Carry*

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Abstract

A security's expected return can be decomposed into its "carry" and its expected price appreciation, where carry can be measured in advance without an asset pricing model. We find that carry predicts returns both in the cross section and time series for a variety of different asset classes that include global equities, global bonds, currencies, commodities, US Treasuries, credit, and equity index options. This predictability underlies the strong returns to "carry trades" that go long high-carry and short low-carry securities, applied almost exclusively to currencies, but shown here to be a robust feature of many assets. We decompose carry returns into static and dynamic components and analyze the economic exposures. Despite unconditionally low correlations across asset classes, we find times when carry strategies across all asset classes do poorly, and show that these episodes coincide with global recessions.

Keywords: Carry Trade, Predictability, Stocks, Bonds, Currencies, Commodities, Corporate Bonds, Options, Global Recessions

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We define an asset's "carry" as its expected return assuming that its price does not change. Based on this simple definition, any security's return can be decomposed into its carry and its expected and unexpected price appreciation:

$$\text{return} = \underbrace{\text{carry} + \text{E(price appreciation)}}_{\text{expected return}} + \text{unexpected price shock}. \qquad (1)$$

Hence, an asset's expected return is its carry plus its expected price appreciation. Carry is directly *observable* ex ante and is model-free. Thus, carry represents a component of expected returns we can measure in advance that is common to any asset pricing model (whereas the part of the expected return coming from expected price appreciation must be estimated from a model).

The concept of "carry" has been studied in the literature almost exclusively for currencies, where it represents the interest rate differential between two countries. While much theoretical and empirical research has focused exclusively on carry strategies in currencies,[1] equation (1) is a general relation that can be applied to any asset. Using this broader concept of carry, we unify and extend the set of predictors of returns across a variety of assets that include global equities, bonds, commodities, currencies, Treasuries, credit, and index options.

Equation (1) shows that the link between carry and expected returns depends on the relation between carry and expected price appreciation, where the latter could be positive, zero, or negative. The uncovered interest rate parity in currencies, and the expectations hypothesis more generally, predict that the expected price appreciation offsets any variation in the carry so that the expected return is constant. In contrast, carry predicts returns in many models with time-varying expected returns. Empirically, we find that carry is a strong positive predictor of returns in each of the major asset classes we study. Since carry varies over time and across assets, this result implies that expected returns also vary through time and across assets and are predicted by carry, rejecting the expectations hypothesis.

Carry provides a unified framework for understanding well-known predictors of returns in these asset classes. For instance, we show how bond carry is closely related to the slope of the yield curve studied in the bond literature, commodity carry is related to the convenience yield, and equity carry is a forward-looking measure related to dividend yields.[2] These literatures have traditionally been treated independently, where various

[1] This literature goes back at least to Meese and Rogoff (1983). Surveys are presented by Froot and Thaler (1990), Lewis (1995), and Engel (1996).

[2] See Cochrane (2011) and Ilmanen (2011) and references therein.

predictors in different asset classes are modeled as separate phenomena, and never (to our knowledge) studied jointly. Our simple concept of carry unifies these measures and allows us to investigate return predictability jointly across these asset classes. Moreover, while carry is related to these known predictors, it is also different from these measures and it can be applied more broadly. We find that the predictability of carry is often stronger than that of these traditional predictors, indicating that carry not only provides a unified conceptual framework for these predictors, but may also improve upon return predictability within each asset class.

Further, because carry is a general concept, we also apply it to other asset markets that have not been extensively studied for return predictability. We examine the cross-section of US Treasuries across maturities, US credit portfolios, and US equity index options across moneyness, and find equally strong return predictability from our carry measure in each of these markets. These out-of-sample tests highlight the generality and robustness of carry as a predictor of returns.

We examine how much of the returns to carry strategies can be explained by other global return factors such as value, momentum, and time-series momentum (following Asness, Moskowitz, and Pedersen (2012) and Moskowitz, Ooi, and Pedersen (2012)) within each asset class as well as across all asset classes. The relation between carry and these other known predictors of returns varies across asset classes. Carry is positively related to value in equities, is related to momentum in fixed income and commodities, and is unrelated to both in Treasuries, currencies, credit, or index options. However, we find that none of these other factors can explain the returns to carry and that carry represents a unique return predictor in each asset class above and beyond these factors.

This joint approach of studying carry and its return predictability simultaneously across different asset classes provides new insights that challenges existing asset pricing theory. First, we find that a zero-cost carry trade portfolio, which goes long high carry securities and short low ones within each asset class earns an annualized Sharpe ratio of 0.7 on average, indicating a strong cross-sectional link between carry and expected returns in each asset class. Forming a portfolio of carry strategies diversified across all asset classes earns a Sharpe ratio of 1.1, suggesting significant diversification benefits from applying carry more broadly across different asset classes. This large Sharpe ratio presents a significantly greater challenge for asset pricing models that already struggle to explain the equity premium, the currency carry strategy, and a number of stock market strategies that have significantly smaller Sharpe ratios (see Hansen and Jagannathan (1997)).

Second, by studying multiple asset classes at the same time, we provide out-of-sample tests of existing theories and new insights on return predictability to guide new theories.

For example, the large literature on carry trades in currencies seeks to explain the high Sharpe ratios of carry strategies based on the crash risk commonly documented for currency carry trades. While we find high positive Sharpe ratios across carry strategies in all asset classes, the negative skewness of currency carry trades is not present in all asset classes. Moreover, the diversified carry portfolio across all asset classes has a skewness close to zero and smaller tails than a diversified passive exposure to all asset classes (e.g., the global market portfolios), presenting a puzzle for models seeking to explain the high average carry returns based on crash risk.[3]

To gain further insight into the source of the carry return premium, we decompose the returns to carry in each asset class into a passive and a dynamic component. The passive component comes from being on average long (short) securities that experience high (low) average returns. The dynamic component captures how well variation in carry (around its average) predicts future returns. We find that the dynamic component of carry strategies contributes to most of the returns to the equity, fixed income, and options carry strategies, and about half of the returns to the US Treasury, currency, credit, and commodity carry strategies. The substantial dynamic component in every asset class indicates that carry fluctuates over time and across assets, and that these fluctuations are associated with variation in expected returns.

Using a set of predictive regressions of future returns of each asset on its carry, we also find strong evidence of time-varying risk premia, where carry predicts future returns with a positive coefficient in every asset class. However, the magnitude of the predictive coefficient differs across asset classes, identifying whether carry is positively or negatively related to future price appreciation (as identified by equation (1)). For most asset classes, the predictive coefficient is (not significantly different from) one, indicating that carry does not predict future price changes, or that a carry investor earns the full carry—nothing more or less—on average. In several cases, the point estimate is greater than one, implying that an investor earns more than the carry as price changes further add to returns. For commodities and options, however, the coefficient is less than one, where carry predicts negative future price changes.

Although the cross-sectional return predictability underlies our basic carry strategies (where we go long high carry securities and short low carry ones), we also find significant

[3]Brunnermeier, Nagel, and Pedersen (2008) show that the currency carry trade is exposed to liquidity risk, which is enhanced by occasional crashes that could lead to limited arbitrage and slow price adjustments. Bacchetta and van Wincoop (2010) present a related explanation based on infrequent revisions of investor portfolio decisions. Lustig and Verdelhan (2007) suggest that the currency carry trade is exposed to consumption growth risk from the perspective of a U.S. investor, Farhi and Gabaix (2008) develop a theory of consumption crash risk (see also Lustig, Roussanov, and Verdelhan (2010), and Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) consider peso problems.

time-series predictability from carry as well, where carry is useful in timing a given security—going long the security when carry is positive (or above its long-run mean) and short when carry is negative (or below its long-run mean). We find that the timing strategies' profitability coincides with the strength of the dynamic component of carry across asset classes.

Despite the high Sharpe ratios of our carry strategies, they are far from riskless and exhibit sizeable declines that are concentrated in time across asset classes. Carry returns tend to be low during global recessions, and this feature appears to hold uniformly across markets.

Flipping the analysis around, we also identify the worst and best carry return episodes for the diversified carry strategy applied across all asset classes. We term these episodes carry "drawdowns" and "expansions." We find that the three biggest global carry drawdowns (August 1972 to September 1975, March 1980 to June 1982, and August 2008 to February 2009) coincide with major global business cycle and macroeconomic events. Reexamining each individual carry strategy within each asset class, we find that during carry drawdowns all carry strategies in every asset class do poorly, and, moreover, perform significantly worse than passive exposures to these markets during these times. Hence, part of the return premium earned on average for going long carry may be compensation for exposure that generates large losses during extreme times of global recessions. Whether these extreme times are related to macroeconomic risks and heightened risk aversion or are times of limited capital and arbitrage activity and funding squeezes remains an open question. Both may be true during these times and may be contributing to the returns associated with carry trades across markets.

While the carry trade clearly has risk, its large returns across a variety of diverse asset classes are nevertheless difficult to explain entirely by macroeconomic risk and challenge many macroeconomic models (Lucas (1978), Campbell and Cochrane (1999), Bansal and Yaron (2004)). Alternatively, carry trade returns could be driven by limited arbitrage (Shleifer and Vishny (1997)), transaction costs and funding liquidity risk from margin requirements or other funding issues (Brunnermeier and Pedersen (2009), Gârleanu and Pedersen (2011)).

Our work relates to the extensive literature on the currency carry trade and the associated failure of uncovered interest rate parity. However, our study offers a much broader concept of carry that not only captures the currency carry trades focused on in the literature, but also an array of assets from many different asset classes. We show that a carry return premium is present in all nine of the asset classes we study and highlight the characteristics that are unique and common across these asset classes that may help identify explanations for the carry return premium in general.

Our study also relates to the literature on return predictability that seems to be segregated by asset class. In addition to the currency literature, the literature on bonds has its own set of predictors, as do commodities, and equities.[4] All of these studies focus on a single asset class or market at a time and ignore how different asset classes or markets behave simultaneously. We show that many of these seemingly different and unrelated variables can in fact be tied together through the concept of carry. Moreover, using this unifying framework of carry, we also identify similar return patterns in markets not previously explored such as US Treasuries, US credit, and US equity index options. These additional asset classes are also shown to be linked to international equities, bonds, currencies, and commodities through carry.

Finally, our paper contributes to a growing literature on global asset pricing that analyzes multiple markets jointly. Asness, Moskowitz, and Pedersen (2012) study cross-sectional value and momentum strategies within and across individual equity markets, country equity indices, government bonds, currencies, and commodities simultaneously. Moskowitz, Ooi, and Pedersen (2012) also document time-series momentum in equity index, currency, commodity, and bond futures that is distinct from cross-sectional momentum. Fama and French (2011) study the relation between size, value, and momentum in global equity markets across four major regions (North America, Europe, Japan, and Asia Pacific). By jointly studying different markets simultaneously, we seek to help identify and rule out various explanations for the existence of return premia globally across markets. Macro-finance theory seeking to explain carry return premia should confront the ubiquitous presence of carry returns across vastly different asset classes and their commonality.

The remainder of the paper is organized as follows. Section I. defines carry and shows how it relates to expected returns for each asset class. Section II. considers the returns of carry strategies globally across asset classes, relating carry to other known predictors of returns and applying carry to assets not previously studied. Section III. decomposes carry returns into the dynamic and static components of a carry trade and examines the relation between carry and expected price appreciation both in the time-series and cross-section of asset returns. Section IV. investigates the risk of carry strategies generally and

[4] Studies focusing on international equity returns include Chan, Hamao, and Lakonishok (1991), Griffin (2002), Griffin, Ji, and Martin (2003), Hou, Karolyi, and Kho (2010), Rouwenhorst (1998), Fama and French (1998), and further references in Koijen and Van Nieuwerburgh (2011). Studies focusing on government bonds across countries include Ilmanen (1995) and Barr and Priestley (2004). Studies focusing on commodities returns include Fama and French (1987), Bailey and Chan (1993), Bessembinder (1992), Casassus and Collin-Dufresne (2005), Erb and Harvey (2006), Acharya, Lochstoer, and Ramadorai (2010), Gorton, Hayashi, and Rouwenhorst (2007), Tang and Xiong (2010), and Hong and Yogo (2010).

how carry relates to global business cycle and liquidity risks. Section V. concludes.

I. Understanding Carry: A Characteristic of Any Asset

We decompose the return to any security into two components: carry and price appreciation. The carry return can be thought of as the return to a security assuming its price stays constant. Hence, carry can be observed in advance. We detail below the decomposition of different securities' returns into carry versus price appreciation across nine diverse asset classes: currencies, equities, global bonds, commodities, US Treasuries, credit, and call and put index options.

We first consider estimating carry from futures contracts, which can be applied generally to many of our asset classes. Consider a futures contract that expires in period $t+1$ with a current futures price F_t and spot price of the underlying security S_t. We first define the return of the futures. Assume an investor allocates X_t dollars today of capital to finance each futures contract (where X_t must be at least as large as the margin requirement). Next period, the value of the margin capital and the futures contract is equal to $X_t(1+r_t^f)+F_{t+1}-F_t$, where r_t^f is the risk-free interest rate today that is earned on the margin capital. Hence, the return per allocated capital over one period is

$$r_{t+1}^{\text{total return}} = \frac{X_t(1+r_t^f)+F_{t+1}-F_t-X_t}{X_t} = \frac{F_{t+1}-F_t}{X_t} + r_t^f \tag{2}$$

Therefore, the return in excess of the risk-free rate is

$$r_{t+1} = \frac{F_{t+1}-F_t}{X_t}. \tag{3}$$

The carry C_t of the futures contract is then computed as the futures excess return under the assumption of a constant spot price from t to $t+1$. (The carry can alternatively be defined as the *total* return under this assumption.) Given that the futures price expires at the future spot price ($F_{t+1}=S_{t+1}$) and the assumption of constant spot prices ($S_{t+1}=S_t$), we have that $F_{t+1}=S_t$. Therefore, the carry is defined as

$$C_t = \frac{S_t-F_t}{X_t}. \tag{4}$$

For most of our analysis, we compute returns and carry based on a "fully-collateralized" position, meaning that the amount of capital allocated to the position is equal to the futures price, $X_t = F_t$.[5] The carry of a fully-collateralized position is therefore

$$C_t = \frac{S_t - F_t}{F_t}. \tag{5}$$

We can explicitly decompose the (fully-collateralized) return into its expected return plus an unexpected price shock to gain insight into how carry relates to expected returns. Using the definition of carry, we can decompose the excess return on the futures as

$$r_{t+1} = \underbrace{C_t + E_t\left(\frac{\Delta S_{t+1}}{F_t}\right)}_{E_t(r_{t+1})} + u_{t+1}, \tag{6}$$

where $\Delta S_{t+1} = S_{t+1} - S_t$ and $u_{t+1} = (S_{t+1} - E_t(S_{t+1}))/F_t$ is the unexpected price shock.

Equation (6) shows how carry, C_t, is related to the expected return $E_t(r_{t+1})$, but the two are *not* necessarily the same. The expected return on an asset is comprised of both the carry on the asset and the expected price appreciation of the asset, which depends on the specific asset pricing model used to form expectations and its risk premia. The carry component of a futures contract's expected return, however, can be measured in advance in a straightforward "mechanical" way without the need to specify a pricing model or stochastic discount factor. Put differently, carry is a simple observable characteristic, that is a component of the expected return on an asset. Furthermore, carry may be relevant for predicting expected price changes which also contribute to the expected return on an asset. That is, C_t may also provide information for predicting $E_t(\Delta S_{t+1}/F_t)$, which we investigate empirically in this paper. Equation (6) provides a unifying framework for carry and its link to risk premia across a variety of asset classes. The rest of the paper explores this relationship empirically across the nine asset classes we study.

We apply this carry definition to currency forwards, equity futures, and commodity futures and discuss in more detail how to interpret the carry for each asset class. Further, we also broaden our definition of carry to other asset classes, such as options and corporate bonds or other assets where futures contracts are not available. Examining these other asset classes provides robustness on both our methodology for computing carry as well as additional test assets.

In general, we *define carry as the return if market conditions stay the same*. We show precisely how we operationalize this definition for each asset class. In most cases, it is clear how to apply this definition; for instance, one can create a synthetic futures price

[5]However, when considering, for instance, yield curve positions with fundamentally different levels of risk, we can choose the position sizes X_t to equalize risk across positions.

of an asset and apply equation (5). In some cases, our general definition has more than one interpretation, however, as one must decide *which* market conditions are assumed constant. For instance, for bonds the carry could be the return assuming that the bond price or the entire yield curve stays constant. As another example, one can compute carry as the return if the nominal or real (i.e., inflation-adjusted) price stays constant. In currencies, for example, defining carry as the return if the real exchange rate stays the same implies that carry is the real interest rate. Appendix A also shows that the same carry measures can be used for foreign-denominated futures contracts. As detailed below, we try to use the simplest possible measures of carry for each asset class, namely the nominal measure consistent with equation (5).

A. Currency Carry

We begin with the classic carry trade studied in the literature—the currency carry trade—which is a trade that goes long high carry currencies and short low carry currencies. For a currency, the carry is simply the local interest rate in the corresponding country—investing in a currency by literally putting cash into a country's money market earns the interest rate if the exchange rate (the "price of the currency") does not change.

Most speculators get foreign exchange exposure through a currency forward and our data on currencies comes from 1-month currency forward contracts (detailed in the next section). To derive the carry of a currency from forward rates, recall that the no-arbitrage price of a currency forward contract with spot exchange rate S_t (measured in number of local currency per unit of foreign currency), local interest rate r^f, and foreign interest rate r^{f*} is $F_t = S_t(1 + r_t^f)/(1 + r_t^{f*})$. Therefore, the carry of the currency is

$$C_t = \frac{S_t - F_t}{F_t} = \left(r_t^{f*} - r_t^f\right) \frac{1}{1 + r_t^f}. \tag{7}$$

The carry of investing in a forward in the foreign currency is the interest-rate spread, $r^{f*} - r^f$, adjusted for a scaling factor close to one, $(1 + r_t^f)^{-1}$. The carry is the foreign interest rate *in excess* of the local risk-free rate r^f because the forward contract is a zero-cost instrument whose return is an excess return.[6]

There is an extensive literature studying the carry trade in currencies. The historical positive return to currency carry trades is a well known violation of the so-called uncovered

[6]The scaling factor simply reflects that a currency exposure using a futures contract corresponds to buying 1 unit of foreign currency in the future, which corresponds to buying $(1 + r_t^f)^{-1}$ units of currency today. The scaling factor could be eliminated if we changed the assumed position size, that is, changed X_t in equation 4.

interest-rate parity (UIP). The UIP is based on the simple assumption that all currencies should have the same expected return, but many economic settings would imply differences in expected returns across countries. For instance, differences in expected currency returns could arise from differences in consumption risk (Lustig and Verdelhan (2007)), crash risk (Brunnermeier, Nagel, and Pedersen (2008), Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011)), liquidity risk (Brunnermeier, Nagel, and Pedersen (2008)), and country size (Hassan (2011)), where a country with more exposure to consumption or liquidity risk could have both a high interest rate and a cheaper exchange rate.

While we investigate the currency carry trade and its link to macroeconomic and liquidity risks, the goal of our study is to investigate the role of carry more broadly across asset classes and identify the characteristics of carry returns that are common and unique to each asset class. As we show in the next section, some of the results in the literature pertaining to currency carry trades, such as crashes, are not evident in all other asset classes, while other characteristics, such as high Sharpe ratios and exposure to global business cycles, are more common to carry trades in general across all asset classes.

B. Global Equity Carry

If market conditions do not change for equities, which in this case corresponds to stock prices and dividends, then the return on equities comes solely from dividends—hence, carry is the dividend yield today.

We implement a global equity carry strategy via futures, which leads to another measure of carry. While we do not always have an equity futures contract with exactly one month to expiration, we interpolate between the two nearest-to-maturity futures prices to compute a consistent series of synthetic one-month equity futures prices.[7]

The no-arbitrage price of a futures contract is $F_t = S_t(1 + r_t^f) - E_t^Q(D_{t+1})$, where the expected dividend payment D is computed under the risk-neutral measure Q, and r_t^f is the risk-free rate at time t in the country of the equity index.[8] Substituting this expression back into equation (5), the carry for an equity future can be rewritten as

$$C_t = \frac{S_t - F_t}{F_t} = \left(\frac{E_t^Q(D_{t+1})}{S_t} - r_t^f \right) \frac{S_t}{F_t}. \tag{8}$$

[7]We only interpolate the futures prices to compute the equity carry. We use the most actively traded equities contract to compute the return series, see Appendix B for details on the data construction.

[8]Binsbergen, Brandt, and Koijen (2012) and Binsbergen, Hueskes, Koijen, and Vrugt (2013) study the asset pricing properties of dividend futures prices, $E_t^Q(D_{t+n})$, $n = 1, 2, \ldots$, in the US, Europe, and Japan.

The carry of an equity futures contract is simply the expected dividend yield minus the local risk-free rate, multiplied by a scaling factor which is close to one, S_t/F_t.

To further understand the relationship between carry and expected returns, consider Gordon's growth model for the price S_t of a stock with (constant) dividend growth g and expected return $E(R)$, $S_t = D/(E(R) - g)$. This standard equity pricing equation implies that the expected return is the dividend yield plus the expected dividend growth, $E(R) = D/S + g$. Or, the expected return is the carry, D/S, plus the expected price appreciation arising from the expected dividend growth, g. If the dividend yield varies independently of g, then the dividend yield is clearly a signal of expected returns. If, on the other hand, dividend growth is high when the dividend yield is low, then the dividend yield would not necessarily predict expected returns, as the two components of $E(R)$ would offset each other. In this case, market prices would on average take back part of the carry.

If expected returns do vary, then it is natural to expect carry to be positively related to expected returns: If a stock's expected return increases while dividends stay the same, then its price drops and its dividend yield increases (Campbell and Shiller (1988)). Hence, a high expected return leads to a high carry. Indeed, this discount-rate mechanism is consistent with standard macro-finance models, such as Bansal and Yaron (2004), Campbell and Cochrane (1999), Gabaix (2009), Wachter (2010), and models of time-varying liquidity risk premia (Acharya and Pedersen (2005)). We investigate in the next section the relation between carry and expected returns for equities as well as the other asset classes and test whether these relations are consistent with theory.

As the above equations indicate, carry for equities is related to the dividend yield, which has been extensively studied as a predictor of returns, starting with Campbell and Shiller (1988) and Fama and French (1988). Our carry measure for equities and the standard dividend yield used in the literature are related, but they are not the same. Carry provides a forward-looking measure of dividends derived from futures prices, while the standard dividend yield used in the prediction literature is backward looking. We show below and in Appendix D that dividend yield strategies for equities are indeed different from our equity carry strategy.

C. Commodity Carry

If you make a cash investment in a commodity by literally buying and holding the physical commodity itself, then the carry is the convenience yield or net benefits of use of the commodity in excess of storage costs. While the actual convenience yield is hard to measure (and may depend on the specific investor), the carry of a commodity futures or forward can be easily computed and represents the expected convenience yield of the commodity. Similar to the dividend yield on equities, where the actual dividend yield may be hard to measure since future dividends are unknown in advance, the expected dividend yield can be backed out from futures prices. Hence, one of the reasons we employ futures contracts is to easily and consistently compute the carry across asset classes. The no-arbitrage price of a commodity futures contract is $F_t = S_t(1 + r_t^f - \delta_t)$, where δ_t is the convenience yield in excess of storage costs. Hence, the carry for a commodity futures contract is,

$$C_t = \frac{S_t - F_t}{F_t} = \left(\delta_t - r^f\right)\frac{1}{1 + r_t^f - \delta_t}, \tag{9}$$

where the commodity carry is the expected convenience yield of the commodity in excess of the risk free rate (adjusted for a scaling factor that is close to one).

To compute the carry from equation (9), we need data on the current futures price F_t and current spot price S_t. However, commodity spot markets are often highly illiquid and clean spot price data on commodities are often unavailable. To combat this data issue, instead of examining the "slope" between the spot and futures prices, we consider the slope between two futures prices of different maturity. Specifically, we consider the price of the nearest-to-maturity commodity futures contract with the price of the next-nearest available futures contract on the same commodity. Suppose that the nearest to maturity futures price is F_t^1 with T_1 months to maturity and the second futures price is F_t^2 with T_2 months to maturity, where $T_2 > T_1$. In general, the no-arbitrage futures price can be written as $F_t^{T_i} = S_t(1 + (r^f - \delta_t)T_i)$. Thus, the carry of holding the second contract can be computed by assuming that its price will converge to F_t^1 after $T_2 - T_1$ months, that is, assuming that the price of a T_1-month futures stays constant:

$$C_t = \frac{F_t^1 - F_t^2}{F_t^2(T_2 - T_1)} = \left(\delta_t - r_t^f\right)\frac{S_t}{F_t^2}, \tag{10}$$

where we divide by $T_2 - T_1$ to compute the carry on a per-month basis. Following Equation (10), we can simply use data from the futures markets—specifically, the slope of the futures curve—to get a measure of carry that captures the convenience yield.[9]

[9] Another interpretation of Equation (10) is as follows: Derive synthetic spot and 1-month futures prices by linearly interpolating the two available futures prices, F^1 and F^2, and then compute the 1-month carry as before using these synthetic prices. It is easy to see that this yields the same expression for carry as equation (10). In principal, we could also compute carry in other asset classes using this method based on two points on the futures curve (i.e., not rely on spot prices). However, since spot price data is readily available in the other asset classes, this is unnecessary. Moreover, we find that the carry calculated from the futures curve in the other asset classes is nearly identical to the carry computed from

As seen from the above equations, carry provides an interpretation of some of the predictors of commodity returns examined in the literature (Gorton, Hayashi, and Rouwenhorst (2007), Hong and Yogo (2010), Yang (2011)) and is linked to the convenience yield on commodities.

D. Global Bond Carry

Calculating carry for bonds is perhaps the most ambiguous since there are several reasonable ways to define carry for fixed income instruments. For example, consider a bond with T-months to maturity, coupon payments of D, par value $\bar{P}$, price P_t^T, and yield to maturity y_t^T. There are several different ways to define the carry of this bond. Assuming that its price stays constant, the carry of the bond would be the current yield, D/P_t^T, if there is a coupon payment over the next time period, otherwise it is zero. However, since a bond's maturity changes as time passes, it is not natural to define carry based on the assumption that the bond *price* stays constant (especially for zero-coupon bonds).

A more useful definition of carry arises under the assumption that the bond's *yield to maturity* stays the same over the next time period. The carry could then be defined as the yield to maturity (regardless of whether there is a coupon payment). To see this, note that the price today of the bond is,

$$P_t^T = \sum_{i \in \{\text{coupon dates} > t\}} D(1+y_t^T)^{-(i-t)} + \bar{P}(1+y_t^T)^{-(T-t)}, \tag{11}$$

and if we assume that the yield to maturity stays the same, then the same corresponding formula holds for the bond next period as well, P_{t+1}^{T-1}. Thus, the value of the bond including coupon payments next period is,

$$P_{t+1}^{T-1} + D \cdot 1_{[t+1 \in \{\text{coupon dates}\}]} = \sum_{i \in \{\text{coupon dates} > t\}} D(1+y_t^T)^{-(i-t-1)} + \bar{P}(1+y_t^T)^{-(T-t-1)}. \tag{12}$$

Hence, the carry is

$$C_t = \frac{P_{t+1}^{T-1} + D \cdot 1_{[t+1 \in \{\text{coupon dates}\}]} - P_t^T}{P_t^T} = y_t^T. \tag{13}$$

The carry in excess of the short-term risk-free rate (i.e., the carry of a position financed

spot and futures prices in those asset classes. Hence, using the futures curve to calculate carry appears to be equivalent to using spot-futures price differences, justifying our computation for carry in commodities.

by borrowing) is then the term spread:

$$C_t = y_t^T - r_t^f. \tag{14}$$

Perhaps the most compelling definition of carry is the return on the bond if *the entire term structure of interest rates* stays constant, i.e., $y_{t+1}^{\tau} = y_t^{\tau}$ for all maturities τ. In this case, the carry is the bond return assuming that the yield to maturity changes from y_t^T to y_t^{T-1}. In this case, the carry (in terms of excess returns) is

$$\begin{aligned} C_t &= \frac{P_{t+1}^{T-1}(y_t^{T-1}) + D \cdot 1_{[t+1 \in \text{coupon dates}]} - P_t^T}{P_t^T} - r_t^f \\ &= y_t^T - r_t^f + \frac{P_{t+1}^{T-1}(y_t^{T-1}) - P_{t+1}^{T-1}(y_t^T)}{P_t^T} \\ &\cong \underbrace{y_t^T - r_t^f}_{\text{slope}} \underbrace{-D^{mod}\left(y_t^{T-1} - y_t^T\right)}_{\text{roll down}} \end{aligned} \tag{15}$$

where the latter approximation involving the modified duration, D^{mod}, yields a simple way to think of carry. Intuitively, equation (15) shows that if the term structure of interest rates is constant, then the carry is the bond yield plus the "roll down," which captures the price increase due to the fact that the bond rolls down the yield curve. As the bond rolls down the (assumed constant) yield curve, the yield changes from y_t^T to y_t^{T-1}, resulting in a return which is minus the yield change times the modified duration.

To be consistent with the other asset classes, we would like to compute the bond carry using futures data. Unfortunately, liquid bond futures contracts are only traded in a few countries and, when they exist, there are often very few contracts (often only one). Further complicating matters is the fact that different bonds have different coupon rates and the futures price is subject to cheapest-to-deliver options. To simplify matters and create a broader global cross-section, we derive synthetic futures prices based on data on zero-coupon rates as follows.[10]

We compute the carry of a synthetic one-month futures. Consider a futures contract that gives the obligation to buy a 9-year-and-11-months zero-coupon bond in one month from now. The current price of this one-month futures is $F_t = (1+r_t^f)/(1+y_t^{10Y})^{10}$, where y_t^{10Y} is the current yield on a 10-year zero-coupon bond. (This expression for the futures price follows from the fact that the futures payoff can be replicated by buying a 10-year bond.) The current "spot price" is naturally the current price of a 9-year-and-11-month

[10]For countries with actual, valid bond futures data, the correlation between actual futures returns and our synthetic futures returns exceeds 0.95.

zero-coupon bond, $S_t = 1/(1+y_t^{9Y11M})^{9+11/12}$. Hence, the carry as defined in equation (5) is given by

$$C_t = \frac{S_t - F_t}{F_t} = \frac{1/(1+y_t^{9Y11M})^{9+11/12}}{(1+r_t^f)/(1+y_t^{10Y})^{10}} - 1. \quad (16)$$

While we compute the carry using this exact formula, we can get an intuitive expression using the same approximation as before

$$C_t \simeq y_t^{10Y} - r_t^f - D^{mod}(y_t^{10Y} - y_t^{9Y11M}). \quad (17)$$

Hence, the futures-based carry calculation corresponds to the assumption that the entire term structure of interest rates stays constant.

Again, the above equations highlight how carry captures standard predictors for bond returns. For example, a standard predictor of bond returns in the time series is the yield spread (Fama and Bliss (1987) and Campbell and Shiller (1991)), where our measure of carry equals the yield spread plus a roll-down component. To understand the importance of the roll-down component, we can compare our carry measure to the yield spread between long-term (10-year) and short-term (3-month) bond yields. In our sample, the average (across countries) time-series correlation between the yield spread and the carry signal is 0.90, and if we use the yield spread, instead of the carry, as a signal for form portfolios, the returns generated are 0.91 correlated.

E. Carry of the Slope of Global Yield Curves

In addition to the synthetic global bond futures described above, we also examine tests assets in each country that capture the slope of the yield curve. Specifically, we consider in each country a long position in the 10-year bond and a short position in the 2-year bond. Naturally, the carry of this slope-of-the-yield-curve position in country i is

$$C_t^{\text{slope},i} = C_t^{10Y,i} - C_t^{2Y,i}. \quad (18)$$

This provides another measure of carry for fixed income securities in each market that, in this case, seeks to predict the returns associated with the slope of the yield curve in each market rather than its level (as above).

F. Carry Across Treasuries of Different Maturities

We also examine carry for US Treasuries from 1 to 10 years of maturity. These bonds naturally have very different risks and are therefore not directly comparable. For instance, a portfolio that invests long \$1 of 10-year bonds and shorts \$1 of 1-year bonds is dominated by the 10-year bonds, which are far more volatile. To put the bonds on a common scale, we consider duration-adjusted bond returns. Specifically, we consider portfolios of duration-adjusted bonds where each bond i is scaled by the inverse of its duration, D_t^i. Naturally, our measure of carry must correspond to the position size. Hence, a position of $1/D_t^i$ bonds with a carry of C_t^i (defined in Section D) is:

$$C_t^{\text{duration-adjusted},i} = \frac{C_t^i}{D_t^i}. \tag{19}$$

This corresponds to duration-adjusting the position size X_t in equations 3 and 4.

G. Credit Market Carry

We also look at the carry of US credit portfolios sorted by maturity and credit quality. We compute the carry for duration-adjusted bonds in the same way as we do for global bonds using equations (17) and (19). Clearly, this definition of carry is the credit spread (the yield over the risk free rate) plus the roll down on the credit curve.

H. Equity Index Option Carry

Finally, we apply the concept of carry to U.S. equity index options. We define the price of a call option at time t with maturity T, strike K, implied volatility σ_T, and underlying S_{it} as $F_t^{Call}(S_{it}, K, T, \sigma_T)$. The equivalent put price is denoted by $F_t^{Put}(S_{it}, K, T, \sigma_T)$. We apply the same concept of carry as before, that is, the return on a security if market conditions do not change.

In the context of options, this implies for the definition of carry ($j = Call, Put$):

$$C_{it}^j(K, T, \sigma_T) = \frac{F_t^j(S_{it}, K, T-1, \sigma_{T-1})}{F_t^j(S_{it}, K, T, \sigma_T)} - 1, \tag{20}$$

which depends on the maturity, the strike, and the type of option traded. We could subtract the risk-free rate from this expression, but all options are traded in US markets and hence this will not change the rank of the signals in our cross-sectional strategies.[11]

To get some intuition, we can approximate the carry in terms of the derivative of the option price with respect to time (i.e., its theta θ) and implied volatility (vega ν) as the

[11]Our equity strategies are a special case of the call options carry strategy, where $\lim K \to 0$ and $T = 1$. In this case, $\lim_{K\to 0} F^C = \lim_{K\to 0} E(M(S-K)^+) = E(MS)$, which is the forward price of equities.

stock price (S_{it}) is constant in the carry calculation:

$$F_t^j(S_{it}, K, T-1, \sigma_{T-1}) \simeq F_t^j(S_{it}, K, T, \sigma_T) - \theta_t^j(S_{it}, K, T, \sigma_T) - \nu_t^j(S_{it}, K, T, \sigma_T)(\sigma_T - \sigma_{T-1}). \tag{21}$$

This allows us to write the option carry as:

$$C_{it}^j(K, T, \sigma_T) \simeq \frac{-\theta_t^j(S_{it}, K, T, \sigma_T) - \nu_t^j(S_{it}, K, T, \sigma_T)(\sigma_T - \sigma_{T-1})}{F_t^j(S_{it}, K, T, \sigma_T)}. \tag{22}$$

The size of the carry is therefore driven by the time decay (via θ) and the roll down on the implied volatility curve (via ν). The option contracts that we consider differ in terms of their moneyness, maturity, and put/call characteristic as we describe further below.[12]

II. Carry Trade Returns Across Asset Classes

We construct our carry trade portfolio returns for each asset class as well as across all the asset classes we examine. First, we briefly describe our sample of securities in each asset class and how we construct our return series, then we consider the carry trade portfolio returns within and across the asset classes and examine their performance over time. Appendix B details the data sources.

A. Data and Summary Statistics

Table I presents summary statistics for the returns and the carry of each of the instruments we use, including the starting date for each of the series. There are 13 country equity index futures: the U.S. (S&P 500), Canada (S&P TSE 60), the UK (FTSE 100), France (CAC), Germany (DAX), Spain (IBEX), Italy (FTSE MIB), The Netherlands (EOE AEX), Norway (OMX), Switzerland (SMI), Japan (Nikkei), Hong Kong (Hang Seng), and Australia (S&P ASX 200).

[12]Starting in 2004, the CBOE introduced futures on the VIX index, where the payoff of these futures contracts equals the VIX index. Following our definition of carry, the carry of these contracts equals the current level of the VIX relative to the futures price or the risk-neutral expectation of the change in the VIX. On average, the carry is negative for these securities, but it turns positive during bad economic periods when the VIX typically spikes upward and the volatility term structure inverts. Our preliminary evidence suggests that the carry predicts the VIX futures returns in the time-series, consistent with what we find for index options. Recently, various exchanges across the world introduced volatility futures on different indices. The history is too short and the contracts too illiquid to implement a cross-sectional strategy, but this may be interesting to explore at a future date when longer and more reliable data becomes available.

We consider 20 foreign exchange forward contracts covering the period November 1983 to September 2012 (with some currencies starting as late as February 1997 and the Euro beginning in February 1999). We also include the U.S. as one of the countries for which the carry and currency return are, by definition, equal to zero.

The commodities sample covers 24 commodities futures dating as far back as January 1980 (through September 2012). Not surprisingly, commodities exhibit the largest cross-sectional variation in mean and standard deviation of returns since they contain the most diverse assets, covering commodities in metals, energy, and agriculture/livestock.

The global fixed income sample covers 10 government bonds starting as far back as November 1983 through September 2012. Bonds exhibit the least cross-sectional variation across markets, but there is still substantial variation in average returns and volatility across the markets. These same bond markets are used to compute the 10-year minus 2-year slope returns in each of the 10 markets.

For US Treasuries, we use standard CRSP bond portfolios with maturities equal to 1 to 12, 13 to 24, 25 to 36, 37 to 48, 49 to 60, and 61 to 120 months. The sample period is August 1971 to September 2012. To compute the carry, we use the bond yields of Gurkaynak, Sack, and Wright.[13]

For credit, we use the Barclays' corporate bond indices for "Intermediate" (average duration about 5 years) and "Long-term" (average duration about 10 years) maturities. In addition, we have information on the average maturity within a given portfolio and the average bond yield. In terms of credit quality, we consider AAA, AA, A, and BAA. The sample period is January 1973 to September 2012.

Finally, for index options we use data from OptionMetrics starting in January 1996 through December 2011. We use the following indices: Dow Jones Industrial Average (DJX), NASDAQ 100 Index (NDX), CBOE Mini-NDX Index (MNX), AMEX Major Market Index (XMI), S&P500 Index (SPX), S&P100 Index (OEX), S&P Midcap 400 Index (MID), S&P Smallcap 600 Index (SML), Russell 2000 Index (RUT), and PSE Wilshire Smallcap Index (WSX).

We take positions in options between 30 and 60 days to maturity at the last trading day of each month. We exclude options with non-standard expiration dates. We hold the positions for one month.[14]

We then construct two delta groups for calls and puts, respectively:[15]

[13]See `http://www.federalreserve.gov/econresdata/researchdata.htm`.

[14]The screens largely follow from Frazzini and Pedersen (2011), but the contracts included in the strategy are less liquid.

[15]Results are stronger if we include all five delta groups as defined in Frazzini and Pedersen (2011).

1. Out of the money: $\Delta^{call} \in [0.2, 0.4)$ or $\Delta^{put} \in [-0.4, -0.2)$
2. At the money: $\Delta^{call} \in [0.4, 0.6)$ or $\Delta^{put} \in [-0.6, -0.4)$

We implement the carry strategies separately for call and put options. We select one option per delta group for each index. If multiple options are available, we first select the contract with the highest volume. If there are still multiple contracts available, we select the contracts with the highest open interest. In some rare cases, we still have multiple matches, and we then choose the option with the highest price, that is, the option that is most in the money (in a given moneyness group). Furthermore, we do not take positions in options for which the volume or open interest are zero for the contracts that are required to compute the carry.

Further details on all of our data and their sources are provided in Appendix B.

B. Defining a Carry Trade Portfolio

A carry trade is a trading strategy that goes long high-carry securities and shorts low-carry securities. There are various ways of choosing the exact carry-trade portfolio weights, but our main results are robust across a number of portfolio weighting schemes. One way to construct the carry trade is to rank assets by their carry and go long the top 20, 25, or 30% of securities and short the bottom 20, 25, or 30%, with equal weights applied to all securities within the two groups, and ignore (e.g., place zero weight on) the securities in between these two extremes. Another method, which we use, is a carry trade specification that takes a position in all securities weighted by their carry ranking. Specifically, the weight on each security i at time t is given by

$$w_t^i = z_t \left(\text{rank}(C_t^i) - \frac{N_t + 1}{2} \right), \tag{23}$$

where the scalar z_t ensures that the sum of the long and short positions equals 1 and -1, respectively. This weighting scheme is similar to that used by Asness, Moskowitz, and Pedersen (2012) and Moskowitz, Ooi, and Pedersen (2012), who show that the resulting portfolios are highly correlated with other zero-cost portfolios that use different weights.

By construction, the carry trade portfolio always has a positive carry itself. We compute the carry of a portfolio of securities as follows. Consider a set of securities indexed by $i = 1, ..., N_t$, where N_t is the number of available securities at time t. Security i has a carry of C_t^i computed at the end of month t and that is related to the return r_{t+1}^i over the following month $t + 1$. Letting the portfolio weight of security i be w_t^i, the return of the portfolio is naturally the weighted sum of the returns on the securities,

$r_{t+1} = \sum_i w_t^i r_{t+1}^i$. Similarly, since carry is also a return (under the assumption of no price changes), the carry of the portfolio is simply computed as,

$$C_t^{portfolio} = \sum_i w_t^i C_t^i. \tag{24}$$

The carry of the carry trade portfolio is equal to the weighted-average carry of the high-carry securities minus the average carry among the low-carry securities:

$$C_t^{\text{carry trade}} \quad = \quad \sum_{w_t^i > 0} w_t^i C_t^i \quad - \sum_{w_t^i < 0} |w_t^i| C_t^i \quad > 0. \tag{25}$$

Hence, the carry of the carry trade portfolio depends on the cross-sectional dispersion of carry among the constituent securities.

C. Carry Trade Portfolio Returns within an Asset Class

For each global asset class, we construct a carry strategy using portfolio weights following equation (23) that invests in high-carry securities while short selling low-carry securities, where each security is weighted by the rank of its carry and the portfolio is rebalanced every month.

We consider two measures of carry: (i) The "current carry", which is measured at the end of each month, and (ii) "carry1-12", which is a moving average of the current carry over the past 12 months (including the most recent one). Carry1-12 helps smooth potential seasonal components that can arise in calculating carry for certain assets.[16] All results in the paper pertain to the current carry, but we report results using carry1-12 in Appendix C, where the results are typically stronger, most likely due to the seasonal issues mentioned.

Table I reports the mean and standard deviation of the carry for each asset, which ranges considerably within an asset class (especially commodities) and across asset classes. Table II reports the annualized mean, standard deviation, skewness, excess kurtosis, and Sharpe ratio of the carry strategies within each asset class. For comparison, the same

[16]For instance, the equity carry over the next month depends on whether most companies are expected to pay dividends in that specific month, and countries differ widely in their dividend calendar (e.g., Japan vs. US). Current carry will tend to go long an equity index if that country is in its dividend season, whereas carry1-12 will go long an equity index that has a high overall dividend yield for that year regardless of what month those dividends were paid. In addition, some commodity futures have strong seasonal components that are also eliminated by using carry1-12. Fixed income (the way we compute it), currencies, and US equity index options do not exhibit much seasonal carry pattern, but we also consider strategies based on both their current carry and carry1-12 for completeness.

statistics are reported for the returns to a passive long investment in each asset class, which is an equal weighted portfolio of all the securities in each asset class.

Panel A of Table II indicates that all of the carry strategies in all nine asset classes have significant positive returns. The average returns to carry range from 0.24% for US credit to 179% for US equity index put options. However, these strategies face markedly different volatilities, so looking at their Sharpe ratios is more informative. The Sharpe ratios for the carry strategies range from 0.37 for call options to 1.80 for put options, with the average being 0.74 across all asset classes. A carry strategy in every asset class outperforms a passive exposure (equal-weighted investment) to the asset class itself, except for the global bond level and slope strategies where the Sharpe ratios are basically the same. A passive exposure to the asset classes only generates a 0.21 Sharpe ratio on average, far lower than the 0.75 Sharpe ratio of the carry strategies on average. Further, the long-short carry strategies are (close to) market neutral, making their high returns all the more puzzling and, as we show below, all their alphas with respect to these passive benchmarks are significantly positive.

Panel B of Table II looks at carry trades in a coarser fashion by first grouping securities by region or broader asset class and then generating a carry trade. For example, for equities we group all index futures into one of five regions: North America, UK, continental Europe, Asia, and New Zealand/Australia and compute the equal-weighted average carry and equal-weighted average returns of these five regions. We then create a carry trade portfolio using only these five regional portfolios. Conducting this coarser examination of carry allows us to see whether carry trade profits are largely driven by across region carry differences or within region carry differences when comparing the results to those in Panel A of Table II. For equities, a carry trade across these five regions produces a Sharpe ratio almost as large as that in Panel A of Table II.

We repeat the same exercise for global bond levels and slopes—again, assigning country bonds to the same five regions—and for currencies, too. For commodities, we assign all futures contracts to one of three groups: agriculture/livestock, metals, or energy. Carry strategies based on these coarser groupings of securities produce similar, but slightly smaller, Sharpe ratios than carry strategies formed on the disaggregated individual security level. This suggests that significant variation in carry comes from differences across regions and that our results are robust to different weighting schemes. For this regional/group level analysis we also exclude US Treasuries, credit, and index options. Hence, our results are robust to these securities as well.

The robust performance of carry strategies across asset classes indicates that carry is an important component of expected returns. The previous literature focuses on currency carry trades, finding similar results to those in Table II. However, we find that a carry strategy works at least as well in other asset classes, too, performing markedly better in equities and put options than in currencies, and about as well as currencies in commodities, global fixed income, and Treasuries. Hence, carry is a broader concept that can be applied to many assets in general and is not unique to currencies.[17]

Examining the higher moments of the carry trade returns in each asset class, we find the strong negative skewness associated with the currency carry trade documented by Brunnermeier, Nagel, and Pedersen (2008). Likewise, commodity and fixed-income carry strategies exhibit some negative skewness and the options carry strategies exhibit very large negative skewness. However, carry strategies in equities, US Treasuries, and credit have positive skewness. The carry strategies in all asset classes exhibit excess kurtosis, which is typically larger than the kurtosis of the passive long strategy in each asset class, indicating fat-tailed positive and negative returns. For instance, the credit carry strategy exhibits positive skewness and large kurtosis as it suffers extreme negative returns, particularly around recessions—something we investigate further in the next section—which are then followed by even more extreme positive returns during the recovery (resulting in positive skewness). Hence, while negative skewness may not be a general characteristic of these carry strategies, the potential for large negative returns appears pervasive.

D. Diversified Carry Trade Portfolio

Table II also reports the performance of a diversified carry strategy across all asset classes, which is constructed as the equal-volatility-weighted average of carry portfolio returns across the asset classes. Specifically, we weight each asset classes' carry portfolio by the inverse of its sample volatility so that each carry strategy in each asset class contributes roughly equally to the total volatility of the diversified portfolio. This procedure is similar to that used by Asness, Moskowitz, and Pedersen (2012) and Moskowitz, Ooi, and Pedersen (2012) to combine returns from different asset classes with very different volatilities.[18] We call this diversified across-asset-class portfolio the global carry factor, GCF.

[17]Several recent papers also study carry strategies for commodities in isolation, see for instance Szymanowska, de Roon, Nijman, and van den Goorbergh (2011) and Yang (2011).

[18]Since commodities have roughly ten times the volatility of Treasuries and options have 300 times the volatility of Treasuries and 30 times the volatility of commodities or equities, a simple equal-weighted average of carry returns across asset classes will have its variation dominated by option carry risk and under-represented by fixed income carry risk. Volatility-weighting the asset classes into a diversified portfolio gives each asset class more equal representation.

As the bottom of Panel A of Table II reports, the diversified carry trade has a remarkable Sharpe ratio of 1.10 per annum. A diversified passive long position in all asset classes produces only a 0.47 Sharpe ratio. These numbers suggest carry is a strong predictor of expected returns globally across asset classes. Moreover, the substantial increase in Sharpe ratio for the diversified carry portfolio relative to the average individual carry portfolio Sharpe ratios in each asset class (which is 0.74), indicates that the correlations of the carry trades across asset classes are fairly low. Sizeable diversification benefits are obtained by applying carry trades universally across asset classes.

Panel A of Table III reports the correlations of carry trade returns across the nine asset classes, and Panel B reports correlations across the regions/groups. Except for the correlation between global bond level carry and the slope carry strategies, the correlations are all close to zero. The low correlations among carry strategies in other asset classes not only lowers the volatility of the diversified portfolio substantially, but also mutes the negative skewness associated with currency carry trades and mitigates the excess kurtosis associated with all carry trades. Table II shows that the negative skewness and excess kurtosis of the diversified portfolio of carry trades are smaller than those of the passive long position diversified across asset classes and are smaller than the average of the individual skewness and kurtosis statistics for each asset class. (Interestingly, the diversified passive position actually has more negative skewness and excess kurtosis than the average across each individual asset class—the opposite of what a diversified carry portfolio achieves.) Hence, the diversification benefits of applying carry across asset classes seem to be larger than those obtained from investing passively long in the same asset classes.

The magnitude of the Sharpe ratios of the diversified carry strategy presents a daunting challenge for current asset pricing models that already struggle to explain the significantly smaller Sharpe ratios typically examined within a single asset class (e.g., currencies). A diversified carry portfolio across asset classes is also less prone to crashes, has less negative skewness, and smaller kurtosis than the diversified passive strategy, making the carry strategy's large average return even more puzzling from a crash risk perspective. On the other hand, the carry strategy faces larger transaction costs, greater funding issues, and limits to arbitrage than a passive strategy.

Figure 1 plots the cumulative monthly returns to the diversified carry strategy across all asset classes. The plot is a lot smoother than that of the currency carry trade (also plotted for reference), where crashes are more evident. The graph highlights the steady positive returns to carry applied globally across all asset classes. These returns come from two sources: the carry itself, plus any price appreciation that may be related to/predicted by carry. In the next section, we investigate in more detail the relationship between carry, expected price changes, and total expected returns.

E. Risk-Adjusted Performance and Exposure to Other Factors

Table IV reports regression results for each carry portfolio's returns in each asset class on a set of other portfolio returns or factors that have been shown to explain the cross-section of global asset returns. Specifically, we regress the time series of carry returns in each asset class on the corresponding passive long portfolio returns (equal-weighted average of all securities), the value and momentum factors for each asset class, and time-series momentum (TSMOM) factors for each asset class. The global value and momentum factors are based on Asness, Moskowitz, and Pedersen (2012) and the TSMOM factors are those of Moskowitz, Ooi, and Pedersen (2012). These factors are computed for each asset class separately for equities, fixed income, commodities, and currencies. For fixed income slope and Treasuries, we use the fixed income factors and for the credit and options strategies we use the diversified value and momentum "everywhere" factors of Asness, Moskowitz, and Pedersen (2012) (which includes individual equity strategies, too) and the globally diversified TSMOM factor of Moskowitz, Ooi, and Pedersen (2012).

Panel A of Table IV reports both the intercepts (or alphas) from these regressions as well as factor exposures to these other known factors. The first column reports the results from regressing the carry trade portfolio returns in each asset class on the equal-weighted passive index for that asset class. The alphas for every carry strategy in every asset class are positive and statistically significant (except for calls), indicating that, in every asset class, a carry strategy provides abnormal returns above and beyond simple passive exposure to that asset class. Put differently, carry trades offer excess returns over the "local" market return in each asset class. Further, we see that the betas are often not significantly different from zero. Hence, carry strategies provide sizeable return premia without much market exposure to the asset class itself. The last two rows report the R^2 from the regression and the information ratio, IR, which is the alpha divided by the residual volatility from the regression. The IRs are large, reflecting high risk-adjusted returns to carry strategies even after accounting for its exposure to the local market index.

Looking at the value and cross-sectional and time-series momentum factor exposures, we find mixed evidence across the asset classes. For instance, in equities, we find that carry strategies have a positive value exposure, but no momentum or time-series momentum exposure. The positive exposure to value, however, does not reduce the alpha or information ratio of the carry strategy much. For fixed income, carry loads positively on cross-sectional and time-series momentum, though again the alphas and IRs remain significantly positive. In commodities, a carry strategy loads significantly negatively on value and significantly positively on cross-sectional momentum, but exhibits little relation to time-series momentum. The exposure to value and cross-sectional momentum captures a significant fraction of the variation in commodity carry's returns, as the R^2 jumps from less than 1% to 20% when the value and momentum factors are included in the regression. However, because the carry trade's loadings on value and momentum are of opposite sign, the impact on the alpha of the commodity carry strategy is small since the exposures to these two positive return factors offset each other. The alpha diminishes by 29 basis points per month, but remains economically large at 64 basis points per month and statistically significant. Currency carry strategies exhibit no reliable loading on value, momentum, or time-series momentum and consequently the alpha of the currency carry portfolio remains large and significant. Similarly, for credit, no reliable loadings on these other factors are present and hence a significant carry alpha remains. For call options, the loadings of the carry strategies on value, momentum, and TSMOM are all negative, making the alphas even larger. Finally, for puts there are no reliable loadings on these other factors. The last two columns of Panel A of Table IV report regression results for the diversified GCF on the all-asset-class market, value, momentum, and TSMOM factors. The alphas and IRs are large and significant and there are no reliable betas with respect to these factors.

Panel B of Table IV reports results of the same regressions for the regional/group carry strategies. Again, significant alphas remain for carry strategies in each of the asset classes, indicating that carry is a unique characterstic that predicts returns and is not captured by known predictors of returns in the same asset class such as general market exposure, value, momentum, and TSMOM.

The regression results in Table IV only highlight the average exposure of the carry trade returns to these factors. However, these unconditional estimates may mask significant dynamic exposures to these factors. There may be times when the carry trade in every asset class has significant positive exposure to the market and other times when it has significant negative market exposure. We further explore the dynamics of carry trade positions in the next section.

F. What Is New About Carry?

Our general concept of carry provides a unifying framework that synthesizes much of the return predictability evidence found in global asset classes. Indeed, return predictors across asset classes have mostly been treated disjointly by the literature. For example, our carry measure in equities is related to the dividend yield and therefore equity carry returns naturally have a positive loading on value in Table IV. Carry in fixed income is related to the yield spread, and in commodities carry is related to the convenience yield. These predictors are typically treated as separate and unrelated phenomena in each asset class. We normally don't think about how the dividend yield in equities might be related to the yield spread in bonds or the convenience yield in commodities or local interest rates for currencies. Yet, the concept of carry provides a unifying framework that captures this evidence, providing a common theme that links these predictors across all asset classes.

However, carry is different from these standard predictors and adds to the predictability literature. Table IV shows that carry is not spanned by other unifying themes such as value and momentum. Moreover, we also show that carry provides additional predictive content above asset-class-specific variables. For example, for global equities the carry is the *expected* dividend yield derived from futures prices relative to the local short term interest rate, which can be quite different from the standard historical dividend yield used in the literature. Appendix D shows that a carry strategy based on expected dividend yield is in fact quite different from a standard value strategy that sorts on historical dividend yields. First, we show for the US equity market, using a long time series, that the dynamics of carry are different from the standard dividend yield. Second, sorting countries directly on historical dividend yield rather than carry results in a portfolio less than 0.30 correlated to the carry strategy in equities. Running a time-series regression of carry returns in equities on a dividend yield strategy in equities produces betas close to zero (0.07) and significant alphas. Hence, carry contains important independent information beyond the standard dividend yield studied in the literature.

In addition to unifying and extending the set of standard predictor variables, we also illustrate how the concept of carry provides useful predictor variables for other cross-sections of assets not previously examined. Our inclusion of the cross-section of US Treasuries, the cross-section of US credit portfolios, and the cross-section of US index options provides several out of sample testing grounds for carry as a novel return predictor. Moreover, applying a carry strategy to options on a single index results in shorting out-of-the money put options and going long at-the-money options, which is known to be a profitable strategy with occasionally large drawdowns. This illustrates once more that the concept of carry can both connect and extend predictor variables and investment strategies across many different asset classes. It may be interesting for future research to explore alternative carry strategies for different cross-sections of assets using the same concept we propose in this paper.

III. How Does Carry Relate to Expected Returns?

In this section we investigate further how carry relates to expected returns. We begin by decomposing carry strategies into their static and dynamic components.

A. Static and Dynamic Return Components

The average return of the carry trade depends on two sources of exposure: (i) a static or "passive" return component due to the *average* carry trade portfolio being long (short) securities that have high (low) unconditional returns, and (ii) a "dynamic" return component that captures how strongly variation in carry predicts returns.

The estimated expected return on a carry strategy can be written as:

$$\hat{E}\left(r_{p,t+1}\right) = \frac{1}{T}\sum_{t=1}^{T}\sum_{n=1}^{N} w_{n,t}^{*} r_{n,t+1}, \tag{26}$$

where N denotes the total number of contracts that are used at any point in the strategy (potentially at different points in time) and $w_{n,t}^{*}$ is the portfolio weight from equation (23) when contract n is available and otherwise $w_{n,t}^{*} = 0$. We rewrite the expression for the expected return by defining $\mathcal{T}_n$ as the set of dates where security n is used and T_n as the number of such dates:

$$\begin{aligned} \hat{E}\left(r_{p,t+1}\right) &= \sum_{n=1}^{N}\frac{T_n}{T}\hat{E}^n\left(w_{n,t}r_{n,t+1}\right) \qquad (27) \\ &= \underbrace{\sum_{n=1}^{N}\frac{T_n}{T}\hat{E}^n\left(w_{n,t}\right)\hat{E}^n\left(r_{n,t+1}\right)}_{\text{Static component}} + \underbrace{\sum_{n=1}^{N}\frac{T_n}{T}\hat{E}^n\left[\left(w_{n,t}-\hat{E}^n\left(w_{n,t}\right)\right)\left(r_{n,t+1}-\hat{E}^n\left(r_{n,t+1}\right)\right)\right]}_{\text{Dynamic component}}, \end{aligned}$$

where we define $\hat{E}^n\left(x_{n,t}\right) \equiv T_n^{-1}\left(\sum_{t\in\mathcal{T}_n} x_{n,t}\right)$ as the time series average for any n and time series $x_{n,t}$.

We see that the overall average return is the sum of a passive and a dynamic component. Naturally, $\hat{E}^n\left(w_{n,t}\right)$ is the portfolio's "passive exposure" to asset n, while the "dynamic exposure" $w_{n,t} - E(w_{n,t})$ is zero on average over time, representing a timing strategy in the asset that goes long and short according to the asset's carry.

Table V reports the results of this decomposition, where we estimate the static and dynamic components of returns according to equation (27). For equities, the dynamic component comprises the entirety of the carry trade's returns. For global bond level and slope carry trades, the dynamic component also captures nearly all of the carry trade profits (86% and 99%, respectively). For Treasuries, a little less than half of the carry returns come from the dynamic component, for commodities a little more than half come from the dynamic component, and for the currency carry returns the split between passive and dynamic components is approximately equal. For credit, only 30% of carry profits come from the dynamic component, and for options all of the carry returns come from dynamic exposure. Overall, carry trade returns appear to be due to both passive exposures and dynamic rebalancing, with some variation across asset classes in terms of the importance of these two components.

B. Does the Market Take Back Part of the Carry?

The significant returns to the carry trade indicate that carry is indeed a signal of expected returns. However, to better understand the relation between carry and expected returns it is instructive to go back to equation (6), which decomposes expected returns into carry and expected price appreciation. To estimate this relationship, we run the following panel regression for each asset class:

$$r_{t+1}^{i} = a^{i} + b_t + cC_t^{i} + \varepsilon_{t+1}^{i}, \tag{28}$$

where a^i is an asset-specific intercept (or fixed effect), b_t are time fixed effects, C_t^i is the carry on asset i at time t, and c is the coefficient of interest that measures how well carry predicts returns.

There are several interesting hypotheses to consider. First, $c = 0$ means that carry does not predict returns, consistent with a generalized notion of the "expectations hypothesis." Second, $c = 1$ means that the expected return moves one-for-one with carry. While $c = 0$ means that the total return is unpredictable, $c = 1$ means that price changes (the return excluding carry) are unpredictable by carry. Third, $c \in (0, 1)$ means that a positive carry is associated with a negative expected price appreciation such that the market "takes back" part of the carry, but not all. Fourth, $c > 1$ means that a positive carry is associated with a positive expected price appreciation so that an investor gets the carry and price appreciation too—that is, carry predicts further price increases. Lastly, $c < 0$ would imply that carry predicts such a negative price change that it more than offsets the direct effect of a positive carry.

Table VI reports the results for each asset class with and without fixed effects. Without asset and time fixed effects, c represents the total predictability of returns from carry from both its passive and dynamic components. Including time fixed effects removes the time-series predictable return component coming from general exposure to assets at a given point in time. Similarly, including asset-specific fixed effects removes the predictable return component of carry coming from passive exposure to assets with different unconditional average returns. By including both asset and time fixed effects, the slope coefficient c in equation (28) represents the predictability of returns to carry coming purely from variation in carry.

The results in Table VI indicate that carry is a strong predictor of expected returns, with consistently positive and statistically significant coefficients on carry, save for the commodity strategy, which may be tainted by strong seasonal effects in carry for commodities. The carry1-12 strategy in Appendix C, which mitigates seasonal effects, is a ubiquitously positive and significant predictor of returns, even for commodities.

Focusing on the magnitude of the predictive coefficient, Table VI shows that the point estimate of c is greater than one for equities, global bond levels and slope, and credit, and smaller than one for US Treasuries, commodities, and options, and around one for currencies (depending on whether fixed effects are included). These results imply that for equities, for instance, when the dividend yield is high, not only is an investor rewarded by directly receiving large dividends (relative to the price), but also equity prices tend to appreciate more than usual. Hence, expected stock returns appear to be comprised of both high dividend yields and additionally high expected price appreciation. Similarly, for fixed income securities buying a 10-year bond with a high carry provides returns from the carry itself (i.e., from the yield spread over the short rate and from rolling down the yield curve), and, further, yields tend to drop, leading to additional price appreciation. This is surprising as the expectations hypothesis suggests that a high term spread implies short and long rates are expected to increase, but this is not what we find. However, these results must be interpreted with caution as the predictive coefficient is not statistically significantly different from one in all but a few cases.

For currencies, the predictive coefficient is close to one, which means that high-interest currencies neither depreciate, nor appreciate, on average. Hence, the currency investor earns the interest-rate differential on average. This finding goes back to Fama (1984), who ran these regressions slightly differently. Fama (1984)'s well-known result is that his predictive coefficient has the "wrong" sign relative to uncovered interest rate parity, which corresponds to a coefficient larger than one in our regression.

For commodities, the predictive coefficient is significantly less than one, so that when a commodity has a high spot price relative to its futures price, implying a high carry, the spot price tends to depreciate on average, thus lowering the realized return on average below the carry. Similarly, we see the same thing for US Treasuries and options.

We can also examine how the predictive coefficient changes across the different regression specifications with and without fixed effects to see how the predictability of carry changes once the passive exposures are removed. For example, the coefficient on carry for equities drops very little when including asset and time fixed effects, which is consistent with the dynamic component to equity carry strategies dominating the predictability of returns. We also see that currency carry predictability is cut roughly in half when the fixed effects are included, implying that the dynamic component of the currency carry strategy contributes to about half of the return predictability.

C. Timing Strategies

Table VII reports results for pure timing strategies on each asset using carry and ignoring any cross-sectional information from carry. Our previous results indicate that for all carry strategies, the dynamic component is an important part of carry returns. Table VII focuses exclusively on this dynamic component by using carry to time an investment in each security. Specifically, for every security we go long if the carry is positive and short if it is negative. We do this for every security within an asset class and then take the equal-weighted average of these timing strategy returns based on carry across all securities within an asset class. Panel A of Table VII reports the results for each asset class as well as for the regional/group level portfolios. The returns and Sharpe ratios to these timing strategies are all positive and significant in all asset classes, indicating that carry is highly useful in timing a security as well as selecting securities.

Comparing the results in Table VII to those in Table II, which used carry to select securities cross-sectionally, the magnitude of the performance of the strategies is similar. These results are consistent with the importance of the dynamic component to carry trades found earlier. Panel B of Table VII repeats the timing exercise, but where we go long (short) a security if its carry is above (below) its sample mean. The specification eliminates any cross-sectional effects from carry and is equivalent to the panel regressions of Table VI that include contract fixed effects. The performance of these timing strategies is also strong and consistently positive, except for index call options. This is consistent with the findings in Table VI where the estimate for c turns negative for call options when only contract fixed effects are included.

From a variety of perspectives and measures, we have shown that carry is a ubiquitously useful and novel predictor of returns both in the cross-section and time-series across all of the diverse asset classes we study. In the final section of the paper, we explore what common risks, if any, carry strategies might be exposed to and whether the return premium associated with carry might be compensation for those risks.

IV. How Risky Are Carry Strategies?

We next investigate further whether the high returns to carry strategies compensate investors for aggregate risk. Previously, we showed that carry strategies are not very sensitive to other known factors such as the market, value, momentum, and time-series momentum. Here, we explore other factors suggested in the literature related to macroeconomic and crash risks.

A. Risk Exposure of Carry Strategies

The large and growing literature on the currency carry strategy considers whether carry returns compensate investors for crash risk or business cycle risk. By studying multiple asset classes at the same time, we provide out-of-sample evidence of existing theories, as well as some guidance for new theories to be developed. We have found that all carry strategies produce high Sharpe ratios and often have high kurtosis, but find mixed results regarding skewness. Further, from Table III, we know that carry strategies across these asset classes are not very correlated. However, the correlations in Table III are unconditional, estimated over the full sample period, yet we know from the results of the previous section that carry strategies contain a large and important dynamic component. Hence, unconditional covariance estimates may miss important dynamic common movements among the carry strategies across asset classes.

To help identify the common risk in carry strategies, we focus on the global carry factor in which we combine all carry strategies across all asset classes. Figure 1, which plots the cumulative returns on the global carry factor shows that, despite its high Sharpe ratio, the global carry strategy is far from riskless, exhibiting sizeable declines for extended periods of time. We investigate the worst and best carry return episodes from this global carry factor to shed light on potential common sources of risk across carry strategies.

B. Drawdowns vs. Expansions

Specifically, we identify what we call carry "drawdowns" and "expansions." We first compute the maximum drawdown of the global carry strategy, which is defined as:

$$D_t \equiv \sum_{s=1}^{t} r_s - \max_{u \in \{1,\dots,t\}} \sum_{s=1}^{u} r_s, \tag{29}$$

where r_s denotes the excess return on the global carry factor. The drawdown dynamics are presented in Figure 2. The three biggest carry drawdowns are: August 1972 to

September 1975, March 1980 to June 1982, and August 2008 to February 2009. The two largest drawdowns are also the longest lasting ones, and the third longest is from May 1997 to October 1998. These drawdowns coincide with plausibly bad aggregate states of the global economy. For example, using a global recession indicator, which is a GDP-weighted average of regional recession dummies (using NBER data methodology), these periods are all during the height of global recessions, including the recent global financial crisis, as highlighted in Figure 2.

We next compute all drawdowns for the GCF, defined as periods over which $D_t < 0$ and define expansions as all other periods. During carry drawdowns, the average value of the global recession indicator equals 0.33 versus 0.19 during carry expansions. To show that these drawdowns are indeed shared among carry strategies in all nine asset classes, Table VIII reports the mean and standard deviation of returns on the carry strategies in each asset class separately over these expansion and drawdown periods. For all strategies in all asset classes, the returns are consistently negative (positive) during carry drawdowns (expansions). This implies that the extreme realizations, especially the negative ones, of the global carry factor are not particular to a single asset class and that carry drawdowns are bad periods for *all* carry strategies at the same time across all asset classes.

Moreover, Table VIII also includes the performance of the long-only passive portfolio in each asset class during expansions and drawdowns. Especially on the downside, carry returns suffer a great deal more than passive exposures to the asset classes themselves. Among carry drawdowns, only half of the passive portfolios in the asset classes suffer negative returns, while *all* carry strategies experience sharp negative performance. The most extreme example being equity index put options, which during these global recessions payoff a handsome 132% per annum, but a carry strategy on those same put options would have returned −22%. Even for the asset classes that also experience negative passive returns at these times (e.g., equities, commodities, currencies, credit), the performance of carry strategies in these same asset classes is even worse during these times.

B.1. Higher Frequency Movements within Drawdowns and Expansions

Table IX recomputes the monthly correlations of the carry strategies across all asset classes during expansions and drawdowns separately. Consistent with the results in Table VIII that the returns to carry seem to move together across all asset classes during drawdowns, there is some evidence in Table IX that the correlations among carry strategies across asset classes are stronger during these drawdown periods, particularly for the options, credit, and currency strategies. However, the evidence is not overwhelming as many of the correlations are close to zero and others not that different from expansions. However, the monthly correlations may be misleading due in part to the lower frequency comovement of carry strategies with the business cycle and the fact that some asset classes respond with different speeds to the business cycle.

To investigate this, Panel A of Table X reports the mean and standard deviation of returns for each carry strategy separately during the first half and second half of the drawdown periods and Panel B does the same during the expansion periods. For this analysis we only look at carry drawdown and expansion periods that last at least four months and divide each drawdown and expansion into two halves. As Panel A of Table X shows, equity and fixed income carry strategies do most of their damage during the first half of drawdowns, and then begin to recover in the second half. Commodities, currencies, and credit do equally poorly throughout both halves of the drawdowns. Option carry strategies, however, do fine during the first half of drawdowns but do miserably during the second half. Hence, although all of these carry strategies do poorly over the entire drawdown period, different asset classes' carry strategies manifest their poor performance over different points during the drawdowns. In this case, equities and bonds suffer immediately, but recover quickly; commodities, credit, and currencies underperform consistently throughout; and options lag in their response to these drawdowns.

This variation in response across asset classes is unique to drawdowns, however, as Panel B of Table X, which examines performance of carry strategies over the first half versus second half of expansions, does not yield a similar pattern. During expansions, we see no differential response in terms of the signs of the carry strategy returns across subperiods. Hence, an interesting avenue for further research is to understand why drawdowns have this unique feature and why different asset classes respond with different timing to the same negative global shocks.

B.2. Static and Dynamic Risk Exposure in Drawdowns and Expansions

Finally, since a large component of the carry trade returns across all asset classes comes from dynamic exposure, Table XI decomposes the returns to carry during both drawdowns and expansions into their static and dynamic components (where the static exposure continues to be computed using the full sample). A useful comparison here are the static and dynamic decomposition numbers from Table V which computed its statistics over the full sample. Several interesting results emerge. First, the breakdown between static versus dynamic carry profits during expansions matches the breakdown in Table V for the whole sample: equities, global bonds, and options being dominated by the dynamic component; Treasuries, commodities, and currencies being split roughly evenly between static and dynamic profits; and credit being split between about 2/3 static and 1/3 dynamic returns.

For drawdowns, however, we get a different picture. Equities, for instance, which during normal times or during expansions have most of their carry profits coming from dynamic exposure, have only half of their negative drawdown returns coming from the dynamic component. In other words, equity carry strategies receive all of their positive returns from the dynamic component of carry strategies, but the negative realizations and risk of these strategies is partly driven by static bets. This implies, for instance, that half of the risk borne by equity carry strategies could potentially be hedged by passive exposures. For global bond slopes and currencies we find a similar pattern, where the dynamic component of these carry trades enjoys more of the updside returns and contributes to less of the downside returns. However, for Treasuries and commodities the opposite is true: the dynamic component of carry strategies in these asset classes is exposed to more downside risk than upside. For global bond levels, credit, and the options carry strategies there are no discernable differences in the breakdown between static versus dynamic profits in drawdowns versus expansions.

These different patterns of static and dynamic risk exposure during drawdowns and expansions may help identify better ways to profit from carry trades in general and may help identify the economic drivers of the carry premium that is present across all of these asset classes.

V. Conclusion: Caring about Carry

A security's expected return can be decomposed into its "carry" and its expected price appreciation, where carry can be measured in advance without an asset pricing model. We find that carry predicts returns both in the cross section and time series for a host of different asset classes that include global equities, global bonds, currencies, commodities, US Treasuries, credit, and equity index options.

This predictability underlies the strong returns to "carry trades" that go long high-carry and short low-carry securities, which have been applied almost exclusively to currencies. Decomposing carry returns into static and dynamic components, we investigate the nature of this predictability across asset classes. We also identify times when carry strategies across all asset classes do poorly simultaneously and show that these episodes coincide with global recessions and liquidity crises.

Our findings present a challenge to existing asset pricing theory. First, we show that the concept of carry can be applied much more broadly to any asset class, not just currencies, and that some aspects of currency carry trades that are prominent features of many models (e.g., negative skewness) are not present more generally across carry trades in other asset classes. Second, carry can provide a unifying framework linking various return predictors across asset classes that have been treated independently by the literature, thus providing a connection between different asset classes not previously recognized. Hence, theories seeking to explain return predictability in one asset class should be aware of how those predictors might relate to other asset classes through carry. Third, we show that carry is also a novel predictor of returns in these asset classes and in asset classes not previously studied. Finally, we find that studying carry jointly across a variety of asset classes raises the bar on carry's performance (doubling its Sharpe ratio) as well as identifies new common risks facing all carry strategies—which seem to coincide with global economic downturns. Further investigating these links and how markets compensate these risks across the asset classes we study is left for future research.

Appendix

A Foreign-Denominated Futures

We briefly explain how we compute the US-dollar return and carry of a futures contract that is denominated in foreign currency. Suppose that the exchange rate is e_t (measured in number of local currency per unit of foreign currency), the local interest rate is r^f, the foreign interest rate is r^{f*}, the spot price is S_t, and the futures price is F_t, where both S_t and F_t are measured in foreign currency.

Suppose that a U.S. investor allocates X_t dollars of capital to the position. This capital is transferred into X_t/e_t in a foreign-denominated margin account. One time period later, the investor's foreign denominated capital is $(1 + r^{f*})X_t/e_t + F_{t+1} - F_t$ so that the dollar capital is $e_{t+1}\left((1 + r^{f*})X_t/e_t + F_{t+1} - F_t\right)$. Assuming that the investor hedges the currency exposure of the margin capital and that covered interest-rate parity holds, the dollar capital is in fact $(1 + r^f)X_t + e_{t+1}(F_{t+1} - F_t)$. Hence, the hedged dollar return in excess of the local risk-free rate is

$$r_{t+1} = \frac{e_{t+1}(F_{t+1} - F_t)}{X_t}. \tag{A.1}$$

For a fully-collateralized futures with $X_t = e_t F_t$, we have

$$\begin{aligned} r_{t+1} &= \frac{e_{t+1}(F_{t+1} - F_t)}{e_t F_t} \\ &= \frac{(e_{t+1} - e_t + e_t)(F_{t+1} - F_t)}{e_t F_t} \\ &= \frac{F_{t+1} - F_t}{F_t} + \frac{e_{t+1} - e_t}{e_t}\,\frac{F_{t+1} - F_t}{F_t} \end{aligned} \tag{A.2}$$

We compute the futures return using this exact formula, but we note that it is very similar to the simpler expression $(F_{t+1} - F_t)/F_t$ as this simpler version is off only by the last term of (A.2) which is of second-order importance (as it is a product of returns).

We compute the carry of a foreign denominated futures as the return if the spot price stays the same such that $F_{t+1} = S_t$ and if the exchange rate stays the same, $e_{t+1} = e_t$.

Using this together with equation (A.2), we see that the carry is[19]

$$C_t = \frac{S_t - F_t}{F_t}. \tag{A.3}$$

B Data Sources

We describe below the data sources we use to construct our return series. Table I provides summary statistics on our data, including sample period start dates.

Equities We use equity index futures data from 13 countries: the U.S. (S&P 500), Canada (S&P TSE 60), the UK (FTSE 100), France (CAC), Germany (DAX), Spain (IBEX), Italy (FTSE MIB), The Netherlands (EOE AEX), Sweden (OMX), Switzerland (SMI), Japan (Nikkei), Hong Kong (Hang Seng), and Australia (S&P ASX 200). The data source is Bloomberg. We collect data on spot, nearest-, and second-nearest-to-expiration contracts to calculate the carry. Bloomberg tickers are reported in the table below.

The table reports the Bloomberg tickers that we use for equities. First and second generic futures prices can be retrieved from Bloomberg by substituting 1 and 2 with the 'x' in the futures ticker. For instance, SP1 Index and SP2 Index are the first and second generic futures contracts for the S&P 500.

Market	Spot ticker	Futures ticker
US	SPX Index	SPx Index
Canada	SPTSX60 Index	PTx Index
UK	UKX Index	Zx Index
France	CAC Index	CFx Index
Germany	DAX Index	GXx Index
Spain	IBEX Index	IBx Index
Italy	FTSEMIB Index	STx Index
Netherlands	AEX Index	EOx Index
Sweden	OMX Index	QCx Index
Switzerland	SMI Index	SMx Index
Japan	NKY Index	NKx Index
Hong Kong	HSI Index	HIx Index
Australia	AS51 Index	XPx Index

We calculate daily returns for the most active equity futures contract (which is the front-month contract), rolled 3 days prior to expiration, and aggregate the daily returns

[19]It is straightforward to compute the carry if the investor does not hedge the interest rate. In this case, the carry is adjusted by a term $r_f^* - r_f$, where r_f^* denotes the interest rate in the country of the index and r_f the US interest rate.

to monthly returns. This procedure ensures that we do not interpolate prices to compute returns.

We consider two additional robustness checks. First, we run all of our analyses without the first trading day of the month to check for the impact of non-synchronous settlement prices. Second, we omit the DAX index, which is a total return index, from our calculations. Our results are robust to these changes.

Currencies The currency data consist of spot and one-month forward rates for 19 countries: Austria, Belgium, France, Germany, Ireland, Italy, The Netherlands, Portugal and Spain (replaced with the euro from January 1999), Australia, Canada, Denmark, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. Our basic dataset is obtained from Barclays Bank International (BBI) prior to 1997:01 and WMR/Reuters thereafter and is similar to the data in Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011), Lustig, Roussanov, and Verdelhan (2011), and Menkhoff, Sarno, Schmeling, and Schrimpf (2010). However, we verify and clean our quotes with data obtained from HSBC, Thomson Reuters, and data from BBI and WMR/Reuters sampled one day before and one day after the end of the month using the algorithm described below.

The table below summarizes the Datastream tickers for our spot and one-month forward exchange rates, both from BBI and WMR/Reuters. In addition, the last two columns show the Bloomberg and Global Financial Data tickers for the interbank offered rates.

At the start of our sample in 1983:10, there are 6 pairs available. All exchange rates are available since 1997:01, and following the introduction of the euro there are 10 pairs in the sample since 1999:01.

There appear to be several data errors in the basic data set. We use the following algorithm to remove such errors. Our results do not strongly depend on removing these outliers. For each currency and each date in our sample, we back out the implied foreign interest rate using the spot- and forward exchange rate and the US 1-month LIBOR. We subsequently compare the implied foreign interest rate with the interbank offered rate obtained from Global Financial Data and Bloomberg. If the absolute difference between the currency-implied rate and the IBOR rate is greater than a specified threshold, which we set at 2%, we further investigate the quotes using data from our alternative sources.

The table summarizes the Datastream tickers for our spot and one-month forward exchange rates, both from BBI and WMR/Reuters. In addition, the last two columns show the Bloomberg and Global Financial Data tickers for the interbank offered rates.

	BBI-spot	BBI-frwd	WMR-spot	WMR-frwd	BB ibor	GFD ibor
Austria	-	-	AUSTSC$	USATS1F	VIBO1M Index	IBAUT1D
Belgium	-	-	BELGLU$	USBEF1F	BIBOR1M Index	IBBEL1D
France	BBFRFSP	BBFRF1F	FRENFR$	USFRF1F	PIBOFF1M Index	IBFRA1D
Germany	BBDEMSP	BBDEM1F	DMARKE$	USDEM1F	DM0001M Index	IBDEU1D
Ireland	-	-	IPUNTE$	USIEP1F	DIBO01M Index	IBIRL1D
Italy	BBITLSP	BBITL1F	ITALIR$	USITL1F	RIBORM1M Index	IBITA1D
Netherlands	BBNLGSP	BBNLG1F	GUILDE$	USNLG1F	AIBO1M Index	IBNLD1D
Portugal	-	-	PORTES$	USPTE1F	LIS21M Index	IBPRT1D
Spain	-	-	SPANPE$	USESP1F	MIBOR01M Index	IBESP1D
Euro	BBEURSP	BBEUR1F	EUDOLLR	USEUR1F	EUR001M Index	IBEUR1D
Australia	BBAUDSP	BBAUD1F	AUSTDO$	USAUD1F	AU0001M Index	IBAUS1D
Canada	BBCADSP	BBCAD1F	CNDOLL$	USCAD1F	CD0001M Index	IBCAN1D
Denmark	BBDKKSP	BBDKK1F	DANISH$	USDKK1F	CIBO01M Index	IBDNK1D
Japan	BBJPYSP	BBJPY1F	JAPAYE$	USJPY1F	JY0001M Index	IBJPN1D
New Zealand	BBNZDSP	BBNZD1F	NZDOLL$	USNZD1F	NZ0001M Index	IBNZL1D
Norway	BBNOKSP	BBNOK1F	NORKRO$	USNOK1F	NIBOR1M Index	IBNOR1D
Sweden	BBSEKSP	BBSEK1F	SWEKRO$	USSEK1F	STIB1M Index	IBSWE1D
Switzerland	BBCHFSP	BBCHF1F	SWISSF$	USCHF1F	SF0001M Index	IBCHE1D
UK	BBGBPSP	BBGBP1F	USDOLLR	USGBP1F	BP0001M Index	IBGBR1D
US	-	-	-	-	US0001M Index	IBUSA1D

Our algorithm can be summarized as follows:

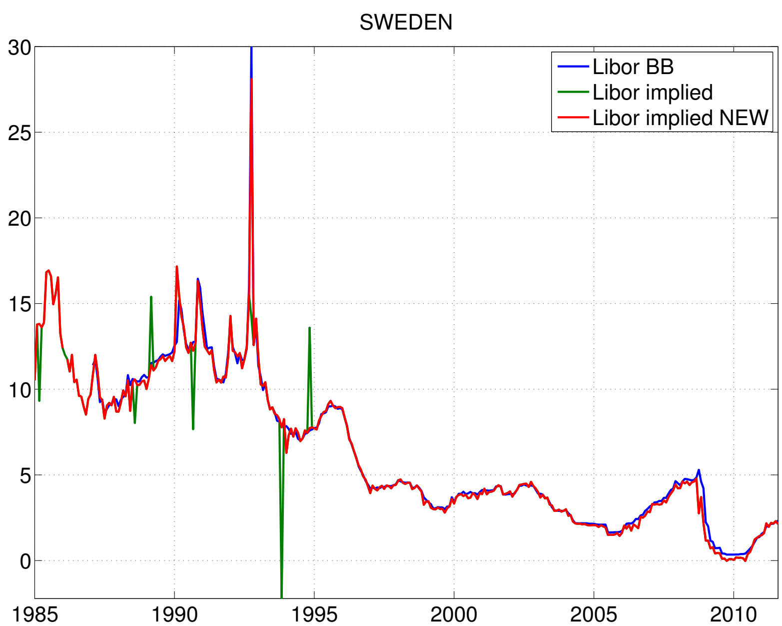
- before (after) 1997:01, if data is available from WMR/Reuters (BBI) and the absolute difference of the implied rate is below the threshold, replace the default source BBI (WMR/Reuters) with WMR/Reuters (BBI)
  - if data is available from WMR/Reuters (BBI) and the absolute difference of the implied rate is also above the threshold, keep the default source BBI (WMR/Reuters)
- else, if data is available from HSBC and the absolute difference of the implied rate is below the threshold, replace the default source with HSBC
  - if data is available from HSBC and the absolute difference of the implied rate is also above the threshold, keep the default source
- else, if data is available from Thomson/Reuters and the absolute difference of the implied rate is below the threshold, replace the default source with Thomson/Reuters
  - if data is available from Thomson/Reuters and the absolute difference of the implied rate is also above the threshold, keep the default source

If none of the other sources is available, we compare the end-of-month quotes with quotes sampled one day before and one day after the end of the month and run the same checks.

In cases where the interbank offered rate has a shorter history than our currency data, we include the default data if the currency-implied rate is within the tolerance of the currency-implied rate from any of the sources described above.

There are a few remaining cases, for example where the interbank offered rate is not yet available, but the month-end quote is different from both the day immediately before and after the end of the month. In these cases, we check whether the absolute difference of the implied rates from these two observations is within the tolerance, and take the observation one day before month-end if that is the case.

The figure below for Sweden illustrates the effects of our procedure by plotting the actual interbank offered rate ("Libor BB") with the currency-implied rate from the original data ("Libor implied") and the currency-implied rate after our data cleaning algorithm has been applied ("Libor implied NEW"). Sweden serves as an illustration only, and the impact for other countries is similar.



Libor rates for Sweden. The figure shows the dynamics of three Libor rates: From Bloomberg ("Libor BB"), the one implied by currency data ("Libor implied"), and the one implied by our corrected currency data ("Libor implied NEW").

Some of the extreme quotes from the original source are removed (for instance, October 1993), whereas other extremes are kept (like the observations in 1992 during the banking crisis).

Commodities Since there are no reliable spot prices for most commodities, we use the nearest-, second-nearest, and third-nearest to expiration futures prices, downloaded from Bloomberg.

Our commodities dataset consists of 24 commodities: six in energy (brent crude oil, gasoil, WTI crude, RBOB gasoline, heating oil, and natural gas), eight in agriculture (cotton, coffee, cocoa, sugar, soybeans, Kansas wheat, corn, and wheat), three in livestock (lean hogs, feeder cattle, and live cattle) and seven in metals (gold, silver, aluminum, nickel, lead, zinc, and copper).

Carry is calculated using nearest-, second-nearest, and third-nearest to expiration contracts. We linearly interpolate the prices to a constant, one-month maturity. As with equities, we only interpolate future prices to compute carry and not to compute the returns on the actual strategies.

Industrial metals (traded on the London Metals Exchange, LME) are different from the other contracts, since futures contracts can have daily expiration dates up to 3 months out. Following LME market practice, we collect cash- and 3-month (constant maturity) futures prices and interpolate between both prices to obtain the one-month future price.

We use the Goldman Sachs Commodity Index (GSCI) to calculate returns for all commodities. Returns exclude the interest rate on the collateral (i.e., excess returns) and the indices have exposure to nearby futures contracts, which are rolled to the next contract month from the 5^{th} to the 9^{th} business day of the month.

The following table shows the tickers for the Goldman Sachs Excess Return indices, generic futures contracts. LME spot and 3-month forward tickers are: LMAHDY and LMAHDS03 (aluminum), LMNIDY and LMNIDS03 (nickel), LMPBDY and LMPBDS03 (lead), LMZSDY and LMZSDS03 (zinc) and LMCADY and LMCADS03 (copper).

First-, second-, and third generic futures prices can be retrieved from Bloomberg by substituting 1, 2 and 3 with the ‘z’ in the futures ticker. For instance, CO1 Comdty, CO2 Comdty, and CO3 Comdty are the first-, second-, and third-generic futures contracts for crude oil.

	GSCI ER	Futures Ticker
Crude Oil	SPGCBRP Index	COx Comdty
Gasoil	SPGCGOP Index	QSx Comdty
WTI Crude	SPGCCLP Index	CLx Comdty
Unl. Gasoline	SPGCHUP Index	XBx Comdty
Heating Oil	SPGCHOP Index	HOx Comdty
Natural Gas	SPGCNGP Index	NGx Comdty
Cotton	SPGCCTP Index	CTx Comdty
Coffee	SPGCKCP Index	KCx Comdty
Cocoa	SPGCCCP Index	CCx Comdty
Sugar	SPGCSBP Index	SBx Comdty
Soybeans	SPGCSOP Index	Sx Comdty
Kansas Wheat	SPGCKWP Index	KWx Comdty
Corn	SPGCCNP Index	Cx Comdty
Wheat	SPGCWHP Index	Wx Comdty
Lean Hogs	SPGCLHP Index	LHx Comdty
Feeder Cattle	SPGCFCP Index	FCx Comdty
Live Cattle	SPGCLCP Index	LCx Comdty
Gold	SPGCGCP Index	GCx Comdty
Silver	SPGCSIP Index	SIx Comdty
Aluminum	SPGCIAP Index	-
Nickel	SPGCIKP Index	-
Lead	SPGCILP Index	-
Zinc	SPGCIZP Index	-
Copper	SPGCICP Index	-

Fixed income Bond futures are only available for a very limited number of countries and for a relatively short sample period. We therefore create synthetic futures returns for 10 countries: the US, Australia, Canada, Germany, the UK, Japan, New Zealand, Norway, Sweden, and Switzerland.

We collect constant maturity, zero coupon yields from two sources. For the period up to and including May 2009 we use the zero coupon data available from the website of Jonathan Wright, used initially in Wright (2011).[20] From June 2009 onwards we use zero coupon data from Bloomberg. Each month, we calculate the price of a synthetic future on the 10-year zero coupon bond and the price of a bond with a remaining maturity of nine years and 11 months (by linear interpolation). For countries where (liquid) bond futures exist (US, Australia, Canada, Germany, the UK, and Japan), the correlations between actual futures returns and our synthetic futures returns are in excess of 0.95.

The table below reports the Bloomberg tickers for the zero coupon yields and the futures contracts (where available).

First and second generic futures prices can be retrieved from Bloomberg by substituting 1 and 2 with the 'x' in the futures ticker. For instance, TY1 Comdty and TY2 Comdty are the first and second generic futures contracts for the US 10-year bond.

	10y ZC Ticker	9y ZC Ticker	Futures Ticker
US	F08210y Index	F08209Y Index	TYx Comdty
Australia	F12710y Index	F12709Y Index	XMx Comdty
Canada	F10110y Index	F10109Y Index	CNx Comdty
Germany	F91010y Index	F91009Y Index	RXx Comdty
UK	F11010y Index	F11009Y Index	Gx Comdty
Japan	F10510y Index	F10509Y Index	JBx Comdty
New Zealand	F25010y Index	F25009Y Index	-
Norway	F26610y Index	F26609Y Index	-
Sweden	F25910y Index	F25909Y Index	-
Switzerland	F25610y Index	F25609Y Index	-

Index Options and U.S. Treasuries The data sources for index options, alongside the screens we use, and for U.S. Treasury returns and yields are discussed in the main text.

C Results for Carry1-12

Reported below are results from Tables II and IV using the Carry1-12 measure, which is a 12-month moving average of the carry of each security over the past $t-12$ to $t-1$

[20]`http://econ.jhu.edu/directory/jonathan-wright/`.

months, to construct carry strategies in each asset class.

Repeat of Table II using Carry1-12 instead of the current (last month's) carry.

Asset class	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Equities	5.45	10.31	0.16	3.91	0.53
FI 10Y	3.11	6.81	-0.11	4.59	0.46
FI 10Y−2Y	2.14	5.35	-0.27	4.66	0.40
Treasuries	0.47	0.60	0.27	8.33	0.78
Commodities	12.69	19.40	-0.82	5.70	0.65
Currencies	4.25	7.71	-0.96	6.08	0.55
Credit	0.27	0.58	-0.06	21.19	0.46
Options calls	32.23	125.31	-1.68	11.82	0.26
Options puts	40.48	80.50	0.49	12.00	0.50

Repeat of Table IV using Carry1-12 instead of the current (last month's) carry.

	Equities global		FI Level		FI Slope		Treasuries		Commodities	
α	0.44	0.32	0.27	0.26	0.21	0.19	0.03	0.02	1.06	0.78
	(2.51)	(1.74)	(2.42)	(2.56)	(2.52)	(2.37)	(4.10)	(3.16)	(3.76)	(3.12)
Passive long	0.04	0.02	-0.02	-0.10	-0.09	-0.23	0.11	0.08	-0.04	-0.06
	(0.76)	(0.51)	(-0.21)	(-1.18)	(-1.28)	(-3.02)	(2.06)	(2.29)	(-0.39)	(-0.66)
Value		0.33		-0.13		-0.15		0.00		-0.26
		(4.30)		(-1.18)		(-2.09)		(-0.39)		(-4.70)
Momentum		0.10		0.52		0.29		0.00		0.37
		(1.34)		(4.44)		(3.77)		(-0.34)		(5.64)
TSMOM		0.01		0.00		0.03		0.00		-0.10
		(0.33)		(0.24)		(1.88)		(0.21)		(-1.11)
R^2	0.00	0.07	0.00	0.16	0.01	0.14	0.05	0.03	0.00	0.29
IR	0.51	0.38	0.47	0.52	0.47	0.48	0.66	0.70	0.66	0.60

	FX		Credits		Calls		Puts		*GCF*	
α	0.32	0.26	0.02	0.02	2.08	0.83	2.01	3.41		
	(2.58)	(1.99)	(2.97)	(1.75)	(0.77)	(0.26)	(0.93)	(1.51)		
Passive long	0.16	0.20	-0.02	0.15	-0.10	-0.11	-0.05	-0.05		
	(2.14)	(2.96)	(-0.33)	(1.98)	(-2.66)	(-2.70)	(-2.00)	(-1.99)		
Value		0.04		0.01		2.68		-2.20		
		(0.30)		(0.88)		(0.71)		(-1.05)		
Momentum		0.03		0.00		-1.44		-0.47		
		(0.24)		(-0.16)		(-0.88)		(-0.31)		
TSMOM		0.00		-0.01		0.89		-0.52		
		(0.07)		(-1.48)		(1.02)		(-0.82)		
R^2	0.03	0.04	0.00	0.07	0.06	0.10	0.04	0.06		
IR	0.50	0.40	0.47	0.40	0.20	0.08	0.30	0.52		

D Equity Carry versus Dividend Yield

To construct the dividend yield for the US, we use the standard CRSP value-weighted index that includes all stocks on AMEX, Nasdaq, and NYSE. We construct the dividend yield as the sum of 12 months of dividends, divided by the current index level following Fama and French (1988).[21] To construct a long time series of carry, we make the following assumptions. First, we measure r_t^f by the 30-day T-bill rate. Second, we approximate $D_{t+1} = E_t^Q(D_{t+1})$. As most firms announce dividends one to three months in advance, index level dividends are highly predictable one month ahead. This implies that we measure $C_t \simeq D_{t+1}/S_t - r_t^f$. The time series of the dividend yield and equity carry cover the period January 1945 to December 2012.

Comparing carry to the dividend yield, at least three aspects are worth mentioning. First, the average short rate is about the same as the average dividend yield. This implies that the average carry equals -7bp during our sample period, while the average dividend yield equals 3.36%. Second, carry displays important seasonal variation as a result of the payout behavior of firms that is concentrated in several months. The importance of seasonalities declines substantially over time. Third, the variation in the interest rate can contribute substantially to the variation in the equity carry. For instance, during episodes of high interest rates, like for instance in the 1980s, these two series move in opposite directions.

The time series correlation between the dividend yield and the carry is only 0.30. This low correlation arises for two reasons. First, we subtract (and average) the one-month interest rate. Second, and more subtle, we average D_{t+1}/P_t over 12 months. For the dividend yield, by contrast, we sum 12 months of dividends and divide by the current price, $DP_t = \sum_{s=0}^{11} D_{t-s}/P_t$. This implies that the carry signal smoothes both prices and dividends, while in case of the dividend yield, only the dividends are smoothed.

We then examine to what extent sorting on carry versus sorting on dividend yield produces different portfolios. We collect cash returns from Bloomberg and construct the dividend yield for the cross-section of countries we consider as described above. The sample for which Bloomberg reports cash returns is smaller than the sample for which we can compute the carry. To ensure comparability, we only look at contracts for which both the carry and the dividend yield are available. The table below reports the results from the various strategies, which includes the mean return, standard deviation, skewness, and Sharpe ratio of the various strategies. While both carry and dividend yield strategies

[21] Binsbergen and Koijen (2010) show that dividend yield dynamics are very similar if instead of simply summing the monthly dividends, the dividends are invested at the 30-day T-bill rate.

produce positive Sharpe ratios, the correlation between the carry and the dividend yield strategy is only 0.07 and between carry1-12 and dividend yield strategies is only 0.29. At the bottom of the table we also report results from regressing each of the carry strategies on the dividend yield strategy. The betas are low and the alphas remain large and significant.

Comparing the Equity Carry vs. the Dividend Yield. The top panel reports the summary statistics of three strategies using either the current carry, the carry1-12, or the dividend yield as the signal.

	Current carry	Carry1-12	Dividend yield
Mean	0.75	0.30	0.46
Stdev	3.02	3.14	3.17
Skewness	0.25	-0.35	0.06
SR	0.87	0.33	0.50

Correlation matrix	Current carry	Carry1-12	Dividend yield
Current carry	1.00	0.41	0.07
Carry1-12		1.00	0.29
Dividend yield			1.00

	Current carry	Carry1-12
alpha	8.70	2.03
beta	0.07	0.28
IR	0.83	0.19

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Tables

Table I: **Summary Statistics**

This table lists all the instruments that we use in our analysis, and reports summary statistics on the beginning date for which the returns and carry are available for each instrument, as well as the annualized mean and standard deviation of the return and the carry for each instrument. Panel A contains the instruments for equities, commodities, currencies, and fixed income, and Panel B contains fixed income slope (10-year − 2-year bonds), US Treasuries, US credit portfolios, and US equity index options, separated by calls and puts and averaged across delta groups.

PANEL A: EQUITIES, COMMODITIES, CURRENCIES, AND FIXED INCOME

Instrument	Begin	Return		Carry	
	sample	mean	stdev	mean	stdev
Equities					
US	Mar-88	6.0	14.9	-1.4	0.7
SPTSX60	Oct-99	5.7	15.8	-0.7	0.8
UK	Mar-88	3.6	15.1	-1.6	1.4
France	Jan-89	3.4	19.6	-0.5	1.9
Germany	Dec-90	6.3	21.5	-3.4	1.1
Spain	Aug-92	8.2	22.0	1.7	2.1
Italy	Apr-04	-1.4	21.1	1.4	1.5
Netherlands	Feb-89	5.6	19.8	0.2	1.5
Sweden	Mar-05	8.5	19.0	1.3	2.2
Switzerland	Nov-91	3.3	16.0	0.2	1.2
Japan	Oct-88	-3.5	22.1	-0.4	1.6
Hong Kong	May-92	10.8	27.8	1.4	2.2
Australia	Jun-00	3.7	13.2	0.9	1.0
Currencies					
Australia	Jan-85	4.7	12.1	3.2	0.8
Austria	Feb-97	-2.6	8.7	-2.1	0.0
Belgium	Feb-97	-2.7	8.7	-2.1	0.1
Canada	Jan-85	2.1	7.2	0.8	0.5
Denmark	Jan-85	3.9	11.1	0.9	0.9
Euro	Feb-99	1.2	10.8	-0.3	0.4
France	Nov-83	4.6	11.2	1.6	0.9
Germany	Nov-83	2.8	11.7	-0.9	0.9
Ireland	Feb-97	-2.5	8.9	0.5	0.2
Italy	Apr-84	5.1	11.1	4.3	0.8
Japan	Nov-83	1.7	11.4	-2.7	0.7
Netherlands	Nov-83	3.0	11.6	-0.7	0.9
New Zealand	Jan-85	7.0	12.6	4.3	1.2
Norway	Jan-85	4.3	11.1	2.3	0.9
Portugal	Feb-97	-2.3	8.4	-0.6	0.2
Spain	Feb-97	-1.5	8.5	-0.7	0.2
Sweden	Jan-85	3.3	11.5	1.7	0.9
Switzerland	Nov-83	1.9	12.1	-1.9	0.7
UK	Nov-83	2.8	10.4	2.0	0.6
US	Nov-83	0.0	0.0	0.0	0.0

Instrument	Begin	Return		Carry	
	sample	mean	stdev	mean	stdev
Commodities					
Crude Oil	Feb-99	21.1	32.0	0.8	5.4
Gasoil	Feb-99	20.7	32.9	2.7	5.3
WTI Crude	Feb-87	11.6	33.5	1.5	7.0
Unl. Gasoline	Nov-05	12.6	36.2	-2.1	9.8
Heating Oil	Aug-86	12.2	32.8	-0.3	8.3
Natural Gas	Feb-94	-16.6	53.6	-26.6	21.3
Cotton	Feb-80	0.4	25.2	-3.8	7.2
Coffee	Feb-81	2.5	37.7	-4.8	5.0
Cocoa	Feb-84	-3.9	29.2	-6.5	3.4
Sugar	Feb-80	0.9	39.4	-2.8	6.1
Soybeans	Feb-80	2.8	23.7	-2.4	5.6
Kansas Wheat	Feb-99	1.1	29.5	-8.7	3.2
Corn	Feb-80	-3.3	25.8	-10.2	5.3
Wheat	Feb-80	-5.0	25.2	-8.5	5.7
Lean Hogs	Jun-86	-3.2	24.5	-14.3	19.8
Feeder Cattle	Feb-02	2.2	15.5	-1.6	4.6
Live Cattle	Feb-80	2.2	14.1	-0.2	6.1
Gold	Feb-80	-0.8	17.6	-5.3	1.1
Silver	Feb-80	-0.8	31.3	-6.1	1.8
Aluminum	Feb-91	-2.3	19.3	-5.0	1.5
Nickel	Mar-93	11.6	35.6	0.4	2.5
Lead	Mar-95	10.4	29.7	-0.7	2.7
Zinc	Mar-91	0.9	25.8	-4.7	2.0
Copper	May-86	15.3	28.1	4.3	3.4
Fixed income					
Australia	Mar-87	5.6	11.2	0.8	0.6
Canada	Jun-90	6.6	8.8	2.3	0.5
Germany	Nov-83	4.7	7.5	2.1	0.5
UK	Nov-83	3.9	10.2	0.1	0.8
Japan	Feb-85	4.5	7.4	2.0	0.4
New Zealand	Jul-03	3.3	8.6	0.7	0.8
Norway	Feb-98	3.9	9.0	0.9	0.5
Sweden	Jan-93	6.1	9.3	1.7	0.4
Switzerland	Feb-88	3.0	6.0	1.5	0.6
US	Nov-83	6.3	10.8	2.5	0.6

Panel B: Fixed Income slope, US Treasuries, Credit, and Equity Index Options					
Instrument	Begin sample	Return mean	Return stdev	Carry mean	Carry stdev
Fixed income, 10y-2y slope					
Australia	Mar-87	4.5	9.5	0.6	0.3
Canada	Jun-90	4.7	7.2	1.4	0.3
Germany	Nov-83	3.6	6.5	1.4	0.4
UK	Nov-83	3.4	8.5	0.3	0.5
Japan	Feb-85	3.8	6.4	1.7	0.3
New Zealand	Jul-03	3.1	7.8	0.9	0.4
Norway	Feb-98	3.5	6.9	1.0	0.3
Sweden	Jan-93	4.7	8.0	1.1	0.2
Switzerland	Feb-88	2.6	5.1	1.4	0.3
US	Nov-83	4.9	9.2	1.7	0.4
US Treasuries					
10Y	Aug-71	1.2	1.6	1.2	0.4
7Y	Aug-71	0.8	1.5	0.7	0.2
5Y	Aug-71	0.7	1.4	0.6	0.2
3Y	Aug-71	0.6	1.2	0.5	0.1
2Y	Aug-71	0.5	1.1	0.4	0.1
1Y	Aug-71	0.4	0.9	0.3	0.1
Credits, US					
A, Intermediate	Feb-73	0.4	1.3	0.4	0.1
AA, Intermediate	Feb-73	0.4	1.2	0.3	0.1
AAA, Intermediate	Feb-73	0.4	1.3	0.3	0.1
BAA, Intermediate	Feb-73	0.6	1.3	0.5	0.1
A, Long	Feb-73	0.3	1.0	0.3	0.1
AA, Long	Feb-73	0.3	1.0	0.2	0.1
AAA, Long	Feb-73	0.2	1.0	0.2	0.1
BAA, Long	Feb-73	0.4	1.1	0.3	0.1
Call options (average across delta groups)					
DJ Industrial Average	Oct-97	-138.5	332.7	-689.4	56.9
S&P Midcap 400	Mar-97	-52.8	370.0	-774.0	57.0
Mini-NDX	Sep-00	11.3	391.3	-708.3	53.3
NASDAQ 100	Jan-96	51.4	422.2	-737.3	57.7
S&P 100	Jan-96	-138.2	326.2	-716.3	59.1
Russell 2000	Jan-96	-84.4	367.5	-701.2	56.7
S&P Smallcap 600	May-05	-446.1	155.2	-746.2	63.6
S&P 500	Jan-96	-152.8	302.1	-713.8	58.2
AMEX Major Market	Jan-96	119.3	452.1	-680.6	46.2
Put options (average across delta groups)					
DJ Industrial Average	Oct-97	-320.6	305.4	-593.0	45.7
S&P Midcap 400	Jan-96	-828.7	117.9	-518.8	64.1
Mini-NDX	Aug-00	-218.8	362.2	-585.0	47.1
NASDAQ 100	Jan-96	-284.7	338.5	-592.1	50.7
S&P 100	Jan-96	-309.3	315.7	-598.8	47.4
Russell 2000	Feb-96	-283.4	318.6	-595.5	48.9
S&P Smallcap 600	Feb-04	-807.9	59.5	-537.6	53.3
S&P 500	Jan-96	-323.1	300.9	-580.6	47.2
AMEX Major Market	Jan-96	-572.2	158.8	-521.5	47.6

Table II: **The Returns to Global Carry Strategies**

Panel A reports for each asset class, the mean, standard deviation, skewness, kurtosis, and Sharpe ratio of the long/short carry trades as well as passive equal-weighted (EW) exposures in each asset class. These statistics are also reported for a diversified portfolio of all carry trades across all asset classes, which we call the "global carry factor," where each asset class is weighted by the inverse of its full sample volatility (standard deviation of returns) estimate. An equal-weighted passive exposure to all asset classes is computed similarly by equal-weighting all securities within an asset class and then weighting each asset class by the inverse of its volatility in the "all asset classes" row. Panel B reports results for carry trades conducted at a much coarser level by first grouping securities by region or broader asset class and then generating a carry trade. For equities, fixed income, and currencies we group all index futures into one of five regions: North America, UK, continental Europe, Asia, and New Zealand/Australia and compute the equal-weighted average carry and equal-weighted average returns of these five regions. For commodities we group instruments into three categories: agriculture/livestock, metals, and energy. We then create carry trade portfolios using only these regional/group portfolios. Credit, US Treasuries, and options are excluded from Panel B.

PANEL A: CARRY TRADES BY SECURITY WITHIN AN ASSET CLASS

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry	9.14	10.42	0.22	4.74	0.88
	EW	5.00	15.72	-0.63	3.91	0.32
Fixed income 10Y global	Carry	3.85	7.45	-0.43	6.66	0.52
	EW	5.04	6.85	-0.11	3.70	0.74
Fixed income 10Y−2Y global	Carry	3.77	5.72	-0.22	5.49	0.66
	EW	4.04	5.73	-0.05	3.67	0.71
US Treasuries	Carry	0.46	0.67	0.47	10.46	0.68
	EW	0.69	1.22	0.58	12.38	0.57
Commodities	Carry	11.22	18.78	-0.40	4.55	0.60
	EW	1.05	13.45	-0.71	6.32	0.08
Currencies	Carry	5.29	7.80	-0.68	4.46	0.68
	EW	2.88	8.10	-0.16	3.44	0.36
Credit	Carry	0.24	0.52	1.32	18.19	0.47
	EW	0.37	1.09	-0.03	7.09	0.34
Options calls	Carry	64	172	-2.82	14.49	0.37
	EW	-73	313	1.15	3.88	-0.23
Options puts	Carry	179	99	-1.75	10.12	1.80
	EW	-299	296	1.94	7.11	-1.01
All asset classes (global carry factor)	Carry	6.75	6.12	-0.02	5.24	1.10
	EW	3.46	7.34	-0.38	7.94	0.47

Panel B: Carry Trades by Region/Group within an Asset Class						
Asset Class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry	5.93	10.93	0.45	4.29	0.54
	EW	4.73	14.68	-0.65	3.93	0.32
Fixed income 10Y	Carry	3.74	8.51	-0.37	5.21	0.44
	EW	5.10	6.92	-0.07	3.69	0.74
Fixed income 10Y−2Y	Carry	4.05	6.89	0.13	4.35	0.59
	EW	4.12	5.80	-0.02	3.64	0.71
Commodities	Carry	14.97	31.00	-0.04	4.93	0.48
	EW	1.37	16.15	-0.56	5.86	0.09
Currencies	Carry	4.76	10.73	-1.00	5.31	0.44
	EW	2.68	7.00	-0.05	3.34	0.38

Table III: **Correlation of Global Carry Strategies**

Panel A reports the monthly return correlations between carry strategies for each asset class where carry trades are performed using individual securities within each asset class. Panel B reports monthly correlations for carry trades across asset classes performed using the regional/group level portfolios.

Panel A: Correlations of Carry Trade Returns by security within an Asset Class

	EQ	FI 10Y	FI 10Y−2Y	Treasuries	COMM	FX	Credit	Calls	Puts
EQ	1.00	0.17	0.13	0.07	-0.02	0.05	0.06	0.11	-0.09
FI 10Y		1.00	0.66	0.09	0.05	0.15	-0.02	-0.07	0.06
FI 10Y−2Y			1.00	0.11	0.08	0.14	-0.08	0.00	0.09
Treasuries				1.00	0.12	-0.05	0.12	0.08	-0.06
COMM					1.00	0.02	0.04	-0.15	0.08
FX						1.00	0.21	-0.14	0.11
Credit							1.00	-0.04	0.09
Calls								1.00	0.15
Puts									1.00

Panel B: Correlation of Carry Trade Returns by Region/Group within an Asset Class

	EQ	FI 10Y	FI 10Y−2Y	COMM	FX
EQ	1.00	0.16	0.10	-0.02	0.06
FI 10Y		1.00	0.64	-0.01	0.04
FI 10Y−2Y			1.00	0.03	0.13
COMM				1.00	-0.02
FX					1.00

Table IV: **Carry Trade Exposures to Other Factors**

The table reports regression results for each carry portfolio's returns in each asset class on a set of other portfolio returns or factors that have been shown to explain the cross-section of asset returns: the passive long portfolio returns (equal-weighted average of all securities) in each asset class, the value and momentum asset class-specific factors of Asness, Moskowitz, and Pedersen (2012), and the time-series momentum (TSMOM) factor of Moskowitz, Ooi, and Pedersen (2012), where these latter factors are computed for each asset class separately for equities, fixed income, commodities, and currencies. For fixed income slope and Treasuries, we use the fixed income factors and for the credit and options strategies we use the global-across-all-asset-class diversified value and momentum "everywhere" factors of Asness, Moskowitz, and Pedersen (2012) (which includes individual equity strategies, too) and the globally diversified across all asset classes TSMOM factor of Moskowitz, Ooi, and Pedersen (2012). Panel A reports both the intercepts or alphas (in percent) from these regressions as well as the betas on the various factors for the carry strategies that on individual securities within each asset class. Panel B reports the same for the regional/group level portfolios within each asset class. The last two columns of Panel A report regression results for the global carry factor, GCF, on the all-asset-class market, value, momentum, and TSMOM factors. The last two rows report the R^2 from the regression and the information ratio, IR, which is the alpha divided by the residual volatility from the regression. Panel B reports results of the same regressions for the regional/group carry strategies. All t-statistics are in parentheses.

Panel A: by security within an Asset Class

	Equities global		FI Level		FI Slope		Treasuries		Commodities	
α	0.79	0.77	0.35	0.33	0.34	0.29	0.03	0.02	0.93	0.64
	(4.51)	(4.51)	(3.06)	(3.08)	(4.00)	(3.63)	(3.38)	(2.74)	(3.43)	(2.57)
Passive long	-0.06	-0.06	-0.07	-0.18	-0.07	-0.23	0.16	0.12	0.01	-0.02
	(-1.10)	(-1.16)	(-0.94)	(-2.10)	(-0.91)	(-3.03)	(2.57)	(3.51)	(0.12)	(-0.31)
Value		0.17		0.07		0.07		0.00		-0.21
		(1.84)		(0.51)		(0.64)		(-0.67)		(-2.96)
Momentum		0.06		0.56		0.43		0.00		0.29
		(0.74)		(4.26)		(4.37)		(0.04)		(3.81)
TSMOM		-0.04		0.03		0.04		0.00		-0.04
		(-1.69)		(1.82)		(3.12)		(0.80)		(-0.45)
R^2	0.01	0.03	0.00	0.16	0.00	0.20	0.08	0.07	0.00	0.20
IR	0.91	0.90	0.57	0.61	0.71	0.70	0.54	0.64	0.60	0.47

	FX		Credits		Calls		Puts		GCF	
α	0.40	0.30	0.02	0.02	3.21	6.93	13.02	12.55	0.53	0.44
	(3.31)	(2.31)	(2.85)	(1.70)	(1.07)	(2.15)	(4.74)	(4.55)	(6.52)	(5.51)
Passive long	0.17	0.22	0.02	0.14	-0.34	-0.35	-0.08	-0.09	0.10	0.14
	(2.47)	(3.46)	(0.50)	(2.31)	(-5.90)	(-6.07)	(-1.85)	(-2.10)	(1.34)	(1.78)
Value		0.11		0.01		-5.96		2.82		0.08
		(1.08)		(0.81)		(-2.14)		(0.98)		(1.00)
Momentum		0.03		0.00		-4.32		2.14		0.10
		(0.31)		(-0.21)		(-2.54)		(1.01)		(1.45)
TSMOM		0.01		0.00		-0.92		-0.77		-0.01
		(0.25)		(-1.42)		(-1.00)		(-1.07)		(-0.22)
R^2	0.03	0.05	0.00	0.07	0.39	0.43	0.05	0.07	0.02	0.04
IR	0.63	0.47	0.45	0.39	0.29	0.64	1.61	1.56	1.05	1.24

Panel B: by region/group within an Asset Class

	Equities global		FI Level		FI Slope		Commodities		FX	
α	0.51	0.50	0.36	0.38	0.39	0.34	1.24	0.77	0.33	0.25
	(2.73)	(2.51)	(2.70)	(2.76)	(3.63)	(3.17)	(2.76)	(1.74)	(1.96)	(1.40)
Passive long	-0.03	-0.03	-0.12	-0.05	-0.15	-0.12	0.11	0.01	0.31	0.37
	(-0.61)	(-0.57)	(-1.43)	(-0.64)	(-1.76)	(-1.35)	(0.71)	(0.08)	(2.68)	(3.14)
Value		0.10		0.16		0.14		0.12		0.10
		(1.05)		(1.36)		(1.56)		(0.88)		(0.63)
Momentum		0.06		0.14		-0.03		0.62		0.04
		(0.67)		(1.09)		(-0.30)		(3.62)		(0.28)
TSMOM		-0.03		-0.02		0.01		-0.03		0.00
		(-1.18)		(-1.49)		(0.70)		(-0.17)		(0.02)
R^2	0.00	0.01	0.01	0.02	0.02	0.02	0.00	0.13	0.04	0.05
IR	0.56	0.54	0.51	0.56	0.68	0.61	0.48	0.32	0.37	0.29

Table V: **Decomposing Carry Trade Returns into Static and Dynamic Components.**
The table reports the results of the static and dynamic decomposition according to equation (27).

Individual securities	Static	Dynamic	% Dynamic
Equities global	-0.1%	9.3%	101%
Fixed income - 10Y global	0.6%	3.3%	86%
Fixed income - 10Y−2Y global	0.1%	3.7%	99%
US Treasuries	0.3%	0.2%	42%
Commodities	4.1%	7.1%	64%
Currencies	2.2%	3.1%	58%
Credit	0.2%	0.1%	30%
Options calls	-7.2%	70.8%	111%
Options puts	-0.4%	179.3%	100%
Regions and groups	**Static**	**Dynamic**	**% Dynamic**
Equities global	-0.6%	6.6%	111%
Fixed income - 10Y global	0.5%	3.3%	87%
Fixed income - 10Y−2Y global	0.2%	3.9%	96%
Commodities	-0.4%	15.4%	103%
Currencies	2.3%	2.4%	51%

Table VI: **How Does Carry Predict Returns?**

The table reports the results from the panel regressions of equation (28) for each asset class with and without asset/instrument and time fixed effects, repeated here:

$$r^i_{t+1} = a^i + b_t + cC^i_t + \varepsilon^i_{t+1},$$

where a^i is an asset-specific intercept (or fixed effect), b_t are time fixed effects, C^i_t is the carry on asset i at time t, and c is the coefficient of interest that measures how well carry predicts returns. Without asset and time fixed effects, c represents the total predictability of returns from carry from both its passive and dynamic components. Including time fixed effects removes the time-series predictable return component coming from general exposure to assets at a given point in time. Similarly, including asset-specific fixed effects removes the predictable return component of carry coming from passive exposure to assets with different unconditional average returns. By including both asset and time fixed effects, the slope coefficient c in equation (28) represents the predictability of returns to carry coming purely from variation in carry. Coefficient estimates, c and their associated t-statistics from the regressions are reported below.

Strategy	Contract FE	Time FE	Coefficient, c	t-statistic	Strategy	Contract FE	Time FE	Coefficient, c	t-statistic
Equities global	X	X	1.14	4.15	Currencies	X	X	1.09	2.69
	X		1.27	2.87		X		1.60	2.69
		X	1.08	4.00			X	0.82	3.00
			1.21	2.85				1.28	3.23
FI, 10Y global	X	X	1.44	3.08	Credit	X	X	1.46	2.01
	X		1.56	3.09		X		2.19	2.82
		X	1.19	2.97			X	1.20	2.57
			1.47	3.24				2.07	2.97
FI, 10-2Y global	X	X	2.51	3.72	Options, calls	X	X	0.16	1.45
	X		2.38	2.94		X		-0.04	-0.20
		X	1.79	3.47			X	0.15	1.35
			2.08	3.00				-0.05	-0.25
US Treasuries	X	X	0.45	2.65	Options, puts	X	X	0.54	7.12
	X		0.60	1.68		X		0.78	3.35
		X	0.59	4.27			X	0.54	7.09
			0.64	2.14				0.77	3.38
Commodities	X	X	0.01	0.13					
	X		0.01	0.13					
		X	0.07	0.87					
			0.06	0.79					

Table VII: **Carry Timing Strategies**

The table reports results for pure timing strategies on each asset using carry and ignoring any cross-sectional information from carry. Specifically, for every security we long if the carry is positive and short if it is negative. We do this for every security within an asset class and then take the equal-weighted average of these timing strategy returns based on carry across all securities within an asset class. Panel A reports the results for each asset class as well as for the regional/group level portfolios. Panel B repeats the timing exercise, but where we go long (short) a security if its carry is above (below) its rolling sample mean over the last five years.

	Panel A: Timing Relative to Zero					Panel B: Timing Relative to Rolling Mean				
Individual securities	mean	stdev	skewness	kurtosis	Sharpe ratio	mean	stdev	skewness	kurtosis	Sharpe ratio
Equities	7.40	18.55	0.39	4.49	0.40	12.15	16.91	0.10	4.97	0.72
FI global, 10Y	7.09	10.93	-0.16	4.05	0.65	6.82	9.89	-0.11	4.56	0.69
FI global, 10Y−2Y	6.90	9.62	-0.15	4.29	0.72	4.97	8.63	-0.13	5.00	0.58
Treasuries	1.36	2.28	-0.48	14.51	0.60	0.59	1.93	-1.26	22.34	0.31
Commodities	8.28	20.78	0.13	5.56	0.40	12.20	16.24	-0.34	3.57	0.75
Currencies	7.86	10.08	-0.72	5.63	0.78	5.04	9.50	-0.50	4.35	0.53
Credit	1.27	2.00	-0.24	8.00	0.64	1.15	1.95	-0.30	8.69	0.59
Options calls	146.45	626.92	-1.15	3.88	0.23	-35.66	264.00	-2.12	13.35	-0.14
Options puts	597.76	592.72	-1.94	7.11	1.01	233.12	244.04	2.61	22.49	0.96
Regions/groups	mean	stdev	skewness	kurtosis	Sharpe ratio	mean	stdev	skewness	kurtosis	Sharpe ratio
Equities	4.81	21.53	0.65	5.90	0.22	10.12	20.69	-0.11	4.00	0.49
FI global, 10Y	6.78	11.38	-0.10	3.72	0.60	7.67	10.84	-0.02	4.08	0.71
FI global, 10Y−2Y	7.21	9.70	-0.14	4.23	0.74	5.51	9.21	-0.07	4.63	0.60
Commodities	7.47	31.22	0.45	6.36	0.24	14.02	28.53	0.60	7.28	0.49
Currencies	8.26	10.48	-0.68	4.72	0.79	4.88	9.28	-0.29	3.90	0.53

Table VIII: **The Returns to Carry Strategies Across Asset Classes During Carry Drawdowns and Expansions.**

The table reports the annualized mean and standard deviation of returns to carry strategies and to the equal-weighted index of all securities within each asset class during carry "expansions" and "drawdowns", where carry "drawdowns" are defined as periods where the cumulative return to carry strategies is negative, defined as follows

$$D_t \equiv \sum_{s=1}^{t} r_s - \max_{u \in \{1,\ldots,t\}} \sum_{s=1}^{u} r_s,$$

where r_s denotes the return on the global carry factor for all periods over which $D_t < 0$. Carry "expansions" are defined as all other periods.

		Carry expansions		Carry drawdowns	
Asset class	Strategy	Mean	Stdev	Mean	Stdev
Equities	Carry	15.03	9.71	-6.15	10.95
	EW	8.31	13.73	-3.62	19.87
FI global, 10Y	Carry	10.84	6.19	-13.90	7.93
	EW	3.75	6.53	8.33	7.55
FI global, 10Y−2Y	Carry	8.10	5.10	-7.25	5.98
	EW	2.94	5.45	6.85	6.34
Treasuries	Carry	0.97	0.64	-0.57	0.65
	EW	0.98	1.14	0.10	1.34
Commodities	Carry	21.49	17.33	-13.23	20.24
	EW	4.54	11.73	-7.24	16.68
Currencies	Carry	10.06	7.29	-6.81	8.00
	EW	5.17	7.68	-2.95	8.89
Credit	Carry	0.60	0.52	-0.50	0.45
	EW	0.84	1.03	-0.61	1.15
Options calls	Carry	152	138	-161	225
	EW	195	272	-237	389
Options puts	Carry	258	77	-22	124
	EW	364	238	132	409

Table IX: **Correlation of Carry Strategies During Expansions and Drawdowns**

Panel A reports the monthly return correlations between carry strategies for each asset class during carry expansions and Panel B reports monthly correlations for carry returns during carry drawdowns. **Bold** indicates significantly different correlation estimates between expansions and drawdowns.

Panel A: Correlations of Carry Trade Returns during expansions

	EQ	FI 10Y	FI 10Y−2Y	Treasuries	COMM	FX	Credit	Calls	Puts
EQ	1.00	0.10	0.03	0.03	-0.08	-0.03	0.02	0.02	**-0.07**
FI 10Y		1.00	0.60	0.04	-0.03	0.06	-0.14	**-0.11**	**0.02**
FI 10Y−2Y			1.00	0.09	0.00	0.08	-0.19	-0.10	-0.01
Treasuries				1.00	0.10	**-0.08**	0.04	0.00	**0.02**
COMM					1.00	-0.05	0.00	-0.19	-0.02
FX						1.00	**0.03**	**-0.13**	**-0.21**
Credit							1.00	-0.06	**-0.14**
Calls								1.00	0.07
Puts									1.00

Panel B: Correlation of Carry Trade Returns during drawdowns

	EQ	FI 10Y	FI 10Y−2Y	Treasuries	COMM	FX	Credit	Calls	Puts
EQ	1.00	0.04	0.06	0.01	-0.04	-0.07	-0.09	0.09	**-0.41**
FI 10Y		1.00	0.61	-0.07	-0.07	-0.03	-0.18	**-0.26**	**-0.19**
FI 10Y−2Y			1.00	-0.08	0.03	-0.01	-0.19	-0.08	-0.11
Treasuries				1.00	0.00	**-0.20**	0.02	0.07	**-0.37**
COMM					1.00	-0.02	-0.10	-0.28	0.03
FX						1.00	**0.48**	**-0.38**	**0.27**
Credit							1.00	-0.19	**0.36**
Calls								1.00	0.08
Puts									1.00

Table X: **Higher Frequency Movements within Carry Drawdowns and Expansions.** The table reports the annualized mean and standard deviation of returns to carry strategies for each asset class during the first and second half of carry "drawdowns" (Panel A) and "expansion" (Panel B), separately. For this analysis we only look at carry drawdown and expansion periods that last at least four months and divide each drawdown and expansion into two halves.

		1st half		2nd half	
Asset class	Strategy	Mean	Stdev	Mean	Stdev
		PANEL A: CARRY DRAWDOWNS			
Equities	Carry	-1.1	4.1	0.8	4.5
FI 10Y	Carry	-1.4	2.1	-0.6	1.7
FI 10Y−2Y	Carry	-1.0	1.6	0.1	1.0
Treasuries	Carry	0.0	0.2	-0.1	0.2
Commodities	Carry	-1.5	5.5	-2.2	6.7
Currencies	Carry	-0.4	2.1	-0.4	1.8
Credit	Carry	0.0	0.1	0.0	0.1
Options calls	Carry	-0.1	78.4	-14.5	42.6
Options puts	Carry	7.7	4.5	-23.5	63.5
		PANEL B: CARRY EXPANSIONS			
Equities	Carry	0.8	2.5	1.5	2.7
FI 10Y	Carry	0.8	1.6	1.0	2.0
FI 10Y−2Y	Carry	0.6	1.5	0.7	1.5
Treasuries	Carry	0.1	0.2	0.1	0.2
Commodities	Carry	1.8	4.9	1.1	4.6
Currencies	Carry	0.5	2.4	1.0	1.9
Credit	Carry	0.1	0.2	0.1	0.1
Options calls	Carry	16.5	19.5	3.9	46.9
Options puts	Carry	23.5	21.8	20.3	22.9

Table XI: **Static and Dynamic Risk Exposure in Drawdowns and Expansions**

The table reports the decomposition of the returns to carry into their static and dynamic components during drawdowns and expansions for each asset class's carry strategy. The static and dynamic decomposition follows equation (27) and drawdowns and expansions are defined according to equation (29). The table reports the profits coming from the static and dynamic positions of each carry strategy, as well as the total carry strategy and reports the percentage of carry profits coming from the dynamic positions, each reported separately during drawdowns and expansions.

	Drawdowns				Expansions			
Asset class	Static	Dynamic	Total	%Dynamic	Static	Dynamic	Total	%Dynamic
Equities	-2.9	-3.3	-6.2	53.0	1.0	14.1	15.0	93.5
FI 10Y	-3.6	-10.3	-13.9	74.4	2.2	8.7	10.8	79.9
FI 10Y−2Y	-3.2	-4.1	-7.3	56.3	1.3	6.8	8.1	83.7
Treasuries	0.1	-0.7	-0.6	122.8	0.3	0.6	1.0	66.0
Commodities	2.5	-15.7	-13.2	119.0	4.7	16.8	21.5	77.9
Currencies	-4.6	-2.2	-6.8	32.7	4.9	5.2	10.1	51.2
Credit	-0.3	-0.2	-0.5	42.0	0.4	0.2	0.6	35.0
Options calls	-15.4	-146.1	-161.5	90.5	-4.0	155.6	151.6	102.7
Options puts	-1.4	-20.8	-22.2	93.8	0.0	257.5	257.6	100.0

Figures

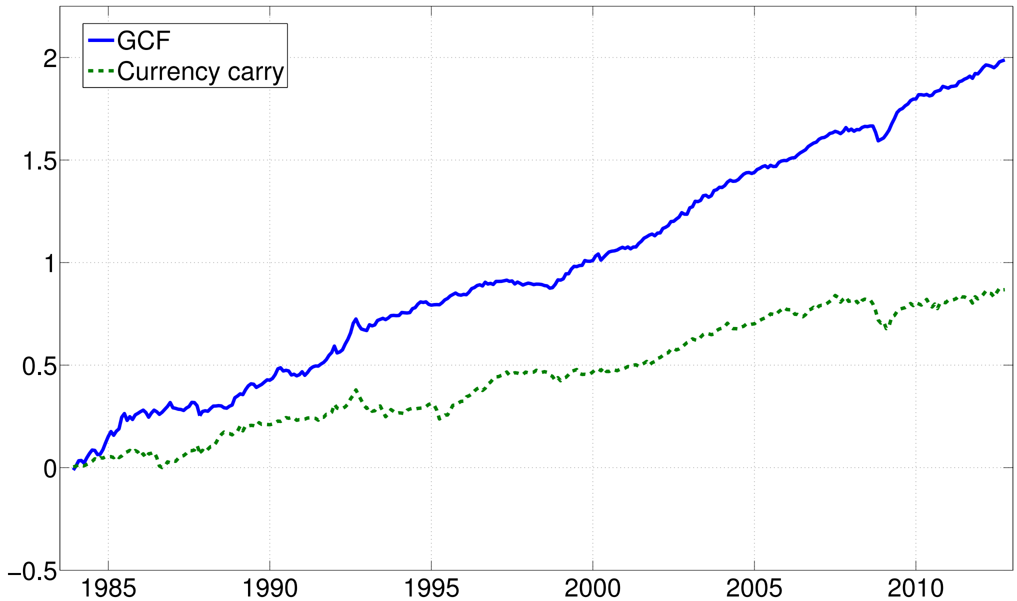

Figure 1: **Cumulative returns on the global carry factor.** The figure displays the cumulative sum of the excess returns of the global carry factor, a diversified carry strategy across all asset classes, and the currency carry portfolio applied only to currencies. The global carry factor is constructed as the equal-volatility-weighted average of carry portfolio returns across the asset classes. Specifically, we weight each asset classes' carry portfolio by the inverse of its sample volatility so that each carry strategy in each asset class contributes roughly equally to the total volatility of the diversified portfolio. The sample period is from 1972 until September 2012. The two series are scaled to the same volatility for ease of comparison.

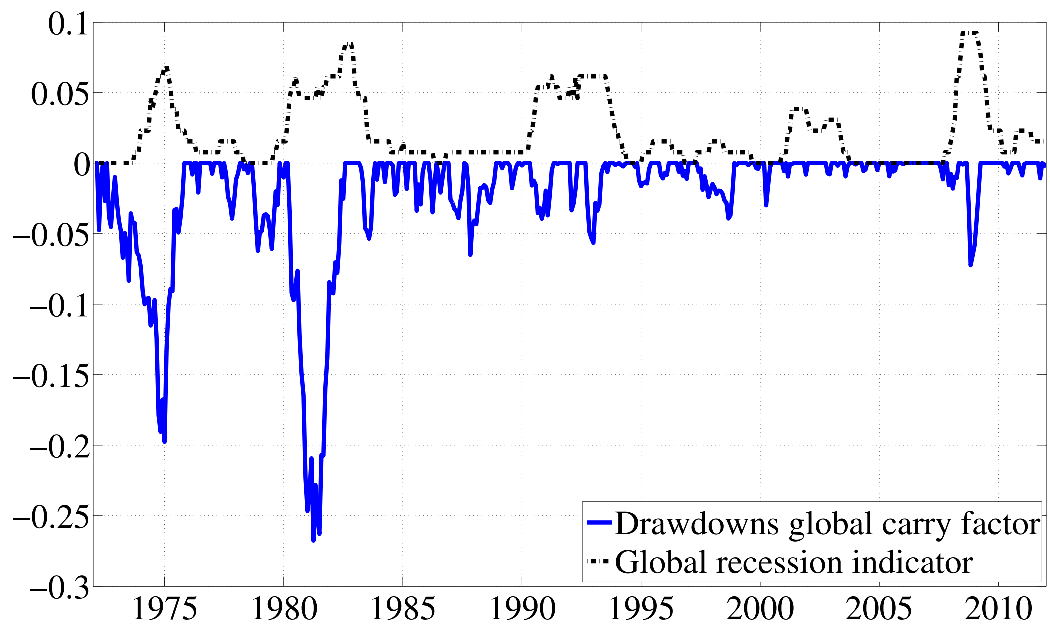

Figure 2: **Drawdown Dynamics of the Global Carry Factor.** The figure shows the drawdown dynamics of the global carry strategy. We define the drawdown as: $D_t \equiv \sum_{s=1}^{t} r_s - \max_{u \in \{1,\ldots,t\}} \sum_{s=1}^{u} r_s$, where r_s denotes the return on the global carry strategy. We construct the global carry factor by weighing the carry strategy of each asset classes by the inverse of the standard deviation of returns, and scaling the weights so that they sum to one. The dash-doted line corresponds to a global recession indicator. The sample period is 1972 to September 2012.