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 in the high-minus-low sorted portfolios 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; these premia impact, for example, the hedging decisions of companies and 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, term premia mainly 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 cross-sectional variation in commodity futures returns to be attributable 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 has identified a number of other variables that lead to predictable variation in futures risk premia but did not differentiate between the 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 are specifically including 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 portfolios 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 portfolios 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 come 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 the 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. The next section 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 $y_t^{(n)}$. In the remainder we will 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 $r^{(n)}_{fut,t\to t+n}$, 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

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

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 finance 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. This 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) will, in general, not be 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, the Excess Holding strategy 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 have 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, e.g., 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

$$R_{Fut,t+1}^{(1)} = \frac{S_{t+1}}{F_t^{(1)}} = \frac{S_{t+1}}{S_t\,(1+RF)\,(1+U) - C_{t+1}}. \tag{13}$$

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 $F_t^{(1)}$ instead of spot S_t price and reflect the cost-of-carry. Taking logs of (13) gives

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

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

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

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 and 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 the current basis to contain 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 $y_t^{(n)}$ to contain information about future cash yield growth and both spot and term premia:

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

We put subscripts n to 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 bi-monthly 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 different months per year, the use of bi-monthly 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 in addition holding period returns for four, six and eight months until the delivery date. We take for each bi-monthly 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 bi-monthly observations, the resulting errors will be small. The 21 commodities were chosen with an eye to minimizing those irregularities in delivery dates. Prices of futures observed a month prior to and during the delivery month are excluded from the analysis to avoid the 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, because we observe for many contracts in our sample low open interest during the last six weeks, we roll over one month earlier, i.e., 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 dataset in detail.

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 Equally Weighted 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 are 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 Equally Weighted 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 and (except for Industrial Materials) never exceed 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 Equally Weighted 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 of capturing 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 months, four months, six months, and eight months for Short Roll and Excess Holding returns. The results for the Holding and Spreading returns are similar to the ones 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 consisting of only 11 commodities and no energy contracts, begins in July 1967. Another, which has 18 different contracts, begins at least for the shortest maturities contracts, in August 1978. 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 gives results very similar to the ones 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 to what extent 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. In order to see to what extent 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 has identified 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 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 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 US 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 US 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 where 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 non-monotonic 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 shop 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 in the 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 US 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.[9]

In sum, except for the US 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.[10]

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

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

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 $\alpha_i^{(n)}$ equals zero. We use a Wald test estimated using Newey-West corrected standard errors to jointly test whether the four $\alpha_i^{(n)}$'s in each sort are zero.[11]

[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 did not report any meaningful results in Table III. The first column gives the average absolute $\alpha_i^{(n)}$ of the four portfolios within a sort, the second column the p-value for the Wald test that these $\alpha_i^{(n)}$'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) $\alpha_i^{(n)}$ varies between 0.6% and 2.3% per annum across the maturities, and the p-values of the Wald test show these $\alpha_i^{(n)}$'s to be indistinguishable from zero.

As can be seen from the p-values of the Wald tests as well as from the $\alpha_i^{(n)}$'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) $\alpha_i^{(n)}$ is about 2% per annum for most sorted portfolios, and exceeds 3% per annum in only 2 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 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, the two basis-factors now being 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 for 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 did 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 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 but one cases 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 the ones from the basis factors in Table V. We thus conclude again that none of the factors based on the other forecasting variables come 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 on the one hand can be identified 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)

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

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

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

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

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

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

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

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

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

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, 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 US 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 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 bi-monthly measure is the average of the daily Amivest measures over the two month period.

References

Amihud, Yakov, Haim Mendelson, and Beni Lauterbach, 1997, Market microstructure and securities values: Evidence from the tel aviv stock exchange, *Journal of Financial Economics* 45, 365–390.

Asness, Cliff, Tobias Moskowitz, and Lasse Heje Pedersen, 2012, Value and momentum everywhere, *Journal of Finance forthcoming.*

Bessembinder, Hendrik, 1992, Systematic risk, hedging pressure, and risk premiums in futures markets, *Review of Financial Studies* 5, 637–667.

——— , and Kalok Chan, 1992, Time-varying risk premia and forecastable returns in futures markets, *Journal of Financial Economics* 32, 169–193.

Black, Fischer, 1976, The pricing of commodity contracts, *Journal of Financial Economics* 3, 167–179.

Campbell, John Y., and Robert J. Shiller, 1988, Stock prices, earnings and expected dividends, *Journal of Finance* 43, 661–676.

——— , 1991, Yield spreads and interest rate movements: A bird's eye view, *Review of Economic Studies* 58, 495–514.

Carter, Colin A., Gordon C. Rausser, and Andrew Schmitz, 1983, Efficient asset portfolios and the theory of normal backwardation, *The Journal of Political Economy* 91, 319–331.

Casassus, Jaime, and Pierre Collin-Dufresne, 2005, Stochastic convenience yield implied from commodity futures and interest rates, *Journal of Finance* 60, 2283–2331.

Chang, Eric C., 1985, Return to speculators and the theory of normal backwardation, *Journal of Finance* 40, 193–208.

Cochrane, John H., 2011, Discount rates, *Journal of Finance* 66, 1047–1108.

——— , and Monika Piazzesi, 2005, Bond risk premia, *American Economic Review* 95, 138–160.

——— , 2008, Decomposing the yield curve, Working paper, Chicago Booth.

Cox, John, Jonathan Ingersoll, and Stephen Ross, 1981, A reexamination of traditional hypotheses about the term struture of interest rates, *Journal of Finance* 36, 321–346.

de Roon, Frans A., Theo E. Nijman, and Chris H. Veld, 1998, Pricing term structure risk in futures markets, *Journal of Financial and Quantitative Analysis* 33, 139–157.

——— , 2000, Hedging pressure effects in futures markets, *Journal of Finance* 55, 1437–1456.

Dhume, Deepa, 2011, Using durable consumption risk to explain commodities returns, Working paper, Harvard University.

Dusak, Katherine, 1973, Futures trading and investor returns: An investigation of commodity market risk premiums, *The Journal of Political Economy* 81, 1387–1406.

Erb, Claude B., and Campbell R. Harvey, 2006, The strategic and tactical value of commodity futures, *Financial Analysts Journal* 62, 69–97.

Fama, Eugene F., 1984, Forward and spot exchange rates, *Journal of Monetary Economics* 14, 319–338.

——— , 1986, Term premiums and default premiums in money markets, *Journal of Financial Economics* 17, 175–196.

——— , and Robert R. Bliss, 1987, The information in long maturity forward rates, *American Economic Review* 77, 680–692.

Fama, Eugene F., and Kenneth R. French, 1987, Commodity futures prices: Some evidence on forecast power, premiums, and the theory of storage, *Journal of Business* 60, 55–73.

——— , 1988, Business cycles and the behavior of metal prices, *Journal of Finance* 43, 1075–1093.

——— , 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Econometrics* 33, 3–56.

———, 1996, Multifactor explanations of asset pricing anomalies, *Journal of Finance* 51, 55–84.

Frank, Julieta, and Philip Garcia, 2009, Time-varying risk premium: Further evidence in agricultural futures markets, *Applied Economics* 41, 715–725.

Gorton, Gary, and Geert K. Rouwenhorst, 2006, Facts and fantasies about commodity futures, *Financial Analysts Journal* 62, 47–68.

Gorton, Gary B., Fumio Hayashi, and K. Geert Rouwenhorst, 2013, The fundamentals of commodity futures returns, *Review of Finance* 17, 35–105.

Gourinchas, Pierre-Olivier, and Helene Rey, 2007, International financial adjustment, *Journal of Political Economy* 115, 665–703.

Greer, Robert J., 2000, The nature of commodity index returns, *Journal of Alternative Investments* 3, 45–52.

Hansen, Lars Peter, and Robert J. Hodrick, 1980, Forward exchange rates as optimal predictors of future spot rates: An econometric analysis, *Journal of Political Economy* 88, 829–853.

Hong, Harrison, and Motohiro Yogo, 2012, What does futures market interest tell us about the macroeconomy and asset prices?, *Journal of Financial Economics* 105, 473–490.

Jagannathan, Ravi, 1985, An investigation of commodity futures prices using the consumption-based intertemporal capital asset pricing model, *Journal of Finance* 40, 175–191.

Koijen, Ralph S.J., Tobias J. Moskowitz, Lasse Heje Pedersen, and Evert B. Vrugt, 2012, Carry, Working paper, Chicago Booth.

Liu, Peng, and Ke Tang, 2011, The stochastic behavior of commodity prices with heteroskedasticity in the convenience yield, *Journal of Empirical Finance* 18, 211–224.

Lustig, Hanno, Nikolai Roussanov, and Adrien Verdelhan, 2011, Common risk factors in currency markets, *Review of Financial Studies forthcoming.*

Marshall, Ben R., Nhut H. Nguyen, and Nuttawat Visaltanachoti, 2012, Commodity liquidity measurement and transaction costs, *Review of Financial Studies* 25, 599–638.

Miffre, Joelle, and Georgios Rallis, 2007, Momentum strategies in commodity futures markets, *Journal of Banking and Finance* 31, 1863–1886.

Piazzesi, Monika, and Eric Swanson, 2008, Futures prices as risk-adjusted forecasts of monetary policy, *Journal of Monetary Economics* 55, 677–691.

Yang, Fan, 2011, Investment shocks and the commodity basis spread, Working paper, University of Hong Kong.

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), Fama (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), de Roon, Nijman, and Veld (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]Gorton, Hayashi, and Rouwenhorst (2013), using similar sorting techniques as we do, also cannot confirm the regression based evidence for hedging pressure effects.

[10]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 component). We discuss these results in detail in the Internet Appendix.

[11]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 market wide 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 Equally Weighted (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 the summary statistics for the Short Roll returns, the second one for the Excess Holding returns. t-statstics are based on Newey-West corrected standard errors. The returns are quoted bi-monthly 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 bi-monthly 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
				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)				
				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, inflation, dollar beta, hedging pressure, open interest, and liquidity. Standard errors are estimated using Newey-West correction. The returns are quoted bi-monthly 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)
	A. Returns sorted on Basis					**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)
	C. Returns sorted on Coefficient of Variation					**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)
	E. Returns sorted on Dollar Beta					**F. Returns sorted on Hedging Pressure**			
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(Hold)	(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(ExcHold)		(-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 the 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, inflation beta, hedging pressure, 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 two highest basis portfolios minus two lowest basis portfolios, and estimate the following regressions:

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

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, the second column 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 bi-monthly 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
	A. Returns sorted on Basis				**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)
	C. Returns sorted on Coefficient of Variation				**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)
	E. Returns sorted on Hedging Pressure				**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 the asset pricing tests for Excess Holding returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, 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 use 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, the second column 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 bi-monthly 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	
A. Returns sorted on Basis					**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)
C. Returns sorted on Coefficient of Variation					**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)
E. Returns sorted on Hedging Pressure					**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 the asset pricing tests for Short Roll returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, 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 two highest portfolios minus two lowest portfolios within each sort, and estimate the following regressions:

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

The first column gives the average absolute $\alpha_i^{(n)}$ of the four portfolios within a sort, the second column 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 bi-monthly 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
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)
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)
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)
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)
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)
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)

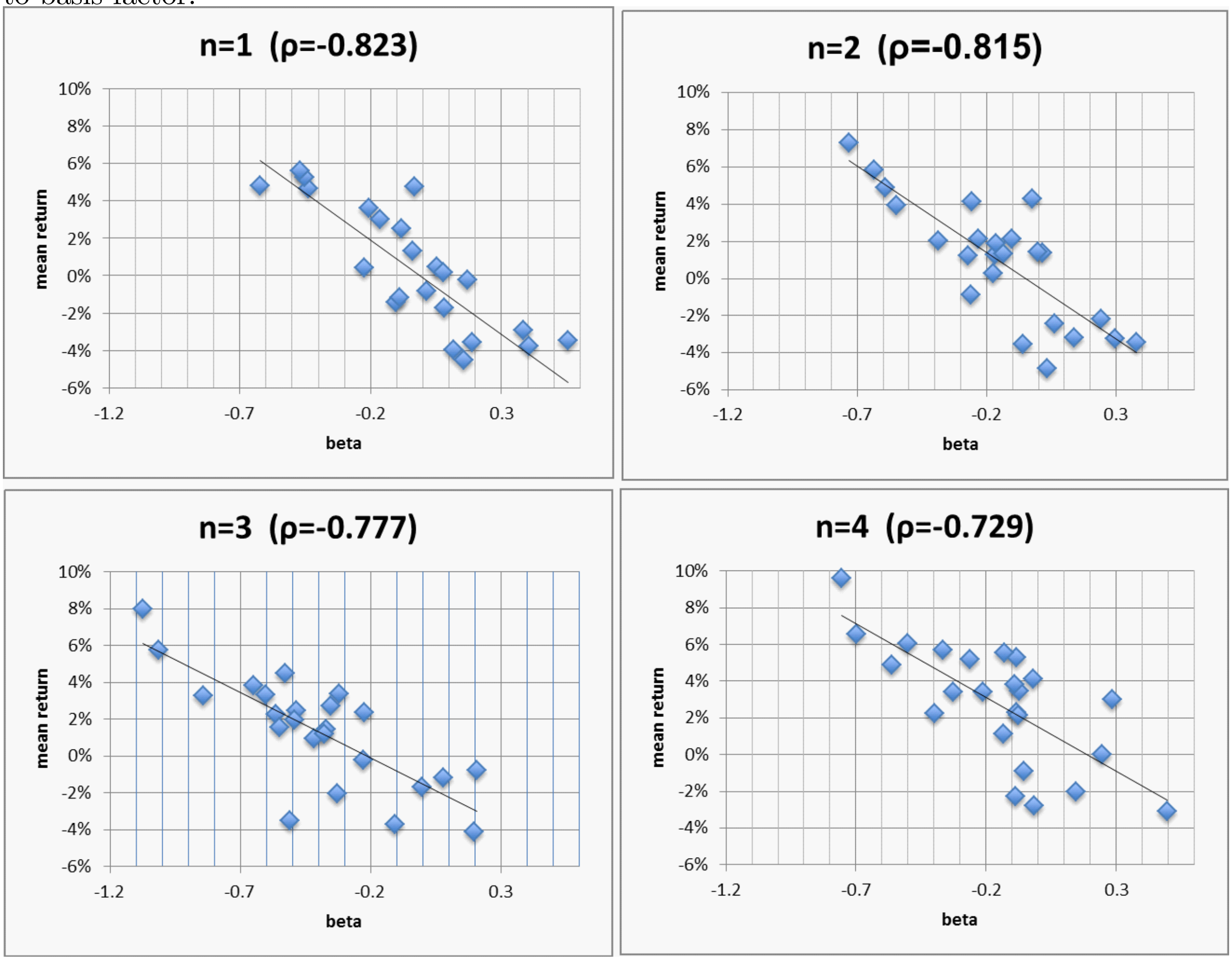
Table VII: **Asset pricing tests for alternative factors from Spreading returns.** The table reports the asset pricing tests for Excess Holding returns when futures contracts are sorted on the basis. We construct two factors using Spreading returns on portfolios sorted on basis, momentum, coefficient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

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

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, the second column 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 bi-monthly for a sample period between March 1986 and December 2010.

	aα(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 basis factor.



Internet Appendix for

"An Anatomy of Commodity Futures Risk Premia"*

In this appendix we provide additional tables that present more detailed results, additional tests and robustness checks that are omitted from the paper for brevity. Below we provide a brief summary and the purpose of each table.

- **Table IA.I: Detailed description of the database.**

We use bi-monthly 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. Table IA.I describes our dataset in detail. For each contract we report the sector to which it belongs; the contract mnemonic; the delivery months that are available for each contract; the delivery months that we use to construct our sample; the exchange on which the contract is traded; the number of nearby return series that we construct per contract (maximum 4); and the starting date of each of the nearby series.

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We compute bi-monthly log returns every second month starting from January, using contracts which have at least two months to maturity or longer as indicated in the table. This means that for several contracts we use the second nearest-to-maturity contract, since we cannot compute two-month returns from contracts expiring in one month. In particular, for Feeder Cattle, Copper, Soybean Oil and Soybean Meal we use contracts maturing in December instead of the missing November contracts. For Silver, Corn, Oats, Wheat, Coffee, and Cocoa contracts we use March and December maturities instead of January and November, respectively. For one contract, Cotton, we use March, October and December contracts in January, September and November, respectively. All other contracts have maturities observed on a regular two-month time interval. The initial date from which we observe a continuous series of bi-monthly returns is indicated for each nearby series constructed. The dates do not differ much except for the fourth nearby series for which we observe shorter time-series and a smaller cross-section of contracts.

- **Table IA.II: Summary statistics.**

This table is an expanded version of Table I reported in the paper. We repeat the results for Short Roll and Excess Holding returns, and show that similar results are obtained when analyzing Holding and Spreading returns. The results for Holding returns are very similar to Short Roll returns, but the differences between maturities (which are indicative of time-variation in risk premia) are usually larger than for Short Roll returns. Spreading returns, similarly to Excess Holding returns, are mostly insignificantly different from zero, but the relatively large differences between the term premia estimated from Excess Holding and Spreading returns suggest that there is time-variation in these term premia.

- **Table IA.III: Sorts based on the basis.**

This table is an expanded version of Table II reported in the paper and shows that the results for the Short Roll and Excess Holding returns are robust to using Holding and

Spreading returns.

- **Table IA.IV: Basis sort for different samples.**

This table shows that our main results for the basis sort (reported in Table II in the paper) are robust with respect to the different sample periods and sizes (in numbers of contracts used). Panel A looks at the sample without the recent crisis using the contracts traded between March 1986 and November 2008. Panel B extends the early part of the sample with data starting at the moment when the first energy contract is introduced using the contracts traded between September 1979 and December 2010. Panel C extends the sample even further starting at July 1967 and ending in December 2010, but this early part of the sample is dominated by agricultural commodities, i.e., the energy contracts are not yet traded and there is only one metal contract.

- **Table IA.V: Basis sort when controlling for seasonalities.**

This table shows how robust the main results for the basis sort (reported in Table II in the paper) are with respect to seasonality in the returns and basis. Panel A looks at the sort where we seasonally adjust returns and the percentage basis. In Panel B only the basis is seasonally adjusted. This table shows similar spreads, significance levels, and monotonicity as we observe in Table II of the paper, which indicates that seasonality effects are minor.

- **Table IA.VI: Stochastic interest rates**

This table analyzes to what extent the sorting results from the basis (reported in Table II in the paper) are driven by interest rates rather than the convenience yield. Sorting futures on the basis is motivated by the cost-of-carry model. When interest rates are stochastic, the cost-of-carry model may hold for forward contracts, but not necessarily for futures contracts, as spot price movements may be correlated with interest rate changes. This induces futures prices that deviate from forward prices (Cox, Ingersoll, and Ross (1981)). In addition, as demonstrated by Casassus and Collin-Dufresne (2005), for gold, silver, copper and oil, convenience yields are positively and significantly correlated with interest rates, implying again that the cost-of-carry model may not hold for these commodities.

The table reports two sets of alternative sorted portfolios. We focus on measuring the interest exposure of the basis using the regression (estimated over the last 30 periods before the sort)

$$basis_{i,t} = y_{i,t} = a_i + b_i \left(interest_t - avg\left(interest\right)\right) + \varepsilon_{i,t},$$

where $interest_t$ is the forward interest rate matching the maturity of the basis.

Panel A.1 sorts on $a_i + \varepsilon_{i,t}$, removing the interest rate component from the basis, leaving the mean of the basis unchanged. These results are very similar to sorting on the basis itself: the patterns are all monotonic again, and the size of the resulting spot and term premia are very similar to the ones reported in Table II in the paper. Panel A.2 shows the sorts for $b_i \left(interest_t - avg\left(interest\right)\right)$, which measure the pure interest rate effect in the basis. The resulting portfolio returns never show a monotonic pattern, except for one term premium, even though the resulting spreads are often significantly different from zero.

These findings suggest that there is not a meaningful effect from the interest rate on the sorted portfolio returns, whereas the main results for sorting on the basis remain, also when controlling for the interest rate in different ways.

- **Table IA.VII: Alternative sorts.**

This table is an expanded version of Table III reported in the paper and shows that the results for the Short Roll and Excess Holding returns are robust to using Holding and

Spreading returns.

- **Table IA.VIII: Inflation-based sorts.**

This table shows how robust the main results for the inflation beta sorts (reported in Table III in the paper) are with respect to different measures of unexpected inflation. In Panel A the unexpected inflation is measured as the difference between realized inflation and its forecast from an ARIMA model (as in Fama and Gibbons (1982)), and in Panel B as the realized inflation minus the risk free rate (Fama and Schwert (1977)). The sorting in Panel B does not show any meaningful results, but it should be noted that using the interest rate as a measure for expected inflation is a rather crude measure that assumes that the real interest rate is constant. The sorting in Panel A, based on the ARIMA model, shows reliable spot premia in the short maturity Holding and Short Roll returns, as well as term premia, except for the longest maturities. These results thus confirm the findings we report in the paper.

- **Table IA.IX: Principal Component Analysis.**

This table looks at the first three principal components from the Short Roll returns (the spot premium component) as well as the Spreading returns (the term premium component) for the four sorted portfolios in six different sorts. We leave out the dollar-sorted portfolios and open interest-sorted portfolios, as for those we did not find any meaningful risk premia. Thus, we look at the principal components of in total 48 return series, reflecting the spot and term premia components for 24 different portfolios. In the first three columns we report for each of the 24 portfolios the variance of the shortest maturity Short Roll return explained by the first three principal components and in the last three columns the variance of the 24 second nearby Spreading returns explained by the same three principal components. On average, the first principal component explains 60% of the variances of the Short Roll return, whereas it explains only 1% of the variances of the Spreading returns as can be seen from the fourth column. On the other hand, the second and third component jointly explain less than 2% of the variance of the Short Roll return, whereas they explain 44% and 8%, respectively, of the Spreading returns. Thus, these results suggest that the spot premia are related to one factor (the first one), whereas term premia, are related to one or two separate factors (the second and third factor). Although the third factor on average explains only 8% of the variance in Spreading returns, in seven individual cases this is more than 10%, indicating that we may need two factors to explain the term premia. Obviously, these factors need not be priced factors. We therefore use in Section IV.B of the paper formal asset pricing tests to identify the factors(s) that may pice the various sorted portfolios.

- **Table IA.X: Correlations between the High and Low factor portfolios.**

This table shows that the factor portfolios themselves, next to the PCA portfolios reported in Table IA.IX above, also have a strong factor structure across the various sorts. Note that in panel A (B) we use the High (Low) portfolios for all factors, except for the basis, as the sorting here has an opposite effect on the spot and term premia compared to all other sorts. Panel A shows that the High factor portfolios (and Low basis portfolio) on average have correlations of 0.84, with the average correlation per factor never below 0.81 (for Hedging Pressure and Liquidity). In Panel B, the corresponding correlations for the Low factor portfolios (and High basis portfolio) are on average 0.79, with the average per factor at least 0.77. Thus, the factor portfolios themselves also show that there is a strong factor structure across the various sorts.

- **Table IA.XI: Asset pricing tests for basis factor from Holding returns.**

This table is an expanded version of Table IV reported in the paper and shows that the results for the Short Roll and Excess Holding returns are robust to using Holding and Spreading returns.

- **Table IA.XII: Asset pricing tests for basis factor from Spreading returns.**

This table is an expanded version of Table V reported in the paper and shows that the results for the Excess Holding returns are robust to using Spreading returns.

- **Table IA.XIII: Asset pricing tests for basis factors from Holding returns: two factors.**

This table checks whether the term premia can be captured with two factors based on Holding returns, similarly to the two factors constructed from Spreading returns as reported in Table V in the paper. If the two factors from Holding returns can capture the term premia we would have only two factors that explain both spot and term premia. The table illustrates that this is not the case.

- **Table IA.XIV: Asset pricing tests for alternative factors from Spreading returns.**

This table is an expanded version of Table VII reported in the paper. Panel A shows that the results reported in Table VII for the basis sort and Excess Holding returns are robust to using Spreading returns. The remaining panels show that none of the alternative factors are able to explain the term premia from alternative sorts.

- **Table IA.XV: Comparison of actal and approximate returns**

This table shows the exact (short maturity) log futures returns and the ones derived from our approximation given in Equation (A2) in the paper. We report the correlation between the two series for each contract (first column), the two standard deviations (second and third column), the two means (fourth an fifth column) and the standard deviation of the percentage basis (last column).

In order to calculate the approximation, in particular the parameter ρ as defined above Equation (A2) in the paper, we need to make the log cash yield, $c_{t+1} - s_t$ observable. To do so, we assume the storage costs and risk free rate to be constant in Panel A. In Panel B, we use the actual interest rates, assuming only storage costs to be constant. We also need that at least once during the sample period the cash yield or convenience yield is (almost) zero, i.e., that the contract is in full carry. From the cost-of-carry relation in Equation (1) in the paper, if the interest rate and storage costs are constant, having $C_{t+n} = 0$ means that the futures spot price ratio F_t/S_t takes on its maximum value. We can thus use this maximum observation to back out the storage costs plus interest rate, and then calculate the cash yield for each period. This allows us to calculate ρ and the approximate futures returns in Equation (A2).

Panel A of Table IA.XV shows that the correlation between the exact log returns and the approximate returns are below 0.90 for only three commodities (Live Cattle, Live Hogs and Cotton), and are above 0.95 for 15 out of the 21 commodities. The difference between the standard deviations of the two series is always smaller than 1% per period, except for Live Hogs. Similarly, the difference in mean returns for the two series exceeds 1% in only three cases (Live Hogs, Oats and Coffee). Thus, overall the actual returns and approximate returns are very similar. Looking at the last column, we see that for the cases where we see the biggest differences, the standard deviation of the percentage basis is relatively high, as we would expect. Panel B shows that when we incorporate time-varying interest rates, especially the correlation between the two series becomes weaker, in particular for the three cases where it was low already: Live Cattle, Live Hogs, and Cotton. This suggests that in cases where the approximation is worse, time-varying interest rates matter most.

References

Casassus, Jaime, and Pierre Collin-Dufresne, 2005, Stochastic convenience yield implied from commodity futures and interest rates, *Journal of Finance* 60, 2283–2331.

Cox, John, Jonathan Ingersoll, and Stephen Ross, 1981, A reexamination of traditional hypotheses about the term struture of interest rates, *Journal of Finance* 36, 321–346.

Fama, Eugene F., and Michael R. Gibbons, 1982, Inflation, real returns and capital investment, *Journal of Monetary Economics* 9, 297–323.

Fama, Eugene F., and G. William Schwert, 1977, Asset returns and inflation, *Journal of Financial Economics* 5, 115–146.

Table IA.I: **Detailed description of the database.**

This table shows a detailed description of our database. For each contract we report its sector, name, mnemonic, and the name of the exchange at which it trades. We also report all delivery months observed in the database as well as the ones we used to construct bi-monthly returns and the starting date of the bi-monthly return series for each maturity.

			Delivery months			No of	Initial date			
Sector	Contract name	Mnemonic	available	used	Exchange	series	n=1	n=2	n=3	n=4
Energy	Heating Oil	HO	All	All	NYMEX	4	197905	197911	198005	198601
	Gasoline	HU/RB	All	All	NYMEX	4	198503	198507	198509	198511
	Crude Oil	CL	All	All	NYMEX	4	198305	198307	198309	198407
Meats	Feeder Cattle	FC	1,3,4,5,8,9,10,11	1,3,5,8,9,11	CME	3	198101	198103	199301	
	Live Cattle	LC	2,4,6,8,10,12	2,4,6,8,10,12	CME	4	196503	196505	196601	197603
	Live Hogs	LH	2,4,6,7,8,10,12	2,4,6,8,10,12	CME	4	196901	196907	197007	197209
Metals	Gold	GC	2,4,6,8,10,12	2,4,6,8,10,12	NYMEX	4	197503	197505	197507	197509
	Copper	HG	1,3,5,7,9,12	1,3,5,7,9,12	NYMEX	4	195911	196001	196003	196105
	Silver	SI	3,5,7,9,12	3,5,7,9,12	NYMEX	4	196401	196403	196405	196603
Grains	Corn	C-	3,5,7,9,12	3,5,7,9,12	CBOT	4	195909	195911	196001	197607
	Oats	O-	3,5,7,9,12	3,5,7,9,12	CBOT	3	195909	197309	197505	
	Wheat	W-	3,5,7,9,12	3,5,7,9,12	CBOT	1	195909			
	Rough Rice	RR	1,3,5,7,9,11	1,3,5,7,9,11	CBOT	2	198907	198907		
Oilseeds	Soybean Oil	BO	1,3,5,7,8,9,10,12	1,3,5,7,9,12	CBOT	4	195911	196001	196301	196501
	Soybeans	S-	1,3,5,7,9,11	1,3,5,7,9,11	CBOT	4	195909	195911	196001	196003
	Soybean Meal	SM	1,3,5,7,8,9,10,12	1,3,5,7,9,12	CBOT	3	196011	196101	196301	
Softs	Coffeee	KC	3,5,7,9,12	3,5,7,9,12	ICE	4	197301	197401	197403	197601
	Oragne Juice	OJ	1,3,5,7,9,11	1,3,5,7,9,11	ICE	3	196709	196711	196801	
	Coccoa	CC	3,5,7,9,12	3,5,7,9,12	ICE	3	196001	196003	196005	
Ind Mat	Cotton	CT	3,5,7,10,12	3,5,7,10,12	ICE	4	196009	196011	196101	196103
	Lumber	LB	1,3,5,7,9,11	1,3,5,7,9,11	CME	3	197001	197003	199107	

Table IA.II: **Summary statistics.**

The table contains summary statistics for the seven sector indices as well as for the Equally Weighted (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 the summary statistics for the Holding returns $r^{(n)}_{fut,t\rightarrow t+n}$ for $n = 1, 2, 3$, and 4. The next panels report the Short Roll returns, Excess Holding returns, and Spreading returns. t-statstics are based on Newey-West corrected standard errors. The returns are quoted bi-monthly 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
Holding	Energy	10.83%	10.02%	9.39%	9.12%	32.88%	28.48%	27.84%	27.0%	(1.64)	(1.75)	(1.68)	(1.67)
	Meats	4.20%	4.13%	3.88%	3.73%	13.03%	11.05%	10.36%	10.9%	(1.60)	(1.86)	(1.86)	(1.70)
	Metals	5.42%	5.05%	4.76%	4.57%	17.16%	15.40%	15.14%	15.1%	(1.57)	(1.63)	(1.56)	(1.51)
	Grains	-6.10%	-5.42%	-4.82%	-5.24%	18.96%	19.55%	20.59%	17.7%	(-1.60)	(-1.38)	(-1.16)	(-1.47)
	Oilseeds	1.86%	1.83%	1.86%	0.44%	20.96%	18.37%	17.24%	17.3%	(0.44)	(0.49)	(0.54)	(0.13)
	Softs	-6.58%	-6.25%	-6.06%	-7.81%	18.48%	16.36%	15.16%	28.3%	(-1.77)	(-1.90)	(-1.99)	(-1.37)
	Ind materials	-4.82%	-3.21%	-1.95%	-1.35%	19.56%	17.07%	17.68%	20.8%	(-1.22)	(-0.94)	(-0.55)	(-0.32)
	EW	0.65%	1.10%	1.18%	2.69%	11.70%	11.34%	11.32%	12.4%	(0.27)	(0.48)	(0.52)	(1.08)
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)
Spreading	Energy		0.40%	0.63%	0.74%		2.51%	3.28%	4.2%		(0.80)	(0.96)	(0.89)
	Meats		0.25%	-0.06%	-0.11%		3.84%	4.85%	5.8%		(0.32)	(-0.07)	(-0.10)
	Metals		-0.04%	-0.04%	-0.11%		0.82%	1.20%	1.6%		(-0.24)	(-0.18)	(-0.33)
	Grains		2.39%	2.70%	3.07%		5.23%	5.39%	6.0%		(2.27)	(2.48)	(2.53)
	Oilseeds		0.45%	0.61%	0.51%		1.94%	2.67%	3.5%		(1.16)	(1.13)	(0.72)
	Softs		0.65%	0.79%	0.37%		2.07%	2.51%	6.9%		(1.56)	(1.56)	(0.26)
	Ind materials		2.82%	3.40%	3.62%		5.33%	7.55%	10.3%		(2.63)	(2.24)	(1.74)
	EW		1.22%	1.39%	2.01%		1.76%	2.29%	3.1%		(3.43)	(3.01)	(3.18)

Table IA.III: **Sorts based on the basis.**

The table contains mean returns and standard deviations (for Holding, Short Roll, Excess Holding, and Spreading 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 bi-monthly for a sample period between March 1986 and December 2010.

		Annualized mean returns				Annualized standard deviations			
		n=1	n=2	n=3	n=4	n=1	n=2	n=3	n=4
				A. basis					
Holding	Low	4.82%	7.32%	7.97%	9.61%	16.97%	15.10%	16.24%	17.0%
	P2	4.68%	4.88%	3.82%	6.05%	14.25%	12.69%	10.92%	12.7%
	P3	-2.93%	-3.24%	-1.17%	0.00%	13.46%	12.72%	12.22%	13.2%
	High	-3.47%	-3.42%	-4.10%	-3.08%	15.98%	12.95%	11.56%	14.5%
	P4-P1	-8.29%	-10.74%	-12.07%	-12.70%	17.15%	12.40%	12.04%	15.1%
	t(P4-P1)	(-2.40)	(-4.29)	(-4.95)	(-4.13)				
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)				
Spreading	Low		0.32%	-0.13%	-0.40%		2.58%	3.09%	3.7%
	P2		0.36%	0.75%	0.58%		1.67%	2.14%	2.6%
	P3		1.24%	1.11%	1.06%		1.59%	1.99%	2.3%
	High		2.02%	2.52%	2.77%		2.50%	3.18%	2.9%
	P4-P1		1.70%	2.64%	3.17%		2.74%	3.36%	3.1%
	t(P4-P1)		(3.07)	(3.88)	(5.08)				
				B. cross-section of basis					
			B.1 Mean basis				B.2 De-meaned Basis		
Holding	Mono	y	y	y	y	y	y	y	y
	P4-P1	-15.42%	-14.06%	-13.27%	-15.65%	-3.82%	-5.04%	-5.86%	-9.07%
	t-stat	(-4.37)	(-4.28)	(-4.07)	(-3.72)	(-1.12)	(-2.01)	(-2.59)	(-3.24)
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)
Spreading	Mono		y		y		y	y	y
	P4-P1		2.27%	2.33%	3.15%		0.84%	1.42%	2.10%
	t-stat		(4.15)	(3.48)	(3.38)		(1.45)	(2.18)	(2.93)

Table IA.IV: **Basis sort for different samples.**

The table contains mean returns and standard deviations (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on the basis. Panel A looks at the sample without the recent crisis using the contracts traded between March 1986 and November 2008. Panel B extends the early part of the sample with data starting at the moment when the first energy contract is introduced, using the contracts traded betwen September 1979 and December 2010. Panel C extends the sample even further starting at July 1967 and ending in December 2010.

		Annualized mean returns				Annualized standard deviations			
		n=1	n=2	n=3	n= 4	n=1	n=2	n=3	n=4
				A. 1986 -2008					
Holding	Low	3.73%	7.38%	8.68%	11.25%	16.99%	13.62%	13.52%	13.5%
	P2	2.86%	3.72%	3.51%	6.29%	13.98%	11.89%	9.57%	11.7%
	P3	-3.55%	-3.45%	-1.19%	0.40%	13.22%	12.35%	11.11%	12.1%
	High	-3.91%	-3.77%	-3.91%	-3.13%	14.95%	11.38%	9.66%	13.6%
	P4-P1	-7.64%	-11.16%	-12.60%	-14.38%	16.80%	12.36%	11.89%	14.4%
	t(P4-P1)	(-2.17)	(-4.28)	(-5.01)	(-4.69)				
Short Roll	Low	3.73%	7.05%	8.57%	11.73%	16.99%	13.94%	14.06%	14.7%
	P2	2.86%	3.56%	3.14%	5.67%	13.98%	12.05%	9.83%	12.0%
	P3	-3.55%	-3.88%	-1.98%	-0.49%	13.22%	12.57%	11.70%	12.6%
	High	-3.91%	-4.44%	-5.08%	-4.48%	14.95%	11.61%	10.00%	14.0%
	P4-P1	-7.64%	-11.49%	-13.65%	-16.21%	16.80%	12.94%	12.68%	15.4%
	t(P4-P1)	(-2.17)	(-4.21)	(-5.09)	(-4.96)				
Excess Holding	Low		0.34%	0.12%	-0.48%		1.66%	2.40%	3.3%
	P2		0.15%	0.37%	0.62%		1.00%	1.63%	2.0%
	P3		0.43%	0.79%	0.89%		0.98%	1.45%	1.9%
	High		0.67%	1.17%	1.36%		1.29%	2.12%	2.2%
	P4-P1		0.33%	1.05%	1.83%		1.67%	2.32%	3.1%
	t(P4-P1)		(0.94)	(2.14)	(2.81)				
Spreading	Low		0.36%	-0.07%	-0.59%		2.67%	3.19%	3.8%
	P2		0.36%	0.76%	0.61%		1.72%	2.22%	2.7%
	P3		1.08%	1.05%	1.09%		1.60%	2.05%	2.4%
	High		1.53%	2.04%	2.66%		2.37%	3.08%	2.9%
	P4-P1		1.17%	2.11%	3.25%		2.56%	3.22%	3.1%
	t(P4-P1)		(2.17)	(3.09)	(4.85)				

Table IA.IV ctd.: **Basis sort for different samples.**

		Annualized mean returns				Annualized standard deviations			
		n=1	n=2	n=3	n= 4	n=1	n=2	n=3	n=4
				B. 1979 -2010					
Holding	Low	1.89%	4.07%	4.86%	6.41%	17.10%	15.47%	15.97%	16.9%
	P2	0.69%	1.01%	-0.32%	1.79%	14.74%	13.19%	11.97%	14.2%
	P3	-2.13%	-4.28%	-3.24%	-2.80%	15.54%	13.09%	12.64%	14.1%
	High	-6.55%	-6.08%	-5.57%	-4.68%	16.68%	14.08%	12.63%	15.3%
	P4-P1	-8.44%	-10.15%	-10.43%	-11.09%	17.92%	14.75%	13.76%	16.1%
	t(P4-P1)	(-2.64)	(-3.84)	(-4.22)	(-3.81)				
Short Roll	Low	1.89%	3.78%	4.86%	6.63%	17.10%	15.79%	16.55%	18.3%
	P2	0.69%	0.79%	-0.49%	1.17%	14.74%	13.31%	12.06%	14.8%
	P3	-2.13%	-4.69%	-4.09%	-3.68%	15.54%	13.36%	13.18%	14.8%
	High	-6.55%	-6.92%	-6.93%	-5.91%	16.68%	14.30%	12.92%	15.7%
	P4-P1	-8.44%	-10.70%	-11.78%	-12.54%	17.92%	15.36%	14.75%	17.9%
	t(P4-P1)	(-2.64)	(-3.89)	(-4.45)	(-3.89)				
Excess Holding	Low		0.29%	0.01%	-0.22%		1.62%	2.46%	3.6%
	P2		0.22%	0.17%	0.62%		1.00%	1.76%	2.2%
	P3		0.41%	0.85%	0.88%		1.03%	1.41%	2.0%
	High		0.84%	1.36%	1.23%		1.31%	2.05%	2.5%
	P4-P1		0.55%	1.35%	1.45%		1.76%	2.50%	3.5%
	t(P4-P1)		(1.74)	(3.01)	(2.28)				
Spreading	Low		0.15%	-0.23%	-0.42%		2.74%	3.38%	4.3%
	P2		0.29%	0.64%	0.56%		1.84%	2.20%	2.8%
	P3		1.21%	1.11%	1.09%		1.61%	1.98%	2.3%
	High		1.90%	2.13%	2.35%		2.35%	2.95%	3.0%
	P4-P1		1.75%	2.37%	2.77%		2.85%	3.60%	3.7%
	t(P4-P1)		(0.00)	(0.00)	(0.00)				
				C. 1967 -2010					
Holding	Low	8.27%	10.08%	9.43%	9.38%	19.97%	17.99%	17.75%	18.6%
	P2	2.63%	3.09%	3.02%	4.91%	15.94%	14.91%	15.34%	18.0%
	P3	1.06%	-0.64%	-0.08%	0.62%	17.01%	15.37%	14.64%	16.4%
	High	-4.91%	-3.47%	-2.13%	-0.91%	16.85%	14.59%	13.92%	17.8%
	P4-P1	-13.18%	-13.55%	-11.56%	-10.23%	19.99%	16.71%	15.30%	18.6%
	t(P4-P1)	(-4.35)	(-5.34)	(-4.96)	(-3.56)				
Short Roll	Low	8.27%	10.45%	10.12%	10.33%	19.97%	18.66%	18.50%	19.8%
	P2	2.63%	3.00%	2.88%	4.38%	15.94%	15.20%	15.94%	19.0%
	P3	1.06%	-0.96%	-0.78%	-0.51%	17.01%	15.56%	15.10%	16.9%
	High	-4.91%	-4.25%	-3.42%	-2.07%	16.85%	14.90%	14.51%	18.7%
	P4-P1	-13.18%	-14.70%	-13.55%	-12.37%	19.99%	17.63%	16.69%	20.9%
	t(P4-P1)	(-4.35)	(-5.49)	(-5.33)	(-3.83)				
Excess Holding	Low		-0.37%	-0.69%	-0.95%		2.02%	2.80%	3.9%
	P2		0.09%	0.14%	0.54%		1.22%	2.00%	2.4%
	P3		0.33%	0.70%	1.13%		1.06%	1.55%	2.0%
	High		0.78%	1.30%	1.16%		1.31%	2.10%	2.9%
	P4-P1		1.15%	1.99%	2.14%		2.29%	3.17%	4.8%
	t(P4-P1)		(3.32)	(4.13)	(2.91)				
Spreading	Low		-1.02%	-1.09%	-1.04%		3.31%	3.66%	4.4%
	P2		0.06%	0.43%	0.44%		2.28%	2.63%	3.2%
	P3		0.83%	1.09%	1.37%		1.87%	2.23%	2.6%
	High		1.75%	1.61%	2.03%		2.39%	3.29%	3.5%
	P4-P1		2.76%	2.70%	3.08%		3.75%	4.24%	5.1%
	t(P4-P1)		(4.85)	(4.18)	(3.92)				

Table IA.V: **Basis sort when controlling for seasonalities.**

The table contains mean returns and standard deviations (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on the basis and when controlling for seasonalities. To seasonally adjust returns and basis we regress each of them on six bi-monthy dummies

$$\begin{aligned} basis_{i,t} &= \sum_{j=1}^{6} \beta_{i,j} d_j + \varepsilon_{i,t}, \\ r_{fut,i,t} &= \sum_{j=1}^{6} \beta_{i,j} d_j + \varepsilon_{i,t}, \end{aligned}$$

and use the residuals for sorting. Panel A seasonally adjusts both returns and basis. Panel B looks at the sort when only basis is seasonally adjusted.

A. Sorting seasonally adjusted returns with seasonally adjusted basis

		Annualized mean returns				Annualized Standard deviations			
		r(1)	r(2)	r(3)	r(4)	r(1)	r(2)	r(3)	r(4)
Holding	Low	6.80%	5.87%	4.82%	5.52%	14.98%	13.46%	13.85%	13.7%
	P2	0.79%	-0.66%	-0.27%	-0.20%	15.58%	14.86%	15.94%	15.1%
	P3	-3.10%	-1.44%	-1.03%	-0.21%	16.04%	13.92%	13.48%	14.8%
	High	-4.33%	-3.90%	-3.25%	-5.73%	14.88%	11.70%	11.44%	12.9%
	P4-P1	-11.12%	-9.77%	-8.08%	-11.25%	17.46%	12.03%	11.89%	12.1%
	t(P4-P1)	(-3.16)	(-4.02)	(-3.35)	(-4.58)				
Short Roll	Low	6.80%	6.32%	5.60%	6.49%	14.98%	13.57%	14.21%	14.7%
	P2	0.79%	-0.46%	-0.30%	-0.13%	15.58%	14.99%	16.13%	15.7%
	P3	-3.10%	-1.65%	-1.46%	-0.41%	16.04%	14.18%	13.95%	15.5%
	High	-4.33%	-4.30%	-3.57%	-6.39%	14.88%	11.95%	11.82%	13.5%
	P4-P1	-11.12%	-10.62%	-9.17%	-12.88%	17.46%	12.48%	12.60%	13.4%
	t(P4-P1)	(-3.16)	(-4.21)	(-3.59)	(-4.72)				
Excess Holding	Low		-0.45%	-0.78%	-0.97%		1.50%	2.24%	3.3%
	P2		-0.21%	0.04%	-0.07%		0.96%	1.51%	2.2%
	P3		0.21%	0.43%	0.20%		1.04%	1.42%	2.1%
	High		0.40%	0.32%	0.66%		1.15%	1.58%	2.1%
	P4-P1		0.85%	1.09%	1.63%		1.66%	2.22%	3.2%
	t(P4-P1)		(2.53)	(2.43)	(2.50)				
Spreading	Low		-1.05%	-0.93%	-1.12%		2.54%	3.15%	3.9%
	P2		-0.09%	0.01%	-0.13%		1.64%	2.06%	2.8%
	P3		0.36%	0.41%	0.05%		1.68%	1.91%	2.6%
	High		0.76%	0.49%	1.15%		2.26%	2.31%	2.7%
	P4-P1		1.81%	1.43%	2.27%		2.69%	3.10%	3.8%
	t(P4-P1)		(3.34)	(2.28)	(2.95)				

Table IA.V ctd.: **Basis sort when controling for seasonalities.**

B. Sorting returns with seasonally adjusted basis

		Annualized mean returns				Annualized standard deviations			
		r(1)	r(2)	r(3)	r(4)	r(1)	r(2)	r(3)	r(4)
Holding	Low	8.35%	7.42%	6.53%	9.21%	15.30%	13.53%	13.39%	14.3%
	P2	2.48%	1.26%	1.20%	2.61%	15.78%	14.71%	14.91%	15.0%
	P3	-1.39%	0.57%	1.20%	3.41%	16.46%	14.57%	13.33%	15.3%
	High	-3.91%	-2.73%	-2.19%	-2.82%	14.88%	11.77%	11.12%	13.4%
	P4-P1	-12.26%	-10.16%	-8.72%	-12.04%	17.54%	12.04%	11.56%	14.3%
	t(P4-P1)	(-3.47)	(-4.18)	(-3.72)	(-4.14)				
Short Roll	Low	8.35%	7.42%	6.76%	9.78%	15.30%	13.63%	13.69%	15.4%
	P2	2.48%	1.11%	0.52%	1.81%	15.78%	14.86%	15.08%	15.7%
	P3	-1.39%	0.05%	0.25%	2.44%	16.46%	14.86%	13.94%	16.0%
	High	-3.91%	-3.73%	-3.57%	-4.07%	14.88%	11.97%	11.53%	13.9%
	P4-P1	-12.26%	-11.15%	-10.33%	-13.84%	17.54%	12.46%	12.18%	15.6%
	t(P4-P1)	(-3.47)	(-4.43)	(-4.18)	(-4.36)				
Excess Holding	Low		0.00%	-0.23%	-0.56%		1.51%	2.25%	3.4%
	P2		0.14%	0.68%	0.81%		0.99%	1.62%	2.2%
	P3		0.52%	0.95%	0.97%		1.06%	1.58%	2.1%
	High		0.99%	1.38%	1.24%		1.19%	2.00%	2.0%
	P4-P1		0.99%	1.61%	1.81%		1.72%	2.42%	3.3%
	t(P4-P1)		(2.85)	(3.28)	(2.72)				
Spreading	Low		-0.13%	-0.22%	-0.51%		2.58%	3.12%	3.9%
	P2		0.68%	1.06%	1.04%		1.72%	2.21%	2.9%
	P3		1.04%	1.30%	1.05%		1.70%	2.10%	2.6%
	High		1.88%	2.01%	1.93%		2.29%	2.89%	2.7%
	P4-P1		2.01%	2.23%	2.44%		2.84%	3.27%	3.9%
	t(P4-P1)		(3.51)	(3.36)	(3.11)				

Table IA.VI: **Stochastic interest rates.**

The table contains summary results for mean returns (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on the non-interest rate components of the basis estimated using the following regression

$$basis_{i,t} = a_i + b_i(interest_t - avg(interest)) + \varepsilon_{i,t}.$$

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. Standard errors are estimated using Newey-West correction. The returns are quoted bi-monthly 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)
		A.1 $basis_{i,t} - b_i(interest_t - avg(interest))$				A.2 $b_i(interest_t - avg(interest))$			
Holding	Mono	y	y	y	y				
	P4-P1	-8.57%	-9.76%	-10.23%	-12.58%	-5.49%	-6.23%	-5.53%	-4.24%
	t-stat	(-2.47)	(-3.80)	(-4.23)	(-4.35)	(-1.38)	(-1.99)	(-1.93)	(-1.70)
Short Roll	Mono	y	y	y	y				
	P4-P1	-8.57%	-10.40%	-11.47%	-13.84%	-5.49%	-6.93%	-6.83%	-5.09%
	t-stat	(-2.47)	(-3.84)	(-4.40)	(-4.36)	(-1.38)	(-2.13)	(-2.15)	(-1.78)
Excess Holding	Mono		y	y	y				
	P4-P1		0.64%	1.24%	1.25%		0.70%	1.30%	0.85%
	t-stat		(1.75)	(2.39)	(1.97)		(0.02)	(0.01)	(0.03)
Spreading	Mono		y	y	y		y		
	P4-P1		1.50%	2.23%	2.55%		1.61%	2.06%	0.86%
	t-stat		(2.68)	(3.32)	(3.83)		(2.66)	(2.48)	(1.00)

Table IA.VII: **Alternative sorts.**
The table contains summary results for mean returns (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on several 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, inflation, dollar beta, hedging pressure, open interest, and liquidity. Standard errors are estimated using Newey-West correction. The returns are quoted bi-monthly 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)
		Basis				**Momentum**			
Holding	Mono	y	y	y	y	y	y	y	
	P4-P1	-8.29%	-10.74%	-12.07%	-12.70%	9.00%	6.10%	4.05%	1.85%
	t-stat	(-2.40)	(-4.29)	(-4.95)	(-4.13)	(2.02)	(1.82)	(1.21)	(0.46)
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)
Spreading	Mono		y	y	y		y	y	y
	P4-P1		1.70%	2.64%	3.17%		-1.13%	-1.14%	-0.35%
	t-stat		(3.07)	(3.88)	(5.08)		(-1.58)	(-1.34)	(-0.42)
		Coefficient of Variation				**Inflation Beta**			
Holding	Mono	y			y	y	y		y
	P4-P1	8.13%	7.67%	8.01%	8.49%	9.56%	9.00%	7.45%	8.58%
	t-stat	(2.37)	(2.63)	(2.85)	(2.52)	(1.99)	(2.11)	(1.70)	(1.71)
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)
Spreading	Mono		y	y			y	y	y
	P4-P1		-1.67%	-1.53%	-0.86%		-1.49%	-1.66%	-2.12%
	t-stat		(-3.16)	(-2.27)	(-1.11)		(-2.10)	(-1.79)	(-1.89)
		Dollar Beta				**Hedging Pressure**			
Holding	Mono	y							y
	P4-P1	-1.86%	-0.49%	0.33%	-0.94%	5.58%	5.17%	3.60%	4.16%
	t-stat	(-0.35)	(-0.11)	(0.08)	(-0.20)	(1.66)	(1.68)	(1.26)	(1.59)
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)
Spreading	Mono							y	y
	P4-P1		1.82%	1.79%	1.32%		-1.03%	-0.81%	-1.69%
	t-stat		(2.84)	(2.11)	(1.22)		(-1.56)	(-0.93)	(-2.02)

Table IA.VII ctd.: **Alternative sorts.**

		Annualized mean returns				Annualized mean returns			
		n=1	n=2	n=3	n=4	n=1	n=2	n=3	n=4
		Open Interest				**Liquidity**			
Holding	Mono					y	y		
	P4-P1	5.78%	4.21%	4.97%	-4.39%	-9.40%	-6.98%	-5.23%	-5.65%
	t(Hold)	(1.71)	(1.46)	(1.56)	(-1.48)	(-2.22)	(-1.96)	(-1.69)	(-1.57)
Short Roll	Mono	y				y			
	P4-P1	5.78%	5.33%	6.35%	-5.08%	-9.40%	-7.47%	-5.89%	-6.92%
	t(Hold)	(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(ExcHold)		(-2.49)	(-2.05)	(0.52)		(1.57)	(1.55)	(2.04)
Spreading	Mono								y
	P4-P1		-1.99%	-2.03%	0.69%		0.87%	0.82%	1.69%
	t(Spread)		(-2.79)	(-2.15)	(0.42)		(1.64)	(1.40)	(2.08)

Table IA.VIII: **Inflation-based sorts.**

The table contains summary results for mean returns (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on different measures of inflation. 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. In Panel A we sort on the unexpected inflation as the difference between realized inflation and its forecast from an ARIMA model (as in Fama and Gibbons (1984)). In Panel B we sort on realized inflation minus the risk free interest rate as in Fama and Schwert (1977). Standard errors are estimated using Newey-West correction. The returns are quoted bi-monthly 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)
		A. ARIMA innovation				**B. Inflation-RF**			
Holding	Mono	y							
	P4-P1	8.04%	6.30%	6.31%	8.49%	0.63%	-0.77%	1.01%	3.95%
	t-stat	(1.68)	(1.56)	(1.65)	(1.92)	(0.14)	(-0.23)	(0.30)	(0.92)
Short Roll	Mono	y							
	P4-P1	8.04%	7.06%	7.62%	10.17%	0.63%	-0.53%	1.24%	4.95%
	t-stat	(1.68)	(1.72)	(1.92)	(2.13)	(0.14)	(-0.15)	(0.35)	(1.06)
Excess Holding	Mono		y	y					
	P4-P1		-0.76%	-1.31%	-1.68%		-0.24%	-0.23%	-0.99%
	t-stat		(-1.97)	(-2.27)	(-2.27)		(-0.70)	(-0.45)	(-1.29)
Spreading	Mono		y	y					
	P4-P1		-1.33%	-1.84%	-1.96%		-0.33%	-0.23%	-1.52%
	t-stat		(-1.98)	(-2.29)	(-2.09)		(-0.56)	(-0.34)	(-1.60)

Table IA.IX: **Principal Component Analysis.**
The table reports for each of the four portfolios in six different sorts on basis, momentum, coefficient of variation, inflation beta, hedging pressure and liquidity, the variance of the shortest maturity of Short Roll returns (n=1) and the the longer maturity Spreading returns (n=2) explained by the first three principal components of those 48 portfolios.

		Short Roll			Spreading		
		PCA1	PCA2	PCA3	PCA1	PCA2	PCA3
Basis	P1	60.8%	0.8%	3.4%	1.8%	54.3%	9.8%
	P2	57.1%	1.5%	1.9%	0.9%	18.0%	16.9%
	P3	66.7%	0.8%	2.9%	2.1%	46.5%	8.8%
	P4	63.5%	0.4%	1.6%	0.1%	50.6%	9.6%
Momentum	P1	50.1%	0.0%	2.9%	0.7%	50.1%	13.5%
	P2	68.2%	0.5%	0.5%	0.3%	39.9%	12.3%
	P3	61.9%	0.1%	0.1%	0.0%	59.7%	1.2%
	P4	58.0%	0.5%	3.2%	0.4%	20.8%	35.5%
Coefficient of Variation	P1	64.3%	0.0%	0.5%	0.2%	51.4%	0.0%
	P2	61.9%	0.6%	0.2%	1.3%	44.6%	1.6%
	P3	65.9%	0.5%	2.1%	0.3%	41.7%	5.8%
	P4	51.7%	0.1%	0.0%	1.2%	34.2%	4.9%
Inflation Beta	P1	53.4%	1.2%	3.2%	0.0%	42.4%	19.9%
	P2	55.4%	0.2%	0.7%	1.4%	54.2%	4.9%
	P3	66.2%	0.5%	0.1%	0.6%	53.3%	0.6%
	P4	58.5%	0.1%	5.6%	3.9%	18.8%	13.1%
Hedging Pressure	P1	54.7%	0.6%	0.2%	0.9%	40.2%	0.6%
	P2	64.0%	0.4%	1.0%	5.4%	42.3%	1.3%
	P3	77.4%	0.1%	0.9%	0.0%	48.4%	5.1%
	P4	55.1%	0.0%	0.0%	0.2%	47.2%	0.0%
Liquidity	P1	46.5%	0.5%	0.3%	0.8%	49.4%	4.7%
	P2	61.3%	0.5%	0.6%	1.7%	44.4%	2.2%
	P3	65.2%	0.4%	0.2%	0.4%	61.2%	0.5%
	P4	54.5%	0.9%	2.5%	0.2%	33.7%	22.0%
	avg	**60.1%**	**0.5%**	**1.4%**	**1.0%**	**43.6%**	**8.1%**
	min	46.5%	0.0%	0.0%	0.0%	18.0%	0.0%
	max	77.4%	1.5%	5.6%	5.4%	61.2%	35.5%

Table IA.X: **Correlations between the High and Low factor portfolios.** The table reports the correlation matrices for the six long (High) and the six short (Low) portfolios that constitute the various factors from Short Roll returns sorted on the basis, momentum, coefficient of variation, inflation, hedging pressure and liquidity. We use bi-monthly returns for a sample period between March 1986 and December 2010.

A: Correlations for Low basis and High other factors

	Low Basis	High MOM	High CV	High Infl	High HP	High Liq
Low Basis	1.000	0.921	0.871	0.912	0.844	0.816
High MOM	0.921	1.000	0.838	0.874	0.831	0.764
High CV	0.871	0.838	1.000	0.851	0.781	0.847
High Infl	0.912	0.874	0.851	1.000	0.828	0.858
High HP	0.844	0.831	0.781	0.828	1.000	0.754
High Liq	0.816	0.764	0.847	0.858	0.754	1.000
average	0.873	0.845	0.837	0.864	0.808	0.808

B: Correlations for High basis and Low other factors

	High Basis	Low MOM	Low CV	Low Inflaiton	Low HP	Low Liq
High Basis	1.000	0.837	0.847	0.787	0.804	0.783
Low MOM	0.837	1.000	0.815	0.755	0.772	0.690
Low CV	0.847	0.815	1.000	0.759	0.794	0.845
Low Infl	0.787	0.755	0.759	1.000	0.731	0.744
Low HP	0.804	0.772	0.794	0.731	1.000	0.806
Low Liq	0.783	0.690	0.845	0.744	0.806	1.000
average	0.812	0.774	0.812	0.755	0.781	0.774

Table IA.XI: **Asset pricing tests for basis factor from Holding returns.** The table reports the asset pricing tests for mean returns (Holding, Short Roll, Excess Holding, and Spreading returns) when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, 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 two highest basis portfolios minus two lowest basis portfolios, and estimate the following regressions:

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

The first column gives the average absolute $\alpha^{(n)}_i$ of the four portfolios within a sort, and the second column 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 bi-monthly for a sample period between March 1986 and December 2010.

	Holding		Short Roll		Excess Holding		Spreading	
	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
A. Returns sorted on Basis								
n=1	0.60%	(0.993)	0.60%	(0.993)				
n=2	0.43%	(0.996)	0.63%	(0.988)	0.48%	(0.102)	1.13%	(0.001)
n=3	1.45%	(0.828)	2.27%	(0.390)	0.82%	(0.031)	1.28%	(0.003)
n=4	1.93%	(0.961)	1.24%	(0.745)	0.71%	(0.007)	1.03%	(0.000)
B. Returns sorted on Momentum								
n=1	1.28%	(0.853)	1.28%	(0.853)				
n=2	0.70%	(0.916)	0.95%	(0.935)	0.49%	(0.072)	1.11%	(0.008)
n=3	1.94%	(0.385)	2.26%	(0.538)	0.81%	(0.073)	1.26%	(0.068)
n=4	2.27%	(0.127)	1.95%	(0.191)	0.61%	(0.099)	0.86%	(0.216)
C. Returns sorted on Coefficient of Variation								
n=1	1.92%	(0.546)	1.92%	(0.546)				
n=2	2.13%	(0.375)	2.35%	(0.258)	0.76%	(0.000)	1.59%	(0.000)
n=3	2.57%	(0.041)	3.03%	(0.024)	1.12%	(0.001)	1.72%	(0.002)
n=4	2.84%	(0.348)	2.63%	(0.277)	1.11%	(0.017)	1.36%	(0.012)
D. Returns sorted on Inflation Beta								
n=1	2.09%	(0.688)	2.09%	(0.688)				
n=2	1.21%	(0.856)	1.53%	(0.798)	0.74%	(0.001)	1.57%	(0.000)
n=3	2.21%	(0.778)	3.35%	(0.676)	1.15%	(0.010)	1.78%	(0.004)
n=4	1.61%	(0.189)	2.13%	(0.181)	1.13%	(0.070)	1.57%	(0.040)
E. Returns sorted on Hedging Pressure								
n=1	2.06%	(0.179)	2.06%	(0.179)				
n=2	2.27%	(0.104)	2.51%	(0.104)	0.50%	(0.025)	1.18%	(0.002)
n=3	1.61%	(0.735)	2.24%	(0.670)	0.87%	(0.021)	1.32%	(0.025)
n=4	1.98%	(0.292)	2.01%	(0.390)	0.70%	(0.126)	0.90%	(0.283)
F. Returns sorted on Liquidity								
n=1	2.11%	(0.678)	2.11%	(0.655)				
n=2	1.63%	(0.428)	1.73%	(0.598)	0.75%	(0.000)	1.55%	(0.000)
n=3	1.98%	(0.575)	3.00%	(0.278)	1.01%	(0.000)	1.58%	(0.000)
n=4	2.57%	(0.015)	2.62%	(0.230)	1.09%	(0.000)	1.38%	(0.000)

Table IA.XII: **Asset pricing tests for basis factor from Spreading returns.** The table reports the asset pricing tests for Excess Holding and Spreading returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, 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, the second column 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 bi-monthly for a sample period between March 1986 and December 2010.

	one factor: $rHML^{(n)}_{t\to t+n}$				two factors: $rH^{(n)}_{t\to t+n}$, $rL^{(n)}_{t\to t+n}$			
	Excess Holding		Spreading		Excess Holding		Spreading	
	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
A. Returns sorted on Basis								
n=1								
n=2	0.50%	(0.053)	1.01%	(0.004)	0.07%	(0.937)	0.20%	(0.780)
n=3	0.75%	(0.053)	1.07%	(0.006)	0.15%	(0.757)	0.33%	(0.999)
n=4	0.79%	(0.008)	1.20%	(0.001)	0.40%	(0.193)	0.45%	(0.000)
B. Returns sorted on Momentum								
n=1								
n=2	0.49%	(0.059)	0.99%	(0.024)	0.09%	(0.910)	0.15%	(0.917)
n=3	0.75%	(0.048)	1.05%	(0.094)	0.18%	(0.814)	0.17%	(0.939)
n=4	0.74%	(0.073)	1.10%	(0.073)	0.25%	(0.536)	0.17%	(0.888)
C. Returns sorted on Coefficient of Variation								
n=1								
n=2	0.75%	(0.000)	1.47%	(0.000)	0.21%	(0.434)	0.41%	(0.357)
n=3	1.08%	(0.004)	1.56%	(0.030)	0.24%	(0.356)	0.21%	(0.909)
n=4	1.24%	(0.003)	1.61%	(0.009)	0.38%	(0.490)	0.42%	(0.575)
D. Returns sorted on Inflation Beta								
n=1								
n=2	0.73%	(0.004)	1.45%	(0.001)	0.08%	(0.964)	0.12%	(0.505)
n=3	1.09%	(0.019)	1.58%	(0.024)	0.14%	(0.900)	0.09%	(0.566)
n=4	1.35%	(0.013)	1.88%	(0.004)	0.38%	(0.579)	0.55%	(0.071)
E. Returns sorted on Hedging Pressure								
n=1								
n=2	0.52%	(0.015)	1.07%	(0.007)	0.18%	(0.601)	0.38%	(0.257)
n=3	0.81%	(0.037)	1.13%	(0.060)	0.20%	(0.531)	0.31%	(0.628)
n=4	0.85%	(0.036)	1.17%	(0.066)	0.25%	(0.477)	0.38%	(0.230)
F. Returns sorted on Liquidity								
n=1								
n=2	0.73%	(0.000)	1.44%	(0.000)	0.30%	(0.097)	0.69%	(0.024)
n=3	1.01%	(0.000)	1.51%	(0.000)	0.75%	(0.000)	1.05%	(0.000)
n=4	1.28%	(0.000)	1.68%	(0.000)	0.89%	(0.000)	1.19%	(0.000)

Table IA.XIII: **Asset pricing tests for basis factors from Holding returns: two factors.**

The table reports the asset pricing tests for Excess Holding and Spreading returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, and liquidity). We construct two factors from Holding returns on the two highest basis portfolios, $rH^{(n)}_{t\to t+n}$, and the two lowest basis portfolios, $rL^{(n)}_{t\to t+n}$, and estimate the following regressions:

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

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

	Excess Holding		Spreading	
	α (abs)	p	α (abs)	p
A. Returns sorted on Basis				
n=1				
n=2	0.48%	(0.104)	1.13%	(0.001)
n=3	0.81%	(0.028)	1.26%	(0.003)
n=4	0.74%	(0.005)	1.06%	(0.000)
B. Returns sorted on Momentum				
n=1				
n=2	0.49%	(0.072)	1.11%	(0.007)
n=3	0.80%	(0.080)	1.25%	(0.074)
n=4	0.68%	(0.051)	0.93%	(0.125)
C. Returns sorted on Coefficient of Variation				
n=1				
n=2	0.76%	(0.000)	1.60%	(0.000)
n=3	1.11%	(0.001)	1.71%	(0.002)
n=4	1.16%	(0.007)	1.42%	(0.009)
D. Returns sorted on Inflation Beta				
n=1				
n=2	0.75%	(0.001)	1.57%	(0.000)
n=3	1.14%	(0.013)	1.78%	(0.006)
n=4	1.16%	(0.046)	1.60%	(0.027)
E. Returns sorted on Hedging Pressure				
n=1				
n=2	0.50%	(0.026)	1.18%	(0.002)
n=3	0.85%	(0.023)	1.31%	(0.029)
n=4	0.75%	(0.048)	0.96%	(0.144)
F. Returns sorted on Liquidity				
n=1				
n=2	0.75%	(0.000)	1.56%	(0.000)
n=3	1.00%	(0.000)	1.57%	(0.000)
n=4	1.12%	(0.000)	1.42%	(0.000)

Table IA.XIV: **Asset pricing tests for alternative factors from Spreading returns: two factors.**
The table reports the asset pricing tests for Excess Holding and Spreading returns when futures contracts are sorted on different instruments (basis, momentum, coefficient of variation, inflation beta, hedging pressure, and liquidity). We construct two factors from Spreading returns on the two highest portfolios, $rH^{(n)}_{t\to t+n}$, and the two lowest portfolios, $rL^{(n)}_{t\to t+n}$, within each sort, and estimate the following regressions:

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

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

	Mom-factor				CV-factor				Infl-factor			
	Excess Holding		Spreading		Excess Holding		Spreading		Excess Holding		Spreading	
	α (abs)	p	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
A. Returns sorted on Basis												
n=1												
n=2	0.16%	(0.659)	0.52%	(0.010)	0.29%	(0.189)	0.52%	(0.043)	0.29%	(0.159)	0.53%	(0.035)
n=3	0.47%	(0.034)	0.69%	(0.002)	0.48%	(0.051)	0.75%	(0.006)	0.45%	(0.033)	0.72%	(0.000)
n=4	0.68%	(0.001)	1.02%	(0.000)	0.60%	(0.038)	0.99%	(0.000)	0.74%	(0.006)	1.09%	(0.000)
B. Returns sorted on Momentum												
n=1												
n=2	0.08%	(0.922)	0.08%	(0.980)	0.13%	(0.805)	0.19%	(0.102)	0.11%	(0.865)	0.16%	(0.580)
n=3	0.08%	(0.989)	0.09%	(1.000)	0.21%	(0.753)	0.29%	(0.667)	0.15%	(0.952)	0.23%	(0.849)
n=4	0.15%	(0.487)	0.11%	(1.000)	0.19%	(0.789)	0.22%	(0.901)	0.21%	(0.781)	0.17%	(0.986)
C. Returns sorted on Coefficient of Variation												
n=1												
n=2	0.23%	(0.516)	0.45%	(0.041)	0.20%	(0.503)	0.38%	(0.823)	0.21%	(0.566)	0.40%	(0.455)
n=3	0.24%	(0.631)	0.24%	(0.832)	0.22%	(0.538)	0.16%	(0.951)	0.26%	(0.619)	0.23%	(0.866)
n=4	0.40%	(0.446)	0.47%	(0.329)	0.43%	(0.365)	0.53%	(1.000)	0.41%	(0.463)	0.47%	(0.442)
D. Returns sorted on Inflation Beta												
n=1												
n=2	0.07%	(0.964)	0.14%	(0.923)	0.16%	(0.745)	0.25%	(0.142)	0.11%	(0.888)	0.20%	(0.935)
n=3	0.15%	(0.951)	0.18%	(0.827)	0.21%	(0.848)	0.21%	(0.568)	0.16%	(0.960)	0.12%	(0.848)
n=4	0.37%	(0.452)	0.46%	(0.241)	0.53%	(0.333)	0.68%	(0.214)	0.35%	(0.598)	0.42%	(0.746)
E. Returns sorted on Hedging Pressure												
n=1												
n=2	0.16%	(0.622)	0.31%	(0.255)	0.44%	(0.047)	0.77%	(0.000)	0.35%	(0.076)	0.61%	(0.010)
n=3	0.12%	(0.948)	0.16%	(0.865)	0.56%	(0.107)	0.67%	(0.082)	0.44%	(0.286)	0.53%	(0.180)
n=4	0.20%	(0.573)	0.33%	(0.512)	0.29%	(0.778)	0.49%	(0.401)	0.30%	(0.488)	0.29%	(0.418)
F. Returns sorted on Trading Volume / OI												
n=1												
n=2	0.17%	(0.298)	0.35%	(0.032)	0.17%	(0.381)	0.36%	(0.042)	0.16%	(0.301)	0.36%	(0.115)
n=3	0.25%	(0.496)	0.33%	(0.382)	0.34%	(0.238)	0.44%	(0.137)	0.33%	(0.098)	0.42%	(0.163)
n=4	0.26%	(0.656)	0.24%	(0.705)	0.31%	(0.505)	0.17%	(0.930)	0.36%	(0.302)	0.23%	(0.835)
F. Returns sorted on Liquidity												
n=1												
n=2	0.34%	(0.031)	0.73%	(0.001)	0.33%	(0.020)	0.69%	(0.002)	0.34%	(0.040)	0.74%	(0.010)
n=3	0.75%	(0.000)	1.03%	(0.000)	0.76%	(0.000)	1.02%	(0.000)	0.74%	(0.000)	1.02%	(0.000)
n=4	0.82%	(0.000)	1.08%	(0.000)	0.71%	(0.000)	0.94%	(0.000)	0.77%	(0.000)	1.01%	(0.001)

Table IA.XIV ctd.: **Asset pricing tests for alternative factors from Spreading returns: two factors.**

	HP-factor				Liquidity-factor			
	Excess Holding		Spreading		Excess Holding		Spreading	
	α (abs)	p	α(abs)	p	α(abs)	p	α(abs)	p
A. Returns sorted on Basis								
n=1								
n=2	0.26%	(0.236)	0.67%	(0.001)	0.19%	(0.259)	0.46%	(0.300)
n=3	0.52%	(0.012)	0.75%	(0.001)	0.52%	(0.093)	0.76%	(0.055)
n=4	0.69%	(0.001)	1.05%	(0.000)	0.72%	(0.037)	1.19%	(0.000)
B. Returns sorted on Momentum								
n=1								
n=2	0.15%	(0.778)	0.31%	(0.576)	0.18%	(0.708)	0.24%	(0.093)
n=3	0.17%	(0.929)	0.25%	(0.891)	0.17%	(0.827)	0.22%	(0.276)
n=4	0.15%	(0.866)	0.15%	(0.928)	0.18%	(0.933)	0.19%	(0.716)
C. Returns sorted on Coefficient of Variation								
n=1								
n=2	0.23%	(0.458)	0.50%	(0.096)	0.21%	(0.261)	0.42%	(0.276)
n=3	0.27%	(0.490)	0.29%	(0.714)	0.37%	(0.124)	0.43%	(0.393)
n=4	0.48%	(0.221)	0.50%	(0.331)	0.59%	(0.137)	0.79%	(0.003)
D. Returns sorted on Inflation Beta								
n=1								
n=2	0.06%	(0.991)	0.16%	(0.662)	0.05%	(0.997)	0.15%	(0.693)
n=3	0.14%	(0.924)	0.17%	(0.649)	0.09%	(0.973)	0.45%	(0.228)
n=4	0.33%	(0.594)	0.40%	(0.296)	0.46%	(0.394)	0.56%	(0.317)
E. Returns sorted on Hedging Pressure								
n=1								
n=2	0.10%	(0.848)	0.04%	(1.000)	0.31%	(0.243)	0.57%	(0.003)
n=3	0.06%	(0.993)	0.10%	(0.437)	0.35%	(0.477)	0.49%	(0.155)
n=4	0.29%	(0.136)	0.30%	(0.163)	0.35%	(0.589)	0.33%	(0.619)
F. Returns sorted on Liquidity								
n=1								
n=2	0.33%	(0.047)	0.73%	(0.005)	0.16%	(0.736)	0.17%	(0.965)
n=3	0.72%	(0.000)	0.97%	(0.003)	0.28%	(0.116)	0.34%	(0.631)
n=4	0.71%	(0.002)	0.98%	(0.006)	0.37%	(0.305)	0.30%	(0.784)

Table IA.XV: **Comparison of actual and apporximate returns.**
This table shows the exact, actual (short maturity) log futures returns and the ones derived from our approximation given in Equation (A2) in the paper. We report the correlation between the two series for each contract (first column), the two standard deviations (second and third column), the two means (fourth an fifth column) and the standard deviation of the percentage basis (last column). In Panel A we assume the storage costs and risk free rate to be constant, in Panel B we use the actual interest rates, assuming only storage costs to be constant.

	Ret correl (act, appr)	Stanard deviation actual	approx	Average return actual	approx	Std. basis
A. Assuming constant interest rate and storage costs						
Heating Oil	0.96	13.2%	12.9%	1.3%	1.0%	2.40%
Gasoline	0.98	14.0%	14.5%	2.2%	1.5%	2.70%
Crude Oil	0.98	14.1%	14.1%	1.9%	1.5%	1.90%
Feeder Cattle	0.96	5.4%	5.7%	0.6%	0.2%	1.40%
Live Cattle	0.79	5.1%	5.5%	0.7%	-0.1%	3.30%
Live Hogs	0.67	8.4%	11.1%	0.8%	-0.6%	7.00%
Gold	1.00	6.0%	6.0%	0.3%	0.2%	0.30%
Copper	0.98	11.6%	11.6%	2.1%	1.4%	2.00%
Silver	1.00	10.1%	10.0%	0.4%	0.2%	0.60%
Corn	0.96	9.9%	10.8%	-1.2%	-2.0%	2.90%
Oats	0.93	12.1%	12.2%	-0.9%	-1.9%	4.20%
Wheat	0.94	9.9%	10.6%	-0.8%	-1.8%	3.50%
Rough Rice	0.97	10.9%	11.7%	-1.6%	-2.1%	2.80%
Soybean Oil	0.99	9.5%	9.6%	-0.4%	-0.7%	1.00%
Soybeans	0.98	9.0%	9.2%	0.3%	-0.2%	1.70%
Soybean Meal	0.98	9.9%	10.1%	1.0%	0.7%	1.90%
Coffeee	0.97	14.9%	15.0%	-1.5%	-2.5%	3.30%
Oragne Juice	0.98	12.1%	12.4%	-0.7%	-1.3%	2.40%
Coccoa	0.99	11.0%	11.0%	-1.1%	-1.5%	1.60%
Cotton	0.87	10.2%	10.4%	-0.2%	-1.1%	4.90%
Lumber	0.94	11.4%	12.1%	-1.4%	-2.4%	3.90%
B. Assuming constant storage costs, actual interest rates						
Heating Oil	0.98	13.2%	13.2%	1.3%	0.6%	2.40%
Gasoline	0.98	14.0%	14.6%	2.2%	1.6%	2.70%
Crude Oil	0.98	14.1%	14.1%	1.9%	1.5%	1.90%
Feeder Cattle	0.95	5.4%	5.8%	0.6%	0.2%	1.40%
Live Cattle	0.77	5.1%	5.7%	0.7%	-0.1%	3.30%
Live Hogs	0.66	8.4%	11.2%	0.8%	-0.8%	7.00%
Gold	0.98	6.0%	6.1%	0.3%	-0.1%	0.30%
Copper	0.97	11.6%	11.6%	2.1%	1.0%	2.00%
Silver	0.99	10.1%	10.0%	0.4%	0.4%	0.60%
Corn	0.96	9.9%	10.8%	-1.2%	-2.1%	2.90%
Oats	0.94	12.1%	12.3%	-0.9%	-2.1%	4.20%
Wheat	0.93	9.9%	10.6%	-0.8%	-2.0%	3.50%
Rough Rice	0.97	10.9%	11.5%	-1.6%	-2.0%	2.80%
Soybean Oil	0.99	9.5%	9.7%	-0.4%	-0.6%	1.00%
Soybeans	0.99	9.0%	9.3%	0.3%	-0.4%	1.70%
Soybean Meal	0.98	9.9%	10.2%	1.0%	0.8%	1.90%
Coffeee	0.96	14.9%	15.1%	-1.5%	-2.7%	3.30%
Oragne Juice	0.97	12.1%	12.4%	-0.7%	-1.4%	2.40%
Coccoa	0.99	11.0%	11.0%	-1.1%	-1.4%	1.60%
Cotton	0.86	10.2%	10.5%	-0.2%	-1.2%	4.90%
Lumber	0.93	11.4%	12.2%	-1.4%	-2.4%	3.90%