.002***	0.001
BetaGDP	−0.060	**0.460**	**−0.240**	**−0.450**	**−0.300**
R2	0.00	0.20	0.07	0.14	0.12

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
The table reports linear regression of returns from factor-mimicking for inflation or real growth onto returns of carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). For developed markets equities and currencies the sample is January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly. Significance at the 1% level is denoted in bold, while significance at the 10% level is denoted in bold and italics.

factor-mimicking portfolio in asset class j at time t.

Through this type of factor-mimicking portfolio, we find that the payoff in carry portfolios in various asset classes is linked to relative growth and inflation expectations across countries. Our regression of carry payoff against relative growth and inflation payoff in Table 8 yields statistically and economically significant betas from 1990 to 2017.

Carry-ranked portfolios in developed currencies, equities and emerging currencies essentially rank assets based on country inflation expectations. While these carry portfolios trade different assets, they share the same macro exposure, overweighting countries with higher inflation expectations. The only exception is the developed fixed income carry portfolio, which has a negative beta to the payoff of the inflation factor-mimicking portfolio.

In a multi-asset carry portfolio context, a portfolio manager could overweight the fixed income carry portfolio to diversify the relative inflation bet embedded in the currency and equity carry portfolios. Carry ranked portfolios have a much more varied relationship with relative growth expectations across countries. We find that only the developed currency carry portfolio payoff has a positive beta to relative growth expectations portfolio payoff. Emerging market currency, developed and emerging market equity carry portfolios have negative beta to relative growth portfolio payoff. Bond carry portfolio has zero beta to the growth portfolio.

We also ran a multivariate regression of asset class-specific carry portfolios on inflation and growth factor-mimicking portfolios. Table 9 shows that the beta estimates from univariate regressions in Table 8 are largely robust to multivariate analysis. More than 70% of the variances of developed and emerging market currency carry portfolios' returns are explained by inflation and

Table 9 Carry portfolio payoff regression on inflation and growth factor-mimicking portfolio payoffs.

	Developed			Emerging	
	FI6	G10FX	DevEquity	EM6FX	EMEquity
c	0.001	0.000	0.001	0.000	0.001
BetaInflM	**−0.246**	**0.816**	**0.415**	**0.921**	**−0.139**
BetaGDPM	0.017	**0.152**	**−0.280**	**−0.051**	**−0.376**
R2	0.08	0.73	0.25	0.72	0.14
Var. % Explained by Infl	0.08	0.67	0.17	0.71	(0.00)
Var. % Explained by GDP	(0.00)	0.07	0.08	0.02	0.14

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
The table reports linear regression of returns from factor-mimicking for inflation or real growth onto returns of carry strategies in developed currencies (G10FX), emerging currencies (EM6FX), developed country equities (DevEquity), emerging country equities (EMEquity) and developed country bonds (FI6). For developed markets equities and currencies the sample is January 1990–December 2017. For emerging markets currencies the sample is January 2001–December 2017. For emerging markets equities the sample is January 1995–December 2017. For developed country bonds, sample is January 1992–December 2017. Portfolios are rebalanced monthly. Significance at the 1% level is denoted in bold, while significance at the 10% level is denoted in bold and italics.

growth factor-mimicking portfolios' returns. The explanatory power of inflation and growth factor-mimicking portfolios is relatively lower in other asset classes (8% in bonds and 14–25% in country equities), but still substantial.

$$\begin{aligned} ReturnCarry(j,t) &= c \\ &+ BetaInflM(j) * ReturnInfl(j,t) \\ &+ BetaGDPM(j) * ReturnGDP(j,t) \\ &+ e(j,t). \end{aligned}$$

As discussed in Section 5.2, an equally weighted carry portfolio across the five asset class segments essentially buys assets of countries with relatively high inflation. This is especially the case in currencies, as confirmed by the variance decomposition analysis in Table 9. These findings are relevant for investors, and can be used to build multi-asset carry portfolios that are better aligned with their goals. For example, investors interested in absolute return strategies with minimal inflation exposures could use the results in Table 9 to neutralize the undesired inflation characteristics of multi-asset carry portfolios by tilting the portfolio composition toward individual carry strategies, such as emerging country equities (EMEquity) and developed country bonds (FI6). On the opposite side of the spectrum, investors looking for an inflation hedge might want to increase their carry portfolio allocation to currencies.

Table 10 compares the Equal Risk Carry portfolio introduced in Table 1 with two alternative multiasset carry portfolios: Alternate Carry 1, which has a roughly neutral exposure to inflation, and Alternate Carry 2, which has a high exposure to inflation. Investors seeking market neutral payoffs will likely prefer Alternate Carry 1, while investors looking to hedge inflation will likely prefer Alternate Carry 2. Not surprisingly, Equal Risk Carry provides a stronger information ratio than the other two alternatives, due to better cross-asset diversification. However, both Alternate Carry 1 and 2 portfolios show that it is

Table 10 Performance of multi-asset carry portfolios with different compositions (1/2001–12/2017).

Performance statistics, 2001–2017			
	Possible carry portfolio combinations		
	Equal risk carry	**Alternate carry 1**	**Alternate carry 2**
Avg Inflation Exposure	1.52	0.15	2.80
Obs	204	204	204
GeoRet	4.1%	3.4%	2.5%
Vol	5.0%	5.0%	5.0%
IR 2001–2017	0.83	0.71	0.51
Corr (MSCI ACWI)	31.2%	10.0%	14.4%

Source: QMA, MSCI, WMR, Bloomberg, Consensus Economics.
Performance statistics are reported for multi-asset Equal Risk Carry, Alternate Carry 1 and Alternate Carry 2. Alternate Carry 1 has the following weights: 10% G10FX, 5% EMFX, 10% Developed Country Equity, 25% Emerging Country Equity and 50% Developed Fixed Income Carry Portfolios. Alternate Carry 2 has the following weights: 40% G10FX, 50% EMFX, 10% Developed Country Equity, 0% Emerging Country Equity and 0% Developed Fixed Income Carry Portfolios. Statistics are computed from monthly return series over the sample time period: January 2001–December 2017. Portfolios are rebalanced monthly. Weights are scaled so that the *ex post* volatility of each strategy is set to 5% over the entire backtest period for comparison purposes. Reported returns do not include transaction costs. Avg Inflation Exposure is computed as described in Section 5.1.

possible to construct a multi-asset carry portfolio with different macroeconomic characteristics while collecting an attractive payoff. Investors who want more balanced exposure to macroeconomic risks should either vary their weights to asset class-specific carry portfolios, or complement the carry portfolio with other factor portfolios, such as value or momentum.

6 Conclusion

Our novel approach to identifying the underlying macroeconomic characteristics of carry factor portfolios through the use of holdings-based and factor-mimicking portfolio analyses provides unique insights. Carry factor portfolios sometimes behave quite differently in different asset classes due to their macroeconomic characteristics, despite their common yield-seeking logic. In addition to determining the typical, or average, characteristics, we can estimate the macroeconomic characteristics of portfolio holdings at any given point in time. However, this time variation does not help explain the carry payoff variation. Rather, we find that carry portfolios are akin to ranking assets on country-specific inflation or growth. This understanding can help investors build better carry portfolios by neutralizing undesired macro characteristics embedded in the portfolio, or by tilting the portfolio composition toward individual carry strategies in order to modify the macro characteristics embedded in the portfolio. Our results also provide a link between the well-known macroeconomic exposures of traditional asset classes and those of risk premia strategies. Finally, an attractive feature of our framework is its generality. We plan to use it in future research to better understand the macroeconomic characteristics of popular multi-asset momentum and value factor portfolios.

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Notes

1 "Large pension plans and sovereign wealth funds such as .... have adopted factor based asset allocation approaches...[]" Pension and Investments 2013.

2 Examples include: Asness *et al.* (2015); Koijen *et al.* (2018); Carhart *et al.* (2014); Ilmanen (2010); Kolanovic and Wei (2013); Noual and Secmen (2013); Bender *et al.* (2010); Mesomeris *et al.* (2012); Rennison *et al.* (2011); Baz *et al.* (2015); and Ahmerkamp and Grant (2013).

3 Koijen *et al.* (2018) explored a different equity carry factor using country equity futures. The carry of an equity futures contract is approximately the expected dividend yield minus the local risk-free rate for a fully collateralized futures position. They report that the correlation between dividend yield-based carry strategies and their carry measurement is only 0.07. Our analysis focuses on using traditional dividend yield as carry, which is widely reported in practitioner and academic literature (Mesomeris *et al.*, 2012; Kolanovic and Wei, 2013).

4 MSCI has not approved, reviewed or produced this report, makes no express or implied warranties or representations and is not liable whatsoever for any data in the report. You may not redistribute the MSCI data or use it as a basis for other indices or investment products.

5 We used approximate GDP weights for G7 countries. The weights were as follows: United States 52.7%, Japan 13.7%, Germany 9.7%, United Kingdom 7.4%, France 7.0%, Italy 5.3% and Canada 4.2%.

6 We also created global growth and inflation forecasts using equal weighting seven major developed countries' growth and inflation forecast. All reported results are robust to the weighting scheme for global growth or inflation. Results are available upon request.

7 Kolanovic and Wei (2013) use annual change in OECD leading economic indicator for growth and OECD global consumer price inflation for inflation.

8 The dividend yield factor is also considered a "defensive value" strategy, and some studies seek to avoid the high correlation between carry and value by computing the value factor based entirely on "cyclical value" metrics (Mesomeris *et al.*, 2012).

9 Expanding the country set from the current six countries to eight by including France and Switzerland did not materially change the results in our reported analysis.

10 The British pound sterling position is the exception. Inflation expectations in the United Kingdom were very high because of the currency depreciation following Brexit.

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