Carry*

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Abstract

We apply the concept of carry, which has been studied almost exclusively in currency markets, to any asset. A security's expected return is decomposed into its "carry" – an ex-ante and model-free characteristic – and its expected price appreciation. Carry predicts returns cross-sectionally and in time series for a host of different asset classes, including global equities, global bonds, commodities, US Treasuries, credit, and options. Carry is not explained by known predictors of returns from these asset classes, and captures many of these predictors, providing a unifying framework for return predictability. We reject a generalized version of Uncovered Interest Parity and the Expectations Hypothesis in favor of models with varying risk premia, where carry strategies are commonly exposed to global recession, liquidity, and volatility risks, though none fully explain carry's premium.

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

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We define an asset's "carry" as its futures (or synthetic futures if none exist) return assuming that prices stay the same. Based on this uniform definition, any security's return can be decomposed into its carry and its expected and unexpected price appreciation:

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

Hence, an asset's expected return is its carry plus its expected price appreciation. What is special about carry is that it is a model-free characteristic that is directly observable ex ante from futures (or synthetic futures) prices, whereas the expected price appreciation must be estimated using an asset pricing model. Empirically, we consider a variety of asset classes and, in every asset class, define carry consistently as the return on a futures (or synthetic futures) position when the price does not change. Carry can be directly observed without relying on any particular model and we show how carry can be used to test a variety of asset pricing theories.

We explore how carry is related to expected returns and expected price appreciation across a wide range of diverse assets that include global equities, global government bonds, currencies, commodities, credit, and options. We examine both the common and independent variation of returns across asset classes through the lens of carry to help shed light on theory.

The concept of carry has been studied in the literature almost exclusively for currencies, where our general definition recovers the well-known currency carry given by the interest-rate differential between two countries. The currency literature focuses on testing uncovered interest rate parity (UIP) and explaining its empirical deviations.[1] However, equation (1) is a general relation that can be applied to any asset. Hence, we test a generalized, across many asset classes, version of UIP, which also tests the expectations hypothesis (EH) in fixed income markets. Under this theory, a high carry should not predict a high return as it is compensated by an offsetting low expected price appreciation. However, under models of time-varying risk premia, a high return premium naturally shows up as a high carry. The concept of carry can therefore be used to empirically address some of the central questions in asset pricing: (i) Do expected returns vary over time and across assets? (ii) If so, by how much? (iii) How can expected

[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). Explanations of the UIP failure include liquidity risk (Brunnermeier, Nagel, and Pedersen (2008)), crash risk (Farhi and Gabaix (2008)), volatility risk (Lustig, Roussanov, and Verdelhan (2010) and Menkhoff, Sarno, Schmeling, and Schrimpf (2012)), peso problems (Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011)), and infrequent revisions of investor portfolio decisions (Bacchetta and van Wincoop (2010)).

returns be estimated ex ante? (iv) Which economic mechanism drives the variation in expected returns? (v) How much common variation in expected returns exists across asset classes?

We find that carry is a strong positive predictor of returns in each of the major asset classes we study, both in the cross section and the time series. A carry trade that goes long high-carry assets and shorts low-carry assets earns significant returns in each asset class with an annualized Sharpe ratio of 0.8 on average. Further, a diversified portfolio of carry strategies across all asset classes earns a Sharpe ratio of 1.2.

The returns to carry are related to, but not explained by, other known return predictors. Carry generates positive and unexplained alpha within each asset class relative to other known factors in each asset class. A long literature studies return predictability in different asset classes, usually focusing on one asset class at a time. Taking the main predictors of returns for each asset class, we show that carry provides unique return predictability. However, in many cases the reverse is not true – carry often subsumes the return predictability of other known factors. This suggests that carry is not only a stronger predictor of returns, but also that it may be a unifying concept that ties together many return predictors disjointly scattered across the literature from many asset classes.

The literature on return predictability has traditionally been somewhat segregated by asset class,[2] where most studies focus on a single asset class or market at a time, ignoring how different asset classes behave simultaneously. As a consequence, return predictability and theory have often evolved separately by asset class. We show that seemingly unrelated predictors of returns across different assets may, in fact, be bonded together through the concept of carry. For instance, the carry for bonds is closely related to the slope of the yield curve studied in the bond literature, plus what we call a "roll down" component that captures the price change that occurs as the bond moves along the yield curve as time passes. The commodity carry is akin to the "basis" or convenience yield, and equity carry is a forward-looking measure of dividend yields.[3]

While carry is related to these known predictors of returns, it is also different from many of these measures and provides unique return predictability. Carry can also be applied more broadly to other asset markets such as the cross-section of US Treasuries

[2]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).

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

across maturities, US credit portfolios, and US equity index call and put options across moneyness. We find equally strong return predictability for carry in these other markets as well, providing an out-of-sample test and a broader unifying framework.

To further quantify carry's predictability, we run a set of panel regressions of future returns of each asset on its carry. While carry predicts future returns in every asset class with a positive coefficient, the magnitude of the predictive coefficient differs across asset classes, indicating whether carry is positively or negatively related to future price appreciation (see equation (1)). In global equities, global bonds, and credit markets, the predictive coefficient is greater than one, implying that carry predicts positive future price changes that add to returns, over and above the carry itself. In commodity and options markets, the estimated predictive coefficient is less than one, implying that the market takes back part of the carry (although not all, as implied by UIP/EH). Hence, there are commonly shared features across different carry strategies and also interesting differences.

The panel regressions also indicate that carry tends to predict returns in the presence of contract fixed effects. To explore the time-series predictability of carry in more detail, we consider carry timing strategies. Instead of a neutral long-short portfolio, carry timing strategies buy (short) a security when the carry is positive or above its historical mean. Consistent with the panel regressions, we find that carry timing strategies also produce positive Sharpe ratios that average 0.6, and a global carry timing strategy that combines all asset classes has a Sharpe ratio of 0.9.

We examine both the commonality and differences across carry strategies to shed light on asset pricing theory. Since the strong return predictability of carry lends support to models of time-varying expected returns, we then ask where the source of this return variation might be coming from? Theory suggests that expected returns can vary due to macroeconomic risk (Campbell and Cochrane (1999), Bansal and Yaron (2004)), limited arbitrage (Shleifer and Vishny (1997)), market liquidity risk (Pástor and Stambaugh (2003), Acharya and Pedersen (2005)), funding liquidity risk (Brunnermeier and Pedersen (2009), Gârleanu and Pedersen (2011)), volatility risk (Bansal, Kiku, Shaliastovich, and Yaron (2013) and Campbell, Giglio, Polk, and Turley (2012)), and downside risk exposure (Henriksson and Merton (1981), Lettau, Maggiori, and Weber (2014)). Further, we examine whether carry can be explained by other predictors of returns across global asset classes such as value and momentum.

We first show that the returns to carry strategies cannot be explained by other known global return factors such as value, momentum, and time-series momentum (following Asness, Moskowitz, and Pedersen (2013) and Moskowitz, Ooi, and Pedersen (2012)) within each asset class as well as across all asset classes. The relation between carry and these factors also varies across asset classes, where carry is positively related to value and momentum in some asset classes, and negative in others. However, none of the carry exposures to value, momentum, or time-series momentum are large in any asset class, and carry consistently produces positive alpha with respect to these factors. Hence, carry represents a different return predictor within and across asset classes, adding to the list of factors that drive returns across many markets.

We then assess whether crash risk can explain the ubiquitous returns to carry strategies as suggested by the literature on currency carry trades (Brunnermeier, Nagel, and Pedersen (2008)). While it is well documented that the currency carry trade has negative skewness (Brunnermeier, Nagel, and Pedersen (2008), Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011)), this is not the case for all carry strategies. In fact, several of the carry strategies we examine have positive skewness and the across-all-asset-class global carry factor has negligible skewness. All carry strategies have excess kurtosis, however, indicating fat-tailed returns with large occasional profits and losses. The across-all-asset-class diversified carry factor has a kurtosis of 5.40, but a diversified passive exposure to all asset classes has an even larger kurtosis. This evidence suggests that crash risk theories, which have been suggested as an explanation for the currency carry premium, are unlikely to explain the general carry premium we document.

We then consider whether downside risk can explain the carry premium by looking at Henriksson and Merton (1981)-type regressions for each asset class as well as Lettau, Maggiori, and Weber's (2014) downside risk measure, which they apply successfully to currency carry strategies specifically and to the cross-section of stocks, equity index options, commodities, and government bonds. The downside beta is often larger than the market beta and the price of downside risk is significantly positive. However, we still find significant alphas in several asset classes.

Standard carry strategies can lead to a substantial amount of turnover. To mitigate turnover, we consider a "carry1-12" strategy by sorting on the average carry signal during the last 12 months. The global carry factor based on the time-averaged carry signal still delivers a Sharpe ratio of 1.1, while reducing turnover, on average, by about 50%. We also use realistic estimates of transaction costs from Bollerslev, Hood, Huss, and Pedersen (2016), and show that our carry strategy net returns are still positive and significant for global equities, global fixed income, Treasuries, commodities, and currencies. For options, we only have conservative estimates of transaction costs using bid-ask spreads from OptionMetrics, and our results for options are naturally lower with these high trading costs. However, taken together, our results cannot be explained by high transaction costs and our carry strategies produce consistently positive returns net of those trading costs.

We also consider carry's exposure to liquidity risk and volatility risk. We find that carry strategies in almost all asset classes are positively exposed to global liquidity shocks and negatively exposed to volatility risk. We also find signficant risk prices for liquidity and volatility shocks in the data. Hence, carry strategies generally tend to incur losses during times of worsened liquidity and heightened volatility. These exposures could therefore help explain carry's return premium, though once again we find that these risk exposures are inadequate to capture the entire carry premium. One notable exception is the carry trade across US Treasuries of different maturities, which has the opposite loadings on liquidity and volatility risks, and thus acts as a hedge against the other carry strategies during these times, which makes the positive average returns of this strategy particularly puzzling.

Consistent with the liquidity and volatility exposures, we also find that carry returns tend to be lower during global recessions, which appears to hold uniformly across asset classes. Flipping the analysis around, we 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," respectively. 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 perform poorly, and, moreover, perform significantly worse than passive exposures to these same markets and asset classes during these times. This lower frequency comovement is obscured when looking at monthly returns. Hence, the modest unconditional pairwise correlations mask some important dynamics and some lower frequency comovements. 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 and funding squeezes, remains an open question. The former could also explain some of the common variation across carry strategies, while the latter could be linked to some of the individual asset class variation, where arbitrage capital is more limiting.

Despite these risks, the large 1.2 Sharpe ratio of the diversified carry factor still presents a high hurdle for asset pricing models to explain (Hansen and Jagannathan (1997)). Hence, although macro/recession risk compensation may contribute partly to the high returns to carry strategies in general, margin requirements and funding costs, volatility risk, and limits to arbitrage may also be necessary to justify the high Sharpe ratios we see in the data. The positive exposures of carry to liquidity and volatility risks are consistent with this notion.

Our paper contributes to a growing literature on global asset pricing that analyzes multiple markets jointly.[4] Studying different markets simultaneously identifies both common and unique features of various return predictors that provide a novel set of facts to test asset pricing theory. Theory seeking to explain time-varying return premia should confront the ubiquitous presence of carry premia across different asset classes.

The remainder of the paper is organized as follows. Section I. defines carry for each asset class and examines theoretically how it relates to expected returns in each asset class. Section II. examines carry's return predictability globally across asset classes. Section III. investigates the common and independent variation of carry strategies across asset classes and tests various asset pricing theories for the carry premium, including liquidity, volatility, downside, and global business cycle risks.

I. Carry: A Characteristic of Any Asset

We decompose the return of any security into three components: carry, expected price appreciation, and unexpected price appreciation. We define carry uniformly as the return on a futures position when the price stays constant over the holding period. We give a precise definition of carry for any futures contract and show how carry can be computed in a consistent manner for other assets by constructing a "synthetic" futures and applying the same definition for carry. We apply this methodology across nine diverse asset classes: currencies, equities, global bonds, commodities, US Treasuries, credit, call index options, and put index options. For each asset class, we discuss how our consistent, uniform futures-based definition of carry can be interpreted and relate it to existing economic theory.

We define the return and carry for a futures contract as follows. At any time t, consider a futures contract that expires in the next time period $t+1$ with a current futures price F_t, spot price of the underlying security S_t, and assume an investor allocates X_t dollars 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 current risk-free interest rate earned on

[4] Asness, Moskowitz, and Pedersen (2013) study cross-sectional value and momentum strategies across eight markets and asset classes, Moskowitz, Ooi, and Pedersen (2012) document time-series momentum across asset classes, Fama and French (2011) study size, value, and momentum in global equity markets jointly, Lettau, Maggiori, and Weber (2014) study downside risk across asset classes jointly, and Koijen, Schmeling, and Vrugt (2015) study survey expectations of returns across asset classes.

the margin capital. Hence, the return per allocated capital over one period is

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

and 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 $t+1$. Under the assumption of constant spot prices ($S_{t+1} = S_t$), we have that $F_{t+1} = S_t$ since the futures price expires at the future spot price ($F_{t+1} = S_{t+1}$). Therefore, the carry is defined simply as

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

This definition makes it clear that carry is directly observable from current futures and spot prices. The scaling factor X_t can be chosen freely depending on the needs of the researcher (or investor) as long as a consistent scaling of returns (3) and carry (4) is used as we discuss below.

Based on this definition of carry we can explicitly decompose the excess return on the futures into its three components:

$$r_{t+1} = \frac{F_{t+1} - S_t + S_t - F_t}{X_t} = \underbrace{C_t + E_t\left(\frac{\Delta S_{t+1}}{X_t}\right)}_{E_t(r_{t+1})} + u_{t+1}, \tag{5}$$

where $\Delta S_{t+1} = S_{t+1} - S_t$ is the price change and $u_{t+1} = (S_{t+1} - E_t(S_{t+1}))/X_t$ is the unexpected price shock with mean zero. Equation (5) shows how the futures return is the sum of the carry, the expected spot price change, and the unexpected price move. Since the last term is zero in expectation, the expected return is the sum of the first two. In other words, 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 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. Carry is therefore a simple observable characteristic that is a component of the expected return on an asset.

Carry may also be relevant for predicting expected price changes on an asset, which also contribute to its expected return. That is, C_t may provide information for predicting $E_t(\Delta S_{t+1})$, which we investigate empirically in this paper. Equation (5) provides a unifying framework for carry and its link to risk premia across a variety of asset classes, since our definition of carry can be applied to many asset classes.

The definition of carry makes it clear how carry scales linearly with the position size X_t. For an investor who uses twice the leverage (i.e., half the capital X), both the return and the measured carry naturally double. In the empirical analysis, we choose the position sizes as follows. In most asset classes, 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, $X_t = F_t$. The carry of a fully-collateralized position is therefore

$$C_t = \frac{S_t - F_t}{F_t}, \tag{6}$$

and the excess return is computed similarly, $r_{t+1} = (F_{t+1} - F_t)/F_t$. As discussed below, in asset classes where the asset volatilities vary significantly in the cross section, we choose position sizes that put the various assets on a comparable scale. However, we emphasize that the definition of carry is the same function of the position size and prices across all assets. Lastly, we note that our carry measure also applies to foreign-denominated futures contracts as explained in Appendix A.

A. **Currency Carry**

We begin by illustrating how our general definition of carry applies to the asset class that has been the center of attention in the "classic" carry-trade literature, namely currencies. The "classic" definition of currency carry is the local interest rate in the corresponding country. This definition captures an investment in a currency by literally putting cash into a country's money market, which earns the interest rate if the exchange rate (the "price of the currency") does not change.

To see how our general futures-based definition compares to the classic one, we derive the carry of a currency from forward or futures prices. Recall that the no-arbitrage price of a currency forward contract with spot exchange rate S_t (measured in number of local currency units 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 currency forward is the interest-rate spread, $r^{f*} - r^f$, adjusted for a scaling factor that is 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. The scaling factor simply reflects that a currency exposure using a forward/futures contract corresponds to buying one 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).

We note that (7) only applies when the currency forward satisfies the covered interest-rate parity, $F_t = S_t(1+r_t^f)/(1+r_t^{f*})$. However, we can always use our general definition of carry, $C_t = (S_t - F_t)/F_t$. In the (unusual) cases when the covered interest-rate parity fails, our definition of carry is still the currency return if the spot exchange rate stays constant (and one can view (7) as a way to derive currency-implied interest rates).

Our focus on forwards and futures in the definition of carry is not only helpful for consistency across markets, it is also the most realistic market for speculators who tend to get foreign exchange exposure through a currency forwards or futures. Consistently, our data on currencies comes from one-month currency forward contracts detailed in the next section.

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 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, our goal is to study 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 negative skewness, are not evident in other asset classes, while other characteristics, such as a high Sharpe ratio and exposure to recessions, liquidity risk and volatility risk, are more common to carry trades across asset classes.

B. Global Equity Carry

For equities, the no-arbitrage price of a futures contract, $F_t = S_t(1 + r_t^f) - E_t^Q(D_{t+1})$, depends on the current equity value S_t, the expected future dividend payment D_{t+1} computed under the risk-neutral measure Q, and the risk-free interest rate r_t^f in the country of the equity index.[5] Substituting this expression back into the general definition of carry in (6), the equity carry can be written as

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

The equity carry 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. This expression for the equity carry is intuitive since, if stock prices stay constant, the stock return comes solely from dividends—hence, carry is the forward-looking dividend yield in excess of r^f. While the literature on value investing studies historical dividend yields, our futures-based measure of carry depends on *expected* dividends derived from futures prices. We show that these two measures can be quite different.

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 excess return $E(R) - r^f = D/S - r^f + g$ is equal to the carry (dividend yield over the risk-free rate) plus the expected price appreciation arising from the expected dividend growth, g.

If expected returns were constant, then the dividend growth would be high when the dividend yield were low such that the two components of $E(R)$ would offset each other. If, on the other hand, 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 and the carry

[5] 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. See Binsbergen and Koijen (2015) for a review of this literature.

predicts returns more than one-for-one. 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 (Pástor and Stambaugh (2003), Acharya and Pedersen (2005), Gârleanu and Pedersen (2011)). We investigate in the next section the relation between carry and expected returns for equities as well as the other asset classes and find evidence consistent with this varying discount-rate mechanism.

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 that dividend yield strategies for equities are indeed different from our equity carry strategy.

Lastly, we note as a practical empirical matter that we do not always have an equity futures contract with exactly one month to expiration. In such cases, we interpolate between the two nearest-to-maturity futures prices to compute a consistent series of synthetic one-month equity futures prices and apply the general carry definition for these.[6]

C. Commodity Carry

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 expected convenience yield in excess of storage costs. Hence, the commodity carry can be written as

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

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 avoid using the often unreliable spot price, we use the two futures contracts closest to expiry and extrapolate the futures curve to compute the synthetic spot price and interpolate the curve to compute

[6]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 Section II. and Appendix B for details on the data construction.

the synthetic 1-month futures price.[7] Based on these synthetic futures prices, we apply our general definition of carry in (6).

As seen from (9), commodity carry is effectively the same as the predictor of commodity returns examined in the literature known as the basis (Gorton, Hayashi, and Rouwenhorst (2007), Hong and Yogo (2010), Yang (2011)).

D. Carry for Finite-Maturity Securities

So far, we have considered infinite-maturity securities such as equities and currencies. When applying a consistent definition of carry for finite-maturity securities such as bonds and options, then special care must be taken. Hence, to be precise, we define the carry C_t^τ at time t for a security with τ time periods to maturity as

$$C_t^\tau = \frac{S_t^{\tau-1} - F_t^\tau}{F_t^\tau}. \tag{10}$$

Here, F_t^τ is the futures price where the underlying security currently has τ periods to maturity and delivery is next period, and $S_t^{\tau-1}$ is the spot price of a security with $\tau - 1$ periods to maturity.

The tricky issue is which spot price to use in the numerator, $S_t^{\tau-1}$ or S_t^τ? Our definition corresponds to assuming that the spot price for securities of maturity τ stays constant, $S_{t+1}^{\tau-1} = S_t^{\tau-1}$. Hence, when the futures expires next period, then the underlying security will have a maturity of $\tau - 1$, corresponding to a spot price of $S_t^{\tau-1}$.

Our definition of carry is more natural than an alternative assumption that the price of the security with a maturity *date* at $t + \tau$ stays constant, $S_{t+1}^{\tau-1} = S_t^\tau$. There are several reasons why our definition is more natural.

First, consider a security with 1 period to maturity, $\tau = 1$. In this case, the alternative assumption clearly makes no sense. Indeed, assuming that $S_{t+1}^0 = S_t^1$ makes no sense since the bond or option value at maturity S_{t+1}^0 are known in advance and almost surely not equal to the current price, i.e., we know for sure that $S_{t+1}^0 \neq S_t^1$. More broadly, the alternative definition fails to recognize that finite-maturity securities have a natural drift toward the known final value at maturity. In contrast, our definition of carry has no such contradiction for securities with 1 period to maturity.

Further, our definition is natural as it treats securities with similar time to maturity as similar, recognizing that the nature of a security changes with maturity. Lastly, we point out that this maturity-sensitive definition of carry is consistent with our earlier definition

[7] We only interpolate futures prices to compute carry. We follow the Goldman Sachs Commodity Index (GSCI) roll conventions in computing futures returns.

for infinite-maturity securities with $\tau = \infty$, for the simple reason that infinite-maturity securities remain infinite maturity.

E. Global Bond Carry

The carry definition (10) can be directly applied to bond futures. However, liquid bond futures contracts are only traded in a few countries and, when they exist, typically only the first-to-expire contract is liquid. To create a broad global cross-section of bonds, we therefore compute synthetic futures prices based on an extensive data set of zero-coupon rates and apply the same carry definition.[8]

With zero-coupon bond yield y_t^τ for a bond with τ periods to maturity at time t, the spot price is naturally given by $S_t^\tau = \frac{1}{(1+y_t^\tau)^\tau}$. The 1-period futures price for a contract where the underlying currently has maturity τ is given by $F_t^\tau = (1+r_t^f)S_t^\tau$. Hence, applying the carry definition (10), the carry of a τ-period bond is

$$C_t^\tau = \frac{(1+y_t^\tau)^\tau}{(1+r_t^f)(1+y_t^{\tau-1})^{\tau-1}} - 1. \tag{11}$$

We can re-write the carry based on the forward interest rate from $\tau - 1$ to τ. Indeed, since the forward rate is $f_t^{\tau-1,\tau} := \frac{(1+y_t^\tau)^\tau}{(1+y_t^{\tau-1})^{\tau-1}}$, we have:

$$C_t^\tau = \frac{f_t^{\tau-1,\tau} - r_t^f}{1+r_t^f}, \tag{12}$$

where the numerator is the forward-spot spread (as discussed by Fama and Bliss (1987) in a time-series connection). To understand the connection between the bond carry and the forward rate, note first that the bond carry is the return you earn if the yield curve stays the same over the next time period (adjusted for the risk-free rate). If you buy a τ-period bond, earn the carry over one period, and then sell it with yield $y_t^{\tau-1}$, then the hold-to-maturity yield must be the initial yield y_t^τ. Likewise, a forward rate is the rate that you can now lock in between time $\tau-1$ to τ such that the full-period yield y_t^τ equals the compound yield of first earning $y_t^{\tau-1}$ over the first $\tau - 1$ periods and then earning the forward rate in the end. Since the order of returns does not matter, this argument shows why carry equals the forward rate (even though the carry is intuitively earned in the first time period and the forward rate is intuitively earned in the last period).

We compute the carry using this exact formula (11), but we can get an intuitive

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

expression using a simple approximation based on the bond's modified duration, D^{mod},

$$C_t^\tau \simeq \underbrace{(y_t^\tau - r_t^f)}_{\text{slope}} \underbrace{-D^{mod}\left(y_t^{\tau-1} - y_t^\tau\right)}_{\text{roll down}}. \tag{13}$$

This equation shows that the bond carry consists of two effects: (i) the bond's yield spread to the risk-free rate, which is also called the slope of the term structure; plus (ii) the "roll down," which captures the price increase due to the fact that the bond rolls down the yield curve. To understand the roll down, note that the carry calculation corresponds to the assumption that the entire yield curve stays constant so, as the bond rolls down the yield curve, the yield changes from y_t^τ to $y_t^{\tau-1}$, resulting in a price appreciation which is minus the yield change times the modified duration.

The intuitive equation (13) highlights how carry captures the standard bond predictor, namely slope (or yield spread). Slope is a standard predictor of bond returns in the time series (Fama and Bliss (1987) and Campbell and Shiller (1991)) and cross-section (Brooks and Moskowitz (2016)). Our carry definition is approximately the slope plus a roll-down component. We explore the link to the slope strategy in more detail in Section II.

F. Carry Across Treasuries of Different Maturities

We also examine carry for US Treasuries in the cross section from 1 to 10 years of maturity. We compute the carry in the same way for these bonds, but adjust the position sizing to account for their very different risks. 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 in terms of volatility, we consider duration-adjusted bond returns or, said differently, adjust the capital X_t^τ supporting each bond of maturity τ as seen in equations (3)-(4). Specifically, we use the natural scaling that each bond τ is supported by an amount of capital $X_t^\tau = F_t^\tau D_t^\tau$ equal to (or proportional to) the product of its duration D_t^τ and the synthetic futures price F_t^τ. Hence, a riskier bond with a larger duration is supported by a larger amount of capital and, as a result, its return and carry are scaled down accordingly using the general equations (3) and (4). This position sizing gives the different bonds similar risk profiles. With this duration-adjusted position size, the carry is given by

$$C_t^\tau(X = F_t^\tau D_t^\tau) = \frac{C_t^\tau(X = F_t^\tau)}{D_t^\tau} \tag{14}$$

where we use the notation that the carry $C(\cdot)$ is a function of the capital amount X and the right-hand side contains the carry of a fully collateralized position $C_t^\tau(X_t^\tau = F_t^\tau)$ defined in (11). Of course, adjusting the capital supporting the position means that realized returns are scaled (i.e., duration adjusted) in the same way as the carry.

G. Carry of the Slope of Global Yield Curves

In addition to the synthetic global bond futures described above, we also examine test 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, where each bond position is sized based on its duration as in section *F*. Hence, the carry of this slope-of-the-yield-curve position in any country is

$$C_t^{\text{slope}} = C_t^{10Y}(X = F_t^{10Y} D_t^{10Y}) - C_t^{2Y}(X = F_t^{2Y} D_t^{2Y}). \tag{15}$$

The return corresponding to this long-short portfolio is computed analogously. Again, we use the same definition of carry, applied to all securities and relevant position sizes.

H. 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 (11) and (14). This definition of carry is the credit spread (the yield over the risk free rate) plus the roll down on the credit curve.

I. Option Carry

Finally, we apply our finite-maturity definition of carry to U.S. equity index options. We use the notation $G^{Call}(\tau, K; S_t, \sigma_{t,\tau})$ for the price of a call option at time t with maturity τ, strike K, underlying equity index price S_t, and implied volatility $\sigma_{t,\tau}$. The corresponding put price is denoted by $G^{Put}(\tau, K; S_t, \sigma_{t,\tau})$. To compute the carry, consider a synthetic 1-month futures that gives the obligation to buy an option that currently has maturity τ with futures price $F_t^\tau = (1+r_t^f)G^j(\tau, K; S_t, \sigma_{t,\tau})$. Given that the option maturity is $\tau - 1$ next month when the futures expires, the corresponding spot price is $G^j(\tau-1, K; S_t, \sigma_{t,\tau-1})$ so using our general framework we arrive at the following option carry C_t^j:

$$C_t^j(\tau, K) = \frac{G^j(\tau - 1, K; S_t, \sigma_{t,\tau-1})}{(1 + r_t^f)G^j(\tau, K; S_t, \sigma_{t,\tau})} - 1, \tag{16}$$

which varies with the type of option traded $j = Call, Put$, maturity τ, and strike K.[9] While we compute option carry using the exact expression (16) throughout the paper, we can get some intuition through an approximation based on the derivative of the option price with respect to time to maturity (i.e., its theta, θ) and implied volatility (i.e., vega, ν):

$$G^j(\tau - 1, K; S_t, \sigma_{t,\tau-1}) \;\; \simeq \;\; G^j(\tau, K; S_t, \sigma_{t,\tau}) + \theta_t^j(-1) + \nu_t^j(\sigma_{t,\tau-1} - \sigma_{t,\tau}).$$

This allows us to write the option carry as:[10]

$$C_t^j(\tau, K) \simeq \frac{-\theta_t^j + \nu_t^j(\sigma_{\tau-1} - \sigma_\tau)}{G^j(\tau, K; S_t, \sigma_{t,\tau})} - r^f. \tag{17}$$

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.[11]

II. Carry and Expected Returns

We examine how carry relates to expected returns across the asset classes we study. This analysis provides a test of a generalized version of UIP/EH versus varying risk premia across asset classes. We first briefly describe our sample of securities in each asset class (Appendix B details the data sources), then examine the predictability of carry for average returns, its relation to other predictors of returns in each asset class, and assess how carry relates to asset price appreciation across asset classes.

[9] Our equity strategies are a special case of the call options carry strategy, where $\lim K \to 0$ and $\tau = 1$. In this case, the numerator of (16) is the current stock price and the denominator is the forward price of equity.

[10] If θ is annualized (as in OptionMetrics) and one uses a data frequency of say $\Delta t = 1/12$ years (i.e., one month), then θ should be replaced by $\theta \Delta t$ in equations (17) and (17), but the simplest approach is to rely on the exact relation (16) as we do.

[11] 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. Their 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 become available.

A. Data and Summary Statistics

Table I presents summary statistics for the returns and the carry of each of the instruments we use. Sample means and standard deviations are reported, as well as the starting date for each of the series.

Equity Index Futures. There are 13 country equity index futures beginning as early as March 1988 through September 2012: 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).

Currencies. 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.

Commodities. 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.

Government Bonds. The global fixed income sample consists of 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.

US Treasury Maturities. 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.[12]

Credit. 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.

Index Options. For index options we use data from OptionMetrics starting in January 1996 through December 2011. We use the following indices: Dow Jones Industrial

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

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.[13] We implement the carry strategies separately for call and put options and we construct two groups for calls and puts, respectively, based on the delta: out-of-the-money ($\Delta^{call} \in [0.2, 0.4)$ or $\Delta^{put} \in [-0.4, -0.2)$) and at-the-money ($\Delta^{call} \in [0.4, 0.6)$ or $\Delta^{put} \in [-0.6, -0.4)$). 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, if we still have multiple matches, then we choose the option with the highest price, that is, the option that is most in the money (in a given moneyness group). 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.

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 $x\%$ of securities and short the bottom $x\%$, 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

$$w_t^i = z_t \left(\text{rank}(C_t^i) - \frac{N_t + 1}{2} \right), \tag{18}$$

where C_t^i is security i's carry, N_t is the number of available securities at time t, and 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

[13]The screens largely follow from Frazzini and Pedersen (2011), but here we focus on the most liquid index options across only two delta groups. Our results are stronger if we include all five delta groups as defined in Frazzini and Pedersen (2011).

Pedersen (2013) who show that the resulting portfolios are highly correlated with other zero-cost portfolios that use different weights. With these portfolio weights, the return of the carry-trade portfolio is naturally the weighted sum of the returns r^i_{t+1} on the individual securities,

$$r_{t+1} = \sum_i w^i_t r^i_{t+1}. \tag{19}$$

We consider two measures of carry: (i) The "current carry" or "carry1m," 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 smoothes potential seasonal components that can arise in calculating carry for certain assets.[14] Most of the results in the paper pertain to the current carry, but we report the basic results for carry1-12 as well.

Since carry is a return (under the assumption of no price changes), the carry of the portfolio is computed analogously to the return on the portfolio, that is,

$$C^{portfolio}_t = \sum_i w^i_t C^i_t. \tag{20}$$

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:

$$C^{\text{carry trade}}_t = \sum_i w^i_t C^i_t = \sum_{w^i_t>0} w^i_t C^i_t \; - \sum_{w^i_t<0} |w^i_t| C^i_t \quad > 0. \tag{21}$$

The carry of the carry trade portfolio is naturally always positive and 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 (18) 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.

[14]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, 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.

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 strategy returns for each asset class.

Panel A of Table II indicates that the carry strategies in all nine asset classes have significant positive returns. The first row of each asset class subheading reports statistics on the returns to carry for each asset class. 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 0.78 across all asset classes.

For comparison, we report 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. The second row for each asset class reports the returns to an equal-weighted benchmark of all securities in that asset class. Comparing the first two rows for each asset class, a carry strategy in every asset class outperforms a simple passive equal-weighted investment in 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 0.13 Sharpe ratio on average (or 0.41 if we short the options strategies), far lower than the 0.78 Sharpe ratio of the carry strategies on average. Furthermore, the long-short carry strategies are (close to) market neutral, making their high returns even more puzzling. More formally, as we show below, all of the alphas of the carry strategies with respect to each asset class' long-only passive benchmark are significantly positive.

The third and final row of each asset class stanza reports return statistics for the main "standard" predictor of returns from the existing literature that is most closely related to carry (if one exists). For example, the standard predictor for equity indices is the dividend yield (D/P), which is similar, but not identical to our futures-based carry measure which is the expected dividend yield in excess of the short rate. For fixed income and credit securities the standard predictor is the yield spread, for commodities the standard predictor is the basis, for options it is short volatility, and for currencies it is carry. Section III.B. also considers a broader set of global factors that include global value and momentum factors.

To put the standard return predictors on an equal footing with carry, we construct these factors using the same methodology and asset classes. Specifically, we construct portfolio weights using (18) based on each security's standard predictor rank, and we construct factor returns based on (19).

As Table II shows, carry produces different and stronger return predictability than the "standard" predictor in all asset classes except for commodities and currencies where they are the same. We explore more formally the link between carry and these other predictors in the next subsection.

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 returns 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. 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 at 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.

In Panel C of Table II, we report the results for the carry1-12 strategy. By averaging the monthly carry across 12 months we remove any effect of seasonalities, which are most pronounced for equities and commodities, but it comes at the expense of using less recent data. We find that the carry1-12 strategy produces slightly lower Sharpe ratios in all asset classes, with the exception of commodities and U.S. credit, but the differences are often small.

Both the region- or group-based and carry1-12 strategies show that measurement error is unlikely to drive our results. However, all strategies still use overlapping data in computing the carry and returns. In Appendix C, we also consider a "carry2-13" strategy, which starts from the carry1-12 signal and then skips a month to avoid any overlap in data used to construct the signal and to compute returns. We find that the carry1-12 and the carry2-13 earn virtually identical returns, illustrating that measurement error in overlapping data cannot explain our results.

The robust performance of carry strategies across asset classes, using a uniform futures-based definition of carry across those asset classes, indicates that carry is an important component of expected returns. The previous literature focuses only on currency carry trades, finding similar results to those we find for currencies 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 performing 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.[15]

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 overall positive skewness). Hence, while negative skewness may not be a general characteristic of all these carry strategies, the potential for large negative returns appears pervasive.

The same can be said for the main predictor of returns in each asset class, too. In all but one case, the main predictor of returns in each asset class has at least as large a kurtosis as carry and often more negative skewness, too.

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 asset classes. Specifically, we weight each carry portfolio by 10% divided by its in-sample volatility so that each carry strategy contributes equally to the total volatility of the diversified portfolio. (Said differently, we scale each portfolio to 10% volatility and then take an equal-weighted average.) This procedure is similar to that used by Asness, Moskowitz, and Pedersen (2013) and Moskowitz, Ooi, and Pedersen (2012) to

[15] 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).

combine returns from different asset classes with very different volatilities.[16] We call this diversified across-asset-class portfolio the global carry factor, GCF. For comparison, we also construct a diversified passive long position across all asset classes using the same method (i.e., we equal weight passive long positions in each asset, each scaled to 10% volatility).

As the bottom of Panel A of Table II reports, the diversified carry trade portfolio has a Sharpe ratio of 1.20 per annum. The diversified passive long position in all asset classes produces only a 0.40 Sharpe ratio. These numbers suggest that 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 of the individual carry portfolio Sharpe ratios in each asset class (which is 0.78), indicates significant diversification benefits of applying carry trades across asset classes. On the other hand, the increase in Sharpe ratio is far lower than expected if these trades were unrelated to each other. Given the nine asset classes we study, if the carry trades were independent, the increase in Sharpe ratio should be three-fold. In fact, the increase is "only" about 60 percent, suggesting that there is some commonality among carry trades in different asset classes. We investigate both the common and independent variation in carry across these markets. In Panel C of Table II, we also report the properties of the global carry1-12 factor. The Sharpe ratio equals 1.12, which is close to the Sharpe ratio of the global carry1m strategy. This illustrates again that little is lost by averaging the carry1m signal across 12 months.

Table II also shows that the global carry factor has little skewness, while the diversified passive long has a modest negative skewness of -0.4. The global carry factor has an excess kurtosis of 5.4, which is actually lower than that of the diversified passive long position, but this kurtosis is nevertheless large, indicating a non-normal return distribution with higher probability of large moves.

Figure II plots the cumulative monthly returns to the global carry factor diversified across all asset classes as well as the standard currency carry trade. The GCF produces significant returns throughout the sample period – significant in absolute terms and in comparison to the currency carry strategy. However, some significant drawdown periods are also evident and they tend to coincide for the two carry strategies; an insight we explore further below.

[16] 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 risk representation.

E. How Does Carry Relate to Other Return Predictors?

The evidence in Table II suggests that carry is a unique predictor of returns in some asset classes, different from other predictors found in the literature, while in other asset classes carry is essentially the same as other predictors. For example, our common futures-based carry measure is related to the dividend yield in equities. Carry in fixed income is related to the yield spread, and in commodities carry is the basis trade related to the convenience yield. While these predictors have traditionally been treated as separate and unrelated phenomena in each asset class, the concept of carry provides a common theme that may link these predictors.

Table III examines the relation between carry and the main predictor of returns in each asset class more formally by performing spanning tests of carry and the main predictor of returns for each asset class. Panel A of Table III reports results from regressing carry's returns on the returns from the main predictive variable in each asset class. The first column of Panel A regresses equity carry returns on the returns to a strategy based on historical D/P.

Recall that carry here is a forward-looking measure of D/P in excess of the local risk-free rate. As the risk-free rate is of a similar order of magnitude as D/P, sorting on carry or D/P leads to quite different strategies. Moreover, being forward-looking, the equity carry strategy tilts towards countries that are expected to pay high dividends in a particular month (without actually receiving the dividends as we only take positions in futures). As Table III indicates, equity carry has a large positive and significant alpha of 77 bps per month (t-stat = 4.36). For fixed income, the relation between carry and the bond's yield is high, where the alpha is positive but not statistically significant and the beta with respect to a yield strategy is 0.91 (t-stat = 24.16). Recall, that carry in fixed income is defined as the yield plus the roll down component, where the latter explains only a small part of carry's returns. For credit, carry is also related to yield, but adds something more, delivering a positive and significant alpha. Likewise, in options, carry is positively related to shorting volatility, but provides additional predictive power for returns even after controlling for the returns to shorting volatility. For commodities, carry is exactly the same as the basis trade and of course in currencies carry itself is the main predictor of returns (hence, we do not report those spanning tests).

Panel B of Table III reports results from the reverse regression of the main predictor's returns in each asset class on carry. In every case, the returns to carry capture the returns to the main predictor variable in every asset class. This suggests that carry spans the returns generated by these predictors.

Panel C of Table III reports the time-series correlation between the returns of carry strategies and the strategy based on standard predictors. The correlation is high for fixed income, around 20% for credit and put options, 10% for equities, while the returns are virtually uncorrelated for call options.

Combining the results from the three panels, carry provides new return predictability not explained by standard predictors of returns, but the reverse is not true − carry explains or spans the predictive power of these other variables across all assets. Hence, our general concept of carry provides a unifying framework that synthesizes much of the return predictability evidence found in global asset classes. While return predictors across asset classes have mostly been treated disjointly by the literature, carry helps link them together and capture their returns within a single framework.

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

The unique return predictability from carry comes from two sources: the carry itself, plus any price appreciation that may be related to/predicted by carry. We now investigate in more detail the relationship between carry, expected price changes, and total expected returns.

The significant returns to the carry trade indicate that carry is indeed a signal of expected returns, but can we learn more by testing the generalized UIP/EH in a regression framework? To better understand the relation between carry and expected returns we examine (5), which decomposes expected returns into carry and expected price appreciation. To estimate this relationship, we run the following panel regression for each asset class:

$$r^i_{t+1} = a^i + b_t + cC^i_t + \varepsilon^i_{t+1}, \tag{22}$$

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 carry predicts returns.

There are several interesting hypotheses to consider.

1. $c = 0$ means that carry does not predict returns, consistent with a generalized notion of the UIP/EH.

2. $c = 1$ 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.

3. $c \in (0, 1)$ 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.

4. $c > 1$ 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.

5. $c < 0$ implies that carry predicts such a negative price change that it more than offsets the direct effect of a positive carry.

Table IV 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 (22) represents the predictability of returns to carry coming purely from variation in carry.

The results in Table IV 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, and for call options.

Focusing on the magnitude of the predictive coefficient, Table IV shows that the point estimate of c is greater than one for equities, global bond levels and slope, and credit, 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 with a high carry, but also equity prices tend to appreciate more than usual, consistent with the discount-rate mechanism discussed in Section I.B.

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 leads to additional price appreciation as yields tend to fall. 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 on average. 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 rate 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 the predictive coefficient has the "wrong" sign relative to uncovered interest rate parity, which corresponds to a coefficient larger than one in our regression.[17]

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 for US Treasuries and options.

We illustrate these findings in an intuitive way in Figure III. For each asset class, Figure III plots the carry trade's cumulative return and cumulative carry (recall equation (21) for the carry of the carry trade). When the cumulative return is higher than the cumulative carry, it indicates that carry investors earn a price appreciation in addition to the carry, corresponding to a regression coefficient c greater than one in equation (22). A cumulative return lower than the cumulative carry indicates that the market takes back part of the carry ($c < 1$). In the panel regressions, we use the carry itself, while the strategies are based on the ranks of the carry (see equation (18)), which may lead to small discrepancies (e.g., the carry strategy for corporate bonds). Looking at carry trade returns thus provides the investment analogue to the regression coefficients above. Specifically, the carry trade corresponds most closely to the regressions with time-fixed effects and without asset-fixed effects because we consider a long-short (i.e., cross-sectional) trade based on raw carry signals.

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 a dynamic component to equity carry strategies dominating the predictability of returns.

In Table V, we explore the correlation between fixed effects in more detail. In the first column, we compute, within each asset class, the correlation between the average return and the average carry of a security. If this correlation is high, a static strategy that sorts on the carry earns positive returns (that is, if the average carry would be known in advance). The correlations are on average high for fixed income, currencies, and commodities.

In the second column of Table V, we compute the correlation between the average carry in period t and the average return in period $t+1$ within each asset class. If the

[17] See also Hassan and Mano (2013) who decompose the currency carry trade into static and dynamic components.

correlation is positive, we can use the carry to time the passive long strategy in a given asset class. We again find positive correlations in all asset classes, with the exception of call options. This suggests that carry is a useful signal for timing as well, which we explore in more detail in the next section.

G. Carry Timing

We now consider a carry timing strategy within each asset class to analyze the time-series predictability of carry in more detail. The weight of security i in this case equals

$$w_t^i = z_t \left(2\mathbb{I}(C_t^i - \overline{C} > 0) - 1\right),$$

where $\mathbb{I}(C_t^i - \overline{C} > 0)$ is an indicator function that equals one if $C_t^i > \overline{C}$. As before, we set z_t so that we have \$2 of exposure in each period. However, instead of being a \$1 long and a \$1 short at all times, this strategy will typically take either aggregate long or short positions. We consider the cases where $\overline{C} = 0$ and $\overline{C} =$ the average carry across all securities in a given asset class up to that point in time. Consequently, like the cross-sectional strategy, the timing strategy is fully out of sample.

Table VI contains the results. Comparing the carry to 0, the carry strategy produces positive returns in all asset classes. However, in some asset classes, the strategy is highly correlated with the passive long strategy as the carry is positive or negative most of the time. Setting $\overline{C}$ equal to the historical mean up to a given point in time provides a better test of the time-series predictability of carry that is less correlated to passive long or short positions. Sharpe ratios of these timing strategies are also large and positive in all asset classes, with the exception of call options. A global carry factor, regardless of the cutoff point, results in a Sharpe ratio of a little over 0.9. In addition, the global carry factor now has positive skewness, but a lot more skewness than the cross-sectional global carry factor. The time-series correlation between both global carry factors (using $\overline{C}$ equal to zero and equal to the historical mean up to a point in time) is 59%.

III. Testing Potential Explanations for Carry

Having established the strong predictability of carry across asset classes and time, we next turn to testing economic theories to address what underlying economic sources might be driving carry's return predictability?

We start by examining the common variation across carry strategies to study the potential for a common risk-based explanation of carry predictability across asset classes.

Next, we examine whether carry can be explained by other known global factors, including value and momentum, and analyze theoretical explanations based on crash risk, volatility risk, liquidity risk, and macroeconomic risk. Finally, we examine the worst episodes for carry returns to see if they coincide with other identified economic shocks.

A. Common Risk: Correlations and Factor Exposures

Table VII reports the monthly correlations of carry trade returns across the nine asset classes. Of the 36 pair-wise correlations, 24 are positive and 10 are significantly positive at the 5%-level (p-values are reported in parentheses in the bottom half of the correlation matrix). These positive correlations are consistent with a factor structure in returns across asset markets, but the correlations tend to be small on average.

Next, we explore what economic factors could be driving the common variation in carry returns. Table VIII reports regression results for each carry portfolio's returns in each asset class on a set of other 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) in each asset class, 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 (2013) 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 (2013) (which includes individual equity strategies, too) and the globally diversified TSMOM factor of Moskowitz, Ooi, and Pedersen (2012).[18]

Table VIII 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

[18]We focus here on global factors that can be defined across asset classes. Recall that Section II.C studied asset-class-specific factors, showing that these do not explain carry.

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 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. Since the carry for global equities is the *expected* dividend yield, the positive loading on value is intuitive. However, an equity carry strategy, which is derived from our futures definition and is the expected dividend yield relative to the short-term interest rate, is in fact quite different from the standard value strategy that sorts on historical dividend yields.[19] The positive exposure of equity carry to value, however, does not significantly reduce the alpha or information ratio of the strategy.

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 report regression results for the diversified GCF on the global all-asset-class market,

[19]First, in unreported results 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. Finally, running a time-series regression of carry returns in equities on a dividend yield strategy in equities produces significant alphas as shown in Table III. Hence, carry contains important independent information beyond the standard dividend yield studied in the literature.

value, momentum, and TSMOM factors. The alphas and IRs are large and significant and there are no reliable betas with respect to these factors. Hence, other known global factors that explain returns across markets and asset classes, such as value, momentum, and time-series momentum, do not capture the returns to carry.

B. Turnover and Transaction Costs

We next consider the role of trading costs in explaining carry returns. To measure trading costs for all asset classes except credits and options, we use the estimates used in Bollerslev, Hood, Huss, and Pedersen (2016). For options, we measure the bid-ask spread in OptionMetrics. This estimate of trading costs is very conservative as OptionMetrics uses the last quotes on a given trading day. As option markets close 15 minutes later than equity markets, bid-ask spreads widen during this period thereby overstating the impact of realistic transaction costs. We nevertheless report the results for completeness. We also compute all statistics for the traditional predictors as a point of reference.

In Table IX, we report the results for carry1m in Panel A and for carry1-12 in Panel B. The first column reports the turnover, which we compute in a given period as

$$Turnover_t = \frac{1}{4} \sum_i \left| w_{t-1}^i (1 + r_t^i) - w_t^i \right| ,$$

where we divide by 4 to avoid double-counting (a factor of 2) and to adjust for the fact that the long/short strategies have \$2 exposure (another factor of 2). We compute the average turnover per month and multiply it by 12 to obtain average annual turnover.

For equities, the turnover is high for the carry1m strategy, being more than four times that of the carry1-12 strategy. The carry1m strategy is sensitive to seasonalities in dividends and the strategy generates a lot of turnover as a result. The same is true for commodities. For all asset classes, turnover reduces significantly when moving from the carry1m to the carry1-12 as the signals are less volatile. Consequently, carry1-12 strategies are a lot less sensitive to trading costs and closer to traditional strategies (e.g., D/P for equities). The turnover of the other strategies is more moderate, with the exception of the options as is to be expected.

The remaining columns report the impact of transaction costs on the strategies' Sharpe ratios. The bottom line is that the impact is quite moderate as the strategies are based on liquid futures markets. For options, on the other hand, the impact is large. For a half-spread, the carry strategies based on put options still result in positive Sharpe ratios, but this is no longer the case for 2 or 5 times the half-spread. As mentioned before, the transaction costs for options are likely to be conservative, which suggests that carry strategies for put options are implementable though trading costs may be too large for the call option strategy.

Taken together, we conclude that our results cannot be explained by nor are subsumed by trading costs. We next explore other factors proposed in the literature to explain currency carry returns to see if those factors capture carry returns more broadly. Specifically, we examine global liquidity risk, volatility risk, and downside risk sensitivity.

C. Crashes and Downside Risk Exposure

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 find that all carry strategies produce high Sharpe ratios and often have high kurtosis, but find mixed results regarding skewness. Furthermore, a diversified carry strategy across all asset classes exhibits little skewness and mitigates the most extreme kurtosis. Hence, these measures of crash risk do not appear to explain carry returns more generally. However, given the common variation in carry strategies, we investigate several other theories that could generate this commonality and perhaps explain (at least part of) carry's returns.

We start by testing whether downside risk can explain the carry returns. Panel A of Table X reports regression results from a Henrikson and Merton (1981)-style regression

$$r_t = \beta_0 + \beta_{mkt} r_{mt} + \beta_{down} \max\{0, -r_{mt}\} + \epsilon_t, \tag{23}$$

where we use the passive long strategy as the market return, r_{mt}, in each of the asset classes. As Panel A shows, the downside betas are not significant, save for the option carry strategies.

Lettau, Maggiori, and Weber (2014) also propose a downside risk measure based on the CAPM that captures currency carry returns and cross-sectional variation in returns from some other asset classes. In their model, expected returns are driven by the market beta, $\beta_{LMW,mkt} = Cov(r_t, r_{mt})/Var(r_{mt})$, and the market beta conditional on low returns, $\beta_{LMW,down} = Cov(r_t, r_{mt} \mid r_{mt} < \mu - \sigma)/Var(r_{mt} \mid r_{mt} < \mu - \sigma)$, where μ and σ are the average and standard deviation of r_{mt}, respectively. Following Lettau, Maggiori, and Weber (2014), we use the CRSP value-weighted excess return as r_{mt}. Panel B of Table X reports the results. We find that the downside betas are significant for fixed income (level), commodities, currencies, and both call and put options, which is consistent with some of the results in Lettau, Maggiori, and Weber (2014). This lends support to the idea that some component of global carry returns may be explained by downside risk. We estimate the risk prices using Fama and MacBeth regressions, and find that both are significant, but the price of market risk has the incorrect sign. The price of downside risk does have the correct sign and is highly significant. The model is successful at explaining the returns on fixed income (level), commodities, and both option carry strategies, but the alphas for all other strategies remain significantly positive. Hence, the downside risk measures of Henriksson and Merton (1981) and Lettau, Maggiori, and Weber (2014) do not seem to fully explain the returns to carry strategies across the asset classes we study.

D. Global Liquidity and Volatility Risk

Other leading explanations of the high average returns to the currency carry trade rely on liquidity risks and volatility risk. We investigate whether our carry strategies across asset classes are also exposed to these risks, as an out-of-sample test of these theories.

We measure global liquidity risk as in Asness, Moskowitz, and Pedersen (2013), who use the first principal component of a large set of liquidity variables that measure market and funding liquidity. The sample period for which we have global liquidity shocks is January 1987 to July 2011.

We measure volatility risk by changes in VXO, which is the implied volatility of S&P100 index options. VIX changes and VXO changes are highly correlated, but the advantage of using VXO instead of VIX is that the sample starts earlier in January 1986. (Results using VIX are similar.)

The top panel of Table XI reports the coefficients of a simple time series regression of carry returns on global liquidity shocks (second column) and volatility changes (fourth column). We scale the returns to have 10% volatility over the sample for comparability and we multiply the loadings by 100. The third and fifth columns report the corresponding t-statistics of the coefficients. We confirm the findings of the currency carry literature: Carry returns are positively exposed to global liquidity shocks and negatively exposed to volatility risk.

We find that the exposures are largely consistent in terms of sign across asset classes. For liquidity risk, the loadings are significant at least at the 5% level for currencies, credits, and put options. For volatility risk, the exposures are significantly negative for fixed income (for the level strategy), commodities, currencies, and put options.

Interestingly, the exposure of the carry strategy using Treasuries is opposite of all the other carry strategies—it has a negative exposure to global liquidity shocks and a positive and significant loading on volatility changes. This implies that the Treasuries carry strategy provides a hedge against liquidity and volatility risk, suggesting that liquidity and volatility risk are an incomplete explanation for the cross section of carry strategy returns (or, alternatively, this could be due to random chance or noise, which investors might not have expected ex ante).

We also run asset pricing tests to see whether carry risk premia can be explained by liquidity and volatility risk. In the bottom panel, we report the risk prices, which we estimate using Fama and MacBeth regressions. We find that the price of liquidity risk is positive and the price of volatility risk is negative, as expected. Both risk prices are statistically significant, which lends support to the idea that liquidity and volatility risk explain part of the carry premia across asset classes.

However, the final two columns of the top panel report the alphas and corresponding t-statistics of the carry strategies. We find that the alphas of equities, fixed income (slope), Treasuries, credits, and put options remain statistically significant at the 5% level. Hence, although we find consistent and significant prices of risk for liquidity and volatility among our carry strategies across all asset classes, the risk premia and exposure to these risks are insufficient to fully explain carry's ubiquitous return premium.

An aggressive interpretation concludes that carry is unexplained by downside, liquidity, or volatility risks and presents a substantial asset pricing puzzle that rejects many theories, possibly offering a wildly profitable investment opportunity. A cautious interpretation might conclude that carry strategies almost uniformly load significantly on these risks that partially explains their returns and that perhaps if we had better measures of these risks, carry's exposure to them, and more precise risk premia estimates, we might be able to explain most of the returns to carry through risk.

In Appendix D, we study the connection between drawdowns of the global carry factor, drawdowns of all individual carry strategies, and global business cycle risk. Overall, there appears to be some common risk faced by carry strategies that manifests itself during global recessionary periods often characterized by illiquidity and volatility spikes. While our attempts at measuring and quantifying these risks and their associated prices yield significant but modest results on carry, these initial findings may lay the groundwork for further empirical and theoretical investigation into the sources of the ubiquitous carry return premium. Explaining the returns to carry simultaneously across all the asset classes we study remains a daunting and challenging task for existing asset pricing theory.

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[20]

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

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

[20]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. 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

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

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)

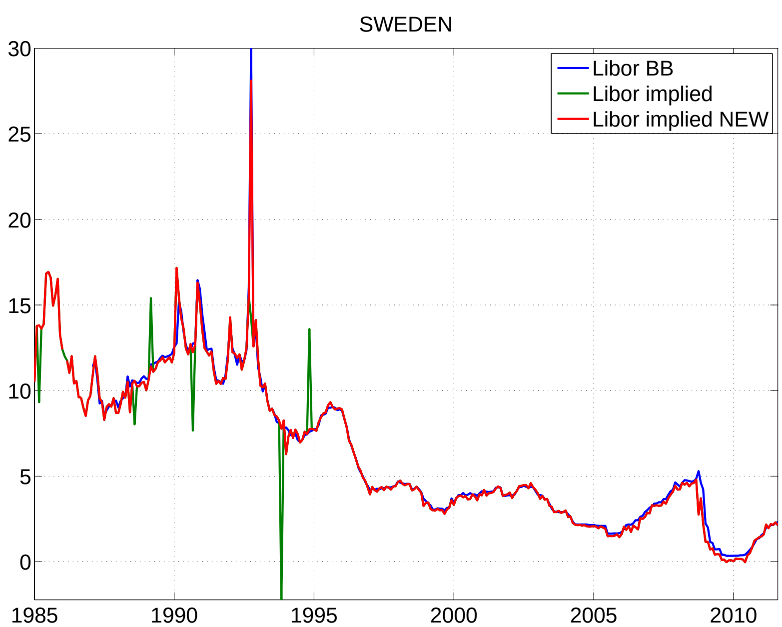
- else, if data is available from HSBC and the absolute difference of the implied rate is below the threshold, replace the default source with HSBC
  - if data is available from HSBC and the absolute difference of the implied rate is also above the threshold, keep the default source
- else, if data is 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).[21] 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 Carry2-13

In Table VI, we compare the carry1-12 and the carry2-13 strategies. Both strategies average the monthly carry1m signal over 12 months. In case of the carry2-13 strategy, we

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

lag the signal by one month to avoid any overlap between the data used to construct the signal and the data used to compute the returns. By skipping a month, we also use more stale data in case of the carry2-13 strategy. Nevertheless, we find very similar results for both strategies. Both global carry factors result in a Sharpe ratio of about 1.1 and the difference is only 0.02. We conclude that our results are not driven by the overlap between carry signals and returns.

Table A1: **The Returns to Carry2-13 and Carry2-13 Strategies By Asset Class**

The table reports for each asset class, the mean annualized excess return, the annualized standard deviation of return, the skewness of monthly returns, kurtosis of monthly returns, and the annualized Sharpe ratio. These statistics are reported for the long/short carry1-12 strategy ("Carry1-12") and for the long/short carry2-13 strategy ("Carry2-13"). 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 standard deviation of returns.

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry2-13	4.50	10.31	0.16	3.69	0.44
	Carry1-12	5.90	10.12	0.22	3.73	0.58
Fixed income 10Y global (level)	Carry2-13	3.42	7.00	0.29	6.02	0.49
	Carry1-12	3.11	6.81	-0.11	4.59	0.46
Fixed income 10Y−2Y global (slope)	Carry2-13	0.17	0.65	-0.08	6.13	0.26
	Carry1-12	0.24	0.67	-0.11	6.26	0.35
US Treasuries (maturity)	Carry2-13	0.46	0.60	0.42	7.59	0.77
	Carry1-12	0.47	0.60	0.27	8.33	0.78
Commodities	Carry2-13	11.06	19.20	-0.90	6.29	0.58
	Carry1-12	12.69	19.40	-0.82	5.70	0.65
Currencies	Carry2-13	4.03	7.72	-0.97	6.04	0.52
	Carry1-12	4.25	7.71	-0.96	6.08	0.55
Credit	Carry2-13	0.26	0.58	-0.10	22.53	0.45
	Carry1-12	0.27	0.58	-0.07	21.20	0.46
Options calls	Carry2-13	67.06	148.93	-1.76	8.94	0.45
	Carry1-12	42.62	158.81	-1.95	8.71	0.27
Options puts	Carry2-13	122.01	87.59	-1.02	7.47	1.39
	Carry1-12	136.13	89.37	-1.22	7.98	1.52
All asset classes (global carry factor)	Carry2-13	6.19	5.65	-0.21	6.20	1.10
	Carry1-12	6.54	5.84	-0.15	6.23	1.12

D Carry Drawdowns

Rather than look at various market downside risk measures and their relation to carry returns, we flip the analysis around by looking at the worst returns for carry strategies to see what common features among these strategies emerge during these times and whether they are related to other macroeconomic variables.

We start by focusing on the global carry factor in which we combine all carry strategies across all asset classes. Figure II, 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.

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

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

where r_s denotes the excess return on the global carry factor. The drawdown dynamics are presented in Figure A1. The three biggest global 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 A1.

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 A2 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 A2 also includes the performance of the long-only passive portfolio in each asset class during expansions and drawdowns. We see that some of the main risks that global investors are exposed to – equities and credits – suffer losses during carry drawdowns, too.

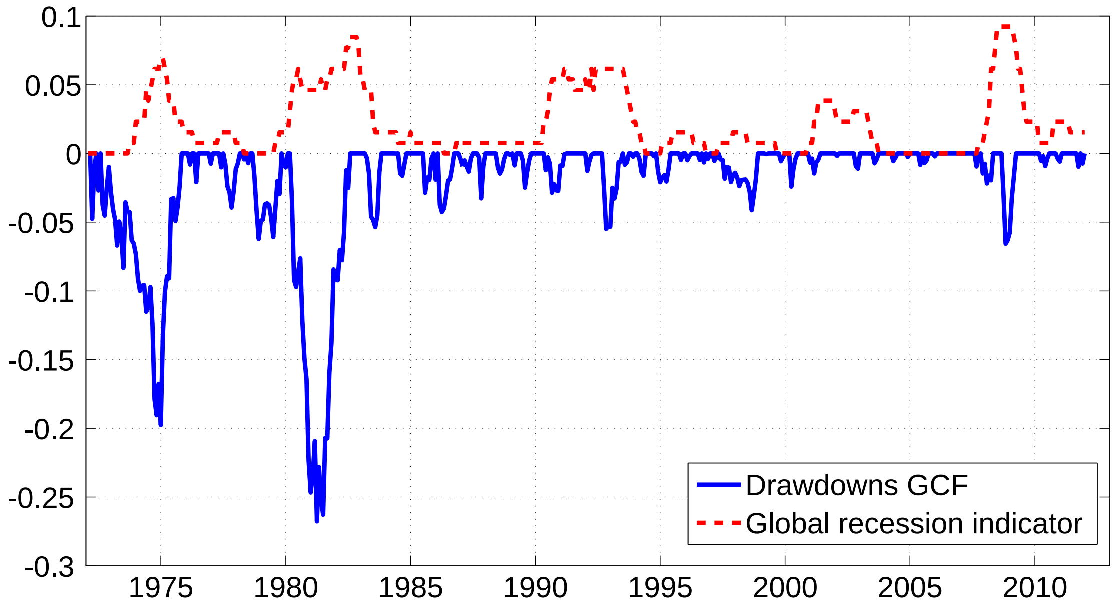


Figure A1: **Drawdown Dynamics of the Global Carry Factor.** The figure shows the drawdown dynamics of the global carry strategy. We define the drawdown as: $D_t \equiv \sum_{s=1}^{t} r_s - \max_{u \in \{1,\ldots,t\}} \sum_{s=1}^{u} r_s$, where r_s denotes the return on the global carry strategy. We 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.

Table A2: **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	15.85	9.67	-10.9	10.52
	EW	7.66	14.31	-2.96	19.25
FI global, 10Y	Carry	8.57	6.54	-9.84	8.48
	EW	3.74	6.51	8.82	7.7
FI global, 10Y-2Y	Carry	1.1	0.63	-0.56	0.61
	EW	-0.03	0.41	0.13	0.49
Treasuries	Carry	0.96	0.63	-0.63	0.67
	EW	0.95	1.12	0.13	1.39
Commodities	Carry	23.54	16.92	-21.62	20.24
	EW	3.71	11.86	-6.02	16.87
Currencies	Carry	8.15	7.33	-2.99	8.63
	EW	5.56	7.67	-4.91	8.9
Credit	Carry	0.59	0.52	-0.53	0.47
	EW	0.76	1.01	-0.53	1.2
Options calls	Carry	157.04	136.89	-216.93	231.52
	EW	157.29	278.23	-178.96	395.66
Options puts	Carry	256.98	74.01	-55.35	131.06
	EW	359.73	251.76	116.32	400.37

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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. For each instrument, we report the beginning date for which the returns and carry are available, the annualized mean excess return, the annualized standard deviation of return, the mean annualized carry, and the annualized standard deviation of carry. Panel A contains equities, commodities, currencies, and fixed income, and Panel B contains fixed income slope trades (10-year vs. 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	Excess 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	7.3	16.4	-0.0	1.3
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	1.9	0.6
US	Nov-83	0.0	0.0	0.0	0.0

Instrument	Begin	Excess 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	7.3	1.9	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	Excess return mean	Excess return stdev	Carry mean	Carry stdev
Fixed income, 10y-2y slope					
Australia	Mar-87	0.0	0.9	0.0	0.2
Canada	Jun-90	-0.3	0.8	-0.2	0.1
Germany	Nov-83	-0.1	0.6	-0.1	0.1
UK	Nov-83	0.2	0.8	0.1	0.2
Japan	Feb-85	0.1	0.5	0.1	0.1
New Zealand	Jul-03	0.2	0.8	0.2	0.2
Norway	Feb-98	0.2	1.1	0.1	0.2
Sweden	Jan-93	-0.1	0.6	-0.1	0.2
Switzerland	Feb-88	0.1	0.6	0.1	0.2
US	Nov-83	-0.1	0.7	-0.1	0.1
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 Carry Strategies By Asset Class**

Panel A reports, for each asset class, the mean annualized excess return, the annualized standard deviation of return, the skewness of monthly returns, kurtosis of monthly returns, and the annualized Sharpe ratio. These statistics are reported for the long/short carry strategy ("Carry"), a passive equal-weighted exposure in each asset class ("EW"), and a strategy based on the main standard predictor of returns in the existing literature. 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 standard deviation of returns, and an equal-weighted passive exposure to all asset classes computed similarly. Panel B reports results for carry trades conducted at a 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. In Panel C, we report the results for the long/short carry1-12 strategy ("Carry1-12").

Panel A: Carry 1M Trades by security within an Asset Class

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry	9.58	10.48	0.24	5.14	0.91
	EW	5.21	15.73	-0.63	3.86	0.33
	D/P	4.22	11.81	-0.14	5.39	0.36
Fixed income 10Y global (level)	Carry	3.85	7.45	-0.43	6.66	0.52
	EW	5.04	6.85	-0.11	3.70	0.74
	Yield	3.55	7.73	-0.81	10.13	0.46
Fixed income 10Y−2Y global (slope)	Carry	0.68	0.66	0.33	4.92	1.03
	EW	0.01	0.43	-0.28	4.08	0.01
US Treasuries (maturity)	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
	Basis	11.22	18.78	-0.40	4.55	0.60
Currencies	Carry	5.29	7.80	-0.68	4.46	0.68
	EW	2.88	8.10	-0.16	3.44	0.36
	Carry	5.29	7.80	-0.68	4.46	0.68
Credit	Carry	0.24	0.52	1.31	18.18	0.47
	EW	0.37	1.09	-0.03	7.10	0.34
	Yield	0.04	0.51	0.43	9.24	0.07
Options calls	Carry	63.55	171.51	-2.82	14.49	0.37
	EW	-73	313	1.15	3.88	-0.23
	Short vol.	5.88	18.00	-7.07	75.58	0.33
Options puts	Carry	178.90	99.30	-1.75	10.12	1.80
	EW	-299	296	1.94	7.11	-1.01
	Short vol.	5.88	18.00	-7.07	75.58	0.33
All asset classes (global carry factor)	Carry	7.18	5.96	-0.03	5.40	1.20
	EW	2.80	6.99	-0.43	9.28	0.40

Panel B: Carry 1M Trades by Region/Group within an Asset Class

Asset Class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry	5.95	10.95	0.45	4.23	0.54
	EW	4.79	14.67	-0.65	3.92	0.33
Fixed income 10Y	Carry	3.71	8.50	-0.37	5.22	0.44
	EW	5.09	6.91	-0.07	3.70	0.74
Fixed income 10Y−2Y	Carry	0.59	0.70	0.12	4.83	0.85
	EW	0.02	0.43	-0.34	3.98	0.04
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

Panel C: Carry 1-12 Trades by security within an Asset Class

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Carry1-12	5.90	10.12	0.22	3.73	0.58
Fixed income 10Y global (level)	Carry1-12	3.11	6.81	-0.11	4.59	0.46
Fixed income 10Y−2Y global (slope)	Carry1-12	0.24	0.67	-0.11	6.26	0.35
US Treasuries (maturity)	Carry1-12	0.47	0.60	0.27	8.33	0.78
Commodities	Carry1-12	12.69	19.40	-0.82	5.70	0.65
Currencies	Carry1-12	4.25	7.71	-0.96	6.08	0.55
Credit	Carry1-12	0.27	0.58	-0.07	21.20	0.46
Options calls	Carry1-12	42.62	158.81	-1.95	8.71	0.27
Options puts	Carry1-12	136.13	89.37	-1.22	7.98	1.52
All asset classes (global carry factor)	Carry1-12	6.54	5.84	-0.15	6.23	1.12

Table III: **Spanning Tests of Carry vs. Standard Return Predictors by Asset Class**

Panel A reports regression results of each carry portfolio's returns in each asset class on the main standard predictor of returns for that asset class. The intercepts or alphas (in percent) from these regressions as well as the betas on the main predictor of returns are reported along with their t-statistics (in parentheses) and the R^2 from the regression. Panel B reports the reverse regression of the returns to the main predictor in each asset class on carry's returns The last row of each panel reports the information ratio (IR) which is the alpha divided by the residual standard deviation from the regression. Panel C reports the time-series correlation between the returns of the traditional strategy returns and the carry strategy returns.

Panel A: Regressing Carry on Standard Return Predictors

	Equities	FI level	Credit	Calls	Puts
Standard predictor:	D/P	Yield spread	Credit spread	Short vol.	Short vol.
α	0.77	0.05	0.02	5.11	14.29
	(4.36)	(1.22)	(2.96)	(1.45)	(6.84)
β	0.08	0.91	0.22	0.37	1.25
	(0.94)	(24.16)	(1.69)	(1.48)	(2.84)
R^2	0.81	89.19	4.56	0.15	5.18
IR	0.88	0.25	0.46	0.36	1.77

Panel B: Regressing Standard Return Predictors on Carry

	Equities	FI level	Credit	Calls	Puts
Standard predictor:	D/P	Yield spread	Credit spread	Short vol.	Short vol.
α	0.27	-0.02	-0.01	0.47	-0.12
	(1.42)	(-0.42)	(-0.15)	(1.25)	(-0.15)
β	0.10	0.98	0.21	0.00	0.04
	(0.95)	(25.25)	(1.93)	(1.61)	(1.18)
R^2	0.81	89.19	4.56	0.15	5.18
IR	0.28	-0.09	-0.03	0.31	-0.09

Panel C: Correlation between Carry Strategies and Traditional Strategies

	Equities	FI level	Credit	Calls	Puts
Correlation	9.0%	94.4%	21.4%	3.9%	22.8%

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

The table reports the results from the panel regressions of equation (22) 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 (22) 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. The standard errors are clustered by time.

Strategy	Contract FE	Time FE	Coefficient, c	t-statistic	Strategy	Contract FE	Time FE	Coefficient, c	t-statistic
Equities global	X	X	1.22	4.18	Currencies	X	X	1.09	2.69
	X		1.34	3.02		X		1.60	2.69
		X	1.15	4.05			X	0.82	3.00
			1.28	3.00				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	0.81	4.91	Options, calls	X	X	0.16	0.77
	X		0.44	2.57		X		-0.32	-0.67
		X	0.83	5.37			X	0.15	1.35
			0.48	2.94				-0.05	-0.25
US Treasuries	X	X	0.45	2.65	Options, puts	X	X	0.60	4.16
	X		0.60	1.68		X		1.16	2.18
		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 V: **Correlation of Fixed Effects by Asset Class**

The table reports for each asset class the correlation between contracts and time fixed effects. In case of contract fixed effects, we compute the average return and the average carry for each security in an asset class, and we report the cross-sectional correlation across all securities in a given asset class. In case of time fixed effects, we compute the average carry across all securities in a given asset class and the average return in the next period, and we report the time-series correlation in a given asset class.

	Contract fixed effects	Time fixed effects
Global equities	11.7%	8.7%
Fixed income 10Y global (level)	60.1%	10.6%
Fixed income 10Y−2Y global (slope)	98.5%	5.9%
US Treasuries (maturity)	99.3%	9.1%
Commodities	83.9%	2.6%
Currencies	72.2%	16.4%
Credit	97.0%	18.5%
Options calls	16.3%	-10.0%
Options puts	28.7%	12.0%

Table VI: **The Returns to Carry Timing Strategies By Asset Class**

The table reports for each asset class, the mean annualized excess return, the annualized standard deviation of return, the skewness of monthly returns, kurtosis of monthly returns, and the annualized Sharpe ratio. These statistics are reported for two carry timing strategies. In the first timing strategy, we compare the carry of a security to zero. In the second timing strategy, we compare the carry to the average carry across all securities in an asset class up to a point in time. 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 standard deviation of returns.

Asset class	Strategy	Mean	Stdev	Skewness	Kurtosis	Sharpe ratio
Global equities	Timing-0	7.69	18.66	0.34	4.41	0.41
	Timing-Mean	12.75	16.92	0.12	5.00	0.75
Fixed income 10Y global (level)	Timing-0	7.09	10.93	-0.16	4.05	0.65
	Timing-Mean	6.82	9.89	-0.11	4.56	0.69
Fixed income 10Y−2Y global (slope)	Timing-0	0.33	0.75	-0.45	5.55	0.44
	Timing-Mean	0.34	0.75	-0.37	5.52	0.46
US Treasuries (maturity)	Timing-0	1.36	2.28	-0.48	14.51	0.60
	Timing-Mean	0.59	1.93	-1.26	22.34	0.31
Commodities	Timing-0	8.28	20.78	0.13	5.56	0.40
	Timing-Mean	12.20	16.24	-0.34	3.57	0.75
Currencies	Timing-0	7.86	10.01	-0.72	5.63	0.78
	Timing-Mean	5.04	9.50	-0.50	4.35	0.53
Credit	Timing-0	1.27	2.00	-0.24	8.00	0.64
	Timing-Mean	1.15	1.95	-0.30	8.69	0.59
Options calls	Timing-0	146.45	626.92	-1.15	3.88	0.23
	Timing-Mean	-35.66	264	-2.12	13.35	-0.14
Options puts	Timing-0	597.76	592.72	-1.94	7.11	1.01
	Timing-Mean	233.12	244.04	2.61	22.49	0.96
All asset classes (global carry factor)	Timing-0	6.03	6.45	0.72	12.89	0.93
	Timing-Mean	5.89	6.27	0.09	18.66	0.94

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

The table reports the monthly return correlations between carry strategies for each asset class where carry trades are performed using individual securities within each asset class. The p-values of the correlations are reported in parentheses.

	EQ	FI 10Y	FI 10Y−2Y	Treasuries	COMM	FX	Credit	Calls	Puts
EQ		0.16	0.09	0.09	-0.03	0.05	0.06	0.11	-0.09
FI 10Y	(0.01)		-0.07	0.09	0.05	0.15	-0.02	-0.07	0.06
FI 10Y−2Y	(0.13)	(0.22)		0.20	0.09	-0.01	0.18	-0.06	0.03
Treasuries	(0.14)	(0.09)	(0.00)		0.12	-0.05	0.12	0.08	-0.06
COMM	(0.60)	(0.32)	(0.09)	(0.02)		0.02	0.04	-0.15	0.08
FX	(0.36)	(0.01)	(0.82)	(0.34)	(0.69)		0.21	-.014	0.11
Credit	(0.32)	(0.69)	(0.00)	(0.01)	(0.40)	(0.00)		-0.04	0.09
Calls	(0.13)	(0.31)	(0.37)	(0.26)	(0.04)	(0.05)	(0.55)		0.15
Puts	(0.24)	(0.39)	(0.66)	(0.44)	(0.25)	(0.13)	(0.21)	(0.03)	

Table VIII: **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 (2013), 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 (2013) (which includes individual equity strategies, too) and the globally diversified across all asset classes TSMOM factor of Moskowitz, Ooi, and Pedersen (2012). The table 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. The last two columns 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. All t-statistics are in parentheses.

	Equities global		FI Level		FI Slope		Treasuries		Commodities	
α	0.82	0.82	0.35	0.33	0.06	0.05	0.03	0.02	0.93	0.64
	(4.70)	(4.71)	(3.06)	(3.08)	(5.53)	(5.01)	(3.38)	(2.74)	(3.43)	(2.57)
Passive long	-0.06	-0.06	-0.07	-0.18	-0.02	0.07	0.16	0.12	0.01	-0.02
	(-1.15)	(-1.21)	(-0.94)	(-2.10)	(-0.22)	(0.67)	(2.57)	(3.51)	(0.12)	(-0.31)
Value		0.17		0.07		-0.01		0.00		-0.21
		(1.82)		(0.51)		(-0.81)		(-0.67)		(-2.96)
Momentum		0.04		0.56		-0.01		0.00		0.29
		(0.44)		(4.26)		(-0.65)		(0.04)		(3.81)
TSMOM		-0.04		0.03		-0.00		0.00		-0.04
		(-1.66)		(1.82)		(-0.62)		(0.80)		(-0.45)
R^2	0.01	0.03	0.00	0.16	0.00	0.01	0.08	0.07	0.00	0.20
IR	0.95	0.95	0.57	0.61	1.03	1.01	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	0.57	0.51
	(3.31)	(2.31)	(2.85)	(1.70)	(1.07)	(2.15)	(4.74)	(4.55)	(7.19)	(6.74)
Passive long	0.17	0.22	0.02	0.14	-0.34	-0.35	-0.08	-0.09	0.11	0.17
	(2.47)	(3.46)	(0.50)	(2.31)	(-5.90)	(-6.07)	(-1.85)	(-2.10)	(1.36)	(2.15)
Value		0.11		0.01		-5.96		2.82		0.05
		(1.08)		(0.82)		(-2.14)		(0.98)		(0.80)
Momentum		0.03		0.00		-4.32		2.14		0.08
		(0.31)		(-0.21)		(-2.54)		(1.01)		(1.40)
TSMOM		0.01		0.00		-0.92		-0.77		-0.02
		(0.25)		(-1.42)		(-1.00)		(-1.07)		(-0.82)
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	1.16	1.55

Table IX: **Turnover and Sharpe Ratios Adjusted for Transaction Costs**

Panel A of the table reports the turnover of the long/short carry1m strategy as well as the Sharpe ratios adjusted for transaction costs when available. The transaction costs are expressed in half-spreads. We also report the results for the traditional predictors for equities (D/P), fixed income (yield spread), and credits (yield spread). In Panel B, we report the same results but then for the carry1-12 strategy. The results for the traditional predictors are the same in both panels.

Panel A: Turnover and After-Cost Sharpe Ratios for Carry1m Strategies

			Transaction costs (half-spreads)			
	Strategy	Turnover	0	1	2	5
Global equities	Carry	6.2	0.91	0.90	0.88	0.82
	D/P	0.9	0.36	0.36	0.35	0.35
Fixed income 10Y global (level)	Carry	1.4	0.52	0.51	0.51	0.49
	Yield	1.4	0.46	0.45	0.45	0.43
Fixed income 10Y-2Y global (slope)		2.3	1.03	0.93	0.84	0.55
US Treasuries (maturity)		2.5	0.68	0.63	0.57	0.39
Commodities		3.6	0.60	0.58	0.57	0.53
Currencies		1.1	0.68	0.67	0.66	0.63
Credits	Carry	1.1	0.47			
	Yield	0.5	0.07			
Options calls		6.7	0.37	-0.77	-1.62	-3.18
Options puts		6.4	1.80	0.42	-0.67	-2.71

Panel B: Turnover and After-Cost Sharpe Ratios for Carry1-12 Strategies

			Transaction costs (half-spreads)			
	Strategy	Turnover	0	1	2	5
Global equities	Carry	1.4	0.58	0.58	0.57	0.56
	D/P	0.9	0.36	0.36	0.35	0.35
Fixed income 10Y global (level)	Carry	0.6	0.46	0.45	0.45	0.44
	Yield	1.4	0.46	0.45	0.45	0.43
Fixed income 10Y-2Y global (slope)		0.8	0.35	0.32	0.29	0.20
US Treasuries (maturity)		0.5	0.78	0.76	0.75	0.71
Commodities		1.1	0.65	0.65	0.65	0.63
Currencies		0.5	0.55	0.55	0.54	0.53
Credits	Carry	0.3	0.46			
	Yield	0.5	0.07			
Options calls		5.8	0.27	-0.80	-1.60	-3.09
Options puts		5.6	1.52	0.20	-0.82	-2.67

Table X: **Exposures to Downside Risk**

The table reports regression results of carry strategy returns in each asset class on measures of downside market risk. The volatility of returns are scaled to 10% over the sample. Two measures of downside risk are employed: Panel A reports regression results from the Henriksson and Merton (1981) model, where downside beta is estimated from a regression of returns on the market ("beta") and the maximum of zero or minus the market return ("downside beta"). We use the passive long strategy as the market return in each of the asset classes. Panel B reports results from the Lettau, Maggiori, and Weber (2014) downside risk measure which estimates the beta of a strategy over the full sample and on the sub-sample where the excess market return is one standard deviation below zero. Following Lettau, Maggiori, and Weber (2014), we use the excess return on the CRSP value-weighted index as the excess market return. The intercept or monthly α, its t-statistic, and the betas and their t-statistics are reported in the table along with the regression R^2 for the Henriksson and Merton (1981) model. We estimate the risk prices, which are reported at the bottom of Panel B, and alphas for the Lettau, Maggiori, and Weber (2014) model using Fama and MacBeth regressions.

Panel A: Henriksson and Merton (1981) downside risk

Asset class	Intercept	t-stat	β_{mkt}	t-stat	β_{down}	t-stat	$R^2(\%)$
Equities	0.42	1.30	0.06	0.52	0.22	1.22	1.9
FI level	0.33	1.78	-0.06	-0.45	0.02	0.09	0.4
FI slope	0.05	3.29	0.08	0.38	0.19	0.60	0.2
Treasuries	0.01	0.39	0.23	1.99	0.18	0.97	9.6
Commodities	1.09	2.76	-0.05	-0.30	-0.11	-0.45	0.1
FX	0.61	3.39	0.06	0.54	-0.23	-1.12	3.6
Credits	0.03	2.44	-0.03	-0.37	-0.10	-0.83	0.7
Calls	49.69	9.83	-0.78	-10.61	-1.21	-9.60	67.9
Puts	43.14	8.20	-0.33	-7.68	-0.74	-7.49	36.3

Panel B: Lettau, Maggiori, and Weber (2014) downside risk

Asset class	α	t-stat	$\beta_{LMW,mkt}$	t-stat	$\beta_{LMW,down}$	t-stat
Equities	0.91%	5.38	-0.03	-0.69	-0.11	-0.52
FI level	-0.12%	-1.21	0.04	0.73	0.36	2.28
FI slope	0.79%	5.14	-0.02	-0.54	0.02	0.23
Treasuries	0.85%	5.76	-0.11	-2.91	-0.13	-1.09
Commodities	0.16%	1.10	0.03	0.91	0.24	3.26
FX	0.27%	2.70	0.21	5.29	0.40	3.85
Credits	0.35%	2.90	0.20	3.98	0.23	1.32
Calls	0.00%	0.00	-0.13	-2.56	0.06	3.34
Puts	0.01%	0.14	0.01	0.14	0.83	5.37

	Risk prices	t-stat
Market risk	-0.019	-2.65
Downside risk	0.017	4.89

Table XI: **Exposures to Global Liquidity Shocks and Volatility Changes**

The top panel of the table reports the loadings of carry strategy returns on both global liquidity shocks and volatility changes. The first reports the asset class, the second and fourth columns the loadings, and the third and first columns the corresponding t-statistics. The exposures are multiplied by 100 and the strategy returns are scaled to an annual volatility of 10%. Global liquidity shocks are measured as in Asness, Moskowitz, and Pedersen (2013). Volatility changes are measured using changes in VXO, the implied volatility of S&P100 options. The fifth column reports the monthly alphas of the strategies and the final column the t-statistics of the alphas. The bottom panel reports the risk prices and the corresponding $t-$statistics. The risk prices and alphas are estimated using Fama and MacBeth regressions.

Asset class	Exposure to liquidity shocks	t-stat	Exposure to volatility changes	t-stat	Alpha	t-stat
Equities	0.70	1.43	0.00	0.01	0.71%	4.09
FI 10Y	0.41	0.76	-0.12	-2.11	0.07%	0.47
FI 10Y-2Y	0.84	1.52	-0.03	-0.92	0.61%	3.67
Treasuries	-0.29	-0.37	0.10	2.37	0.94%	5.98
Commodities	0.51	1.26	-0.08	-2.19	0.26%	1.59
Currencies	2.19	3.01	-0.15	-4.46	-0.08%	-0.64
Credit	3.89	3.34	-0.01	-0.15	-0.31%	-5.46
Options calls	-0.25	-0.95	-0.04	-1.57	0.19%	0.90
Options puts	1.26	2.01	-0.13	-2.00	0.70%	4.14
	Risk prices	t-stat				
Liquidity	0.16	3.53				
Volatility	-2.28	-2.65				

Figures

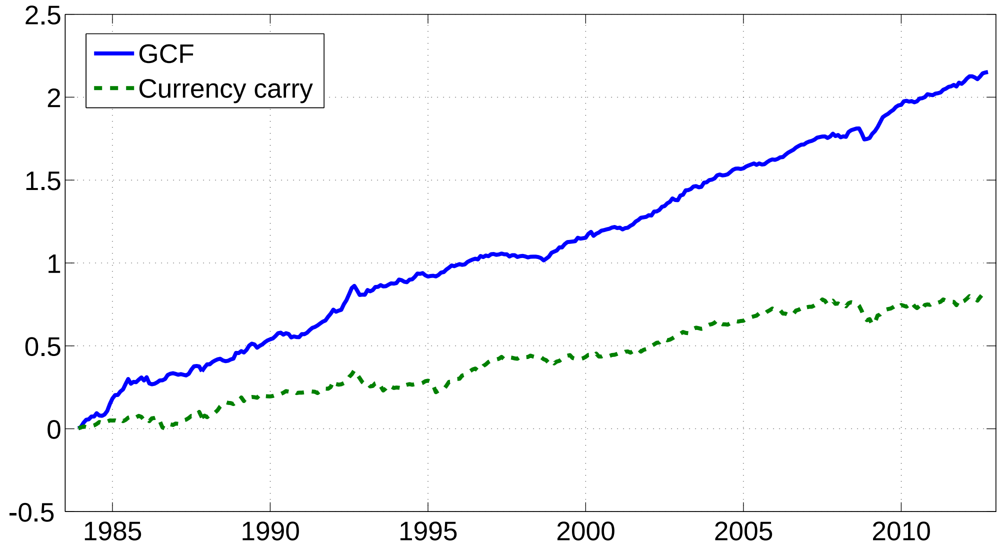

Figure II: **Cumulative returns on the global carry factor.** The figure displays the cumulative sum of the excess returns of the global carry factor, a diversified carry strategy across all asset classes, and the currency carry portfolio applied only to currencies. The global carry factor is constructed 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 1983 until September 2012. For ease of comparison, the currency carry series is scaled to the same ex post volatility as that of the global carry factor (6% annualized).

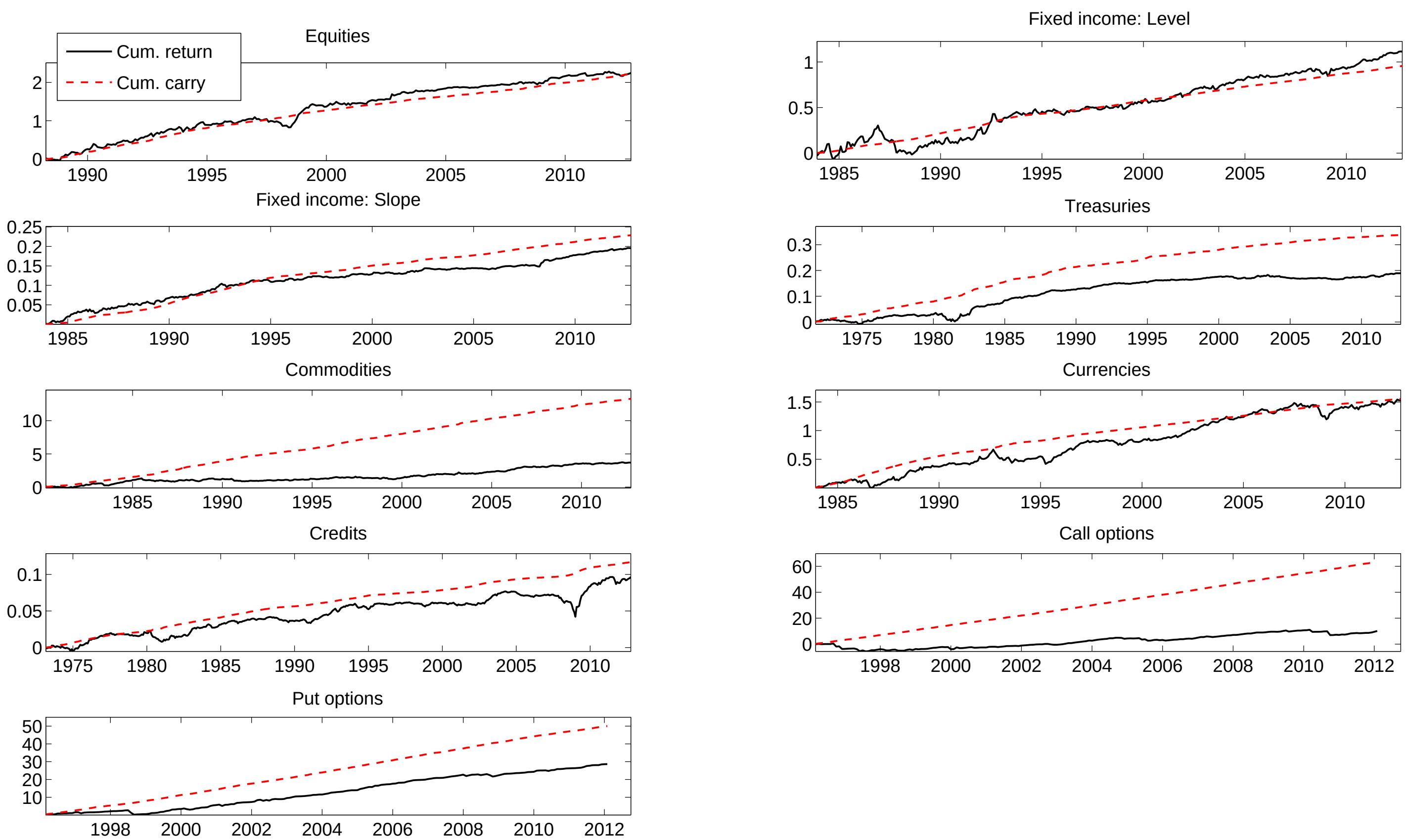

Figure III: **Global Carry Strategies: Cumulative Return and Cumulative Carry.** The figure shows, for each asset class, the cumulative sum of the excess returns of the long-short carry portfolio. Also, the figure shows the cumulative carry (that is, cumulative return if prices stay the same over each month) of the carry trade. The difference between the return and the carry is the realized price appreciation of the long versus short positions. A cumulative return below the cumulative carry indicates that the market "takes back" part of the carry, otherwise the carry investor earns capital appreciation in addition to the carry. The sample period is 1972 to September 2012.