An Anatomy of Commodity Futures Risk Premia

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ABSTRACT

We identify two types of risk premia in commodity futures returns: spot premia related to the risk in the underlying commodity, and term premia related to changes in the basis. Sorting on forecasting variables such as the futures basis, return momentum, volatility, inflation, hedging pressure, and liquidity results in sizable spot premia between 5% and 14% per annum and term premia between 1% and 3% per annum. We show that a single factor, the high-minus-low portfolio from basis sorts, explains the cross-section of spot premia. Two additional basis factors are needed to explain the term premia.

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Futures contracts are zero-cost securities, that is, they do not require an initial investment. Hence, expected futures returns consist only of risk premia. Understanding these premia is important, as they impact, for example, the hedging decisions of companies and the investment decisions of financial institutions. The purpose of this paper is to characterize the cross-sectional and time-series variation in commodity futures risk premia.[1] The cross-section of commodity futures risk premia has at least two dimensions. First, for each commodity there are multiple futures contracts that differ in time-to-maturity. Therefore, analogous to bonds, there is a term structure both of futures prices and of futures expected returns or risk premia. Second, like stocks, individual commodity futures differ on characteristics such as the sector to which they belong (e.g., Energy versus Metals), as well as on characteristics like momentum and valuation ratios. The latter also lead to time-series variation in expected futures returns.

The contribution of this paper is threefold. First, we decompose commodity futures expected returns into spot and term premia that can be identified by taking long positions in short maturity (nearby) contracts and by combining long and short (spreading) positions in contracts with different maturities, respectively. These premia, or discounts, show up in different ways in multiperiod strategies that hold the contract until maturity or that roll over short-term contracts. Whereas rolling over short-term contracts isolates the spot premia in multiple periods, holding the contract until maturity yields expected returns that consist of the spot premia plus term premia. This decomposition is important because the two risk premia are likely to compensate for different risk factors. For instance, in the case of oil futures, the spot premium reflects oil price risk, while the term premia mainly reflect the risk present in the convenience yield. Like risk premia in the term structure of interest rates, term premia are also present in the term structure of the futures cost-of-carry or (percentage) basis.

Second, we show that differences in expected returns on various trading strategies also result from time-variation in risk premia due to commodity futures characteristics. As for stocks, the cross-sectional and time-series variation in commodity futures returns is related not so much to sector (or industry) as to characteristics like the basis, momentum, volatility, and other instruments.

Finally, just as variation in stock returns can be attributed to a limited number of factors like the three Fama-French factors, we show that cross-sectional variation in commodity futures returns can be attributed to a single basis factor for spot premia and to two additional basis factors for term premia.

A log-linear approximation similar to Campbell and Shiller's (1988) analysis of the dividend yield implies that the futures percentage basis contains information about expected futures returns or risk premia. This suggests that the predictive power of valuation ratios such as dividend yield for stocks, forward premium for bonds, carry trade for foreign exchange, and house price-to-rent ratio for real estate, among others, also applies to commodity markets.[2] This is also in line with a number of other papers in the commodity literature that relate futures risk premia to the basis or carry (e.g., Fama (1984), Erb and Harvey (2006), Gorton and Rouwenhorst (2006), and Liu and Tang (2011)).

Previous literature identifies a number of other variables that lead to predictable variation in futures risk premia but does not differentiate between spot and term premia in futures markets. Instruments known to induce time variation in commodity futures risk premia other than the basis include hedging pressure and momentum.[3] In addition to these instruments, or characteristics, commodity risk premia have been related to futures volatility, inflation, and open interest.[4] As we specifically include futures contracts with longer maturities to analyze the term premia, we also consider the liquidity of the contracts.

Our results are based on a broad cross-section of 21 commodity futures markets with as many as four different maturities. Sorting on the percentage basis of the futures, our center-stage variable, we find in the high-minus-low basis portfolio that the spot premia are between -8% and -14% per annum, depending on the maturity of the contracts, and the term premia are of opposite sign, between 0.5% and 2% per annum. In an in-sample analysis, we show that about 70% of these premia are due to cross-sectional differences in the average basis, whereas 30% are due to time-series deviations of the basis from its mean.

When sorting on other commonly used predictive variables we also find it is important to distinguish between spot and term premia. Apart from the basis sorts, spot premia show up when sorting on momentum, volatility, inflation beta, and liquidity. The resulting spot premia are usually between 8% and 10% per annum in absolute terms. Term premia, on the other hand, mainly show up when sorting on the basis, volatility, and inflation beta, and marginally when sorting on hedging pressure and liquidity. The term premia are mostly between 0.5% and 2% per annum, and always of the opposite sign as spot premia. Our findings thus imply that previously identified forecasting variables affect expected futures returns in different ways via the spot and term premia. These findings also contribute to the debate on the existence of time-varying risk premia in commodity futures markets (e.g., Dusak (1973), Carter, Rausser, and Schmitz (1983), and more recently, Frank and Garcia (2009), as well as references therein) as we find spot and term premia to reliably show up when sorting on the various characteristics.

Although we find many significant spot and term premia among the various portfolio sorts, standard asset pricing tests show that especially the cross-sectional patterns in spot premia can be attributed to only a single basis factor. A factor portfolio that goes long the high basis commodity futures and short the low basis commodity futures, similar to carry trade for currencies, can explain most of the other sorted portfolio returns that capture spot premia, leaving only small unexplained mean returns on the table. A horse race with similar factor portfolios based on the other characteristics shows that none comes close to the performance of the basis factor. The basis factor, however, fails to explain the term premia in the sorted portfolios. This is also the case for single-factor portfolios based on any of the other characteristics. On the other hand, using two separate basis factor portfolios, the high basis and the low basis commodity futures portfolios, explains nearly all of the term premia in our portfolio sorts. Bessembinder and Chan (1992) find that nearby returns in 12 different futures markets are driven by two latent factors. Unlike their latent factors, we identify one observable factor for the spot premia in 21 commodity futures markets, and two observable factors for the corresponding term premia.

Our findings also add to the literature on cross-sectional predictability across markets. Papers like Fama and French (1993, 1996), Cochrane and Piazzessi (2005, 2008), and Lustig, Roussanov, and Verdelhan (2011), among others, find that the cross-section of stocks, bonds, and currency returns, respectively, can be explained by relatively few factors. A paper close to ours is Lustig, Roussanov, and Verdelhan (2011), who show that the cross-section of international currency returns can be explained by a single factor, the return on the highest minus the return on the lowest interest rate currency portfolio. As high interest rates imply low futures prices, this factor is similar to a futures carry trade. We contribute to this literature by demonstrating that a similar phenomenon exists in commodity futures markets.

The rest of the paper is structured as follows. Section I presents a simple decomposition of futures returns and characterizes the time-variation in commodity expected returns using a present value relation. Section II describes the data and analyzes unconditional risk premia. The conditional risk premia and their implications for asset pricing are discussed in Sections III and IV, respectively. Section V concludes.

I. Theory

A. A Decomposition of Expected Futures Returns

We begin our analysis with a simple decomposition of expected futures returns that highlights the different premia (or discounts if they are negative) that may be present in futures markets. Denote by S_t the spot price of the underlying commodity, and by $F_t^{(n)}$ the futures price for delivery at time $t+n$, of a commodity with per-period physical storage costs, $U_t^{(n)}$, that are a percentage of the spot price, and a cash payment, C_{t+n}. This cash payment is the net dollar-equivalent income from convenience yield that accrues to the commodity owner (stemming, for instance, from the value of the option to sell out of storage). We assume that the payment C_{t+n} occurs at time $t+n$, but is already known at time t. The cost-of-carry model (e.g., Fama and French (1988)) then implies that the futures price equals[5]

$$F_t^{(n)} = S_t \left(1 + RF_t^{(n)}\right)^n \left(1 + U_t^{(n)}\right)^n - C_{t+n}, \tag{1}$$

where $RF_t^{(n)}$ is the n-period risk-free interest rate at time t, matching the maturity of the futures contract. We can use the same cost-of-carry relation to define the per-period log or percentage basis, $y_t^{(n)}$

$$F_t^{(n)} = S_t \exp\{y_t^{(n)} \times n\}, \tag{2}$$

with

$$y_t^{(n)} = \frac{1}{n} \ln \left\{ \left(1 + RF_t^{(n)}\right)^n \left(1 + U_t^{(n)}\right)^n - \frac{C_{t+n}}{S_t} \right\}. \tag{3}$$

This log basis is also known as the futures (cost of) carry. Thus, $y_t^{(n)}$ is the per-period cost of carry for maturity n, analogous to a bond's n-period interest rate. If the cost-of-carry model holds, it consists of the n-period interest rate ($RF_t^{(n)}$), and possibly other items, such as storage costs ($U_t^{(n)}$) and convenience yields (C_{t+n}), depending on the nature of the underlying asset. It is also the slope of the term structure of (log) futures prices, as follows from solving (2) for $y_t^{(n)}$. Hereafter we simply refer to $y_t^{(n)}$ as the basis. It is important to note that although the cost-of-carry model gives an easy interpretation of the decomposition of futures risk premia, our decomposition is also valid when the cost-of-carry model does not hold.[6]

From the one-period expected log-spot return, we define the spot risk premium $\pi_{s,t}$ as the expected spot return in excess of the one-period basis,

$$E_t\left[r_{s,t+1}\right] = E_t\left[\ln(S_{t+1}) - \ln(S_t)\right] = E_t\left[s_{t+1} - s_t\right] = y_t^{(1)} + \pi_{s,t}, \tag{4}$$

where we take expectations $E_t[\cdot]$ conditional on the information available at time t and denote log prices using lower case. The spot premium, $\pi_{s,t}$, can be interpreted as the expected return in excess of the short-term basis, in the manner of stock returns in excess of the short-term interest rate (and adjusted for the dividend yield).

Next, we define a term premium $\pi_{y,t}^{(n)}$ as the (expected) deviation from the expectations hypothesis of the term structure of the basis,

$$ny_t^{(n)} = y_t^{(1)} + (n-1)E_t[y_{t+1}^{(n-1)}] - \pi_{y,t}^{(n)}. \tag{5}$$

Note that without imposing more structure, the term premium $\pi_{y,t}^{(n)}$ also shows up in the expected return on a futures contract for delivery at time $t+n$. This follows from the log return on such a contract, again using (2).

B. Trading Strategies

To illustrate how spot and term premia can be earned, we consider several different trading strategies. First, from equation (2) and the fact that the futures price converges to the spot price at the delivery date, we can identify the spot premium with a long position in a short-term futures contract, $r^{(1)}_{fut,t+1}$, that is, the return on the futures contract that matures at time $t+1$,

$$E_t[r^{(1)}_{fut,t+1}] = E_t[s_{t+1} - f^{(1)}_t] = E_t[s_{t+1} - s_t - y^{(1)}_t] = \pi_{s,t}. \tag{6}$$

It follows immediately from (6) that $\pi^{(1)}_{y,t} = 0$, that is, the short-term futures contract does not contain a term premium.

Next, consider the return $r^{(n)}_{fut,t\rightarrow t+n}$, which is simply the holding period return from buying an n-period futures contract at time t and holding it until the maturity date $t+n$. We refer to this as the *Holding* return, the conditional expectation of which is

$$\begin{aligned} \text{Holding:} \quad & E_t\left[r^{(n)}_{fut,t\rightarrow t+n}\right] = E_t\left[s_{t+n} - f^{(n)}_t\right] \\ = \; & E_t[\left(s_{t+n} - f^{(1)}_{t+n-1}\right) + \left(f^{(1)}_{t+n-1} - f^{(2)}_{t+n-2}\right) + \ldots + \left(f^{(n-1)}_{t+1} - f^{(n)}_t\right)] \\ = \; & \sum_{j=0}^{n-1} E_t\left[\pi_{s,t+j}\right] + \sum_{j=0}^{n-1} E_t\left[\pi^{(n-j)}_{y,t+j}\right]. \end{aligned} \tag{7}$$

Thus, the expected return of the holding strategy is the sum of expected spot premia and term premia for all maturities up to n. Note that the expected return in (7) involves the expectation at time t of the risk premia that show up in later periods. To the extent that risk premia are time-varying, this will make the longer-term expected returns different from simply adding up one-period expected returns.

Second, instead of holding an n-period futures contract until maturity, consider investing in one-period futures contracts for n consecutive periods, that is, rolling them over each period. The returns on those contracts are $r^{(1)}_{fut,t+j}$, $j = 1, 2, ..., n$, and the expected return on this *Short Roll* strategy is

$$\text{Short Roll: } E_t\left[\sum_{j=1}^{n} r^{(1)}_{fut,t+j}\right] = \sum_{j=0}^{n-1} E_t\left[\pi_{s,t+j}\right]. \tag{8}$$

Naturally, the expected return on this strategy consists of only expected (future) spot premia. Note that the spot premia in (8) are identical to those in (7), and again, if risk premia are time-varying, differ from n times the one-period spot premia in (6).

Comparing the expected returns in (7) and (8), we can isolate the term premia by going long in the Holding strategy and taking a short position in the Short Roll strategy, which we refer to as the *Excess Holding* return, the expectation of which is

$$\text{Excess Holding: } E_t\left[r^{(n)}_{fut,t\to t+n} - \sum_{j=1}^{n} r^{(1)}_{fut,t+j}\right] = \sum_{j=0}^{n-1} E_t\left[\pi^{(n-j)}_{y,t+j}\right]. \tag{9}$$

This is similar to buying a long-term bond and financing this with short-term loans rolled-over until maturity. The *Excess Holding* expected return consists of the expected term premia for all maturities up to n, which are identical to those in (7).

The term premia for those maturities can also be earned by taking a portfolio of one-period spreads $r^{(k)}_{fut,t+1} - r^{(1)}_{fut,t+1}$, for $k = 1, 2, ..., n$. Using the definitions of $\pi_{s,t}$ and $\pi^{(n)}_{y,t}$ in (4) and (5), it can be seen that the expected one-period futures return for a contract that matures at time $t + k$ is

$$E_t[r^{(k)}_{fut,t+1}] = E_t[f^{(k-1)}_{t+1} - f^{(k)}_t] = \pi_{s,t} + \pi^{(k)}_{y,t}. \tag{10}$$

Thus, if we combine a long position in a long-term contract with a short position in a short-term contract, the expected return on the spreading strategy is generated by only one term premium $\pi_{y,t}^{(k)}$,

$$E_t\left[r_{fut,t+1}^{(k)}-r_{fut,t+1}^{(1)}\right]=\pi_{y,t}^{(k)}. \tag{11}$$

Note that (9) is simply the multiperiod equivalent of this one-period spreading return. The one-period spreading strategy would yield the same term premia, but only for period $t+1$. Also note that the per-period expected returns in (9) and (11) are generally not equal, unless the term premia are constant. The term premia are earned by the spreading strategy in (11) in one period $(t+1)$, and by the Excess Holding return in (9) in n consecutive periods $(t+1,...,t+n)$. Buying a portfolio of spreads every period and rolling it over creates a multiperiod *Spreading* strategy, similar to the Short Roll strategy, the conditional expected return of which is

$$\text{Spreading: } E_t\left[\frac{1}{n}\sum_{k=1}^{n}\sum_{j=1}^{n}\left(r_{fut,t+j}^{(k)}-r_{fut,t+j}^{(1)}\right)\right]=\frac{1}{n}\sum_{k=1}^{n}\sum_{j=0}^{n-1}E_t\left[\pi_{y,t+j}^{(k)}\right]. \tag{12}$$

Basically, the Spreading strategy earns $1/n$ of each term premium each period, while the Excess Holding strategy earns each of the individual term premia consecutively. If the term structure of the basis is changing over time, or more generally if risk premia are time-varying, the two strategies have different types of roll-over risk and different expected returns.

C. Time-Varying Risk Premia

The foregoing decompositions indicate that differences in the various expected returns (on commodity futures) occur because (i) the different returns (trading strategies) are exposed to spot and term premia in different ways, and (ii) both risk premia may be time-varying. Time-varying risk premia, or expected returns, are by now understood to be a common element across markets. As noted by Cochrane (2011), "for stocks, bonds, credit spreads, foreign exchange, sovereign debt, and houses, a basis or valuation ratio translates one-for-one to expected excess returns [or risk premia]." It is similarly common in the commodity futures literature to relate expected futures returns to the (log) basis or carry (see, for example, Fama (1984), Erb and Harvey (2006), Yang (2011), Gorton, Hayashi, and Rouwenhorst (2013), and Koijen et al. (2012)).

As for stocks and other markets, the use of the basis can be motivated by a present value relation, as in Campbell and Shiller's (1988) analysis of the dividend yield. To see this, we start from the cost-of-carry model in (1). Basically, we interpret C_{t+1}/S_t as a valuation ratio, and use a log-linear approximation to relate the basis to expected returns.

Using (1) and assuming for ease of exposition that the risk-free rate and storage costs are constant over time and across maturities, the return on a one-period futures contract is

$$R^{(1)}_{Fut,t+1} = \frac{S_{t+1}}{F^{(1)}_t} = \frac{S_{t+1}}{S_t\,(1+RF)\,(1+U) - C_{t+1}}. \tag{13}$$

Relative to the stock return that underlies the Campbell and Shiller linearization, (13) looks unusual: the cash payment occurs in the denominator instead of the numerator and the current spot price S_t is compounded at the risk-free rate and storage costs. Both adjustments follow from the fact that the return is calculated from the futures $F^{(1)}_t$ instead of spot S_t price and reflects the cost-of-carry. Taking logs of (13) gives

$$\begin{aligned} r^{(1)}_{fut,t+1} &= \ln\left(\frac{S_{t+1}}{F^{(1)}_t}\right) = \ln S_{t+1} - \ln\left(S_t\,(1+RF)\,(1+U) - C_{t+1}\right) \\ &= s_{t+1} - s_t - \ln\left((1+RF)\,(1+U) - \frac{C_{t+1}}{S_t}\right). \end{aligned}$$

From (5) the expectation of this is $\pi_{s,t}$. In Appendix A we show that log-linearizing the last term around the mean (log) basis $\overline{c-s} - rf - u$, and defining $\theta = 1 - \exp\left(\overline{c-s} - rf - u\right)$, we obtain

$$y^{(1)}_t \approx \frac{\kappa}{1-\theta} + E_t\left[\sum_{j=0}^{\infty} \theta^j \left\{\Delta c_{t+j+1} - \pi_{s,t+j}\right\}\right], \tag{14}$$

where κ contains constants that follow from the linearization. As shown in the appendix, for $0 < \theta < 1$ we need the average cash yield to be strictly positive and not exceed the current spot price of the commodity compounded at the risk-free rate plus storage costs. The equivalent assumption for stock prices would be that the average dividend payment does not exceed the current stock price compounded at the risk-free rate. These are mild assumptions. If the average cash yield does go to zero, the basis will be constant and naturally not contain any information about either risk premia.

Equation (14) shows that the current basis contains information about future cash yield growth and future spot premia. It follows that $y_t^{(1)}$ is a natural predictor of spot risk premia. Performing the same analysis for longer-term contracts, Appendix A shows that $y_t^{(n)}$ contains information about future cash yield growth and both spot and term premia:

$$y_t^{(n)} \approx s_t + n\,(rf + u) - c_{t+n} = \frac{\kappa_n}{1-\theta_n} + E_t\left[\sum_{j=0}^{\infty} \theta_n^j \left\{\Delta c_{t+(j+1)n} - \textstyle\sum_{i=0}^{n-1} \pi_{s,t+i} - \sum_{i=0}^{n-1} \pi_{y,t+i}^{(i)}\right\}\right]. \tag{15}$$

We use subscripts n on κ_n and θ_n in equation (15) to emphasize that these parameters do depend on the maturity n chosen.

Thus, similar to dividend yields for stocks, the yield curve for bonds, and the interest rate spread for currency returns, equation (15) suggests that the commodity futures basis predicts commodity (excess) returns. The basis is therefore a natural candidate for explaining time-variation in commodity risk premia. The extent to which basis reflects changing risk premia or growth in cash flow yields is an empirical question.

II. Futures Data and Summary Statistics

A. Futures Data

We use bimonthly returns constructed from data obtained from the Commodity Research Bureau (CRB) on 21 commodity futures contracts. Data are available for different sample periods, depending on the contract. We use March 1986 as the starting date for our sample to ensure that we have at least three commodities per portfolio when sorting returns for each maturity series into four portfolios. From this date onwards we can also construct hedging pressure data as one of our predictive instruments. The end of our sample is December 2010.

As futures contracts are unevenly spread over the calendar year in terms of available delivery dates, with available delivery dates varying between five and 12 months per year, the use of bimonthly data allows us to construct more evenly distributed maturity contracts. We construct two-month (which is one period) returns for nearest-to-maturity contracts as the short maturity contracts and holding period returns for four, six, and eight months until the delivery date. We take for each bimonthly date the nearest-to-maturity contract as the spot contract, the second nearest-to-maturity contract as the futures contract with one period to maturity, and so forth.

As commodity spot markets are known to be illiquid, we use the nearest-to-maturity futures price as the spot price, similar to most other studies on commodity futures. Although this gives rise to some irregularities in delivery date, given that we use bimonthly observations, the resulting errors will be small. The 21 commodities were chosen with an eye to minimizing the irregularities in delivery dates. Prices of futures observed a month prior to and during the delivery month are excluded from the analysis to avoid irregular price behavior close to the delivery date. Although it is common in the literature to roll over to the next nearest contract at the end of the month prior to delivery month T, we observe for many contracts in our sample low open interest during the last six weeks, and thus we roll over one month earlier, that is, just before month $T-1$, to avoid thinly traded prices. Moreover, for many contracts traders often start rolling over their contracts from four to six weeks before the delivery date, implying that we can expect to observe erratic price behavior this long before the maturity date.

We divide the data into seven commonly used categories: Energy (3), Meats (3), Metals (3), Grains (4), Oilseeds (3), Softs[7] (3), and Industrial Materials (2).[8] These markets have relatively large trading volumes and provide a broad cross-section of commodity futures contracts. In the Internet Appendix we describe our data set in detail.[9]

For each of the seven categories, we construct equally weighted "sector-maturity" indices of the futures contracts as the equally weighted average of log returns. The average index returns (and later portfolio returns) should therefore be interpreted as average log returns, not real portfolio returns (which would have rebalancing returns in them). Indices are created for the nearest-to-maturity contracts (referred to as "nearby" indices) and for the next three farther-to-maturity contracts. In addition to the seven sector indices, we create equally weighted (EW) indices by taking the simple average of the log returns over all 21 contracts.

B. Unconditional Expected Returns

Table I contains summary statistics for the seven sector indices and the EW index of 21 commodities. The first panel shows average returns and standard deviations for the Short Roll returns that isolate the spot premia. Except for Metals and Meats, Short Roll returns show clear downward- or upward-sloping patterns. Recall that the difference between expected Short Roll returns across maturities is due to time-variation in spot premia. Thus, these patterns in the average Short Roll returns are indicative of time-varying spot premia. The t-statistics indicate that approximately one-third of individual sector-maturity indices have average Short Roll returns significantly different from zero. Between-sector variation is quite high, with average spot premia ranging from around 10% per annum for Energy contracts to around -6.5% for Grains and Softs. The resulting average of the EW index for the 21 futures contracts is close to and indistinguishable from zero.

[Table I about here]

The average Excess Holding returns in the second panel isolate the term premia and show them to be an order of magnitude smaller than the spot premia, (except for Industrial Materials) never exceeding 2% per annum. For individual sectors, t-statistics confirm the average Excess Holding returns to be mostly indistinguishable from zero, except for Industrial Materials. The EW index shows average returns to be significantly different from zero though, implying that average term premia across sectors are reliably different from zero.

We report the results for the Holding and Spreading returns in the Internet Appendix. We find that Holding returns are similar to Short Roll returns, although differences between maturities are usually larger for Holding than Short Roll returns. As Holding returns are the sum of Short Roll and Excess Holding returns, these differences are due to the term premia that are more distinct in longer-maturity contracts. We also observe that Spreading returns, although also mostly indistinguishable from zero, are different from Excess Holding returns, suggesting that there is time-variation in these term premia.

III. Analysis of Conditional Expected Returns

The patterns in the different return strategies are indicative of time-variation in both spot and term premia. We use portfolio sorts as a way to capture time-variation in risk premia. Extensively used in studying stock market returns, the portfolio sorting approach has been adopted in recent papers on commodity futures (e.g., Dhume (2011), Gorton, Hayashi, and Rouwenhorst (2013)). We sort 21 commodities into four portfolios based on the quartiles of the instruments described in detail below. We choose four portfolios to (i) reduce return variance by balancing a sufficient number of commodities per portfolio, and (ii) be able to detect monotonic increasing or decreasing patterns in estimated premia across sorts. For each sort, we consider maturities of two, four, six, and eight months for Short Roll and Excess Holding returns. The results for the Holding and Spreading returns are similar to those reported here and are tabulated in the Internet Appendix.

A. Sorting on the Basis

Table II, which presents our first main result, shows the different types of mean returns and standard deviations (Short Roll and Excess Holding) when futures contracts are sorted on the short maturity (log) basis. The table is structured the same as for the sector returns presented in Table I.

[Table II about here]

Panel A of Table II shows clear patterns in the portfolio returns resulting from the sorts. The Short Roll returns provide a direct estimate only of the spot premia. Looking at these returns, we see that for all holding periods ($n = 1, 2, 3$, and 4) mean returns always decrease as the basis increases. The resulting spread in the high-minus-low basis portfolios (P4-P1) decreases from -8.3% to -14.5% per annum across the holding periods. Thus, sorting on the basis results in a spread of about -10% for the high versus low portfolio, which is both economically and statistically highly significant. Commodities with the lowest basis, and thus highest convenience yield, have the highest mean returns, which increase from 4.8% to 9.9% per year as the maturity of the Short Roll return increases. For the highest basis portfolio, mean returns are all between -3.5% and -5.6%. Total spreads between the high and low basis portfolios are comparable to those reported in Dhume (2011) and Gorton, Hayashi, and Rouwenhorst (2013), who find (absolute) spreads of 9.7% and 10.0%, respectively (although their studies neither distinguish between maturities nor differentiate between spot and term premia). Erb and Harvey (2006) use a slightly different strategy, going long in commodities that are backwardated (i.e., have a negative basis) and short in commodities that are contangoed (i.e., have a positive basis), and obtain an excess return of 8.2% relative to a long-only strategy.

The Excess Holding returns isolate the term premia. Except for $n = 2$, we also see a monotonic pattern in the term premia, which now increase as a function of the basis. The resulting spreads for the high-minus-low basis portfolios range from 0.6% to 1.8% per annum. Although the term premia are much smaller than the spot premia, their spreads are significantly different from zero, and the standard deviations of the Excess Holding returns are also modest between 1.0% and 3.2% across all portfolios.

The Internet Appendix reports, as a robustness check, tables similar to Table II but for different sample periods. We first construct a sample that starts at the same date of January 1986, but ends in November 2008, before the start of the financial market crisis. We then construct two samples that start at earlier dates. One begins in July 1967 that consists of only 11 commodities and no energy contracts. Another, begins, at least for the shortest maturities contracts, in August 1978 and has 18 different contracts. The results of sorting on basis are similar across these samples.

As many commodities show seasonal patterns, at least in the basis, the Internet Appendix also reports sorting results when correcting for seasonalities. Sorting returns and seasonally adjusted returns on the seasonally adjusted basis again give results very similar to those we report in Table II. Finally, given that the sorting based on the basis is motivated by the cost-of-carry model, we report in the Internet Appendix the extent to which the sorting results from the basis are driven by interest rates rather than the convenience yield, and find that there is no meaningful effect from the interest rate on the sorted portfolio returns.

B. Sorting on the Cross-Section of the Basis

Sorting futures on the current level of the basis produces clear patterns in the cross-section of commodity futures returns, with significant spot and term premia. To see the extent to which the resulting spreads (premia) are due to the fact that the average level of the basis is high or low, Panel B.1 of Table II sorts the commodity futures on their mean basis. Notice that this sort is done on the total sample mean of the basis and therefore, unlike the results in Panel A, does not represent an investable strategy. For each of the two returns (Short Roll and Excess Holding) the first row, "mono", indicates whether the underlying mean returns on the four portfolios show a monotonic pattern across the sort. The next two rows show the average return spread for the high-minus-low portfolio (P4-P1) and the corresponding t-statistic.

Sorting on the mean basis in Panel B.1 produces monotonic return patterns in all cases except one, and the resulting spreads in both spot and term premia are highly significant and especially for the spot premia even higher than the sorts for the basis itself. Although these returns do not represent an investable strategy, Panel B.1 suggests that most if not all of the results from sorting on the basis come from the cross-section of the mean basis. However, Panel B.2 shows the results when sorting commodities on the deviation of the current basis from its sample mean. Thus, if we take the mean basis as given, the portfolio goes long in commodities whose basis is currently high relative to its mean and short in commodities whose basis is currently low relative to its mean. The resulting returns are again monotonic and yield a significant spread for the Short

Roll returns, except for the shortest maturity. For Excess Holding returns the patterns are weaker and the implied term premia are significant for the longest maturities only. Although the implied spot and term premia are smaller, they still represent about 50% of the basis premia in Panel A. If we add the two premia in Panels B.1 and B.2, on average about 70% of the spot and term premia is due to sorting on the (in-sample) mean, and the remaining 30% is due to sorting on deviations from the mean.

IV. Explaining the Cross-Section of Commodity Expected Returns

Although from the analysis of the valuation ratio in Section II the basis is a natural predictor for both spot and term premia, the literature on commodity futures identifies many other variables that may predict commodity futures returns. We first sort our commodity futures according to a number of forecasting variables and characterize the resulting portfolios in terms of spot and term premia. We then attempt to answer the question of whether the different sorts capture different types of risk or can be explained by one factor or a limited number of factors. Bessembinder and Chan (1992) find for a set of eight commodity and four currency futures that the (unconditional) returns on the nearest-to-maturity contracts (reflecting spot premia in our terminology) are driven by two latent (unobservable) factors. We construct observable factor portfolios from the basis sort and use standard asset pricing tests to analyze whether the resulting basis factors explain the cross-sectional patterns in the various portfolio returns. Again, given that we observe consistent results across the different types of trading strategies that capture spot and term premia, we only report here the results for the Short Roll and Excess Holding returns, leaving the other results for the Internet Appendix.

A. *Alternative Sorts*

Similarly to the analysis of the basis above, every two months we sort our 21 commodities into four portfolios based on a forecasting variable and then analyze the different types of returns that capture spot and term premia. A detailed description of the way we construct the different forecasting variables is given in Appendix B. The set of forecasting variables we use is not meant to be exhaustive, but rather to be representative of earlier studies.

We use the following forecasting variables. First, similar to other asset classes, there is momentum in commodity futures returns ((Erb and Harvey (2006), Gorton, Hayashi, and Rouwenhorst (2013), Miffre and Rallis (2007), and Asness, Moskowitz, and Pedersen (2012)). Second, reflecting the fact that high risk induces high expected returns, commodities with high spot price volatility (measured by the coefficient of variation) are known to have higher expected futures returns (Dhume (2011)). Third, commodity returns are positively correlated with inflation (Greer (2000), Erb and Harvey (2006), and Gorton and Rouwenhorst (2006)) and commodity's unexpected inflation betas are highly correlated with roll returns (Erb and Harvey (2006)). Fourth, somewhat related, as most commodity markets are denominated in U.S. dollars, this implies that commodity markets are likely exposed to currency risk. Erb and Harvey (2006) find a significant negative exposure of commodities with respect to changes in the U.S. dollar versus a basket of foreign currencies. Fifth, an extensive literature relates expected futures returns to the net (long versus short) positions of hedgers in the futures market, known as hedging pressure. Markets in which hedgers are net short (long) are found to have positive (negative) expected futures returns (Carter, Rausser, and Schmitz (1983), Chang (1985), Bessembinder (1992), and de Roon, Nijman, and Veld (2000)). More recently, next to hedging pressure, Hong and Yogo (2012) show open interest in a futures market to (positively) predict commodity, currency, stock, and bond prices. Their model, supported by empirical findings, implies that, owing to hedging demand and downward-sloping demand curves in futures markets, open interest is an informative signal of future price inflation, which we us as a sixth instrument. Finally, as liquidity may differ widely between different commodity futures and between different maturities, expected futures returns may reflect the liquidity of the contract. We use the Amivest measure (Amihud, Mendelson, and Lauterbach (1997)) as suggested by Marshall, Nguyen, and Visaltanachoti (2012) as our last forecasting variable.

Using the same format as in Panel B of Table II, Table III summarizes the results for the alternative portfolio sorts. For comparison, the first panel of Table III also summarizes the results from sorting on the basis as reported in Table II. Spot premia in the short-maturity Short Roll returns show up reliably when sorting on the (percentage) basis, momentum, volatility, inflation beta, and liquidity, but not in the other sorts. For the shortest maturity contracts, the (absolute) spreads in the high-minus-low portfolios vary between 8.1% per annum for the volatility sorts to 9.6% per annum for the (unexpected) inflation beta sorts. It is only for the basis and inflation beta that the Short Roll returns are also monotonic and show significant spreads for longer maturities, whereas for momentum and liquidity the sorted returns become nonmonotonic and/or the spreads become insignificant as the maturity of the contract increases. The results for volatility sorts are somewhat mixed in this respect. The high-minus-low spreading returns for the Short Roll returns are relatively stable across maturities for sorts on inflation beta, indicating that there is no additional time-variation in these spot premia (unlike for basis spreads).

[Table III about here]

Term premia, as measured by the Excess Holding returns, show up reliably when sorting on the basis, volatility, and inflation beta. They show up marginally in the longest-maturity hedging pressure and liquidity sorted portfolios, based on the Spreading returns as reported in the Internet Appendix. Term premia are always of the opposite sign as spot premia, and on an order of magnitude of 0.5% to 1.5% per annum with little cross-sectional variation between the sorts.

It is only for sorts on beta with respect to changes in the U.S. dollar and for sorts on open interest that we observe neither reliable spot nor term premia in the various portfolio returns. Also, although for hedging pressure and open interest previous studies show regression-based evidence for a significant relation with commodity futures returns, this shows up only marginally, if at all, in our sorted portfolios.[10]

In sum, except for the U.S. dollar and open interest, sorting on other forecasting variables yields similar patterns in spot and term premia as in sorting on the basis - the order of magnitude of the premia is often very similar, with term premia being of the opposite sign and much smaller in absolute value than spot premia.

B. A Factor-Model for Commodity Returns

Our next task is to investigate whether the different sorts capture different types of risk factors or can be explained by one factor or a limited number of factors. We therefore proceed with formal asset pricing tests to identify the factor(s) that may price the various sorted portfolios.[11]

B.1. A Basis-Based Factor Model

Our starting point is again the basis sorts, from which we first construct a factor portfolio based on the Holding returns for the two highest basis portfolios (P3+P4) minus the two lowest basis portfolios (P1+P2). We start with the Holding returns, as these consist of both spot and term premia and thus may be able to capture all types of returns. We go long in an equally weighted portfolio of the 10 commodities with the highest basis and short in an equally weighted portfolio of the 10 commodities with the lowest basis. Using this factor portfolio, with Holding return $rHML^{(n)}_{t\to t+n}$, we then test whether this portfolio can explain the risk premia on the sorted portfolios using the regressions

$$ri^{(n)}_{t\to t+n} = \alpha^{(n)}_i + \beta^{(n)}_i rHML^{(n)}_{t\to t+n} + \varepsilon^{(n)}_{it\to t+n}, \quad i = 1, .., 4, \tag{16}$$

where i is the indicator for the four portfolios within each sort and $ri^{(n)}_{t\to t+n}$ is the return on sorted portfolio i with maturity n. Note that for $ri^{(n)}_{t\to t+n}$ we use Short Roll returns and Excess Holding returns. If the factor portfolio can explain the portfolio sorts, standard asset pricing tests imply that $\alpha^{(n)}_i$ equals zero. We use a Wald test estimated using Newey-West corrected standard errors to jointly test whether the four $\alpha^{(n)}_i$'s in each sort are zero.[12]

[Table IV about here]

Table IV reports the test results for the basis factor. The first two columns present the results of the tests for Short Roll returns $ri^{(n)}_{t\to t+n}$ based on all the sorts discussed earlier save those on dollar beta and open interest, for which we do not report any meaningful results in Table III. The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, and the second column gives the p-value for the Wald test that these $\alpha^{(n)}_i$'s are zero. By way of example, the first four lines show that when confronting the basis-sorted portfolios with the basis factor, the average (absolute) $\alpha^{(n)}_i$ varies between 0.6% and 2.3% per annum across maturities, and the p-values of the Wald test show these $\alpha^{(n)}_i$'s to be indistinguishable from zero.

As can be seen from the p-values of the Wald tests as well as from the $\alpha^{(n)}_i$'s, the basis factor can explain almost all portfolio Short Roll returns for the other sorted portfolios. The hypothesis of zero intercepts is rejected for only one individual portfolio sort at the 5% level. The (absolute) $\alpha^{(n)}_i$ is about 2% per annum for most sorted portfolios, and exceeds 3% per annum in only two out of 24 cases. Overall, the basis factor does a good job explaining the sorted portfolio Short Roll returns in our sample.

Figure 1 graphically shows the explanatory power of the basis factor for the portfolio returns. For each maturity, the four panels show the relation between $\beta_i^{(n)}$ and the mean return for each of the four portfolios in every sort, resulting in 24 portfolios. These graphs show that the mean returns line up with their beta with respect to the basis factor. The (absolute) correlations between the mean returns and the betas are all about 0.80.

[Figure 1 about here]

This is quite different from the story told by the next two columns in each panel of Table IV, which show the test results for the Excess Holding returns on the various portfolios. These returns, which capture the term premia on the various sorts, are virtually unexplained by the Holding returns from the basis factor. The Wald tests reject the zero intercepts in almost all sorts for all maturities, and the $\alpha_i^{(n)}$'s are of the same order of magnitude as the mean sorted portfolio returns. Thus, the basis factor (from Holding returns) explains almost all of the spot premia but cannot explain the term premia in our sample.

B.2. Explaining Term Premia

Since the basis factor from Holding returns explains spot premia well but cannot explain term premia, we first check whether term premia can be captured by basing the factor portfolio $rHML_{t\to t+n}^{(n)}$ on the Excess Holding or Spreading returns, which are directly related to term premia. Although we might use either to construct the factor portfolio, we prefer the Spreading returns, as they contain all term premia for $n = 1, 2, ...$ each period, whereas the Excess Holding returns contain only one in each period, and all of them only in the n consecutive periods. Having deemed them more informative about the different term premia, we create the factor portfolio based on the Spreading returns for the two highest basis portfolios (P3+P4) minus the two lowest basis portfolios (P1+P2), which implies that we go long in the spreads, as in (11), for the 10 commodities with the highest basis, and short in the spreads for the 10 commodities with the lowest basis. Depending on the maturity n, we then roll the spreads forward for n periods as in (12).

The first two columns in each panel of Table V clearly indicate that this factor portfolio does not improve upon the factor portfolio based on the Holding returns presented in Table IV. The Wald tests reject the hypothesis that the $\alpha_i^{(n)}$'s are zero for all sorts and across all maturities, and the $\alpha_i^{(n)}$'s are themselves similar in magnitude to the term premia estimated in Table III. Thus, one basis factor cannot explain any of the term premia.

[Table V about here]

The last two columns in each panel of Table V report the results of similar tests, but with two factors. That is, we do not create a high-minus-low basis portfolio of spreads, but use the two portfolios separately: $rH_{t\to t+n}^{(n)}$ is the equally weighted average of the Spreading returns for the commodities with the highest basis; $rL_{t\to t+n}^{(n)}$ is the equally weighted average of the Spreading returns for the lowest basis commodities. The tests are now based on the regression

$$ri_{t\to t+n}^{(n)} = \alpha_i^{(n)} + \beta_{Hi}^{(n)} rH_{t\to t+n}^{(n)} + \beta_{Li}^{(n)} rL_{t\to t+n}^{(n)} + \varepsilon_{it\to t+n}^{(n)}, \quad i = 1, .., 4. \tag{17}$$

The results of this two-factor model are very different, with the two basis factors now able to capture almost all term premia across the sorts and maturities save for the sorts on liquidity. The average absolute alphas are usually less than 40 basis points per year, with the exception of the sorts on liquidity, where almost all average absolute alphas exceed 50 basis points per annum and are highly significant. But note from Table III that sorting on liquidity in itself does not yield a clear pattern of term premia. We therefore interpret the failure of the basis factors to explain the liquidity portfolios as a pure liquidity effect, rather than as unexplained risk premia.

Thus, save for the liquidity sorts, two basis factors from Spreading returns capture most of the cross-sectional variation in the term premia. These factors are different from the basis factor that explains the spot premia, implying that we need in total three factors to explain both spot and term premia. In the Internet Appendix we find that the term premia cannot be explained from two factors based on Holding returns, which would imply only two factors to explain both spot and term premia.

B.3. Alternative Factors

At this point, the reader may wonder whether only the basis factor can explain the spot and term premia, or whether factors based on other forecasting variables explain the various portfolio sorts as well? Because sorting on the basis is only one way to capture time-variation in commodity risk premia, and Table III shows sorting on other variables to result in meaningful risk premia as well, we can also construct factors based on these alternative sorts.

Table VI addresses the question of whether the Short Roll returns $ri^{(n)}_{t \to t+n}$ (which capture spot premia) for the various sorts can be explained by Holding returns on factor portfolios $rHML^{(n)}_{t \to t+n}$ that come from sorts other than the basis. The table presents the average absolute $\alpha_i^{(n)}$ for all sorted portfolio Short Roll returns and for different factor portfolios as well as the Wald test (p-values) that the four $\alpha_i^{(n)}$'s in each sort are zero. The columns in Table VI can thus be compared to the first two columns in each panel of

Table IV for the basis factor.

[Table VI about here]

The horse race presented in Table VI shows that the various factor portfolios can explain the own-portfolio sorts well, as well as the sorts on momentum, inflation, and hedging pressure, but generally fail to explain the portfolios sorted on basis and most of the volatility-sorted portfolios. The factor portfolios also have difficulties with the sorts on liquidity, especially for the longer maturities where liquidity is likely to play a more important role. Overall, none of the factor portfolios comes close to the performance of the basis factor (in Table IV). The Wald tests reject the factor models in many more cases, and the $\alpha_i^{(n)}$'s show much more unexplained return to be left on the table than in the case of the basis factor. We conclude that spot premia are better characterized by the basis factor than by any one of the other factors.

[Table VII about here]

Finally, Table VII shows similar results for the term premia. To save space, we only report whether two factors based on the various sorts are able to explain the term premia from the basis sorts. The Internet Appendix shows the explanatory power for the alternative factors for the other portfolio sorts as well. The results in Table VII clearly show that none of the alternative factors are able to explain the term premia from sorting on the basis. In all cases but one the hypothesis of zero intercepts is rejected at least at the 5% level and the alphas themselves vary between 0.50% and 1% per year, double those from the basis factors in Table V. We thus conclude again that none of the factors based on the other forecasting variables comes close to the explanatory power of the two basis factors.

V. Summary and Conclusions

This paper analyzes the various risk premia present in commodity futures markets that can be identified on the one hand when sorting commodity futures on characteristics such as the basis, volatility, and momentum, and on the other hand by distinguishing contracts according to their maturity. A simple decomposition of futures returns shows futures expected returns to consist of two risk premia: spot premia related to the risk in the underlying commodity, and term premia related to the changes in basis. We show how these different premia can be isolated using simple trading strategies. We find that, in most cases, spot and term premia have opposite signs and are highly predictable. Sorting on the futures basis, momentum, volatility, inflation, and liquidity results in sizable spot premia in the high-minus-low portfolios between 5% and 14% per annum and term premia between 1% and 3% in absolute value.

We also find that the cross-sectional patterns in spot premia based on these characteristics can be captured by one basis factor, whereas two additional factors are needed to explain term premia. Thus, for asset pricing models to explain commodity futures risk premia, the challenge is to explain the basis-sorted high-minus-low Holding portfolio for spot premia, and the high and low Spreading portfolios for term premia.

Appendix A. Relating Basis to Expected Futures Returns

We start by writing (13) for the n-period return for an n-period contract (the Holding return),

$$R^{(n)}_{F,t\to t+n} = \frac{S_{t+n}}{F^{(n)}_t} = \frac{S_{t+n}}{S_t\left(1+RF\right)^n\left(1+U\right)^n - C_{t+n}}. \tag{A1}$$

Taking logs gives

$$
\begin{aligned}
r_{f,t\to t+n}^{(n)} &= \ln\left(\frac{S_{t+n}}{F_t^{(n)}}\right) = \ln S_{t+n} - \ln\left(S_t\left(1+RF\right)^n\left(1+U\right)^n - C_{t+n}\right) \\
&= \ln S_{t+n} - \ln\left(S_t\left(\left(1+RF\right)^n\left(1+U\right)^n - \frac{C_{t+n}}{S_t}\right)\right) \\
&= s_{t+n} - s_t - \ln\left(\left(1+RF\right)^n\left(1+U\right)^n - \frac{C_{t+n}}{S_t}\right).
\end{aligned}
$$

Note that the last term would be $y_t^{(n)}$ in our setting. Proceeding with log returns, we write this as

$$
\begin{aligned}
r_{f,t\to t+n}^{(n)} &= s_{t+n} - s_t - \ln\left(\left(1+RF\right)^n\left(1+U\right)^n\left(1-\frac{C_{t+n}/S_t}{\left(1+RF\right)^n\left(1+U\right)^n}\right)\right) \\
& \quad s_{t+n} - s_t - n\left(rf+u\right) - \ln\left(1-\exp\left(c_{t+n} - s_t - n\left(rf+u\right)\right)\right).
\end{aligned}
$$

Following Campbell and Shiller (1988), the last term on the right-hand side, $n\left(rf+u\right) - ny_t^{(n)}$, can be approximated using a first-order Taylor series expansion,

$$
\begin{aligned}
& \ln\left(1-\exp\left(c_{t+n} - s_t - n\left(rf+u\right)\right)\right) \\
\approx & \ln\left(1-\exp\left(\overline{c_n - s} - n\left(rf+u\right)\right)\right) + \frac{\exp\left(\overline{c_n - s} - n\left(rf+u\right)\right)}{1-\exp\left(\overline{c_n - s} - n\left(rf+u\right)\right)}\left(c_{t+n} - s_t - \overline{c_n - s}\right).
\end{aligned}
$$

Defining $\rho_n = 1/\left(1-\exp\left(\overline{c_n - s} - n\left(rf+u\right)\right)\right)$, the log futures return can be written as

$$
\begin{aligned}
r_{f,t\to t+n}^{(n)} &\approx \kappa_n' + s_{t+n} - s_t - n\left(rf+u\right) + \left(1-\rho_n\right)\left(c_{t+n} - s_t - n\left(rf+u\right)\right) \quad \text{(A2)} \\
&= \kappa_n' + s_{t+n} - \rho_n s_t - \rho_n n\left(rf+u\right) + (1-\rho_n)c_{t+n} \\
\theta_n r_{f,t\to t+n}^{(n)} &\approx \kappa_n + \theta_n\left(s_{t+n} - n\left(rf+u\right)\right) + \left(1-\theta_n\right)\left(c_{t+n} - n\left(rf+u\right)\right) - s_t.
\end{aligned}
$$

Here, κ_n contains all the constant terms (including rf and u) and $\theta_n = 1/\rho_n$.

As in Campbell and Shiller, we can now solve forward

$$s_t = \frac{\kappa_n}{1-\theta_n} + \sum_{j=0}^{\infty} \theta_n^j \left\{ (1-\theta_n)\, c_{t+n+jn} - r^{(n)}_{f,t+jn\to t+(j+1)n} - n\,(rf+u) \right\}.$$

Note that for $0 < \theta_n < 1$, we need the average value of $\frac{C_{t+n}/S_t}{(1+RF)^n(1+U)^n}$ to be between zero and one. This means that the average cash yield must be strictly positive, and that, on average, the cash yield cannot exceed the current spot price compounded at the risk free-rate and storage costs. Taking expectations and rewriting gives

$$s_t - c_{t+n} = \frac{\kappa_n}{1-\theta_n} + E_t \left[\sum_{j=0}^{\infty} \theta_n^j \left\{ \Delta c_{t+(j+1)n} - r^{(n)}_{f,t+jn\to t+(j+1)n} - n\,(rf+u) \right\} \right]. \tag{A3}$$

For our purposes, it is useful to subtract $n\,(rf+u)$ from both sides and use the definition of the spot and term premia

$$y_t^{(n)} \approx s_t + n\,(rf+u) - c_{t+n} = \frac{\kappa_n}{1-\theta_n} + E_t \left[\sum_{j=0}^{\infty} \theta_n^j \left\{ \Delta c_{t+(j+1)n} - \textstyle\sum_{i=0}^{n-1} \pi_{s,t+i} - \sum_{i=0}^{n-1} \pi^{(i)}_{y,t+i} \right\} \right]. \tag{A4}$$

For $n = 1$ this simplifies to (14).

Appendix B. Forecasting Variables

Momentum: We sort on momentum by sorting on the cumulative log return from month $t-12$ to $t-1$.

Coefficient of Variation: As in Dhume (2011), we use the coefficient of variation as a measure of volatility, that is, variance scaled by mean return. We calculate the coefficient of variation over the period $t-36$ to $t-1$. Scaling the variance by the mean return can be interpreted as correcting the volatility effect for a momentum effect.

Inflation Beta: We use commodities inflation beta from a 60-month rolling regression of monthly commodity futures returns on unexpected inflation, measured by the change in one-month CPI inflation. In the Internet Appendix, we use two additional measures of unexpected inflation, namely inflation minus the risk-free interest rate, and inflation minus its prediction from an ARIMA-model.

Dollar Beta: We use commodities dollar beta from a 60-month rolling regression of monthly commodity futures returns on changes in the U.S. dollar versus a basket of foreign currencies.

Hedging Pressure: The hedging pressure variable in a futures market is defined as the difference between the number of short and the number of long hedge positions by large traders relative to the total number of hedge positions by large traders in that market,

$$hp_t = \frac{\text{\# of short hedge positions} - \text{\# of long hedge positions}}{\text{total \# of hedge positions}},$$

where positions are measured by the number of contracts in the market. Hedging pressure is calculated using data published in the Commitment of Traders reports issued by the Commodity Futures Trading Commission (CFTC).

Open Interest: Following Hong and Yogo (2012), we use the total open interest in a futures market.

Liquidity: Following Marshall, Nguyen, and Visaltanachoti (2012) we use the Amivest measure (Amihud, Mendelson, and Lauterbach (1997)) for liquidity, which divides the volume on a trading day by the absolute return on that trading day. The bimonthly measure is the average of the daily Amivest measures over the two-month period.

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Notes

[1]Although we refer to them as risk premia, notice that in futures markets these may be both negative or positive as futures markets are zero-sum games.

[2]See, for example, Hansen and Hodrick (1980), Fama (1984, 1986), Fama and Bliss (1987),

Campbell and Shiller (1991), Gourinchas and Rey (2007), Piazzesi and Swanson (2008), Koijen et al. (2012), or Cochrane (2011) for an excellent review and references therein.

[3]See, for example, Carter, Rausser, and Schmitz (1983), Fama (1984), Chang (1985), Fama and French (1987), Bessembinder (1992), de Roon, Nijman, and Veld (1998, 2000), Erb and Harvey (2006), Miffre and Rallis (2007), and Gorton, Hayashi, and Rouwenhorst (2013).

[4]See, for example, Erb and Harvey (2006), Dhume (2011), and Hong and Yogo (2012).

[5]This way of expressing the cost-of-carry model, which assumes that storage costs must be paid up front, therefore implies financing costs. The expression in Fama and French (1988), equation (1), differs from ours in that we express storage costs as a fraction of the current spot price. This representation is more useful for our analysis.

[6]If the cost-of-carry model does not hold, for instance, because of stochastic interest rates (as in Cox, Ingersoll, and Ross (1981) or Casassus and Collin-Dufresne (2005)), or because the commodity is non-storable, the basis is still defined as the log (or percentage) difference between the futures price and the spot price.

[7]The category "Softs" as used by the CRB consists of Coffee, Orange Juice, and Cocoa.

[8]The classification we use is similar to that used by the Institute for Financial Markets (IFM).

[9]The Internet Appendix is available in the online version of the article on the Journal of Finance website.

[10]Gorton, Hayashi, and Rouwenhorst (2013), using similar sorting techniques as we do here, also cannot confirm the regression-based evidence for hedging pressure effects.

[11]We also investigate a possible factor structure in the different sorts by analyzing the return variance explained by their principal components. We find that the spot premia are related to one factor (the first principal component of Short Roll and Spreading returns), whereas term premia are related to one or two separate factors (the second and third principal components). We discuss these results in detail in the Internet Appendix.

[12]The reader may argue that this test relates commodity risk premia only to commodity factors,

whereas asset pricing models like the CAPM or Consumption CAPM imply that these premia should be explained by the market factor or consumption risk. Many papers, however, show commodity returns to be basically unrelated to such marketwide factors. See, for example, Dusak (1973), Black (1976), Carter, Rausser, and Schmitz (1983), Jagannathan (1985), Bessembinder (1992), de Roon, Nijman, and Veld (2000), and Erb and Harvey (2006). We thus believe that, at this stage, in order to obtain a better understanding of the structure of these premia within the commodity markets, it is more useful to try to characterize the commodity risk premia in terms of commodity factors.

Table I
Summary Statistics

The table contains summary statistics for the seven sector indices as well as for the EW (overall) commodity index. The table presents mean returns, standard deviations, and *t*-statistics for the various sector indices for the nearest-to-maturity contracts, second nearest-to-maturity contracts, and so on. The first panel shows summary statistics for the Short Roll returns, and the second one for the Excess Holding returns. *t*-statstics are based on Newey-West corrected standard errors. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

		Annualized Mean Returns				Annualized Standard Deviations				t-statistics			
		n=1	n=2	n=3	n=4	n=1	n=2	n=3	n=4	n=1	n=2	n=3	n=4
Short Roll	Energy	10.83%	9.83%	8.96%	8.56%	32.88%	29.06%	28.80%	28.5%	(1.64)	(1.68)	(1.55)	(1.49)
	Meats	4.20%	4.03%	3.93%	3.89%	13.03%	11.98%	12.08%	12.6%	(1.60)	(1.67)	(1.62)	(1.53)
	Metals	5.42%	5.02%	4.76%	4.63%	17.16%	15.42%	15.10%	15.0%	(1.57)	(1.62)	(1.57)	(1.54)
	Grains	-6.10%	-6.24%	-6.50%	-6.74%	18.96%	18.56%	18.11%	17.8%	(-1.60)	(-1.67)	(-1.78)	(-1.88)
	Oilseeds	1.86%	1.61%	1.46%	1.26%	20.96%	18.44%	17.65%	16.8%	(0.44)	(0.43)	(0.41)	(0.37)
	Softs	-6.58%	-6.57%	-6.58%	-6.70%	18.48%	16.72%	15.52%	14.7%	(-1.77)	(-1.95)	(-2.11)	(-2.27)
	Ind materials	-4.82%	-4.62%	-4.83%	-4.87%	19.56%	18.21%	17.94%	18.6%	(-1.22)	(-1.26)	(-1.34)	(-1.30)
	EW	0.65%	0.38%	0.11%	-0.07%	11.70%	11.32%	11.42%	11.3%	(0.27)	(0.16)	(0.05)	(-0.03)
Excess Holding	Energy		0.19%	0.43%	0.56%		1.45%	2.32%	3.2%		(0.65)	(0.92)	(0.86)
	Meats		0.10%	-0.06%	-0.16%		2.08%	3.52%	4.7%		(0.24)	(-0.08)	(-0.16)
	Metals		0.03%	0.00%	-0.06%		0.49%	0.87%	1.3%		(0.29)	(0.02)	(-0.24)
	Grains		0.82%	1.68%	1.49%		4.90%	7.64%	10.0%		(0.83)	(1.09)	(0.74)
	Oilseeds		0.22%	0.40%	-0.82%		1.10%	1.91%	4.9%		(0.97)	(1.03)	(-0.83)
	Softs		0.32%	0.52%	-1.11%		1.20%	1.80%	21.1%		(1.32)	(1.43)	(-0.26)
	Ind materials		1.41%	2.88%	3.52%		2.91%	6.91%	16.4%		(2.40)	(2.07)	(1.07)
	EW		0.73%	1.08%	2.77%		1.20%	2.07%	4.3%		(3.01)	(2.58)	(3.21)

Table II
Sorts Based on the Basis

The table contains mean returns and standard deviations (for Short Roll and Excess Holding returns) when futures contracts are sorted on the basis in Panel A and mean and de-meaned basis in Panel B. In Panel B for each of the returns, the first row, "mono," indicates whether the underlying mean returns on the four portfolios show a monotonic pattern across the sort. The next two rows show mean returns and *t*-statistics for the spread in mean return across the four portfolios. *t*-statistics are based on Newey-West corrected standard errors. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

		n=1	n=2	n=3	n=4	n=1	n=2	n=3	n=4
				Panel A. Basis					
		Annualized Mean Returns				Annualized Standard Deviations			
Short Roll	Low	4.82%	7.00%	7.89%	9.92%	16.97%	15.39%	16.83%	18.3%
	P2	4.68%	4.68%	3.46%	5.46%	14.25%	12.83%	11.18%	13.1%
	P3	-2.93%	-3.71%	-2.01%	-0.89%	13.46%	12.93%	12.78%	13.9%
	High	-3.47%	-4.35%	-5.61%	-4.62%	15.98%	13.16%	11.95%	15.0%
	P4-P1	-8.29%	-11.35%	-13.51%	-14.53%	17.15%	12.96%	12.76%	16.1%
	t(P4-P1)	(-2.40)	(-4.33)	(-5.22)	(-4.45)				
Excess Holding	Low		0.32%	0.07%	-0.30%		1.61%	2.33%	3.2%
	P2		0.20%	0.35%	0.59%		0.98%	1.57%	2.0%
	P3		0.47%	0.84%	0.88%		0.95%	1.41%	1.9%
	High		0.93%	1.51%	1.53%		1.37%	2.20%	2.2%
	P4-P1		0.61%	1.44%	1.84%		1.75%	2.43%	3.0%
	t(P4-P1)		(1.72)	(2.91)	(3.00)				
				Panel B. Cross-Section of Basis					
		B.1 Mean Basis				B.2 De-Meaned Basis			
Short Roll	Mono	y	y	y	y	y	y	y	y
	P4-P1	-15.42%	-15.36%	-14.86%	-18.02%	-3.82%	-5.27%	-6.66%	-10.22%
	t-stat	(-4.37)	(-4.40)	(-4.17)	(-3.91)	(-1.12)	(-2.01)	(-2.74)	(-3.27)
Excess Holding	Mono		y		y				
	P4-P1		1.12%	1.59%	2.37%		0.23%	0.80%	1.15%
	t-stat		(3.55)	(3.20)	(3.22)		(0.62)	(1.56)	(1.64)

Table III
Alternative Sorts

The table contains summary results for mean returns (Short Roll and Excess Holding returns) when futures contracts are sorted on different instruments. For each of the returns, the first row, "mono," indicates whether the underlying mean returns on the four portfolios show a monotonic pattern across the sort. The next two rows show mean returns and *t*-statistics for the spread in mean return across the four portfolios. We report the results for portfolios sorted on the basis, momentum, coefficient of variation (CV), inflation, dollar beta, hedging pressure (HP), open interest, and liquidity. Standard errors are estimated using Newey-West correction. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

		Annualized Mean Returns				Annualized Mean Returns			
		r(1)	r(2)	r(3)	r(4)	r(1)	r(2)	r(3)	r(4)
		Panel A. Returns Sorted on Basis				Panel B. Returns Sorted on Momentum			
Short Roll	Mono	y	y	y	y	y	y	y	
	P4-P1	-8.29%	-11.35%	-13.51%	-14.53%	9.00%	6.57%	4.68%	2.11%
	t-stat	(-2.40)	(-4.33)	(-5.22)	(-4.45)	(2.02)	(1.90)	(1.35)	(0.51)
Excess Holding	Mono			y	y				
	P4-P1		0.61%	1.44%	1.84%		-0.47%	-0.63%	-0.26%
	t-stat		(1.72)	(2.91)	(3.00)		(-1.12)	(-1.01)	(-0.40)
		Panel C. Returns Sorted on CV				Panel D. Returns Sorted on Inflation Beta			
Short Roll	Mono	y			y	y	y		y
	P4-P1	8.13%	8.67%	9.27%	9.28%	9.56%	9.60%	8.60%	10.04%
	t-stat	(2.37)	(2.94)	(3.18)	(2.56)	(1.99)	(2.19)	(1.87)	(1.86)
Excess Holding	Mono		y	y			y	y	y
	P4-P1		-1.00%	-1.25%	-0.79%		-0.60%	-1.15%	-1.46%
	t-stat		(-3.09)	(-2.69)	(-1.16)		(-1.53)	(-1.76)	(-1.67)
		Panel E. Returns Sorted on Dollar Beta				Panel F. Returns Sorted on HP			
Short Roll	Mono	y							y
	P4-P1	-1.86%	-1.41%	-0.91%	-1.81%	5.58%	5.75%	4.17%	5.09%
	t-stat	(-0.35)	(-0.30)	(-0.21)	(-0.34)	(1.66)	(1.77)	(1.31)	(1.64)
Excess Holding	Mono						y		
	P4-P1		0.91%	1.24%	0.87%		-0.50%	-0.57%	-0.93%
	t-stat		(2.48)	(2.10)	(1.05)		(-1.30)	(-0.89)	(-1.34)
		G. Returns sorted on Open Interest				H. Returns sorted on Liquidity			
Short Roll	Mono	y				y			
	P4-P1	5.78%	5.33%	6.35%	-5.08%	-9.40%	-7.47%	-5.89%	-6.92%
	t-stat	(1.71)	(1.77)	(1.83)	(-1.39)	(-2.22)	(-2.05)	(-1.85)	(-1.82)
Excess Holding	Mono								
	P4-P1		-1.01%	-1.38%	0.69%		0.49%	0.66%	1.26%
	t-stat		(-2.49)	(-2.05)	(0.52)		(1.57)	(1.55)	(2.04)

Table IV
Asset Pricing Tests for Basis Factor from Holding Returns

The table reports asset pricing tests for mean returns (Short Roll and Excess Holding returns) when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation (CV), inflation beta, hedging pressure (HP), and liquidity). We construct a single factor from Holding returns on basis-sorted portfolios by forming a long-short portfolio, $rHML^{(n)}_{t\to t+n}$, from the two highest basis portfolios minus the two lowest basis portfolios, and estimate the following regression:

$$ri^{(n)}_{t\to t+n} = \alpha^{(n)}_i + \beta^{(n)}_i rHML^{(n)}_{t\to t+n} + \varepsilon^{(n)}_{it\to t+n}, \quad i = 1, .., 4.$$

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, and the second column gives the p-values for the Wald test that these $\alpha^{(n)}_i$'s are zero. Standard errors are estimated using Newey-West correction. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

	Short Roll		Excess Holding		Short Roll		Excess Holding	
	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
	Panel A. Returns Sorted on Basis				Panel B. Returns Sorted on Momentum			
n=1	0.60%	(0.993)			1.28%	(0.853)		
n=2	0.63%	(0.988)	0.48%	(0.102)	0.95%	(0.935)	0.49%	(0.072)
n=3	2.27%	(0.390)	0.82%	(0.031)	2.26%	(0.538)	0.81%	(0.073)
n=4	1.24%	(0.745)	0.71%	(0.007)	1.95%	(0.191)	0.61%	(0.099)
	Panel C. Returns Sorted on CV				Panel D. Returns Sorted on Inflation Beta			
n=1	1.92%	(0.546)			2.09%	(0.688)		
n=2	2.35%	(0.258)	0.76%	(0.000)	1.53%	(0.798)	0.74%	(0.001)
n=3	3.03%	(0.024)	1.12%	(0.001)	3.35%	(0.676)	1.15%	(0.010)
n=4	2.63%	(0.277)	1.11%	(0.017)	2.13%	(0.181)	1.13%	(0.070)
	Panel E. Returns Sorted on HP				Panel F. Returns Sorted on Liquidity			
n=1	2.06%	(0.179)			2.11%	(0.655)		
n=2	2.51%	(0.104)	0.50%	(0.025)	1.73%	(0.598)	0.75%	(0.000)
n=3	2.24%	(0.670)	0.87%	(0.021)	3.00%	(0.278)	1.01%	(0.000)
n=4	2.01%	(0.390)	0.70%	(0.126)	2.62%	(0.230)	1.09%	(0.000)

Table V
Asset Pricing Tests for Basis Factor from Spreading Returns

The table reports asset pricing tests for Excess Holding returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation (CV), inflation beta, hedging pressure (HP), and liquidity). We use either one long-short factor, $rHML^{(n)}_{t\to t+n}$, constructed from Spreading returns on the two highest basis portfolios minus the two lowest basis portfolios, or the two portfolios as two factors, $rH^{(n)}_{t\to t+n}$ and $rL^{(n)}_{t\to t+n}$. We estimate the following regressions:

$$\begin{aligned} ri^{(n)}_{t\to t+n} &= \alpha^{(n)}_i + \beta^{(n)}_i rHML^{(n)}_{t\to t+n} + \varepsilon^{(n)}_{it\to t+n}, \quad i = 1, .., 4, \\ ri^{(n)}_{t\to t+n} &= \alpha^{(n)}_i + \beta^{(n)}_{Hi} rH^{(n)}_{t\to t+n} + \beta^{(n)}_{Li} rL^{(n)}_{t\to t+n} + \varepsilon^{(n)}_{it\to t+n}, \quad i = 1, .., 4. \end{aligned}$$

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, and the second column gives the p-values for the Wald test that these $\alpha^{(n)}_i$'s are zero. Standard errors are estimated using Newey-West correction. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
	One Factor		Two Factors		One Factor		Two Factors	
	Panel A. Returns Sorted on Basis				Panel B. Returns Sorted on Momentum			
n=1								
n=2	0.50%	(0.053)	0.07%	(0.937)	0.49%	(0.059)	0.09%	(0.910)
n=3	0.75%	(0.053)	0.15%	(0.757)	0.75%	(0.048)	0.18%	(0.814)
n=4	0.79%	(0.008)	0.40%	(0.193)	0.74%	(0.073)	0.25%	(0.536)
	Panel C. Returns Sorted on CV				Panel D. Returns Sorted on Inflation Beta			
n=1								
n=2	0.75%	(0.000)	0.21%	(0.434)	0.73%	(0.004)	0.08%	(0.964)
n=3	1.08%	(0.004)	0.24%	(0.356)	1.09%	(0.019)	0.14%	(0.900)
n=4	1.24%	(0.003)	0.38%	(0.490)	1.35%	(0.013)	0.38%	(0.579)
	Panel E. Returns Sorted on HP				Panel F. Returns Sorted on Liquidity			
n=1								
n=2	0.52%	(0.015)	0.18%	(0.601)	0.73%	(0.000)	0.30%	(0.097)
n=3	0.81%	(0.037)	0.20%	(0.531)	1.01%	(0.000)	0.75%	(0.000)
n=4	0.85%	(0.036)	0.25%	(0.477)	1.28%	(0.000)	0.89%	(0.000)

Table VI
Asset Pricing Tests for Alternative Factors from Holding Returns

The table reports asset pricing tests for Short Roll returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation (CV), inflation beta, hedging pressure (HP), and liquidity). We construct a single factor from Holding returns on portfolios sorted on each of the instruments by forming a long-short portfolio, $rHML^{(n)}_{t\to t+n}$, from the two highest portfolios minus the two lowest portfolios within each sort, and estimate the following regression:

$$ri^{(n)}_{t\to t+n} = \alpha^{(n)}_i + \beta^{(n)}_i rHML^{(n)}_{t\to t+n} + \varepsilon^{(n)}_{it\to t+n}, \quad i = 1, .., 4.$$

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, and the second column gives the p-values for the Wald test that these $\alpha^{(n)}_i$'s are zero. Standard errors are estimated using Newey-West correction. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

	Mom factor		CV factor		Infl factor		HP factor		Liquidity factor	
	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
Panel A. Returns Sorted on Basis										
n=1	2.88%	(0.105)	2.68%	(0.219)	2.73%	(0.134)	3.89%	(0.018)	3.23%	(0.077)
n=2	4.53%	(0.000)	3.68%	(0.007)	3.24%	(0.009)	5.01%	(0.000)	3.74%	(0.003)
n=3	4.40%	(0.000)	3.50%	(0.001)	3.16%	(0.000)	4.76%	(0.000)	3.68%	(0.000)
n=4	5.07%	(0.000)	4.57%	(0.009)	3.68%	(0.009)	5.38%	(0.000)	4.77%	(0.001)
Panel B. Returns Sorted on Momentum										
n=1	0.16%	(1.000)	3.21%	(0.278)	2.86%	(0.295)	3.21%	(0.270)	3.49%	(0.187)
n=2	1.07%	(0.739)	1.96%	(0.627)	1.75%	(0.735)	2.26%	(0.384)	1.71%	(0.540)
n=3	0.62%	(0.933)	1.34%	(0.797)	1.74%	(0.862)	1.76%	(0.611)	1.31%	(0.820)
n=4	2.50%	(0.728)	3.30%	(0.821)	0.85%	(0.957)	2.54%	(0.741)	1.46%	(0.992)
Panel C. Returns Sorted on Coefficient of Variation										
n=1	2.12%	(0.380)	2.00%	(0.598)	2.75%	(0.293)	2.48%	(0.160)	2.37%	(0.149)
n=2	2.30%	(0.092)	2.19%	(0.060)	2.94%	(0.042)	2.81%	(0.020)	2.54%	(0.014)
n=3	2.85%	(0.024)	2.59%	(0.087)	2.53%	(0.026)	3.30%	(0.013)	3.05%	(0.006)
n=4	3.95%	(0.045)	2.88%	(0.250)	3.02%	(0.147)	4.65%	(0.004)	3.92%	(0.028)
Panel D. Returns Sorted on Inflation Beta										
n=1	2.15%	(0.610)	3.13%	(0.372)	1.52%	(0.952)	3.37%	(0.296)	2.85%	(0.385)
n=2	2.70%	(0.233)	3.23%	(0.122)	1.85%	(0.890)	3.40%	(0.124)	2.88%	(0.199)
n=3	2.66%	(0.198)	2.91%	(0.172)	1.82%	(0.558)	3.18%	(0.133)	2.92%	(0.158)
n=4	3.72%	(0.070)	3.53%	(0.014)	0.70%	(0.727)	3.79%	(0.079)	3.78%	(0.061)
Panel E. Returns Sorted on Hedging Pressure										
n=1	1.78%	(0.221)	2.51%	(0.192)	3.21%	(0.142)	1.80%	(0.215)	2.50%	(0.216)
n=2	1.72%	(0.299)	2.86%	(0.075)	3.49%	(0.020)	1.75%	(0.178)	2.62%	(0.072)
n=3	1.17%	(0.750)	2.06%	(0.441)	2.67%	(0.250)	1.36%	(0.562)	1.67%	(0.444)
n=4	2.70%	(0.348)	3.47%	(0.150)	2.37%	(0.299)	2.79%	(0.325)	2.13%	(0.349)
Panel F. Returns Sorted on Liquidity										
n=1	1.96%	(0.690)	3.20%	(0.238)	1.95%	(0.574)	2.52%	(0.444)	1.12%	(0.143)
n=2	1.67%	(0.509)	3.35%	(0.109)	1.70%	(0.578)	2.16%	(0.338)	1.19%	(0.157)
n=3	1.84%	(0.321)	3.70%	(0.038)	2.48%	(0.135)	2.52%	(0.207)	1.88%	(0.005)
n=4	3.27%	(0.141)	4.93%	(0.033)	2.57%	(0.163)	3.25%	(0.194)	2.92%	(0.068)

Table VII
Asset Pricing Tests for Alternative Factors from Spreading Returns

The table reports asset pricing tests for Excess Holding returns when futures contracts are sorted on the basis. We construct two factors using Spreading returns on portfolios sorted on basis, momentum, coefficient of variation, inflation, hedging pressure, and liquidity. The first factor is the return on the two highest basis portfolios $rH_{t\to t+n}^{(n)}$ and the second one is the return on the two lowest basis portfolios $rL_{t\to t+n}^{(n)}$. We estimate the following regression:

$$ri_{t\to t+n}^{(n)} \quad = \quad \alpha_i^{(n)} + \beta_{Hi}^{(n)} rH_{t\to t+n}^{(n)} + \beta_{Li}^{(n)} rL_{t\to t+n}^{(n)} + \varepsilon_{it\to t+n}^{(n)}, \quad i = 1, .., 4.$$

The first column gives the average absolute $\alpha_i^{(n)}$ of the four portfolios within a sort, and the second column gives the p-values for the Wald test that these $\alpha_i^{(n)}$'s are zero. Standard errors are estimated using Newey-West correction. The returns are quoted bimonthly for a sample period between March 1986 and December 2010.

	α(abs)	p	α(abs)	p
	Basis factor		Mom factor	
n=1				
n=2	0.07%	(0.937)	0.16%	(0.659)
n=3	0.15%	(0.757)	0.47%	(0.034)
n=4	0.40%	(0.193)	0.68%	(0.001)
	CV factor		Infl factor	
n=1				
n=2	0.29%	(0.189)	0.29%	(0.159)
n=3	0.48%	(0.051)	0.45%	(0.033)
n=4	0.60%	(0.038)	0.74%	(0.006)
	HP factor		Liquidity factor	
n=1				
n=2	0.26%	(0.236)	0.19%	(0.259)
n=3	0.52%	(0.012)	0.52%	(0.093)
n=4	0.69%	(0.001)	0.72%	(0.037)

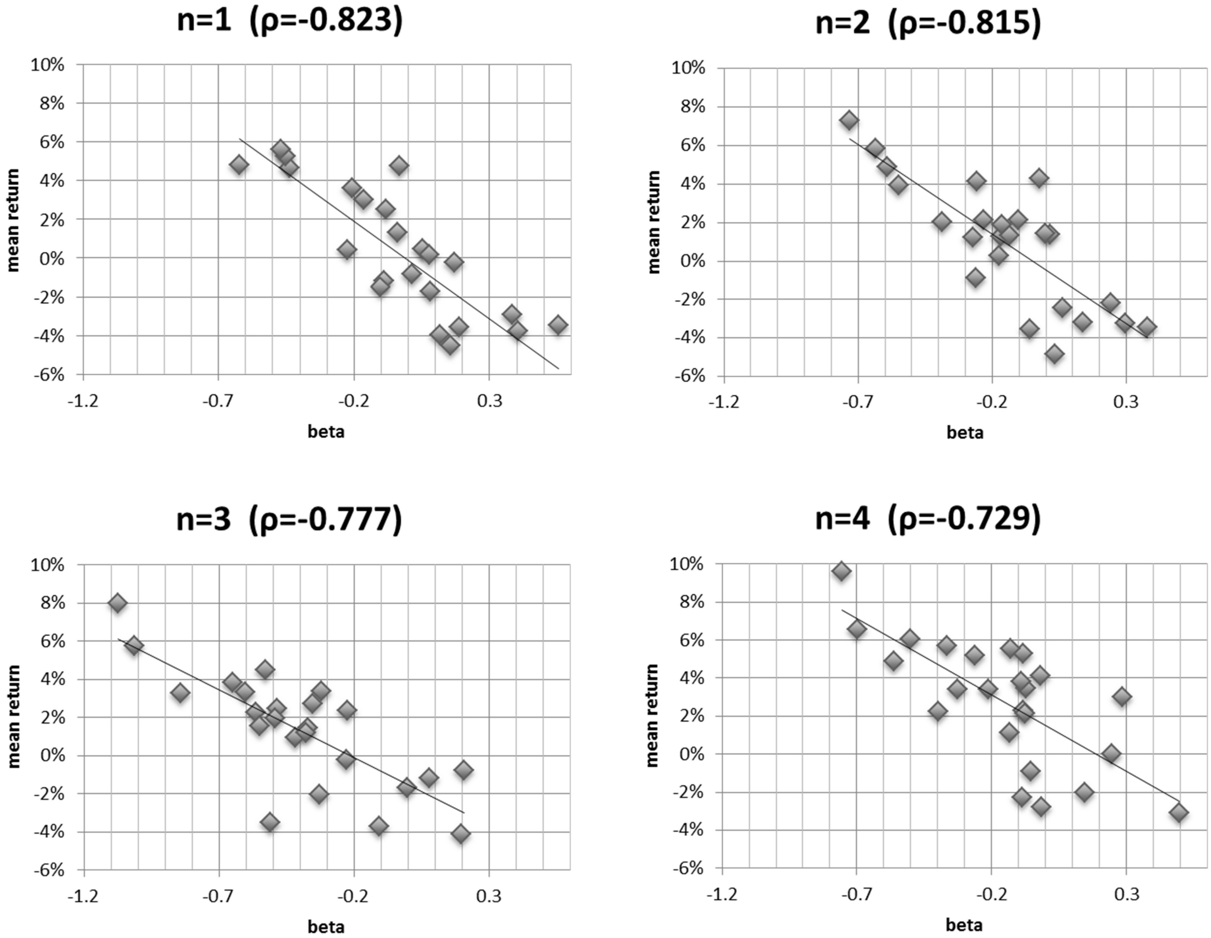

Figure 1. Average Returns and Basis Factor Betas
This figure plots the average returns on 24 portfolios sorted on basis, momentum, coefficient of variation, inflation, hedging pressure, and liquidity, and their beta with respect to the basis factor.