Carry*

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Abstract

A security's expected return can be decomposed into its "carry" and its expected price appreciation, where carry can be measured in advance without an asset pricing model. We find that carry predicts returns both in the cross section and time series for a variety of different asset classes that include global equities, bonds, currencies, and commodities, as well as within US Treasuries, credit, and equity index options. This predictability underlies the strong returns to "carry trades" that go long high-carry and short low-carry securities, which have been applied almost exclusively to currencies. Decomposing carry returns into static and dynamic components, we investigate the nature of this predictability across asset classes. We identify "carry downturns"—when carry strategies across all asset classes do poorly—and show that these episodes coincide with global recessions and liquidity crises.

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

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We decompose a security's expected return into its "carry", which is observable ex ante and model-free, and its expected price appreciation. We define an asset's "carry" as its expected return assuming its price does not change. For any asset,

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

where the expected return is the carry on the asset plus its expected price appreciation. Using this concept of carry, we unify and extend the set of predictors of returns across a variety of assets that include global equities, bonds, commodities, and currencies. While the concept of "carry" has been applied almost exclusively to currencies, where it simply represents the interest rate differential between two countries, equation (1) shows that carry is a more general phenomenon that can be applied to any asset.

We decompose a security's return into its carry plus its price appreciation across a broad set of assets. Carry is a model-free measure of a component of expected returns that can be *observed directly*, whereas the part of the expected return coming from expected price appreciation must be estimated from a model. Carry is therefore a measurable characteristic of a security that we examine in relation to its expected return for a variety of different assets.

This simple measure of a component of expected returns provides a unifying framework for return predictability across asset classes. First, we find that carry is closely and positively related to total expected returns in each of the major asset classes we study. Since carry varies over time and across assets, this result implies that expected returns vary through time and can be predicted by carry. Second, carry provides a unified framework for understanding well-known predictors of returns across global asset classes. For instance, we show how carry in bonds is very much related to the slope of the yield curve used in the bond literature, how carry in commodities is related to the convenience yield, and how carry is a forward looking measure related to dividend yields in equities.[1] However, carry is also somewhat different than these measures, and we find empirically that the predictability of carry is sometimes stronger than that of these traditional predictors. Hence, carry not only provides a unified conceptual framework for thinking about these traditional predictors, but may also improve upon return predictability within each asset class. Finally, because carry is a general concept, we also apply it to other asset markets that have not been extensively studied for return predictability. We examine the cross-section of US Treasuries across maturities, US credit portfolios, and US equity index

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

options across moneyness and find equally strong predictability from our carry measure in each of these markets, highlighting the generalizability and predictability of carry.

While we find consistent and ubiquitous evidence that carry predicts total expected returns, economic theory is ambiguous about the nature of the relation between carry and total expected returns. For example, an asset's carry can change even when expected returns are constant, where carry is being offset by an equal but opposite-signed expected price appreciation. Carry could also be positively related to expected price appreciation, amplifying its relation to expected returns. Or, carry could be negatively related to total expected returns, depending upon the strength and nature of its relation with expected price appreciation/depreciation. We show empirically that carry is closely and positively related to expected returns in each of the major asset classes we study, and since carry varies over time, this result implies that expected returns vary through time and are predicted by carry.

We start by analyzing "carry trades" in each asset class, which go long high carry securities and short low ones. The sample periods we consider differ across asset classes—the longest (shortest) for commodities (government bonds)—but in all cases the sample contains more than 20 years of data. We find that a carry trade within each asset class earns an annualized Sharpe ratio between 0.6 to 0.9, and a portfolio of carry strategies across all asset classes earns a Sharpe ratio of 1.5. This evidence suggests a strong cross-sectional link between carry and expected returns, as well as diversification benefits from applying carry more broadly across different asset classes. The enormous Sharpe ratio from the portfolio of carry strategies across all asset classes presents a significantly greater challenge for asset pricing models that already struggle to explain the equity premium and many stock market strategies such as value and momentum. This Sharpe ratio represents an even higher hurdle for asset pricing models to meet (see Hansen and Jagannathan (1997)).

In addition, by studying multiple asset classes at the same time, we provide some out-of-sample evidence of existing theories, as well as some guidance for new theories to be developed on what might be driving carry returns. The common feature we highlight is that all carry strategies produce high Sharpe ratios. However, the crash risk commonly documented for currency carry trades (Brunnermeier, Nagel, and Pedersen (2008)) is largely absent in other asset classes. Moreover, a diversified carry strategy across all asset classes does not exhibit negative skewness. Hence, theories of carry return premia being compensation for crash risk do not appear to hold in other asset classes or generally in a diversified carry strategy.

The question remains whether other risks inherent in carry strategies extend across asset classes at the same time and whether the high average returns to carry strategies are compensation for those risks. We examine the extent to which the time-varying risk premia we find linked to carry are driven by macroeconomic risk (Lucas (1978), Campbell and Cochrane (1999), Bansal and Yaron (2004)), market liquidity risk (Pastor and Stambaugh (2003) and Acharya and Pedersen (2005)) or funding liquidity risk (Brunnermeier and Pedersen (2009), Gârleanu and Pedersen (2011)).

We decompose the returns to carry in each asset class into a passive and a dynamic component to better understand the return premia associated with carry. The passive component is due to being long (short) on average high (low) unconditional expected return securities and the dynamic component captures how well carry predicts future price appreciation. We find that the dynamic component contributes to most of the returns to the equity carry strategy, a little more than half of the returns to the bond carry strategy, and about half of the returns to the currency and commodity carry strategies. The substantial dynamic component in every asset class indicates that carry fluctuates over time and across assets, and that these fluctuations are associated with variation in expected returns.

We then consider a series of predictive regressions of future returns of each asset on its carry, and also find strong evidence of time-varying risk premia, where carry predicts future returns with a positive coefficient in every asset class. However, the magnitude of the predictive coefficient differs across asset classes and identifies whether carry is positively or negatively related to future price appreciation. For equities, carry positively predicts future price appreciation and thus enhances expected returns beyond the carry itself. The same is true for bonds, but to a lesser extent. For currencies and commodities, carry has no additional predictability for future price appreciation. These results are consistent with those from the static/dynamic decomposition, where asset classes with the greatest return predictability from carry derive the bulk of their carry trade profits from dynamic trading.

We then investigate how carry and the returns to carry vary with macroeconomic business cycle risk and liquidity risk, and whether the dynamic or static component of carry returns is more sensitive to these risks. Despite the very high Sharpe ratios of our carry strategies, we find that they are far from riskless and exhibit sizeable declines that occur simultaneously across asset classes, for extended periods of time. Examining the carry strategy's downside returns across asset classes, we find they coincide with plausibly bad aggregate states of the global economy. For example, carry returns tend to be low during global recessions, and this feature appears to hold uniformly across markets.

Flipping the analysis around, we also identify the worst and best carry return episodes for the global carry strategy applied across all asset classes, which we term carry "downturns" and "expansions." We find that the three biggest global carry downturns (September 1992 to December 1992, May 1997 to September 1998, and November 2007 to January 2009) coincide with major global business cycle and macroeconomic events and are also characterized by lower levels of global liquidity. Reexamining each individual carry strategy within each asset class, we further find that individual carry strategies in each asset class separately do poorly during these times as well. Specifically, we find that during carry downturns, equity, currency (except Asia) and commodities markets do poorly, while fixed income markets do well. Carry strategies therefore appear risky since they are long equity, currency, and commodity markets that decline more during these episodes and are short the securities that decline less during these times. For fixed income, the opposite is true as fixed income does well overall during carry downturns. Hence, part of the return premium earned on average for going long carry may be compensation for this exposure that generates large losses during extreme times of global recessions and liquidity crunches.

Our work relates to the extensive literature on the currency carry trade and the associated failure of uncovered interest rate parity.[2] Recently, several theories have been put forth to explain the currency carry trade premium. Brunnermeier, Nagel, and Pedersen (2008) show that the currency carry trade is exposed to liquidity risk, which is enhanced by occasional crashes that could lead to slow price adjustments. Bacchetta and van Wincoop (2010) present a related explanation based on infrequent revisions of investor portfolio decisions. Lustig and Verdelhan (2007) suggest that the currency carry trade is exposed to consumption growth risk from the perspective of a U.S. investor and Farhi and Gabaix (2008) develop a theory of consumption crash risk (see also Lustig, Roussanov, and Verdelhan (2010)).

Our study offers a much broader concept of carry that not only captures the currency carry trades focused on in the literature, but also an array of assets from many different asset classes. We highlight the characteristics that are unique and common across these asset classes that may help identify explanations for the carry return premium. For example, the crashes that characterize currency carry trades and are prominent features of models seeking to explain currency carry returns, are unique to currencies and are not exhibited in the carry trades of other asset classes. While this may possibly be linked to currency carry trades also having the most significant funding liquidity risk exposure, it also indicates that this feature is not a robust explanation for carry strategies in general

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

outside of currencies.

Our study also relates to the literature on return predictability that seems to be somewhat segmented across asset classes. In addition to the currency literature above, the literature on bonds has its own set of predictors, as do commodities, and equities.[3] We show that many of these seemingly different and unrelated variables are in fact related and can be captured by our simple concept of carry. Moreover, using this unifying concept of carry, we also identify similar return patterns in markets not previously explored along this dimension: US Treasuries, US credit, and US equity index options. These additional asset classes are also shown to be linked to international equities, bonds, currencies, and commodities through carry. This unifying framework allows us to study carry jointly across markets to understand how carry returns behave simultaneously across markets and what features of carry are common across very different asset classes.

Our paper contributes to a growing literature on global asset pricing that analyzes mutiple markets jointly. Asness, Moskowitz, and Pedersen (2012) study cross-sectional value and momentum strategies within and across individual equity markets, country equity indices, government bonds, currencies, and commodities simultaneously. Moskowitz, Ooi, and Pedersen (2012) also document time-series momentum in equity index, currency, commodity, and bond futures that is distinct from cross-sectional momentum. Fama and French (2011) study the relation between size, value, and momentum in global equity markets across four major regions (North America, Europe, Japan, and Asia Pacific). By jointly studying different markets simultaneously, these papers help identify and rule out various explanations for the existence of return premia globally across markets. Our joint approach to carry seeks to do the same, and offers a new set of related results in markets not previously studied that are all linked by the simple concept of carry.

The remainder of the paper is organized as follows. Section 1 defines carry and how it relates to expected returns and how we measure carry for each asset class. Section 2 describes the data and the returns of carry strategies globally across asset classes. Section 3 analyzes the predictability of carry for returns, including the dynamic

[3] 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). All of these studies focus on a single asset class or market at a time and ignore how different asset classes or markets behave simultaneously.

and static components of a carry trade and the relation between carry and expected price appreciation. Section 4 investigates how carry relates to global business cycle and liquidity risk. Section 5 applies the concept of carry to asset classes not previously studied. Section 6 concludes.

1 Understanding Carry: A Characteristic of Any Asset

We decompose the return to any security into the security's carry and its price appreciation. The carry return can be thought of as the return to the security assuming prices stay constant, and is therefore often easy to observe in advance. We detail below the decomposition of different securities' returns into carry versus price appreciation across four diverse asset classes: currencies, equities, bonds, and commodities. Since we examine futures contracts across these various asset classes, it is instructive to consider the carry of a futures contract in general, which we can then apply across different asset classes.

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

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

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

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

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

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

For most of our analysis, we compute returns and carry based on a "fully-collateralized" position, meaning that the amount of capital allocated to the position is equal to the futures price, $X_t = F_t$.[4]

The carry of a fully-collateralized position is naturally

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

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

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

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

We see that the 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 the discount rate, including risk premia, applied to future cash flows. 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 model or stochastic discount factor. Put differently, carry is a simple observable characteristic, which is a component of the expected return on an asset. Further, carry may be relevant for predicting expected price changes which also contribute to the expected return on an asset. That is, C_t may also provide information for predicting $E_t(\Delta S_{t+1}/F_t)$, which we investigate empirically in the paper.

We next discuss in more detail how to interpret the carry for the asset classes we study. Applying this general approach to carry for each specific asset class provides a unifying framework for carry and its link to risk premia. The rest of the paper explores these relations empirically.

1.1 Currency Carry

We begin with the classic carry trade studied in the literature—the currency carry trade—which is a trade that goes long high carry currencies and short low carry currencies. For

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

a currency, the carry is simply the local interest rate in the corresponding country. For instance, investing in a currency by literally putting cash into a country's money market earns the interest rate if the exchange rate (the "price of the currency") does not change.

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

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

The carry of investing in a forward in the foreign currency is the interest-rate spread, $r^{f*} - r^f$, adjusted for a scaling factor close to one, $(1 + r_t^f)^{-1}$. The carry is the foreign interest rate *in excess* of the local risk-free rate r^f because the forward contract is a zero-cost instrument whose return is an excess return. (The scaling factor simply reflects that a currency exposure using a futures contract corresponds to buying 1 unit of foreign currency in the future, which corresponds to buying $(1 + r_t^f)^{-1}$ units of currency today. The scaling factor could be eliminated if we changed the assumed leverage, that is, the denominator in the carry and return calculations.)

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 (2006)), liquidity risk (Brunnermeier, Nagel, and Pedersen (2008)), and country size (Hassan (2011)), where a country with more exposure to consumption or liquidity risk could have both a high interest rate and a cheaper exchange rate.

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

1.2 Global Equity Carry

For equities, carry is simply the expected dividend yield. If stock prices and dividends do not change, then the return on equities comes solely from dividends—hence, carry is the dividend yield today.

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

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

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

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

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

If expected returns do vary, then it is natural to expect carry to be positively related to expected returns: If a stock's expected return increases while dividends stay the same, then its price drops and its dividend yield increases. Hence, a high expected return leads to a high carry. Indeed, this discount-rate mechanism follows from standard macro-

[5] Binsbergen, Brandt, and Koijen (2012) and Binsbergen, Hueskes, Koijen, and Vrugt (2010) 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.

finance models, such as Bansal and Yaron (2004), Campbell and Cochrane (1999), Gabaix (2009), Wachter (2010), and models of time-varying liquidity risk premia (Acharya and Pedersen (2005), Brunnermeier and Pedersen (2009), Gârleanu and Pedersen (2011)). We investigate in the next section the relation between carry and expected returns for each asset class and whether these relations are consistent with theory. We also discuss in Section 5 the link with the standard dividend yield that sums a year of dividends and divides it by the current price (Fama and French (1988)) and our measure for the equity carry.

1.3 Commodity Carry

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

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

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

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

where we divide by $T_2 - T_1$ to compute the carry on a per-month basis. Following Equation (10), we can simply use data from the futures markets—specifically, the slope of the futures curve—to get a measure of carry that captures the convenience yield.[6]

1.4 Global Fixed Income Carry

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

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

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

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

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

including coupon payments next period is,

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

Hence, the carry is

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

The carry on a funded position (the carry in excess of the short-term risk-free rate) is then the term spread:

$$C_t = y_t^T - r_t^f. \quad (14)$$

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

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

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

To be consistent with the other asset classes, we would like to compute the bond carry using futures data. Unfortunately, liquid bond futures contracts are only traded in a few countries and, when they exist, there are often very few contracts (often only one). Further complicating matters is the fact that different bonds have different coupon rates and the futures price is subject to cheapest-to-deliver options. To simplify matters and create a broader global cross-section, we derive synthetic futures prices based on data on zero-coupon rates as follows.[7]

We want to compute the carry of a synthetic one-month futures. Hence, consider a futures contract that gives the obligation to buy a 9-year-and-11-months zero-coupon bond in one month from now. The current price of this one-month futures is $F_t = (1+r_t^f)/(1+y_t^{10Y})^{10}$, where y_t^{10Y} is the current yield on a 10-year zero-coupon bond. (This expression for the futures price follows from that fact that the futures payoff can be replicated by buying a 10-year bond.) The current "spot price" is naturally the current price of a 9-year-and-11-month zero-coupon bond, $S_t = 1/(1+y_t^{9Y11M})^{9+11/12}$. Hence, the carry using the standard formula is given by

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

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

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

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

1.5 Carry: A Broad Framework

We define carry as the return if the nominal price stays the same. However, as is the case for bond carry, it is sometimes necessary to decide *which* price is assumed constant (e.g., the price of the bond or the yield curve?). Further, one could alternatively compute carry as the return if the *real* (i.e., inflation-adjusted) price stays constant. For example for currencies, if we define carry as the return if the real exchange rate stays the same, it is straightforward to see that a currency's carry is its real interest rate. Hence, carry can be viewed broadly as a framework for computing a simple, observable, measure of the income an investor receives if market conditions stay constant, however defined. We focus on a consistent definition of carry based on futures prices for all asset classes because it mitigates estimation issues, but we provide several other examples in Section 5 based on different cross-sections of assets that do not use futures contracts.

Appendix A also shows that the same carry measures can be used for foreign-denominated futures contracts assuming the currency risk is hedged, as we do empirically.

[7] For countries with actual, valid bond futures data, the correlation between actual futures returns and our synthetic futures returns is greater than 0.95.

1.6 The Carry of a Portfolio

We compute the carry of a portfolio of securities as follows. Consider a set of securities indexed by $i = 1, ..., N_t$, where N_t is the number of available securities at time t. Security i has a carry of C_t^i computed at the end of month t and that is related to the return r_{t+1}^i over the following month $t + 1$. Letting the portfolio weight of security i be w_t^i, the return of the portfolio is naturally the weighted sum of the returns on the securities, $r_{t+1} = \sum_i w_t^i r_{t+1}^i$. Similarly, since carry is also a return (under the assumption of no price changes), the carry of the portfolio is simply computed as,

$$C_t^{portfolio} = \sum_i w_t^i C_t^i. \tag{18}$$

1.7 Defining a Carry Trade Portfolio

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

$$w_t^i = z_t \left(\text{rank}(C_t^i) - \frac{N_t + 1}{2} \right), \tag{19}$$

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

By construction, the carry trade portfolio always has a positive carry itself. The carry of the carry trade portfolio is equal to the weighted-average carry of the high-carry securities minus the average carry among the low-carry securities:

$$C_t^{\text{carry trade}} = \sum_{w_t^i > 0} w_t^i C_t^i - \sum_{w_t^i < 0} |w_t^i| C_t^i > 0. \tag{20}$$

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

2 Carry Trade Returns Across Asset Classes

Following Equation (19), we construct carry trade portfolio returns for each asset class as well as across all the asset classes we examine. First, we briefly describe our sample of securities in each asset class and how we construct our return series, then we consider the carry trade portfolio returns within and across the asset classes and examine their performance over time.

2.1 Data and Summary Statistics

Appendix B details the data sources we use for the country equity index futures, currency forward rates, commodity futures, and synthetic bond futures returns (as described above). Table 1 presents summary statistics for returns and the carry for each of the instruments we use, including the starting date for each of the series.

There are 13 country equity index futures: the U.S. (S&P 500), Canada (S&P TSE 60), the UK (FTSE 100), France (CAC), Germany (DAX), Spain (IBEX), Italy (FTSE MIB), The Netherlands (EOE AEX), Norway (OMX), Switzerland (SMI), Japan (Nikkei), Hong Kong (Hang Seng), and Australia (S&P ASX 200).

There are 20 foreign exchange forward contracts covering the period November 1983 to February 2011 (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 currency return is, by definition, equal to zero.

The commodities sample covers 24 commodities futures dating as far back as January 1980 (through February 2011). 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.

Finally, the fixed income sample covers 10 government bonds starting as far back as November 1991, but beginning in January 1995 for most countries, through February 2011. Bonds exhibit the least cross-sectional variation across markets, but there is still substantial variation in average returns and volatility across the markets.

2.2 Carry Trade Portfolio Returns within an Asset Class

For each global asset class, we construct a carry strategy that invests in high-carry securities while short selling low-carry instruments, where each instrument is weighted by the rank of its carry and the portfolio is rebalanced each month end following equation (19).

We consider two measures of carry: (i) The "current carry", which is measured at the end of each month, and (ii) "carry1-12", which is a moving average of the current carry over the past 12 month ends (including the most recent one). We include carry1-12 because of potential seasonal components that can arise in calculating carry for certain assets. 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. Averaging over the past year helps eliminate the potential influence of these seasonal components. Fixed income (the way we compute it) and currencies do not exhibit much seasonal carry pattern, but we also consider strategies based on both their current carry and carry1-12 for robustness. Table 1 also reports the mean and standard deviation of the carry for each asset, which range considerably across assets within an asset class (especially commodities) and across asset classes.

Table 2 reports the annualized mean, standard deviation, skewness, excess kurtosis, and Sharpe ratio of the carry strategies within each asset class. For comparison, the same statistics are reported for the returns to a passive long investment in each asset class, which is just an equal weighted portfolio of all the securities in each asset class. The sample period for equities is March 1988 to February 2011, for fixed income it is November 1991 to February 2011, for commodities it is February 1980 to February 2011, and for currencies it is November 1983 to February 2011.

Table 2 indicates that all the carry strategies in all asset classes have significant positive returns. Using current carry, the average returns range from 5.1% for the fixed income trade to 11.7% for the commodity carry trade. Using carry1-12, the average returns range from 3.0% for the fixed income carry trade to 13% for the commodity carry trade. Sharpe ratios for the current carry range from 0.62 in commodities to 0.93 for equities and for carry1-12 they range from 0.48 in bonds to 0.67 in commodities. The current carry portfolio exhibits stronger performance than carry1-12 for equities,[8] bonds, and slightly for currencies, which may reflect that more timely data provides more predictive power

[8]This suggests that expected returns may vary over the dividend cycle, which can potentially be tested more directly using dividend futures as in Binsbergen, Hueskes, Koijen, and Vrugt (2010).

for returns. However, for commodities, carry1-12 performs better, which may be due to the strong seasonal variation in commodity carry that is not necessarily related to returns.

The robust performance of carry strategies across asset classes indicates that carry is an important component of expected returns. The previous literature focuses on currency carry trades, finding similar results to those in Table 2. However, we find that a carry strategy works at least as well in other asset classes, too. In fact, the current carry strategy performs markedly better in equities and fixed income than currencies, and the carry1-12 strategy performs slightly better in equities and commodities than currencies. Hence, carry is a broader concept that can be applied to many assets in general and is not unique to currencies.[9]

Both the current carry and carry1-12 portfolios also seem to outperform a passive investment in each asset class. For example, in equities, the Sharpe ratio of a passive long position in all equity futures is only 0.37, compared to 0.93 for the current carry strategy and 0.61 for the carry1-12 strategy. In commodities, the passive portfolio delivers only a 0.10 Sharpe ratio, while the carry portfolios achieve 0.62 and 0.67 Sharpe ratios, respectively. Consistent with the literature, currency carry strategies also outperform a passive investment in currencies. For fixed income, the carry strategy appears to perform about the same as a passive long investment. However, these comparisons are misleading because the beta of a carry strategy is typically close to zero. As we show below, the alphas of the carry strategies with respect to these passive benchmarks are all consistently and significantly positive, even for fixed income.

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). However, negative skewness is not a feature of carry trades in other asset classes, such as equities and fixed income. Commodity carry portfolios seem to exhibit some negative skewness, but not as extreme as currencies. Hence, the "crashes" associated with currency carry trades do not seem to be as strong a feature in carry trades in other asset classes. Thus, explanations for the return premium to carry trades in currencies that rely on crash risk may not be suitable for explaining return premia to carry in other asset classes. All carry portfolios in all asset classes seem to exhibit excess kurtosis, however.

Figure 2 plots the cumulative monthly returns to each carry strategy in each asset class over their respective sample periods. The currency carry trade "crashes" are evident on the graphs, but there is less evidence for sudden crashes among carry strategies in

[9]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).

other asset classes. In addition, the graphs also plot the cumulative carry itself, which represents the component of the carry portfolios' expected return that is observable ex ante and would comprise the total expected return if underlying spot prices remained constant. Hence, the difference between the two lines on each graph represents the component of expected returns to the carry trade that come from price appreciation. In the next section, we investigate in more detail the relationship between carry, expected price changes, and total expected returns.

2.3 Diversified Carry Trade Portfolio

Table 2 also reports the performance of a diversified carry strategy across all asset classes, which is constructed as the equal-volatility-weighted average of carry portfolio returns across the asset classes. Specifically, we weight each asset classes' carry portfolio by the inverse of its sample volatility so that each carry strategy in each asset class contributes roughly equally to the total volatility of the diversified portfolio. This procedure is similar to that used by Asness, Moskowitz, and Pedersen (2012) and Moskowitz, Ooi, and Pedersen (2012) to combine returns from different asset classes with very different volatilities. Since commodities have roughly two to three times the volatility of fixed income, a simple equal-weighted average of carry returns across asset classes will have its variation dominated by commodity carry risk and under-represented by bond carry risk. Volatility-weighting the asset classes into a diversified portfolio gives each asset class more equal representation.

As the bottom of Table 2 reports, the diversified carry trade based on the current carry has a remarkable Sharpe ratio of 1.49 per annum and the diversified carry1-12 portfolio has an impressive 0.95 Sharpe ratio. A diversified passive long position in all asset classes produces only a 0.75 Sharpe ratio. These numbers suggest carry is a strong predictor of expected returns globally across asset classes. Moreover, the substantial increase in Sharpe ratio for the diversified carry portfolio relative to the individual carry portfolio Sharpe ratios in each asset class, indicates that the correlations of the carry trades across asset classes are quite low. Hence, sizeable diversification benefits are obtained by applying carry trades universally across asset classes.

Table 3 reports the correlations of carry trade returns across the four asset classes. Except for the correlation between currency carry and bond carry, the correlations are all very close to zero, and even for bonds and currencies, the correlation of their carry returns is only 23%. The low correlations among carry strategies in other asset classes not only lowers the volatility of the diversified portfolio substantially, but also mutes the negative skewness associated with currency carry trades and mitigates the excess kurtosis associated with all carry trades. In fact, the negative skewness and excess kurtosis of the diversified portfolio of carry trades is smaller than those of the passive long position diversified across asset classes. Hence, the diversification benefits applying carry across asset classes seem to be larger than those obtained from investing passively long in the same asset classes. The magnitude of the Sharpe ratios of the diversified carry strategy presents a daunting challenge for current asset pricing models that already struggle to explain the significantly smaller Sharpe ratios typically examined within a single asset class (e.g., currencies). A diversified carry portfolio across asset classes is also less prone to crashes, which also challenges risk-based stories.

2.4 Risk-Adjusted Performance and Exposure to Other Factors

Table 4 reports regression results for each carry portfolio's returns in each asset class on a set of other portfolio returns or factors.

For both the current carry and carry1-12 portfolios in each asset class, we regress the time series of their returns on the passive long portfolio returns (equal-weighted average of all securities) in each asset class, the value and momentum "everywhere" factors of Asness, Moskowitz, and Pedersen (2012), which are diversified portfolios of value and cross-sectional momentum strategies in global equities, equity indices, bonds, commodities, and currencies, and the time-series momentum (TSMOM) factor of Moskowitz, Ooi, and Pedersen (2012) which is a diversified portfolio of time-series momentum strategies in futures contracts in the same asset classes we examine here for carry.

Panel A of Table 4 reports both the intercepts or alphas from these regressions as well as the betas on the various factors to evaluate the exposure of the carry trade returns to these other known strategies or factors. The first two columns of each panel of Table 4 report the results from regressing the carry trade portfolio returns in each asset class (both for the current carry, "CC," and for the carry1-12, "C1-12," strategies) on the equal-weighted passive index for that asset class (e.g., CAPM for the asset class). The alphas for every carry strategy in every asset class are positive and statistically significant, 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. Examining the betas of the carry portfolios on the local market index for each asset class, we see that the betas are not significantly different from zero. Hence, carry strategies provide sizeable return premia without much market exposure to the asset class itself. The last two rows of each panel of Table 4 report the R^2 from the regression and the information ratio, IR, which is the alpha divided by residual volatility from the regression, of each carry strategy. The IRs are quite large, reflecting high risk-adjusted returns to carry strategies even after accounting for its exposures to standard risk factors.

Looking at the value and momentum everywhere and time-series momentum factor exposures we find mixed evidence across the asset classes. For instance, in equities, we find that carry strategies have a positive value exposure, but no momentum or time-series momentum exposure. The positive exposure to value reduces the alpha slightly, especially for carry1-12, but the remaining alpha and information ratio are still 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 more that 25% when the value and momentum everywhere 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 alphas diminish by about 20-30 basis points per month, but remain economically large and statistically significant. Finally, for both fixed income and currency carry strategies, there is no reliable loading of the carry strategies' returns on value, momentum, or time-series momentum (except current carry for bonds seems to have a negative loading on TSMOM), and consequently the alphas of bond and currency carry portfolios remain significant.

The regression results in Table 4 only highlight the average exposure of the carry trade returns to these factors. However, these may mask significant dynamic exposures to these factors. To see if the risk exposures vary significantly over time, Figure 3 examines the variation over time in the carry portfolio's returns to the market by plotting the three-year rolling correlations (using monthly returns data) of each carry trade's returns with the passive portfolio for that asset class. As the figure shows, the carry trade's correlation to the market in all asset classes varies significantly over time, perhaps most evident for currencies. Although on average the market exposure of each carry trade is insignificantly different from zero, there are times when the carry trade in every asset class has significant positive exposure to the market and other times when it has significant negative market exposure. We further explore the dynamics of carry trade positions in the following section.

3 How Does Carry Relate to Expected Returns?

In this section we investigate further how carry relates to expected returns and the nature of carry's predictability for future returns. We begin by decomposing carry trades into static and dynamic components.

3.1 Does the Market Take Back Part of the Carry?

The significant returns to the carry trade indicate that carry is indeed a signal of expected returns. However, to better understand the relation between carry and expected returns it is instructive to go back to equation (1), which decomposes expected returns into carry and expected price appreciation. To do this formally, we run the following panel regression for each asset class:

$$r^i_{t+1} = a^i + b_t + cC^i_t + \varepsilon^i_{t+1}, \tag{21}$$

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.

To interpret this regression, we note that there are several interesting hypotheses to consider. First, $c = 0$ means that carry does not predict returns, consistent with a generalized notion of the "expectations hypothesis." Second, $c = 1$ means that the expected return moves one-for-one with carry. While $c = 0$ means that the total return behaves like a random walk, $c = 1$ means that the price (not including carry) is a random walk. Third, $c \in (0, 1)$ means that a high carry is associated with a low expected price appreciation such that the market "takes back" part of the carry, but not all. Fourth, $c > 1$ means that a high carry is associated with a high expected price appreciation so that you get your carry and price appreciation too. Lastly, $c < 0$ implies that the price appreciation/depreciation more than offsets the effect of the carry.

Table 5 reports the results for each asset class, for current carry and carry1-12, and 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 (21) represents the predictability of returns to carry coming purely from variation in carry.

The results in Table 5 indicate that carry is a strong predictor of expected returns, with consistently positive and statistically significant coefficients on carry, save for the current carry commodity strategy, which may be tainted by strong seasonal effects in carry for commodities. The carry1-12 strategy, which mitigates seasonal effects, is a ubiquitously positive and significant predictor of returns, even in commodities.

Focusing on the magnitude of the predictive coefficient, Table 5 shows that the point estimate of c is greater than one for equities and fixed income, and smaller than one for commodities and around one for currencies (depending on whether fixed effects are included). These results imply that for equities, for instance, when the dividend yield is high, not only is an investor rewarded by directly receiving large dividends (relative to the price), but also equity prices tend to appreciate more than usual. Hence, expected stock returns appear to be comprised of both high dividend yields and additionally high expected price appreciation. Similarly for fixed income securities, buying a 10-year bond with a high carry provides returns from the carry itself (i.e., from the yield spread over the short rate and from rolling down the yield curve), and, further, yields tend to drop, not rise, leading to additional price appreciation. The is somewhat surprising as the expectations hypothesis suggests that a high term spread implies short and long rates are expected to increase, but this is not what we find. However, these results must be interpreted with caution as the predictive coefficient is not statistically significantly different from one in all but a few cases.

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

For commodities, the predictive coefficient is significantly less than one, so that when a commodity has a high spot price relative to its futures price, implying a high carry, the spot price tends to depreciate on average, thus lowering the realized return on average below the carry.

Looking back at Figure 2, which plots the carry trades' cumulative returns and their cumulative carries, the difference between the two return series highlights the relation between carry and expected returns. Since carry is similar to a return (namely, it is the hypothetical return if the price does not change), the cumulative carry can be computed and interpreted just like any cumulative return. For simplicity, we compute the cumulative returns and cumulative carry by summation: for instance, the cumulative carry at time t

is computed as $\sum_{\tau=1}^{t} C_\tau$. Consistent with the regression results in Table 5, the cumulative carry is greater than the cumulative return for equities and fixed income, carry is similar to returns for currencies, and carry is substantially lower than returns for commodities. These plots indicate that carry "under-predicts" returns on average in equities and fixed income, "over-predicts" in commodities, and neither really over- or under-predicts in currencies.

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

Finally, for robustness, Table C in the appendix shows the results from similar predictive regressions where the value of each security's carry is replaced by its cross-sectional rank (scaled by the number of securities N_t) to rely less on the magnitude of the carry. More specifically, we consider the following panel regression:

$$r_{t+1}^i = a^i + b_t + c\frac{\text{rank}(C_t^i)}{N_t} + \varepsilon_{t+1}^i. \tag{22}$$

The predictive power of these rank-based carry weights is even stronger than the carry itself, particularly for commodities, which provides the weakest results when using the magnitude of the carry to weight securities. However, the drawback of using rank-based carry weights is that the magnitudes of the coefficients from these regressions are more difficult to interpret. The additional predictive power we get from using ranks instead of the magnitude of the carry itself may be due to the benefits of trimming outliers in measured carry. This explanation is consistent with the biggest improvement coming for commodities, where their seasonal components and their heterogeneity likely generate the most noisy carry measures. On the other hand, the stronger predictive power of ranks may also indicate that a very large value of the carry is not associated with a commensurately high expected return, an issue we study further below.

3.2 How Far Into the Future Does Carry Predict Returns?

It is also interesting to consider how far into the future carry predicts returns. To address this question, we run the following regression

$$r^i_{t+1} = a^i + b_t + cC^i_{t+1-k} + \varepsilon^i_{t+1}, \tag{23}$$

where we consider carry with $k = 1$ as well as lagged values of the carry for $k = 3, 6, 12$, and 24. Figure 4 reports the regression coefficients and their 95%−confidence intervals. We include both asset and time fixed effects and use the carry1-12.

All of the coefficients for the most recent value of carry are significantly positive, consistent with the results in Table 5 and, in most cases, the predictive strength of carry declines over the course of one year. Hence, carry's predictive power for returns seems to extend to about a year before dissipating for every asset class.

The fact that carry predicts returns only for a relatively short time period suggests that a carry trade portfolio changes frequently and that a large part of the return comes from this dynamic rebalancing, consistent with our previous results. We next study in more detail the importance of this dynamic return component relative to the passive component.

3.3 Does the Carry of the Carry Trade Predict Returns?

Table 6 reports how the carry of the carry trade predicts the returns of the carry trade. Specifically, we report results from the following regression

$$r^{\text{carry trade}}_{t+1} = a + bC^{\text{carry trade}}_t + \varepsilon^i_{t+1}, \tag{24}$$

where $r^{\text{carry trade}}_t$ is the return of the carry trade and $C^{\text{carry trade}}_t$ is the carry of the carry trade portfolio at time t. As Table 6 reports, the carry of the carry trade does not predict the returns to the carry trade, except marginally in equities. Hence, while carry predicts returns in general, such that the carry trade makes money on average in all asset classes, it does not appear to be the case that a larger spread in the carry itself is associated with larger expected returns. That is, timing the carry strategy using the size of the carry itself does not seem to yield much predictive power.[10,11]

Table 6 also shows how the average carry in each asset class predicts the return to the passive long position in each asset class. This is similar to the panel regression of equation (21), with the exception that it only relies on time series information for a single diversified portfolio, whereas the previous regressions used all the information from all the securities as well as their cross-sectional differences. The point estimates of the predictive coefficients for the passive index in each asset class are positive, but are significant only for equities and currencies.

4 How Risky Are Carry Strategies?

In this section we investigate whether the high returns to carry strategies compensate investors for certain risk factors.

4.1 Risk Exposure of Carry Strategies

A large and growing literature studying the currency carry strategy suggests that carry returns may compensate investors for crash risk, liquidity risk, US business cycle risk, or global volatility risk. By studying multiple asset classes at the same time, we provide some out-of-sample evidence of existing theories, as well as some guidance for new theories to be developed. The common feature we highlight is that all carry strategies produce high Sharpe ratios. However, the crash risk for currency carry appears to be unique to currencies, and does not extend to other asset classes. The question remains whether other risks inherent in carry strategies extend across asset classes at the same time and whether the high average returns to carry strategies can be plausibly explained as compensation for those risks.

To identify the risk in carry strategies, we focus on the global carry factor in which we combine all four carry strategies across all asset classes. We argue that the carry1-12

[10]This might be due to a non-linear effect, where a very large difference in carry across securities in an asset class might suggest that the higher-carry securities are exposed to risks or expected price depreciation. For instance, a currency under attack tends to have a high carry but may also have a low expected return. For example, when George Soros attacked the British pound in 1992, the Bank of England raised interest rates to defend the currency, thus making the pound a high-carry currency, but, as judged by Soros and other speculators, the expected return was still quite low, and, as it turned out, so was the realized return when the British Pound eventually plummeted.

[11]The results of the predictive regression may be weakened by the fact that certain contracts enter, and drop from, the sample, which may lead to breaks in the time series of the carry of the carry portfolio. Consistent with this view, we find that the carry of the carry portfolio predicts the Treasuries and credit carry returns in Section 5, for which the cross-section of contracts is stable over time.

strategy is more plausibly related to macro-economic risk than the current carry strategy, which moves at a higher frequency and is more susceptible to seasonal features. In the top panel of Figure 5 we plot the cumulative return on the global carry1-12 strategy. The bottom panel removes a linear time trend from the cumulative returns and plots the cyclical component of returns over time. We find that, despite the high Sharpe ratio, the global carry strategy is far from riskless and exhibits sizeable declines for extended periods of time.

Examining the carry strategy's downside returns, the most striking feature is that the downturns tend to coincide with plausibly bad aggregate states of the global economy, which we measure using a global recession indicator, which is a GDP-weighted average of the regional recession dummies. Global carry returns tend to be low during global recessions. The figure also indicates that the timing between real variables and asset prices differs per recession. Hence, it may not be best to focus on recessions as measured by the NBER methodology.

As an alternative approach, we identify what we call carry "downturns" and "expansions." We first compute the maximum draw-down of the global carry strategy, which is defined as:

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

where r_s denotes the return on the global carry1-12 strategy. The draw-down dynamics are presented in Figure 6. Three carry downturns stand out: September 1992 to December 1992, May 1997 to September 1998, and November 2007 to January 2009. The first period is identified as a recession in Continental Europe and Asia. The second period coincides with the Asian crisis. The third carry downturn, November 2007 to January 2009, coincides with the recent "Great Recession." This preliminary evidence suggests carry strategies are exposed to global business cycles.

To show that these downturns are indeed shared among all four asset classes, we further explore the return properties of the different asset classes in Table 7. The top panel reports average annualized returns on the current carry and the carry1-12 strategy for each asset class during carry downturns and carry expansions. For all strategies in all asset classes, the returns are lower during carry downturns. This implies that the downturns of the global carry factor are not particular to a single asset class.

The middle panel breaks the average returns down for each of the three downturns and for all strategies. The returns are below the average returns for 23 out of 24 cases. This evidence implies that carry downturns are bad periods for all carry strategies at the same time across all asset classes.

The bottom panel then illustrates that these are also periods in which global economic activity, as measured by the global recession indicator, slows down. During carry downturns, the average value of the global recession indicator equals 0.41 versus 0.17 during carry expansions. The difference is statistically significant at the 5%-significance level. We further show that carry downturns are characterized by lower levels of global liquidity as well. If we average global liquidity shocks (obtained from Asness, Moskowitz, and Pedersen (2012)) during carry downturns and carry expansions, we find that the average level of liquidity is lower during carry downturns. The difference is again significant at the 5%-significance level.

Figure 7 displays the drawdowns per carry strategy, based on the broad regions or groups, alongside the drawdown dynamics of the global carry factor. The shaded areas indicate the carry drawdowns identified before. The drawdown dynamics of the different strategies tend to coincide with the drawdown dynamics of the global carry factor, consistent with the evidence in Table 7. Furthermore, the figure highlights that there are severe drawdowns that are specific to a single asset class, such as in 2001 for equities and in 2003 for commodities.

To further illustrate that carry downturns correspond to bad aggregate states, we study the returns in all asset classes by five broad geographic regions and three broad groups of commodities during carry downturns and expansions. The results are summarized in Table 8. The average return for equities, currencies, and commodities are much lower during carry downturns. Fixed income returns, by contrast, are much higher, reflecting the fact that the yield curve tends to flatten during recessions. This implies that equally weighted strategies do poorly during carry episodes as well for equities, currencies, and commodities, while fixed income is a hedge.

At a more micro level, we see that for equities, commodities, and fixed income, this pattern emerges for each and every region or group. For currencies, the returns are lower for all regions, apart from Asia, where the Japanese Yen tends to appreciate during carry downturns. Carry strategies do poorly during these episodes as, for instance for equities, it is long the regions that decline most and short the regions that do not decline as much. This makes carry strategies risky bets on global business cycles.

4.2 Static and Dynamic Risk Exposure

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

The estimate of the expected return on a carry strategy can be written as:

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

where $w_{n,t}^{*} = w_{n,t}$ when the contract is available and $w_{n,t}^{*} = 0$ otherwise. N denotes the total number of contracts that are used at any point in the strategy (potentially at different points in time). We define the set of dates for which the weight at time t and the return at time $t+1$ are available for security n by $\mathcal{T}_n$. The number of observations for contract n are denoted by T_n. It then follows:

$$\begin{aligned} E\left(r_{p,t+1}\right) &= \sum_{n=1}^{N} \frac{T_n}{T} E^n\left(w_{n,t} r_{n,t+1}\right) \qquad (25) \\ &= \sum_{n=1}^{N} \underbrace{\frac{T_n}{T} E^n\left(w_{n,t}\right) E^n\left(r_{n,t+1}\right)}_{\text{Static component}} + \sum_{n=1}^{N} \underbrace{\frac{T_n}{T} E^n\left[\left(w_{n,t} - E^n\left(w_{n,t}\right)\right)\left(r_{n,t+1} - E^n\left(r_{n,t+1}\right)\right)\right]}_{\text{Dynamic component}}, \end{aligned}$$

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

Here, $E(w_{n,t})$ is the portfolio's "passive exposure" to asset i, while the "dynamic exposure" $w_{n,t} - E(w_{n,t})$ is zero on average over time, representing a timing strategy in the asset that goes long and short according to the asset's carry.

Table 9 reports the results of this decomposition, where we estimate the static and dynamic components of returns according to equation (26). For equities, the dynamic component comprises the entirety of the current carry trade's returns and 87% of the carry1-12 portfolio returns. The results for commodities, fixed income, currencies are less extreme, where a little more than half of the bond and commodities carry returns come from the dynamic component and for the currency carry returns the split between passive and dynamic components is approximately equal. Overall, carry trade returns appear to be due to both passive exposures and dynamic rebalancing, with some variation across asset classes in terms of the importance of these two components.

Lastly, we study whether the poor returns of carry strategies are the result of the passive or the dynamic component of carry strategies. For instance, for equities, are the poor returns driven by the fact that regions with a high average carry (and hence on average held long in the carry strategy) experience larger declines in their stock market during carry downturns? Or, does the carry shift during carry downturns such that carry strategies become risky during these bad aggregate states?

In Table 10, we decompose the return during carry expansions and downturns into the passive and dynamic components. We find that carry downturns are largely driven by the passive component, in particular for equities. Hence, hedging out the passive component of carry strategies could mitigate the impact of carry downturns.

5 What Is New About Carry?

In this paper, we generalize the concept of carry, typically only applied to currencies, and apply it to a broader set of assets that include global equities, global fixed income, and commodities, in addition to currencies. In addition, we also discuss how carry provides a unifying framework that synthesizes much of the return predictability evidence found in these other asset classes and mostly treated disjointly across those asset classes.

For example, we discuss how the concept of carry and our carry measures relate to standard predictor variables in each of the asset classes, such as the dividend yield for global equities, the yield spread for global fixed income, and the convenience yield for commodities. These predictors are typically treated as separate and unrelated phenomena in each asset class, but we show how carry provides a unifying characteristic that can capture much of this evidence and provides a related theme across all asset classes.

However, we also show that carry can be quite different from standard predictors and therefore adds to the predictability literature. For example, for global equities the carry is the expected dividend yield which can be quite different from the standard historical dividend yield.

In addition to unifying and extending the set of standard predictor variables, we also illustrate how the concept of carry provides useful predictor variables for other cross-sections of assets not previously examined. We focus on the cross-section of US Treasuries, the cross-section of US credit portfolios, and the cross-section of US index options. It may be interesting for future research to explore alternative carry strategies for different cross-sections of assets using the same concept of carry as we propose in this paper.

5.1 Link to Standard Predictor Variables

Global Fixed Income For fixed income, a standard predictor of bond returns in the time series is the yield spread (Fama and Bliss (1987) and Campbell and Shiller (1991)). As we show in Section 1, the fixed income carry equals the yield spread plus a roll-down component. To understand the importance of the roll-down component, we also compute the yield spread between the 10-year and 3-month bond yields. In our sample, the average (across countries) time-series correlation between the yield spread and the carry signal is 0.90. If we use the yield spread, instead of the carry, as a signal, the returns, not surprisingly, look very similar. The correlation between the returns generated from yield spreads and those from the current carry signal is 0.91 and for the carry1-12 signal is 0.95.

Global Equities For global equities, Section 1 shows that the carry signal approximately equals $C_t = E_t^Q (D_{t+1}) / S_t - r_t^f$, where r_t^f is the local short rate. Based on this insight, it appears that carry strategies sort countries on dividend yields and hence closely resemble a value strategy. We illustrate that the carry strategy is in fact quite different from a standard value strategy that sorts on dividend yields.

First, we show for the US equity market, using a long time series, that the dynamics of carry are different from the standard dividend yield. Second, we sort countries directly on the dividend yield rather than on carry. The resulting return series has a low correlation with our carry strategy.

To construct the dividend yield for the US, we use the standard CRSP value-weighted index that includes all stocks on AMEX, Nasdaq, and NYSE. We construct the dividend yield as the sum of 12 months of dividends, divided by the current index level following Fama and French (1988).[12]

To construct a long time series of carry, we make the following assumptions. First, we measure r_t^f by the 30-day T-bill rate. Second, we approximate $D_{t+1} = E_t^Q (D_{t+1})$. As most firms announce dividends one to three months in advance, index level dividends are highly predictable one month ahead. This implies that we measure $C_t \simeq D_{t+1}/S_t - r_t^f$.

The time series of the dividend yield and equity carry are displayed in Figure 8 for the period January 1945 until December 2011. To highlight the differences, the bottom panel of Figure 8 standardizes both series.

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

The time series correlation between the dividend yield and the current carry is 0.30,

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

and between the dividend yield and the carry1-12 it is 0.36, while the correlation between both carry measures equals 0.80. Hence, the time-series correlation between carry and value signals is quite different, even for the carry1-12 signal. This is for two reasons. First, we subtract (and average) the one-month interest rate. Second, and more subtle, we average D_{t+1}/P_t over 12 months. For the dividend yield, by contrast, we sum 12 months of dividends and divide by the current price, $DP_t = \sum_{s=0}^{11} D_{t-s}/P_t$. This implies that the carry signal smooths both prices and dividends, while in case of the dividend yield, only the dividends are smoothed.

We next verify to what extent carry and value signals produce different portfolio returns. We collect cash returns from Bloomberg and construct the dividend yield for the cross-section of countries we consider as described above. The sample for which Bloomberg reports cash returns is smaller than the sample for which we can compute the carry. To ensure comparability, we only take positions in contracts for which both the carry and the dividend yield are available.[13]

The results are reported in Table 11. The top panel reports the summary statistics of the strategies and the middle panel reports the correlations between the strategy returns. All strategies produce substantial Sharpe ratios, although the carry1-12 strategy performs worse for the restricted sample. The return correlations are low. The correlation between the current carry and the dividend yield strategy is only 0.07; it is 0.29 for the carry1-12 and the dividend strategy. The bottom panel illustrates the results of a time-series regression in which we try to explain the returns on the carry strategies with the value factor. Consistent with the evidence in Table 4, the betas are close to zero for the current carry strategy and about 0.3 for the carry1-12 strategy (despite the fact that all strategies have about the same return volatility). Hence, we conclude that the carry signals contain important independent information beyond the standard value signals studied extensively in the literature.

5.2 Illustrations of Alternative Carry Strategies

US Treasuries As a first example of an alternative carry strategy, we implement the carry strategy 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, 61 to 120 months. The sample period is January 1971 to February 2011. To compute the carry, we use the bond yields of Gurkaynak, Sack, and Wright.[14] We use the average maturity to compute the price of a zero-coupon bond, and compute the carry of a Treasury bond of maturity τ as

[13] [IN PROGRESS: EXPAND THE SAMPLE OF DIVIDEND YIELD DATA].

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

$C_t^\tau = P_t^{\tau-1}/P_t^\tau - 1$.

The results are presented in the left panel of Table 12. The top panel shows that the carry strategy based on US Treasuries has a Sharpe ratio of about 0.35. However, due to the different volatilities of the contracts, this strategy is not neutral to the Treasury market, which we define as the difference between the return on an equally-weighted portfolio of all Treasury bonds and the LIBOR rate. The beta is about 0.45 for the current carry strategy and 0.3 for the carry1-12 strategy. The resulting information ratios are about 0.3.

In the middle panel, we report the results of a predictive regression in which we use the carry of the carry portfolio to predict carry returns. We find that for both carry strategies, the carry of the carry portfolio predicts returns at a 10% significance level.

Lastly, we measure the returns during carry expansions and downturns. We find, in contrast to the other carry strategies, that the carry strategy based on the cross-section of U.S. Treasuries performs well during carry recessions. This result is in part driven by the positive beta, but this result survives even if we control for the exposure to the overall Treasury market.

US Credit Portfolios As a second example, we form carry portfolios based on eight US credit portfolios sorted by maturity and credit quality. We use the Barclays' corporate bond indices from Datastream 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 February 2011. We compute the carry in the same way as for Treasuries.

The results are presented in the right panel of Table 12. The Sharpe ratios, betas,[15] and information ratios are very similar to the results for Treasuries, although the return distribution of the carry1-12 strategy displays substantial negative skewness.

For credit portfolios, we find even stronger evidence that the carry of the carry portfolio predicts carry returns, with t-statistics on the predictive coefficient of about 3 for monthly returns as reported in the middle panel.

In the bottom panel, we verify the performance of the credit carry strategies during carry recessions and downturns. For credits we find, consistent with the other asset classes, that credit carry strategies perform poorly during carry downturns.

[15] As before, we define the market as the equally-weighted average of all credit portfolios in excess of the LIBOR rate.

US Index Options As a third example of an alternative carry strategy, we apply the concept of carry to U.S. index options.

We define the price of a call option at time t with maturity T, strike K, implied volatility σ_T, and underlying S_{it} as $F_t^C(S_{it}, K, T, \sigma_T)$. The equivalent put price is denoted by $F_t^P(S_{it}, K, T, \sigma_T)$. We apply the same concept of carry as before, that is, the return on a security if prices do not change.

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

$$C_{it}^j(K, T, \sigma_T) = \frac{F_t^j(S_{it}, K, T-1, \sigma_{T-1})}{F_t^j(S_{it}, K, T, \sigma_T)} - 1, \tag{26}$$

which depends on the maturity, the strike, and the type of option traded. We could subtract the risk-free rate from this expression, but all options are traded in US markets and hence this will not change the rank of the signals in our cross-sectional strategies.[16]

We can write the carry in terms of the option's theta (θ) and vega (ν). We first approximate:

$$\begin{aligned} F_t^j(S_{it}, K, T-1, \sigma_{T-1}) \;\simeq\; & F_t^j(S_{it}, K, T, \sigma_T) \\ & -\theta_t^j(S_{it}, K, T, \sigma_T) - \nu_t^j(S_{it}, K, T, \sigma_T)(\sigma_T - \sigma_{T-1}). \end{aligned} \tag{27}$$

This allows us to write the option carry as:

$$C_{it}^j(K, T, \sigma_T) \simeq \frac{-\theta_t^j(S_{it}, K, T, \sigma_T) - \nu_t^j(S_{it}, K, T, \sigma_T)(\sigma_T - \sigma_{T-1})}{F_t^j(S_{it}, K, T, \sigma_T)}. \tag{28}$$

The size of the carry is therefore driven by the time value (via θ) and the "roll-down" component of the volatility curve (via ν). The option contracts we consider differ in terms of moneyness and whether it is a put or call option.

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

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

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

positions for one month.[17]

We then construct two delta groups:[18]

1. Out of the money: $\Delta \in [0.2, 0.4)$ or $\Delta \in [-0.4, -0.2)$

2. At the money: $\Delta \in [0.4, 0.6)$ or $\Delta \in [-0.6, -0.4)$

We implement the carry strategies separately for call and put options. We select one option per delta group for each index. If multiple options are available, we first select the contract with the highest volume. If there are still multiple contracts available, we select the contracts with the highest open interest. In some rare cases, we still have multiple matches, and we then choose the option with the highest price, that is, the option that is most in the money (in a given moneyness group). Furthermore, we do not take positions in options for which the volume or open interest are zero for the contracts that are required to compute the carry.[19]

The results are presented in Table 13, where we focus on the current-carry strategy. We find that for both options carry strategies, the return distribution displays substantial negative skewness. The Sharpe ratio for call options equals 0.3, but is much higher for put options at 1.7. If we were to apply the carry strategy to a single index, the carry strategy tends to short out-of-the money put options, and is long at-the-money options, which is known to be a profitable strategy with occasionally large drawdowns. This illustrates once more that the concept of carry connects and extends predictor variables and investment strategies across many different asset classes.

We furthermore find that the carry of the carry portfolio significantly predicts returns on the carry portfolio for put options. This is perhaps even more surprising given that the sample is relatively short as it starts only in 1996.

Interestingly, if we study the performance of carry strategies during carry downturns, we find that the options carry strategies behave differently during these episodes. The put options strategy, which generates the largest Sharpe ratios, performs poorly during carry downturns, but does well during carry expansions. The opposite is true for the carry strategy using call options. It may therefore be valuable to combine both strategies.

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

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

[19] [IN PROGRESS: DELTA-HEDGED CARRY STRATEGIES AND CARRY STRADDLES]

6 Conclusion: Caring about Carry

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

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

Appendix

A Foreign-Denominated Futures

Here we briefly explain how we compute the US-dollar return and carry of a futures contract which 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 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 1 provide 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), Norway (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 as described in Section 1. We calculate the returns on the most active equity futures contract for each market (which is typically the front-month contract). This procedure ensures that we do not require any form of interpolation to compute returns.

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.

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.

[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.

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. More specifically:

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

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

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

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

Figure 1 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.

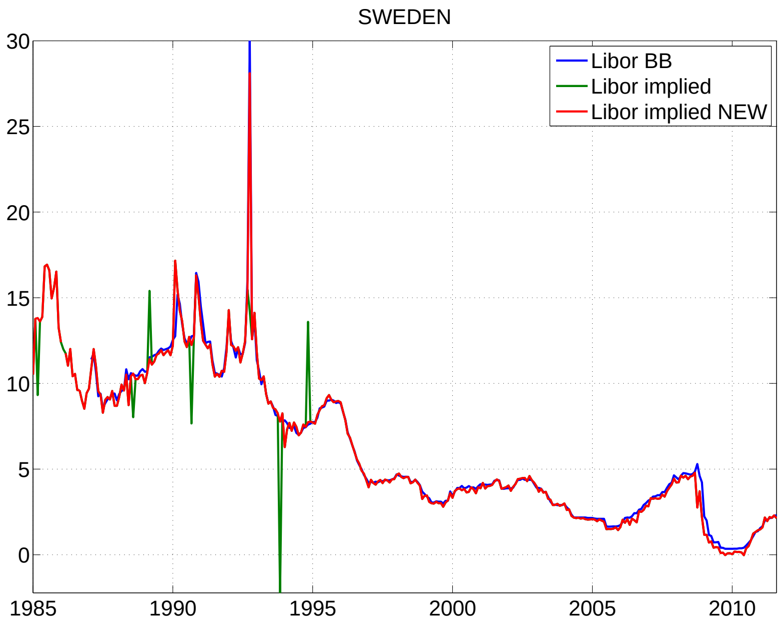

Figure 1: **Libor rates for Sweden.** The figure shows the dynamics of three Libor rates: From Bloomberg ("Libor BB"), the one implied by currency data ("Libor implied"), and the one implied by our corrected currency data ("Libor implied NEW").

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 commodities, we use the nearest-, second-nearest, and third-nearest to expiry futures prices from Bloomberg. Our commodities data set consists of 24 commodities: 7 in metals (aluminum, copper, nickel, zinc, lead, gold, and silver), 6 in energy (brent crude oil, gasoil, WTI crude, RBOB gasoline (spliced with the unleaded gasoline contract which was delisted at the end of 2006), heating oil, and natural gas), 8 in agriculture (cotton, coffee, cocoa, sugar, soybeans, Kansas wheat, corn, and wheat), and 3 in livestock (lean hogs, feeder cattle, and live cattle).

The industrial metals contracts (from the London Metals Exchange, LME) are different from the other contracts, as futures contracts can have daily expiration dates up to 3 months out. We collect cash- and 3-month (constant maturity) futures prices and use linear interpolation to calculate returns.

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 zero coupon 10-year, 9-year, and 3-month constant maturity yields from Bloomberg. Each month, we calculate the price of the 10-year zero coupon bond and a bond with a remaining maturity of nine year and 11 months (by linearly interpolating the 9- and 10-year yields). Our fixed income carry measure is the percent price difference between these two bonds, minus the short rate (to make it comparable to a non-funded basis like a futures contract). The rate of return is defined similarly. For countries with bond futures data, the correlation between actual futures returns and our synthetic futures returns is in excess of 0.95.

C Predictive Regressions Using Ranks

The table below shows the results from predictive regressions where the value of each security's carry is replaced by the cross-sectional rank of its carry (scaled by the number of securities N_t) to rely less on the magnitude of the carry. More specifically,

$$r^i_{t+1} = a^i + b_t + c\frac{\text{rank}(C^i_t)}{N_t} + \varepsilon^i_t. \tag{C.1}$$

	Global Equities				Commodities			
Slope current carry	1.16%	1.15%	1.28%	1.25%	1.42%	1.47%	0.87%	0.96%
t-stat	4.32	4.12	4.64	4.34	3.12	3.09	1.72	1.81
Slope carry 1-12	0.69%	0.68%	0.94%	0.95%	1.52%	1.57%	0.87%	0.97%
t-stat	2.50	2.36	2.73	2.65	3.32	3.27	1.72	1.81
Contract FE	No	No	Yes	Yes	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes	No	Yes

	Fixed Income				Currencies			
Slope current carry	0.62%	0.62%	0.66%	0.68%	0.56%	0.58%	0.79%	0.97%
t-stat	3.92	3.79	3.61	3.52	2.82	2.80	2.26	2.70
Slope carry 1-12	0.32%	0.32%	0.23%	0.26%	0.46%	0.47%	0.54%	0.72%
t-stat	2.04	1.94	1.25	1.33	2.39	2.38	1.56	2.07
Contract FE	No	No	Yes	Yes	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes	No	Yes

Table B.1: **How Carry Predicts Returns: Using Ranks.**

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Tables

Instrument	Begin sample	Return Mean	Return St.dev.	Carry Mean	Carry St.dev.
Equities					
SPX	Mar-88	5.8	14.9	-1.6	0.7
SPTSX60	Oct-99	7.4	16.3	-1.0	0.8
UKX	Mar-88	3.7	15.2	-2.0	1.4
CAC	Jan-89	4.1	19.8	-0.9	1.9
DAX	Dec-90	6.2	21.6	-3.7	1.1
IBEX	Aug-92	9.6	21.6	1.1	2.0
FTSEMIB	Apr-04	2.4	20.3	1.0	1.5
AEX	Feb-89	7.2	20.6	-0.1	1.5
OMX	Mar-05	10.1	19.5	1.3	2.2
SMI	Nov-91	5.3	15.1	-0.1	1.2
NKY	Oct-88	-3.1	22.4	-0.5	1.7
HIS	May-92	12.5	27.9	1.2	2.3
AS51	Jun-00	5.0	13.4	0.7	1.0
Currencies					
Australia	Jan-85	4.6	11.9	3.1	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	2.2	7.1	0.8	0.5
Denmark	Jan-85	4.4	11.1	1.0	0.9
Euro	Feb-99	1.8	10.8	-0.4	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	1.6	11.6	-2.9	0.6
Netherlands	Nov-83	3.0	11.6	-0.7	0.9
New Zealand	Jan-85	6.8	12.4	4.4	1.2
Norway	Jan-85	4.5	10.9	2.3	1.0
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	3.5	11.4	1.7	1.0
Switzerland	Nov-83	2.0	11.9	-2.0	0.7
UK	Nov-83	2.9	10.5	2.0	0.6
US	Nov-83	0.0	0.0	0.0	0.0

Instrument	Begin sample	Return Mean	Return St.dev.	Carry Mean	Carry St.dev.
Commodities					
Crude Oil	Feb-99	22.8	33.0	0.2	5.7
Gasoil	Feb-99	22.5	34.2	2.7	5.6
WTI Crude	Feb-87	12.6	33.7	1.9	7.2
Unl. Gasoline	Nov-05	9.4	39.0	-7.6	9.8
Heating Oil	Aug-86	12.6	33.3	-0.2	8.5
Natural Gas	Feb-94	-15.0	54.9	-26.2	22.1
Cotton	Feb-80	2.5	24.8	-4.6	7.0
Coffee	Feb-81	4.2	38.0	-4.8	5.1
Cocoa	Feb-84	-2.9	28.9	-6.8	3.4
Sugar	Feb-80	1.3	39.8	-3.4	6.1
Soybeans	Feb-80	2.0	23.4	-2.7	5.7
Kansas Wheat	Feb-99	1.5	28.6	-8.6	3.4
Corn	Feb-80	-4.4	24.7	-10.8	5.3
Wheat	Feb-80	-5.2	24.5	-8.0	5.8
Lean Hogs	Jun-86	-2.7	24.8	-14.1	19.9
Feeder Cattle	Feb-02	3.2	15.0	0.6	4.7
Live Cattle	Feb-80	2.5	14.1	0.4	6.1
Gold	Feb-80	-1.7	17.3	-5.5	1.1
Silver	Feb-80	-1.5	30.2	-6.4	1.8
Aluminum	Feb-91	-1.2	19.1	-5.0	1.6
Nickel	Feb-93	14.8	35.6	0.5	2.6
Lead	Feb-95	10.9	29.9	-0.7	2.8
Zinc	Feb-91	2.1	25.6	-4.8	2.1
Copper	May-86	16.8	28.1	4.6	3.4
Fixed income					
Australia	Jan-95	4.5	10.6	1.3	0.4
Canada	Jan-95	6.5	7.9	2.6	0.5
Germany	Nov-91	4.6	7.0	1.9	0.5
UK	Jan-95	4.2	8.2	0.9	0.7
Japan	Nov-91	5.6	7.0	2.9	0.3
New Zealand	Jan-95	2.6	9.8	0.6	0.6
Norway	Aug-98	2.5	7.6	1.1	0.5
Sweden	Jan-95	7.3	8.9	2.3	0.4
Switzerland	Jan-95	4.9	5.7	2.7	0.3
US	Jan-95	5.1	10.0	1.8	0.6

Table 1: **Summary Statistics.** This table contains all the instruments that we use, the date as of which the returns and carry are available, and the annualized mean and standard deviation of the return and the carry.

	Carry Trade: Current Carry	Carry Trade: Carry 1-12	Passive Long: Equal Weighted
		Global Equities	
Average	9.9%	6.5%	5.8%
St.dev.	10.6%	10.7%	15.8%
Skewness	0.17	0.11	-0.63
Kurtosis	4.79	3.82	4.01
SR	**0.93**	**0.61**	**0.37**
		Commodities	
Average	11.7%	13.0%	1.3%
St.dev.	19.0%	19.5%	13.3%
Skewness	-0.41	-0.83	-0.66
Kurtosis	4.53	5.74	6.52
SR	**0.62**	**0.67**	**0.10**
		Global Fixed Income	
Average	5.1%	3.0%	5.0%
St.dev.	6.3%	6.3%	6.5%
Skewness	-0.11	0.05	0.02
Kurtosis	5.03	4.86	3.12
SR	**0.82**	**0.48**	**0.77**
		Currencies	
Average	5.3%	4.2%	3.0%
St.dev.	7.8%	7.6%	8.0%
Skewness	-0.75	-1.07	-0.10
Kurtosis	4.64	6.42	3.41
SR	**0.68**	**0.55**	**0.37**
		Diversified Across All Asset Classes	
Average	7.3%	4.8%	4.0%
St.dev.	4.9%	5.1%	5.4%
Skewness	-0.22	-0.53	-1.07
Kurtosis	3.81	5.06	8.17
SR	**1.49**	**0.95**	**0.75**

Table 2: **The Returns to Global Carry Strategies.** For each asset class, we construct long/short carry trades and this table reports the average, standard deviation, skewness, and kurtosis.

Correlations of Carry Trades: Current Carry				
	Equities	Commodities	Fixed Income	Currencies
Equities	100%			
Commodities	-5%	100%		
Fixed Income	-2%	4%	100%	
Currencies	4%	3%	23%	100%

Correlations of Carry Trades: Carry1-12				
	Equities	Commodities	Fixed Income	Currencies
Equities	100%			
Commodities	-1%	100%		
Fixed Income	6%	-11%	100%	
Currencies	14%	12%	21%	100%

Table 3: **The Correlation across Global Carry Strategies.** The reports the monthly return correlation between carry strategies. The top panel reports the results for the current carry strategies; the bottom panel for the carry1-12 strategies.

Global Equities

	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12
Alpha	0.86%	0.53%	0.82%	0.39%	0.85%	0.39%	0.86%	0.40%	0.85%	0.40%
t-stat	4.67	2.81	4.46	1.96	4.63	1.93	4.73	2.01	4.62	2.01
Passive long	-0.07	0.03	-0.08	0.03	-0.07	0.03	-0.10	0.02	-0.10	0.02
t-stat	-1.29	0.59	-1.40	0.52	-1.25	0.54	-1.69	0.44	-1.74	0.40
Value "everywhere"			0.12	0.32	0.14	0.33	0.08	0.30	0.08	0.30
t-stat			1.19	3.64	1.38	3.71	0.81	3.39	0.85	3.43
Momentum "everywhere"			0.02	0.09	0.06	0.09	0.02	0.10	0.01	0.09
t-stat			0.20	1.11	0.69	1.18	0.19	1.22	0.08	1.19
TS momentum					-0.04	0.00				
t-stat					-1.42	-0.16				
Funding liquidity							0.01	0.00		
t-stat							1.50	-0.02		
Market liquidity									0.00	0.00
t-stat									1.10	0.14
R-square	1.1%	0.3%	1.9%	5.8%	2.7%	5.8%	2.5%	5.0%	2.4%	5.0%
IR	0.98	0.59	0.93	0.45	0.96	0.45				

Commodities

	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12
Alpha	0.98%	1.09%	0.85%	0.97%	0.73%	0.82%	0.71%	0.57%	0.68%	0.53%
t-stat	3.45	3.75	3.47	3.88	2.76	3.23	2.68	2.16	2.55	2.00
Passive long	0.00	-0.08	-0.07	-0.17	-0.03	-0.11	-0.04	-0.16	-0.01	-0.11
t-stat	-0.03	-0.75	-0.96	-1.82	-0.39	-1.12	-0.42	-1.73	-0.11	-1.15
Value "everywhere"			-0.17	-0.24	-0.21	-0.27	-0.19	-0.21	-0.18	-0.21
t-stat			-2.81	-4.21	-3.11	-4.73	-2.61	-3.66	-2.49	-3.83
Momentum "everywhere"			0.29	0.33	0.33	0.38	0.28	0.36	0.29	0.36
t-stat			4.96	6.32	4.05	5.33	4.24	6.95	4.38	6.89
TS momentum					-0.11	-0.11				
t-stat					-0.93	-1.09				
Funding liquidity							0.01	0.02		
t-stat							0.91	2.68		
Market liquidity									0.00	0.01
t-stat									0.04	1.40
R-square	0.0%	0.3%	18.1%	25.8%	21.0%	30.1%	20.3%	30.9%	19.8%	29.7%
IR	0.61	0.67	0.59	0.69	0.53	0.63				

Global Fixed Income

	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12
Alpha	0.40%	0.28%	0.42%	0.27%	0.45%	0.28%	0.41%	0.28%	0.42%	0.29%
t-stat	3.11	2.18	3.12	2.08	3.51	2.17	2.96	2.08	3.05	2.17
Passive long	0.06	-0.07	0.05	-0.07	0.20	-0.04	0.06	-0.07	0.05	-0.08
t-stat	0.79	-0.82	0.60	-0.83	1.81	-0.34	0.66	-0.84	0.54	-0.98
Value “everywhere”			-0.04	0.05	-0.07	0.04	-0.05	0.05	-0.05	0.04
t-stat			-0.27	0.31	-0.48	0.27	-0.29	0.29	-0.31	0.27
Momentum “everywhere”			0.12	0.07	0.21	0.09	0.10	0.05	0.11	0.06
t-stat			0.95	0.47	1.67	0.59	0.82	0.34	0.89	0.40
TS momentum					-0.06	-0.01				
t-stat					-2.41	-0.49				
Funding liquidity							0.00	0.00		
t-stat							1.24	1.28		
Market liquidity									0.00	0.00
t-stat									-0.81	-1.28
R-square	0.4%	0.5%	1.3%	0.7%	4.5%	0.8%	1.8%	1.4%	1.4%	1.2%
IR	0.77	0.53	0.80	0.52	0.88	0.53				

Currencies

	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12	CC	C1-12
Alpha	0.41%	0.32%	0.37%	0.32%	0.31%	0.26%	0.35%	0.30%	0.35%	0.29%
t-stat	3.27	2.57	2.89	2.57	2.23	1.95	2.73	2.42	2.60	2.26
Passive long	0.12	0.11	0.14	0.11	0.18	0.15	0.16	0.13	0.20	0.17
t-stat	1.72	1.41	2.16	1.70	2.67	2.12	2.29	1.84	2.61	2.19
Value “everywhere”			0.07	0.00	0.11	0.02	0.15	0.08	0.08	-0.01
t-stat			0.72	-0.04	0.99	0.19	1.90	1.04	0.86	-0.08
Momentum “everywhere”			0.03	0.01	0.00	-0.01	0.13	0.11	0.14	0.11
t-stat			0.39	0.14	0.00	-0.11	1.99	1.58	1.68	1.33
TS momentum					0.02	0.02				
t-stat					0.43	0.34				
Funding liquidity							0.03	0.03		
t-stat							6.09	5.90		
Market liquidity									0.01	0.01
t-stat									2.79	3.03
R-square	1.6%	1.4%	2.2%	1.5%	3.5%	2.2%	17.8%	22.6%	10.0%	13.1%
IR	0.64	0.51	0.58	0.51	0.47	0.41				

Table 4: **Carry Trade Risk Exposures.** The table reports the exposires to various risk factors. “CC” corresponds to the current-carry strategies; “C1-12” to the carry1-12 strategies.

	Global Equities				Commodities			
Slope current carry	1.50	1.22	1.55	1.26	0.06	0.07	0.01	0.01
t-stat	3.57	4.29	3.52	4.31	0.75	0.84	0.12	0.15
Slope carry1-12	2.47	1.46	2.92	1.76	0.37	0.42	0.24	0.29
t-stat	3.55	2.87	3.52	2.86	3.15	3.57	1.86	2.19
Contract FE	No	No	Yes	Yes	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes	No	Yes
	Global Fixed Income				**Currencies**			
Slope current carry	1.52	1.64	1.54	1.83	1.28	0.80	1.62	1.10
t-stat	2.59	3.78	2.19	3.61	3.19	2.93	2.68	2.67
Slope carry1-12	1.51	1.07	1.54	1.02	1.09	0.59	1.38	0.69
t-stat	2.44	2.38	2.03	1.91	3.03	1.96	2.48	1.37
Contract FE	No	No	Yes	Yes	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes	No	Yes

Table 5: **How Does Carry Predict Returns?**

	Current carry returns predicted by its current carry	Carry 1-12 returns predicted by its carry 1-12	Passive long returns predicted by its current carry	Passive long returns predicted by its carry 1-12
	Global Equities			
Intercept	-0.2%	-0.5%	0.6%	0.8%
t-stat	-0.45	-1.24	2.21	2.67
Carry	1.32	2.52	1.90	3.47
t-stat	2.64	2.65	1.53	2.16
R-square	3.1%	3.2%	1.1%	1.6%
	Commodities			
Intercept	1.1%	0.8%	0.2%	0.3%
t-stat	1.43	0.60	0.86	1.36
Carry	-0.05	0.14	0.14	0.39
t-stat	-0.22	0.26	0.44	0.83
R-square	0.0%	0.0%	0.1%	0.2%
	Global Fixed Income			
Intercept	0.3%	0.3%	0.3%	0.3%
t-stat	0.61	0.48	1.69	1.32
Carry	0.52	-0.12	0.64	1.06
t-stat	0.28	-0.05	0.57	0.91
R-square	0.1%	0.0%	0.1%	0.3%
	Currencies			
Intercept	0.5%	0.5%	0.1%	0.1%
t-stat	1.81	1.60	0.60	0.64
Carry	-0.22	-0.38	2.41	2.32
t-stat	-0.35	-0.53	2.60	2.80
R-square	0.0%	0.1%	2.9%	2.5%

Table 6: **How the Carry of a Portfolio Predicts the Portfolio Return.**

	Carry Trade: Current Carry				Carry Trade: Carry 1-12			
Average return	Equities	Fixed income	Currencies	Commodities	Equities	Fixed income	Currencies	Commodities
Carry expansions	11.1%	5.9%	8.9%	16.2%	8.4%	4.0%	8.6%	13.0%
Carry downturns	1.2%	1.3%	-15.7%	1.6%	-8.4%	-2.5%	-19.6%	-8.8%
Average return per carry downturn	Equities	Fixed income	Currencies	Commodities	Equities	Fixed income	Currencies	Commodities
September 1992 - December 1992	-7.6%	-4.4%	-47.8%	-7.8%	4.9%	-4.4%	-52.7%	-4.9%
May 1997 - September 1998	3.8%	3.4%	-2.7%	-12.6%	-13.2%	-0.6%	-2.7%	-6.7%
November 2007 - January 2009	0.5%	0.3%	-21.8%	20.1%	-6.4%	-4.0%	-29.9%	-12.2%
Number of downturns below average	3	3	3	2	3	3	3	3
Average macro and liquidity variables		Carry expansions		Carry downturns				
Global recession dummy		0.17		0.41				
Global liquidity shocks		0.02		-0.17				

Table 7: **The Returns to Global Carry Strategies across Regions During Carry Recessions and Expansions.**

		North America	Continental Europe	United Kingdom	Asia	Australia / New Zealand	Average
Equities	Downturn	-8.59	-11.82	-7.37	-34.79	-50.55	-22.62
	Expansion	10.62	9.98	5.50	10.84	12.28	9.84
Fixed income	Downturn	15.42	12.20	15.08	10.03	18.24	14.20
	Expansion	3.86	3.69	2.05	4.80	0.66	3.01
Currencies	Downturn	-6.68	-9.06	-16.70	2.70	-21.15	-10.18
	Expansion	1.96	4.05	4.81	-0.54	9.13	3.88
		Energy	**Agricultural / Livestock**	**Metals**			**Average**
Commodities	Downturn	-35.13	-15.56	-31.59			-27.42
	Expansion	12.25	3.27	15.06			10.19

Table 8: **The Returns across Regions During Carry Downturns and Expansions.**

	Mean	Static	Dynamic	% dynamic	Mean	Static	Dynamic	% dynamic
	Global Equities				**Commodities**			
Current carry	0.83%	0.01%	0.82%	99%	0.98%	0.35%	0.63%	64%
Carry 1-12	0.55%	0.07%	0.48%	87%	1.08%	0.43%	0.66%	60%
	Global Fixed Income				**Currencies**			
Current carry	0.43%	0.10%	0.33%	77%	0.44%	0.18%	0.26%	59%
Carry 1-12	0.25%	0.12%	0.14%	54%	0.35%	0.18%	0.17%	48%

Table 9: **Decomposing Carry Trade Returns into Static and Dynamic Components.**

		Total	Static	Dynamic	% dynamic
Global equities	Downturn	-8.38%	-8.09%	-0.28%	3%
	Expansion	8.43%	2.33%	6.11%	72%
Global fixed income	Downturn	-2.46%	-2.55%	0.09%	-4%
	Expansion	4.02%	2.11%	1.91%	48%
Currencies	Downturn	-19.59%	-11.52%	-8.07%	41%
	Expansion	8.56%	4.14%	4.42%	52%
Commodities	Downturn	-8.75%	-4.63%	-4.12%	47%
	Expansion	12.95%	8.44%	4.51%	35%
		Total	**Static**	**Dynamic**	**% dynamic**
Average	Downturn				22%
	Expansion				52%

Table 10: **Return Decomposition during Carry Downturns and Expansions.**

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

Correlation matrix	Current carry	Carry1-12	Dividend yield
Current carry	100%	41%	7%
Carry1-12	41%	100%	29%
Dividend yield	7%	29%	100%

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

Table 11: **Using the Equity Carry or the Dividend Yield.** The top panel reports the summary statistics of three strategies using either the current carry, the carry1-12 or the dividend yield as the signal.

Cross-section of U.S. Treasuries			**Cross-section of U.S. Credit portfolios**		
Summary statistics	CC	C1-12	**Summary statistics**	CC	C1-12
Mean	1.25%	1.36%	Mean	1.54%	1.75%
St.dev.	3.81%	3.88%	St.dev.	4.21%	4.31%
Skewness	0.15	0.02	Skewness	-0.03	-1.03
SR (annualized)	0.33	0.35	SR (annualized)	0.37	0.41
Market beta	0.45	0.29	Market beta	0.23	0.29
IR (annualized)	0.27	0.33	IR (annualized)	0.28	0.30
Predictive regressions	CC	C1-12	**Predictive regressions**	CC	
Predictive coefficient	1.13	1.02	Predictive coefficient	4.64	4.44
T-statistic	1.72	1.68	T-statistic	2.96	3.05
R-squared	0.86%	0.61%	R-squared	3.98%	2.66%
Decomposition carry returns	CC	C1-12	**Decomposition carry returns**	CC	C1-12
Returns during carry downturns	4.91%	4.97%	Returns during carry downturns	-2.03%	-0.23%
Returns during carry expansions	1.18%	1.10%	Returns during carry expansions	2.15%	2.09%

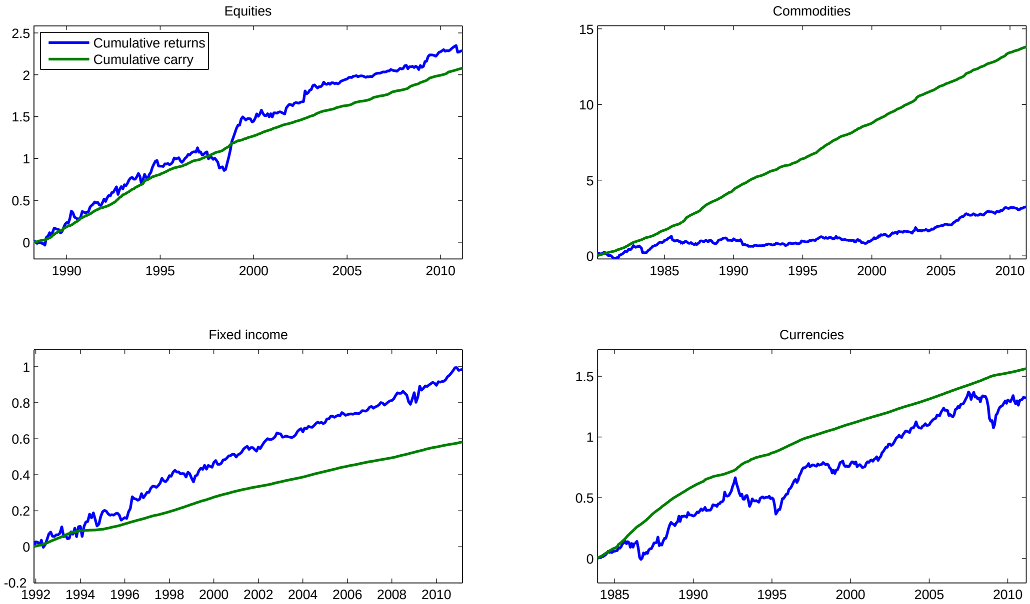
Table 12: **Carry Strategies Based on the Cross-section of U.S. Treasuries and Credits.**

Summary statistics	Call options	Put options
Mean	4.3%	14.6%
St.dev.	50.4%	29.2%
Skewness	-2.81	-1.74
SR (annualized)	0.30	1.73
Predictive regressions	Call options	Put options
Predictive coefficient	-0.19	0.78
T-statistic	-0.27	2.09
R-squared	0.04%	2.39%
Decomposition carry returns	Call options	Put options
Returns during carry downturns	13%	-1.3%
Returns during carry expansions	2%	18.0%

Table 13: **Current-Carry Strategies Based on the Cross-section of U.S. Index Options.**

Figures

Panel A: Current Carry



Panel B: Carry1-12

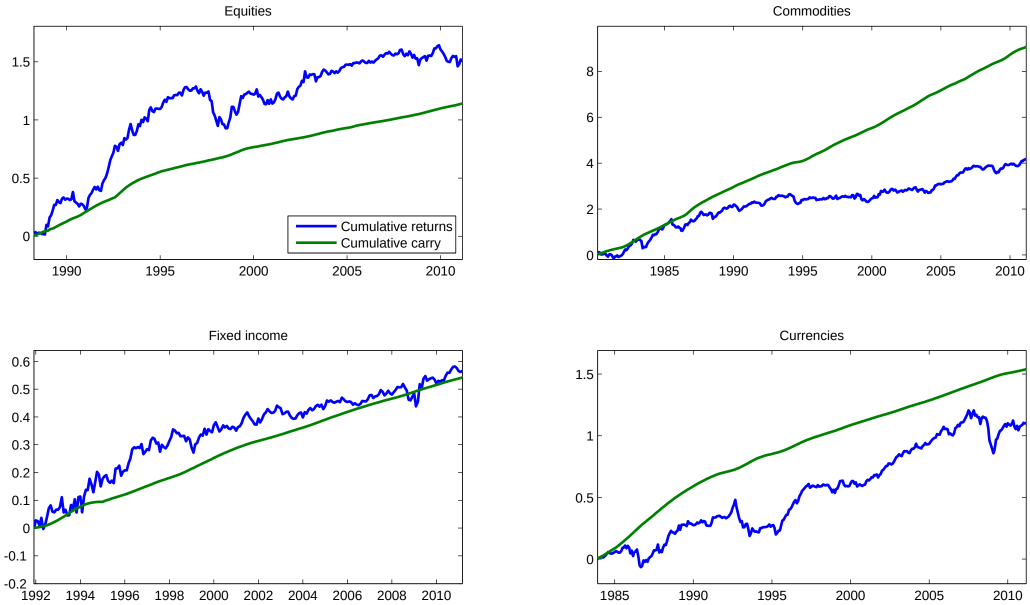


Figure 2: **Cumulative Return and Cumulative Carry of the Global Carry Trades.** The figure shows the cumulative return on carry strategies and the cumulative carry for equities (top-left panel), fixed income (bottom-left panel), commodities (top-right panel), and currencies (bottom-right panel). Panel A uses the current carry to construct the carry trade and to compute the cumulative carry, whereas Panel B uses carry1-12 for both of these. The sample period is February 1988 - February 2011 for equities, October 1991 - February 2011 for fixed income, January 1980 - February 2011 for commodities, and October 1983 - February 2011 for currencies.

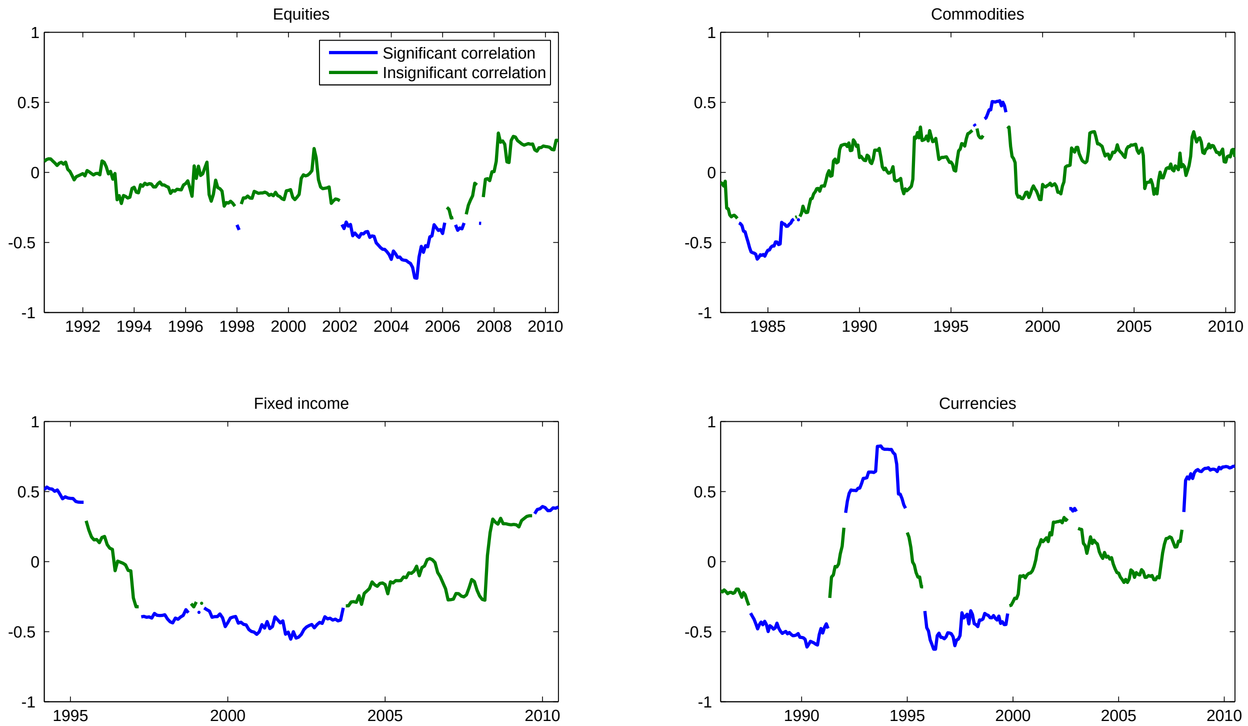


Figure 3: **Rolling Correlations of Carry Strategies with the Stock Market.** The figure shows the 3-year rolling correlation between carry returns and the passive, equal-weighted strategy for equities (top-left panel), fixed income (bottom-left panel), commodities (top-right panel), and currencies (bottom-right panel). We use the current carry in the carry strategies. The sample period is February 1988 - February 2011 for equities, October 1991 - February 2011 for fixed income, January 1980 - February 2011 for commodities, and October 1983 - February 2011 for currencies.

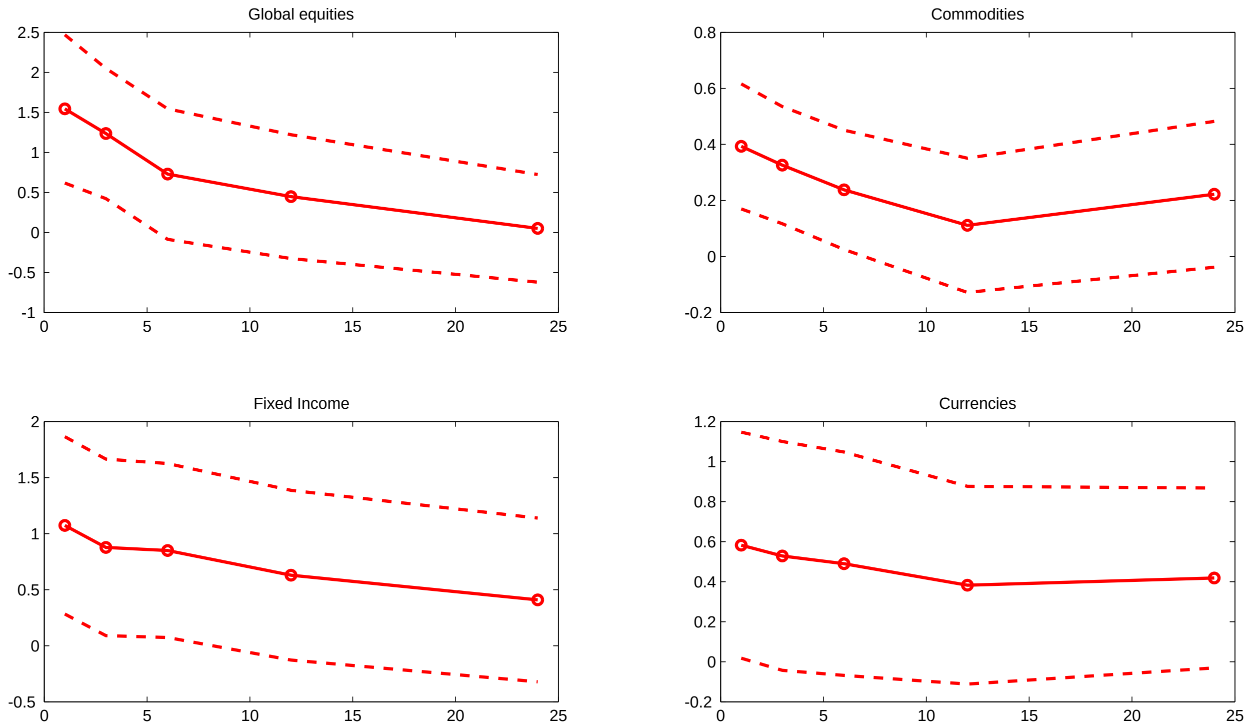


Figure 4: **Carry Predicts Returns: Panel Regression.** The figure shows the predictive coefficient (c) of panel regressions of the form $r_{i,t+1} = a + b_t + cC_{i,t+1-k} + \varepsilon_{i,t+1}$ (for $k = 1, 3, 6, 12$, and 24) for equities (top-left panel), fixed income (bottom-left panel), commodities (top-right panel), and currencies (bottom-right panel). We use the Carry1-12 to forecast future returns. The dashed lines indicate the 95%-confidence interval, where the standard errors are clustered by time period. The sample period is February 1988 - February 2011 for equities, October 1991 - February 2011 for fixed income, January 1980 - February 2011 for commodities, and October 1983 - February 2011 for currencies.

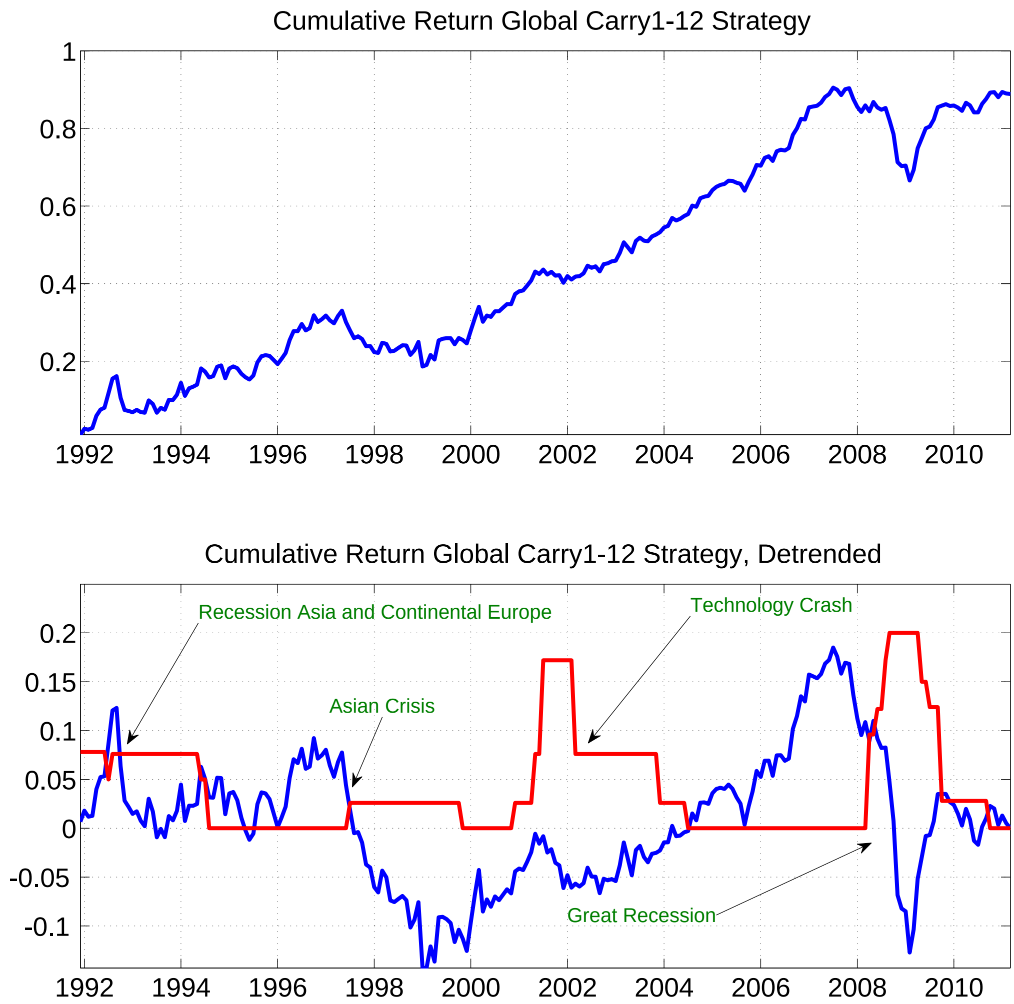


Figure 5: **Returns on the Global Carry1-12 Factor and Global Recessions.** The figure shows the cumulative return on the global carry1-12 factor in the top panel. We construct the global carry factor by weighing the carry strategy of each asset classes by the inverse of the standard deviation of returns, and scaling the weights so that they sum to one. The bottom panel displays the de-trended cumulative return alongside the global recession dummy. We construct the global recession dummy by weighting regional recession dummies by GDP. We de-trend the cumulative return series using a linear time trend. We indicate the major recessions. The sample period is November 1991 to February 2011.

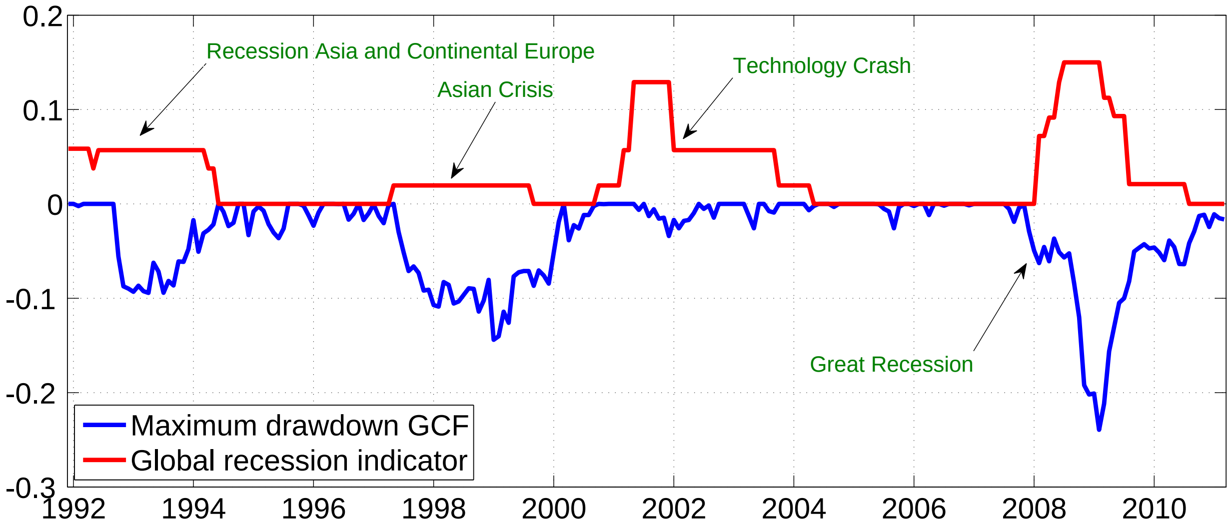


Figure 6: **Draw-down Dynamics of the Global Carry1-12 Factor.** The figure shows the maximum draw-down dynamics of the global carry1-12 strategy. We define the draw down as: $D_t \equiv \sum_{s=1}^{t} r_s - \max_{u\in\{1,\ldots,t\}} \sum_{s=1}^{u} r_s$, where r_s denotes the return on the global carry1-12 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 sample period is November 1991 to February 2011.

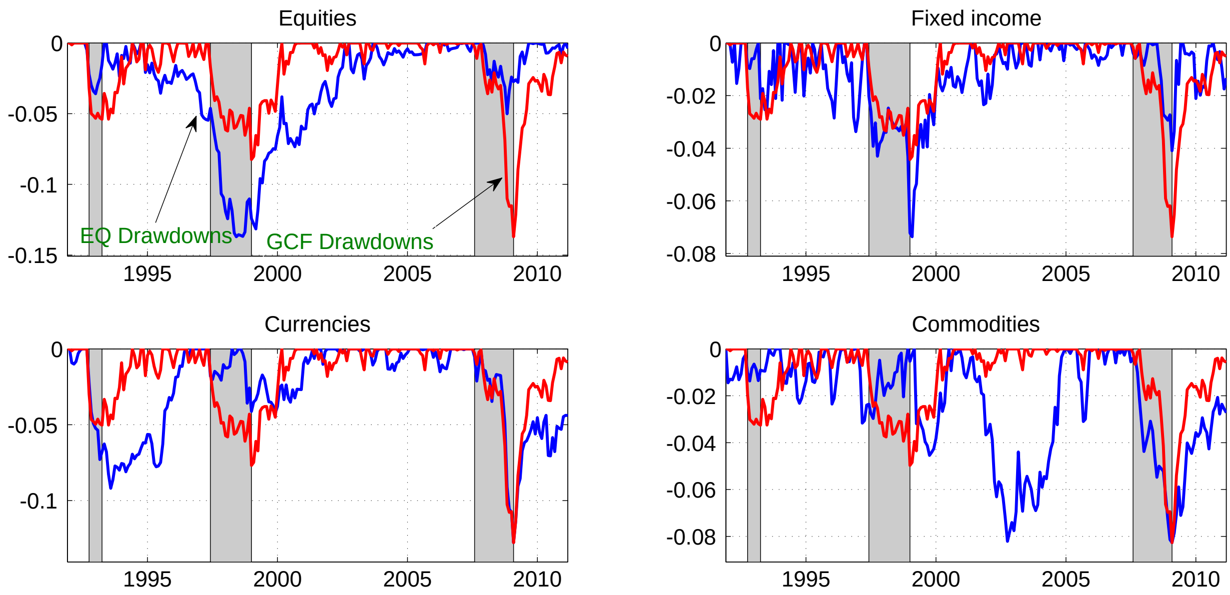


Figure 7: **Draw-down Dynamics Per Asset Class.** The figure shows the maximum draw-down dynamics of the global carry1-12 strategy. We define the draw down as: $D_t \equiv \sum_{s=1}^{t} r_s - \max_{u\in\{1,\ldots,t\}} \sum_{s=1}^{u} r_s$, where r_s denotes the return on the global carry1-12 strategy. 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 sample period is November 1991 to February 2011.

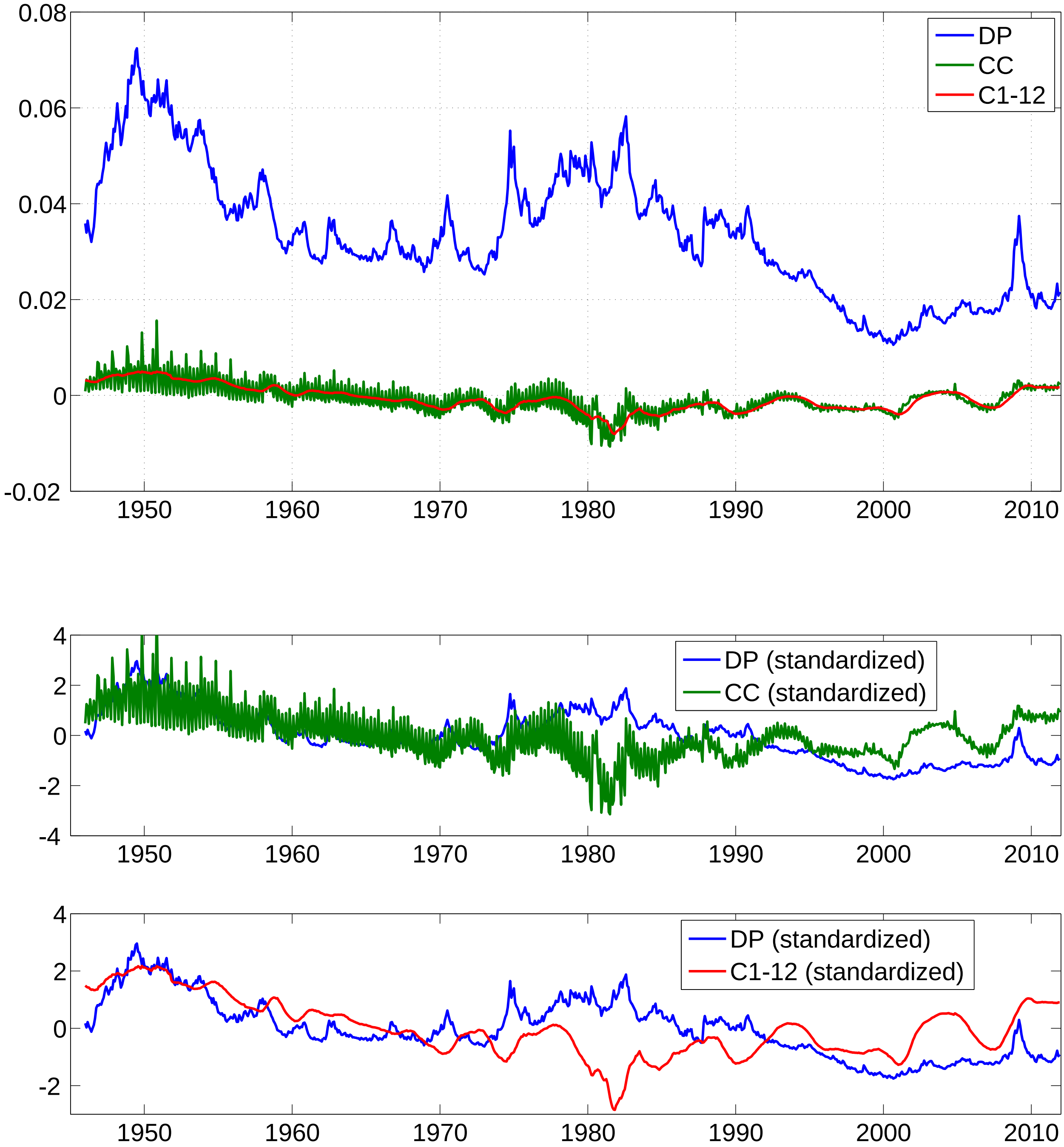


Figure 8: **Time-Series of the Equity Carry.** The figure shows the time series of the equity carry for the US from January 1945 until December 2011.