Conditional Risk Premia and Correlations in Commodity Futures Markets

James Chong[*] and Joëlle Miffre[#]

Abstract

The article studies the conditional risk premia of commodity futures and the variation over time in their correlations with traditional asset classes. We find that investors in commodity futures markets earned significant risk premia over the period 1979-2004. We also reveal that the conditional correlations between commodity futures and equity returns fell over time, a sign that commodity futures have become better tools for strategic asset allocation. The correlations with equity returns also fell in periods of above average market volatility. We see this as welcome news to long institutional investors as they need the benefits of diversification most in periods of high market volatility.

Keywords: Commodity Futures, Risk Premia, Correlation, Market Volatility

JEL Classification: G13

This version: 4 September 2006

---

[*] California State University, Northridge, USA,
[#] Cass Business School, City University, UK.

Author for correspondence: Joëlle Miffre, Cass Business School, City University London, 106 Bunhill Row, London, EC1Y 8TZ, England. Tel: +44 (0)20 7040 8617, Fax: +44 (0)20 7040 8881, e-mail: J.Miffre@city.ac.uk.

The article was presented in a research seminar at the University of Essex, at the 2005 conferences for the Academy of Financial Services and the Financial Management Association. We would like to thank Chris Brooks, Jerry Coakley, and Ozzy Akay for helpful comments. A grant from CSUN in support of this study is also gratefully acknowledged.

1. Introduction

Commodity futures have low return correlation with traditional asset classes and thus are useful tools for strategic asset allocation (Jensen, Johnson, and Mercer, 2000; Erb and Harvey, 2006). They are also a good hedge against inflation (Bodie and Rosansky, 1980; Bodie, 1983). They offer leverage, high liquidity, low transaction costs and complete transparency (relative to commodity trading advisors). Finally, recent research has made it clear that tactical trading has generated abnormal returns in commodity futures markets in the past (Jensen, Johnson, and Mercer, 2002; Vrugt, Bauer, Molenaar, and Steenkamp, 2004; Wang and Yu, 2004; Erb and Harvey, 2006; Miffre and Rallis, 2006). For all these reasons, commodity futures have recently attracted much attention among both institutional investors and academics.

It is well-known that the decision to include commodity futures in a well-diversified portfolio is not solely based on the temporal risk-return characteristics of the contracts. The decision also depends on how commodity futures correlate with the rest of the portfolio over time. The paper, therefore, not only measures the conditional risk premia of 21 commodity futures contracts, it is also the first academic study, to the authors' knowledge, that evaluates the conditional correlation between commodity futures returns and those of traditional securities. We draw the following two conclusions from our analysis.

First, we show that investors in commodity futures earned significant risk premia over the period 1979-2004. This applies to 19 of the 21 commodity futures markets we studied. This result strongly supports the normal backwardation and contango theories (Keynes, 1930; Hicks, 1939)[1] and the notion that risk transfers occur in commodity

[1] The normal backwardation theory states that, when commodity hedgers are net short, futures prices are expected to rise as maturity approaches to entice speculators to open long positions in commodity futures markets. Conversely, the contango theory asserts that, when commodity hedgers are net long, futures prices before maturity are expected to fall as maturity approaches to entice speculators to open short positions. In both scenarios, the premium that speculators require for bearing price risk equals the insurance that hedgers are willing to pay to get rid of that risk. On the contrary, when net hedgers are neither long nor short, futures prices before maturity equal futures prices at maturity. Hedgers then transfer their price risks to one another at no cost and are not willing to pay a premium to speculators.

futures markets between hedgers and speculators.[2] This finding is interesting as it addresses one of the longest lasting controversies in financial economics on the validity of the normal backwardation theory.[3] More specifically, the risk premia of 12 commodity futures markets were negative over the period 1979-2004, while the risk premia of 7 commodity futures were positive. Twelve commodity futures markets were therefore contangoed and 7 were backwardated. Six commodity futures markets (out of the 21 we analyzed) also switched from contango (over the period 1979-1991) to normal backwardation (over the period 1992-2004). Caution should thus be exercised while extrapolating our results into the future and, subsequently, taking long positions in historically backwardated markets or short positions in previously contangoed markets.

The second contribution of the paper relates to the temporal variations in correlations between commodity futures returns and returns of traditional asset classes (S&P500 composite index and US Treasury-bond index). We reveal that correlations between commodity futures and equity returns fell over time. This suggests that the risk reduction obtained by adding long positions in commodity futures to an equity portfolio has increased over the period analyzed. Ultimately, this implies that commodity futures have become, over time, better portfolio diversifiers and thus better instruments for strategic asset allocation. Correlations between commodity futures and equity returns also fell in turbulent periods; namely, when market risk rose. This is good news to institutional investors with long positions in equities and commodity futures as it is precisely when market volatility is high that the benefits of diversification are most appreciated. On the other hand, correlations between Treasury-bonds and commodity futures returns tend to rise with bond volatility. This suggests that, unlike for stocks, adding commodity futures to a bond portfolio will not reduce risk further in periods of high interest rate volatility.

---

[2] Besides the normal backwardation theory (also known as the insurance perspective), Erb and Harvey (2006) also provided other theoretical frameworks in understanding the source of commodity futures excess returns. They are the capital asset pricing model (CAPM), the hedging pressure hypothesis, and the theory of storage.

[3] See, for example, Dusak (1973), Baxter, Conine, and Tamarkin (1985), Ehrhardt, Jordan, and Walkling (1987), Park, Wei, and Frecka (1988), Kolb (1992), Miffre (2000), Erb and Harvey (2006), Gorton and Rouwenhorst (2006) for an analysis of commodity futures markets.

The decrease in correlations between commodity and equity returns that we observe in periods of market stress could be interpreted as a flight-to-quality. Namely, equity investors, in times of panic in equity markets, treat commodity futures (such as gold) as refuge securities. They stop their losses by selling their equity portfolios and re-invest the proceeds in commodity futures. The increase in stock volatility then generates an upsurge of interest in commodity futures markets that could explain the decrease in correlations that we observe during market stress.[4] Alternatively, our results could be explained through the different impacts that major events have on commodity and equity returns. A hurricane, for example, may increase the volatility of equity markets. Simultaneously, it creates positive skewness in commodity returns and negative skewness in equity returns. Thus, and as observed in this paper, an upsurge in market risk could occur at the same time as a decrease in correlations between equity and commodity returns.

The paper proceeds as follows. Section 2 presents the GARCH methodology employed to measure the time-varying risk premia and conditional correlations. Section 3 introduces the dataset. Section 4 studies the conditional risk premia of commodity futures contracts and the link between conditional correlations and conditional market volatilities. Finally, Section 5 concludes.

2. Methodology

The decision to tilt a portfolio's optimal asset allocation towards, or away from, commodity futures depends on the expected returns and standard deviations of different asset classes and on the expected correlations between different investment vehicles. An increase in the weights allocated to commodity futures would depend on the expectation of commodity futures having i) higher average returns, ii) lower volatility and/or iii) lower correlations with other asset classes. To analyze the factors that may influence the optimal allocation in equity and commodity futures markets, a bivariate GARCH(1,1) model that simultaneously estimates the conditional expected

[4] Note that, even in turbulent times, correlations between commodity futures and equity returns remain, for the most part, positive. We do not claim therefore that commodity futures prices rise in periods of market stress. Instead, we hypothesize that in times of high volatility the stop-loss orders of equity asset managers and the subsequent re-allocation of resources towards commodity futures put more downward pressure on equity prices than on commodity futures prices.

returns and the conditional variance-covariance matrix is used (this system is sometimes referred to as the diagonal VECH, first conceived by Bollerslev, Engle, and Wooldridge, 1988):

$$R_{S,t} - R_{f,t} = \alpha_0 + \alpha_1 Z_{t-1} + u_{S,t}\,, \tag{1a}$$

$$R_{F,t} = \beta_0 + \beta_1 Z_{t-1} + u_{F,t}\,, \tag{1b}$$

$$h_{S,t}^2 = c_S + a_S h_{S,t-1}^2 + b_S u_{S,t-1}^2, \tag{1c}$$

$$h_{F,t}^2 = c_F + a_F h_{F,t-1}^2 + b_F u_{F,t-1}^2, \tag{1d}$$

$$h_{SF,t} = c_{SF} + a_{SF} h_{SF,t-1} + b_{SF} u_{S,t-1} u_{F,t-1}\,. \tag{1e}$$

$R_{S,t}$, $R_{f,t}$ and $R_{F,t}$ are the returns on the S&P500 composite index, the Treasury-bill and commodity futures, respectively. Z_{t-1} is a vector of information variables that capture the variations through time in the prices of risk present in equity and commodity futures markets. $u_{S,t}$ and $u_{F,t}$ are residuals on the S&P500 index and the commodity futures, $h_{S,t}^2$ and $h_{F,t}^2$ are conditional variances, $h_{SF,t}$ is a conditional covariance. The parameters to estimate are α_0, α_1, β_0 and β_1 for the conditional risk premia and a_i, b_i and c_i, $i = \{S, F, SF\}$, for the conditional variances and covariances. The conditional correlations between the S&P500 index and commodity futures are measured as $\rho_{SF,t} = h_{SF,t} / (h_{S,t} h_{F,t})$ in (1c), (1d) and (1e). To account for the opportunity cost of investing in stocks, returns are measured in excess of the risk-free rate for the S&P500 index. Raw returns are used for commodity futures because of the absence of initial investment in futures markets (at least, if one ignores margin requirements).

Since the seminal paper by Engle (1982), there have been numerous studies on the GARCH model and its extensions (see surveys by Poon and Granger, 2003; Andersen, Bollerslev, Christoffersen, and Diebold, 2006; Bauwens, Laurent, and Rombouts, 2006). The popularity of the GARCH model lies in its ability to mimic the (co-)variance of asset returns by taking into account volatility clustering (where large or small volatility changes tend to be followed by large or small volatility changes), leverage effects (where volatility is higher for negative returns than positive returns of the same magnitude) and fat tails (extreme positive or negative returns that occur more frequently than depicted by the normal distribution). A further benefit of employing the GARCH model in this study is that the conditional variance enter the mean computation, with the conditional variance itself depending on a vector of explanatory variables, Z_{t-1}.

While there are several multivariate GARCH models, we employ the diagonal VECH model. It is very similar to the univariate GARCH(1,1) model except that its covariance also evolves over time. A disadvantage of the diagonal VECH is that there is no guarantee of a positive definite covariance matrix.[5] The BEKK model (the acronym is for Baba, Engle, Kraft, and Kroner; Engle and Kroner, 1995) addresses and solves the issue of positive definiteness of the covariance matrix. However, it is difficult to interpret its coefficients since the parameters are in quadratic form. An alternative would be a combination of a univariate GARCH model and the dynamic conditional correlation (DCC) model (Engle, 2002). However, Conrad, Gultekin, and Kaul (1991) are of the opinion that multivariate models provide more precise parameter estimates because the model uses information from the entire variance-covariance matrix of the errors. On balance, we chose the diagonal VECH model.

Within the framework presented in (1a) to (1e), we can test two hypotheses. The first test looks at the sign and significance of $\beta_0 + \beta_1 Z_{t-1}$, the conditional risk premia in commodity futures. This simple test will give us an idea of the applicability, or lack thereof, of the normal backwardation and contango theories in commodity futures markets. A positive risk premium ($\beta_0 + \beta_1 Z_{t-1} > 0$) lends support to the normal backwardation theory. In this scenario, speculators are net long and require a risk premium for underwriting the price risk of net short hedgers. A negative risk premium ($\beta_0 + \beta_1 Z_{t-1} < 0$) lends support to the contango theory. In this case, speculators are net short and require a risk premium for undertaking the price risk of net long hedgers. Finally, a lack of risk premium ($\beta_0 + \beta_1 Z_{t-1} = 0$) suggests that there is no risk transfer between hedgers and speculators. In this setting, long and short hedgers transfer their risk to one another at no cost, leaving no incentive for speculators to enter the futures markets. To summarize, a significant risk premium suggests that risk

[5] This is not a concern in our study since the coefficients of the diagonal VECH are well behaved (as evident from Table 3).

transfers do occur between hedgers and speculators in commodity futures markets. The sign of the risk premium, in turn, indicates whether the data support the normal backwardation or contango theory.

The second test analyzes the conditional correlations between equity and commodity futures returns. First, we investigate how they changed over time by simply regressing them on a constant and a time trend. Second, we study the relation between conditional correlations and conditional volatilities by regressing the former on the latter as follows:

$$\rho_{SF,t} = \alpha + \beta_S h_{S,t} + \beta_F h_{F,t} + \varepsilon_t \tag{2}$$

A finding that β_S is positive suggests that conditional correlations between equities and commodity futures returns rise with the volatility of the S&P500 index. If so, the evidence from international stock markets (Solnik, Boucrelle, and Le Fur, 1996; Longin and Solnik, 2001) can be extrapolated to equity and commodity futures markets. A finding that β_S is negative, however, indicates that correlations between commodity futures and equity returns fall in periods of high volatility in equity markets. Ultimately, this result would imply that the usefulness of commodity futures as a diversification tool increased in periods of above average market volatility.

To study the conditional correlations between commodity futures and Treasury-bond returns, we modify equations (1a), (1c), (1e) and (2) and replace them with the following equations:

$$R_{B,t} - R_{f,t} = \alpha_0 + \alpha_1 Z_{t-1} + u_{B,t}, \tag{3a}$$

$$h_{B,t}^2 = c_B + a_B h_{B,t-1}^2 + b_B u_{B,t-1}^2, \tag{3c}$$

$$h_{BF,t} = c_{BF} + a_{BF} h_{BF,t-1} + b_{BF} u_{B,t-1} u_{F,t-1}, \tag{3e}$$

$$\rho_{BF,t} = \alpha + \beta_B h_{B,t} + \beta_F h_{F,t} + \varepsilon_t \tag{4}$$

where subscript *B* denotes bond.

3. Data

The data, obtained from Datastream International, comprise weekly returns of the S&P500 composite index, Datastream US Treasury-bond index and 21 US commodity futures contracts.[6] We consider 11 agricultural commodities (cocoa, coffee, corn, cotton, oats, orange juice, soybean meal, soybean oil, soybeans, sugar and wheat), 4 livestock commodities (feeder cattle, frozen pork bellies, lean hogs and live cattle) and 6 other, mainly metal, commodities (gold, heating oil, lumber, palladium, platinum and silver). The dataset spans the period January 31, 1979 to May 31, 2004. To avoid weekend effect, thin trading effect and maturity effect, we collect Wednesday settlement prices on the nearest maturity futures contract, except in maturity months when prices on the second nearest futures are used. Compiling futures prices in such a way introduces some uncertainty about the spread between the futures price of the contract that is closed out and the futures price of the new contract that is entered into. To avoid the possibility of roll-over risk clouding our inference on conditional correlation and volatility, the cross-over returns are deleted from the dataset.

Table 1 presents summary statistics for the S&P500 excess return, the US Treasury-bond excess return and the 21 commodity futures returns,[7] where the three-month Treasury-bill rate is subtracted to measure excess returns. The results indicate that the relation between risk and average return is not necessarily positive. Higher volatility in commodity futures markets does not necessarily translate into higher average returns. For example, futures contracts on corn, oats, lumber and silver have average returns inferior to -6% a year and relatively high standard deviations. The reward-to-risk ratios suggest that only heating oil offers a better risk-return trade-off than the

[6] We convert prices into returns by taking log difference. We employ weekly data so as to accommodate the availability of the information variable, S&P500 dividend yield. However, should high frequency commodity futures returns be used instead, discontinuous inter- and intra-day periodicities that may exist in the data should be accounted for so as to avoid inferior forecasts of future return volatility (Taylor, 2004).

[7] The mean and standard deviations are annualized using the formulae $\left(1+\overline{R}_P\right)^n-1$ and $\sqrt{n}\sigma_P$, where $\overline{R}_P$ and σ_P are the de-annualized mean and standard deviation, respectively and n is the average number of weeks in a given year. (Note that, as the analysis omits roll-over returns, n is less than 52).

S&P500 composite index over the period considered. Treasury-bond, oats and corn exhibit the worst risk-adjusted performance.

<< Insert Table 1 around here >>

Table 1 also reports the skewness, excess kurtosis and Jarque-Bera test of normality. It is clear from this table that the return distribution of commodity futures departs from normality, with strong evidence of positive skewness and positive excess kurtosis (Gorton and Rouwenhorst, 2006). Table 1 also presents unconditional correlations between (i) commodity futures and Treasury-bond returns and (ii) commodity futures and S&P500 returns. As previously reported (Jensen, Johnson, and Mercer, 2000; Erb and Harvey, 2006), correlations with S&P500 returns are very low, ranging from -0.0310 for frozen pork bellies to 0.1678 for lumber, with a mean at 0.0621. Commodity futures and bond returns also behave independently with an average correlation between the two of only 0.0253.

On balance, commodity futures appear to present both undesirable and desirable properties to long commodity futures traders. On one hand, their average return is as likely to be positive as it is to be negative and can be as low as -9.39% a year (oats). Their volatility often exceeds that of the S&P500 index and Treasury-bonds and their return distribution has fat tails relative to the normal. On the other hand, commodity futures returns present two features, positive skewness and low correlations with stocks and bonds returns, which are sought-after by risk-averse investors.

Z_{t-1} in equations (1a), (1b) and (3a) is a vector of information variables used as predictors of the business cycle one period ahead. Following Fama and French (1989), we include the first lag in the S&P500 dividend yield, default spread and the term structure of interest rates.[8] To capture any momentum or reversal in returns, three additional information variables are considered. These are the first lag in i) the S&P500 excess returns in (1a), ii) the US Treasury-bond excess returns in (3a) and iii) the returns of the commodity futures under review in (1b).

[8] Default spread is measured as the difference in yields between Moody’s Baa and Aaa-rated corporate bonds. The term structure of interest rates is measured as the difference in the yield on US Treasury-bonds with any maturity and the three-month Treasury-bill rate.

4. Empirical Results

This section tests the hypothesis that investors earned a risk premium in commodity futures risk premia over the period 1979-2004 (Section 4.1). We then turn our attention to the temporal variation in the conditional correlations between commodity futures and equity returns (Section 4.2). Finally, we conclude with an analysis of the dynamics in the co-movements between commodity futures and Treasury-bond returns (Section 4.3).

4. 1. Risk Premia in Commodity Futures Markets

Table 2 reports the average commodity futures risk premia and their associated *t*-statistics. The results, reported over the whole sample (1979-2004) and over two consecutive sub-samples of equal length (1979-1991 and 1992-2004), can also be viewed as a test of the applicability of the normal backwardation and contango theories.

<< Insert Table 2 around here >>

The results over the whole sample indicate that 19 of the 21 commodity futures risk premia are significant at the 5% level, lumber and platinum futures being the two exceptions. Therefore, the tests overwhelmingly support the hypothesis that risk transfers do occur between hedgers and speculators in commodity futures markets. Contango is supported for 12 commodity futures, of which the risk premia are negative and significant. Normal backwardation is supported for 7 commodity futures, of which the risk premia are positive and significant. Table 2, Panel D reports the average size of the commodity futures risk premia in backwardated and contangoed markets. On average, the annualized risk premium in contangoed markets equals -5.12%, ranging from -14.41% for oats to -1.34% for frozen pork bellies. The annualized risk premium in backwardated markets equals 3.36% on average, ranging from 1.74% for palladium to 6.66% for heating oil.

As the past is not a certain guide to the future, the positive return earned in the past by shorting contangoed commodities does not necessarily imply that a short position will be profitable in the future. Similarly, the positive return earned in the past by taking long positions in backwardated commodities might become illusory in the future. To test whether commodity futures markets switched from normal backwardation to contango or, vice versa, from contango to normal backwardation, Table 2 reports the annualized commodity risk premia over two consecutive periods of equal duration (1979-1991 and 1992-2004). The conditional risk premia retained the same sign for 11 commodity futures markets, for which the markets stayed backwardated (feeder cattle, heating oil, live cattle) or contangoed (cocoa, coffee, corn, cotton, gold, oats, orange juice, silver) throughout. On the other hand, 6 markets (frozen pork bellies, palladium, platinum, soybean meal, soybeans, sugar), while contangoed in the period 1979-1991, eventually became backwardated. Thus, the initial profit earned by shorting these commodities turned out to be negative over the period 1992-2004. Vice versa, lean hog switched from normal backwardation in the period 1979-1991 to contango in the period 1992-2004. This ultimately reveals that caution should be exercised while extrapolating the size and sign of the commodity risk premia of Table 2 into the future. Taking long positions in backwardated markets and short positions in contangoed markets might prove to be loss-making strategies in the future.

This point notwithstanding, Table 2 shows that investors in commodity futures markets earned significant risk premia over both the whole sample and the two sub-samples. Therefore, it highlights that that the normal backwardation and contango theories have some merits in describing the pricing of commodity futures. This result is noteworthy as it answers one of the most enduring questions in financial economics with regards the validity of the normal backwardation theory (Dusak, 1973; Baxter, Conine, and Tamarkin, 1985; Ehrhardt, Jordan, and Walkling, 1987; Park, Wei, and Frecka, 1988; Kolb, 1992; Miffre, 2000; Erb and Harvey, 2006; Gorton and Rouwenhorst, 2006).

Consistent with risk aversion, consumption smoothing and asset pricing models, the equity risk premium in Table 2 is positive and significant irrespective of the commodity futures under review. The average size of the equity risk premium is 5.09% over the whole sample, 4.69% in the first half of the sample and 7.20% in the second half. These estimates exceed Fama and French (2002) earnings-based calculation of 4.32%. The difference probably reflects the fact that Fama and French (2002) covered a different period (1951-2000). Different methodologies and variable measures are also likely reasons.

4. 2. Conditional Correlation and Conditional Stock Volatility

Robust inferences on the relation between conditional correlation and conditional volatility can only be drawn within a well-specified model. To ensure that this condition is met, Table 3 reports the parameter estimates from the diagonal VECH model. It is clear from this table that, irrespective of the commodity futures under consideration, the GARCH specification does capture the time-variation in variances and covariances. Note that the sum of the parameter estimates a_S and b_S, is close to, but less than, unity, as is the sum of a_F and b_F, suggesting strong persistence in variance. The covariance GARCH parameters a_{SF} and b_{SF}, which account for the conditional covariance between the S&P500 and futures returns, are positive and significant.

<< Insert Table 3 around here >>

Table 4 presents summary statistics of conditional correlations estimated from our GARCH model. The results warrant three comments. First, the average conditional correlation (at 0.0368 in Table 4) is lower than the average unconditional correlation (at 0.0621 in Table 1). The conditional correlations are also, for the most part, insignificant at the 5% level. Second, there is considerable divergence in the volatilities of the conditional correlations, with standard deviations ranging from 0.79% for cocoa to 15.12% for gold. Third, and possibly most importantly, regressions of conditional correlations on a time trend reveal a fall over time in conditional correlations for 17 (18) commodities at the 5% (10%) level. The remaining coefficients are insignificant. The decrease in correlation, measured as $\Delta\rho_{SF}$ [9] in Table 4, is significant in economic terms too. Over the period 1979-2004, conditional correlations have decreased by 7.15% on average. The decrease in correlation is particularly large for gold (for which $\Delta\rho_{SF}$ equals -29.19%) and platinum ($\Delta\rho_{SF}$ = -18.45%). These results suggest that segmentation between the S&P500 index and commodity futures markets has increased over time. As a result, the diversification benefits of being long equities and commodity futures and the importance of commodity futures for strategic asset allocation also increased. The

[9] Conditional correlations are regressed on a constant and a zero-mean time trend. For each commodity, $\Delta\rho_{SF}$, the difference between the last and first fitted values, measures the amount by which the correlations have decreased or increased over the period analyzed.

decrease in correlation over time that we observed in Table 4 could in turn be explained by the results of Table 5; namely, by the fact that correlations decrease in period of high market volatility. We turn our attention to this now.

<< Insert Tables 4 and 5 around here >>

Table 5 looks at the relation between conditional correlations and conditional market volatility. Twelve (thirteen) β_S coefficients on $h_{S,t}$ in equation (2) are negative at the 5% (10%) level, while only 5 β_S coefficients are positive. Therefore, conditional correlations between 13 commodity futures and equity returns fall in periods when market risk rises. This is good news to institutional investors with long positions in commodity futures and equities as it is precisely when market volatility is high that benefits of diversification are most needed. [10]

Take, for example, Figure 1, where we plot the conditional correlations between corn futures returns and the S&P500 excess returns against the conditional volatilities of the S&P500 excess returns. The conditional correlation plunges, when the S&P500 volatility experiences a spike (for example, on October 13, 1982; October 21, 1987; October 28, 1987 and October 16, 2002). On the other hand, when S&P500 volatility decreases, conditional correlation increases as, for example, in 1985 or in 1993-1994. As a result, the correlation between conditional correlations and conditional market volatilities in Figure 1 is as low as -0.4635. This implies that corn futures contracts possess diversification benefits in times of increased market stress. Figure 1 also depicts a straight line that is fitted on the conditional correlations to illustrate how they changed over time. Clearly the line is downward-sloping, suggesting, as in Table 4, that the correlation between S&P500 and corn futures returns fell over the period analyzed.

<< Insert Figure 1 around here >>

Across the 21 futures, the average β_S coefficient in equation (2) is -0.7660 in Table 5. Namely, a 1% rise in market risk leads, on average, to a 0.77% fall in correlation. This ultimately indicates that higher market volatility implies a higher allocation to

[10] Since the explanatory power of the model is, at times, low and the constant in equation (2) is always significant, conditional volatilities may not be the only drivers of conditional correlations.

commodity futures. Investors, by allocating higher portfolio weights to commodity futures during turbulent periods, can benefit more from the decrease in correlation and the enhanced risk reduction that ensues. The β_S coefficients are particularly low, and statistically significant, for gold (-4.2479), corn (-3.4539), oats (-2.3895) and soybeans (-2.3392). It follows that these futures contracts are the best candidates for inclusion in equity portfolios in periods of market turbulence. In the case of gold, its low β_S coefficient is accompanied by a negative conditional correlation with, and a comparative volatility to, the market (Tables 1 and 4), therefore enhancing its diversification properties even further and living up to its reputation as a good hedge in times of market stress.

Flight-to-quality is a possible economic rationale for the observed negative relation between conditional correlation and market volatility. Put differently, institutional investors may view commodity futures (such as gold) as refuge securities in periods of high market volatility. Our results are indeed consistent with the notion that, when market risk rises, institutional investors sell their shares to stop the loss in value of their equity portfolio and invest the proceeds in commodity futures. At times when equity markets experience high volatility, the stop-loss orders of equity asset managers and the subsequent re-allocation of resources towards commodity futures, such as gold, put more downward pressure on equity prices than on commodity futures prices. This, in turn, could explain the decrease in correlation between commodity futures and equity returns that we observe in periods of high market volatility.

Another plausible explanation for our finding is based on the difference that major events have on the two securities. Specifically, Table 1 shows that commodity futures frequently have positively skewed return distributions because events such as hurricanes or wars positively affect commodity prices. In contrast, such events create turmoil in equity markets and negative skewness in their return distribution (as in Table 1, Panel A). Therefore, one may expect that turbulent periods witness a decrease in the correlation between the returns of the two asset classes and a simultaneous rise in market volatility. Furthermore, since commodities are inputs for most firms, an increase in commodity prices will tend to increase costs and increase uncertainty. Thus, higher commodity prices are favorable (unfavorable) for long positions in commodity futures (equities) and may create higher stock market volatility. This also would explain the observed inverse relationship between correlation and stock market volatility.

4. 3. Co-Movements between Commodity Futures and Treasury-Bond Returns

The negative β_S coefficients in Table 5 suggest that commodity futures are similar to bonds, in as much as, like bonds, they reduce the volatility of an equity portfolio in periods of above average market volatility (Hunter and Simon, 2005). It is interesting therefore to replicate part of our analysis with the US Treasury-bond index in place of the S&P500 composite index and to examine its dynamics with commodity futures. Table 6 presents the average conditional risk premia of commodity futures when Treasury-bonds are used as the alternative asset class (on the left-hand side), along with results of the relationship between conditional correlations and conditional bond volatilities (on the right-hand side).[11]

<< Insert Table 6 around here >>

As previously reported for the S&P500 index, investors earned negative risk premia in 12 contangoed markets (cocoa, coffee, corn, cotton, frozen pork bellies, gold, oats, orange juice, silver, soybean oil, soybeans, wheat) and positive risk premia in 6 backwardated markets (feeder cattle, heating oil, lean hogs, live cattle, soybean meal, sugar). These results corroborate the conclusions of Table 2 on the size and sign of commodity futures risk premia.

On the whole, conditional correlations between US Treasury-bonds and commodity futures returns witnessed a fall over time: the change in correlation $\Delta\rho_{BF}$ in Table 6 equals -4.70% over the period 1979-2004. Compared to the 7.15% average decrease in correlation reported for the S&P500 in Table 4, the temporal decline in correlation between US Treasury-bonds and commodity futures returns is less pronounced. Lumber experienced the steepest decline ($\Delta\rho_{BF}$ = -34.53%), followed by platinum ($\Delta\rho_{BF}$ = -15.39%), feeder cattle ($\Delta\rho_{BF}$ = -13.81%) and live cattle ($\Delta\rho_{BF}$ = -11.58%).

[11] Once again, the bivariate GARCH model is well-specified with coefficients within expectations. To conserve space, the coefficients of the GARCH model are not reported here but are available upon request.

A maximum increase in conditional correlation is observed for orange juice ($\Delta\rho_{BF}$ = 1.48%).

We also estimate regressions of conditional correlations between Treasury-bonds and commodity futures returns on a constant and a time trend. The coefficients and *t*-statistics on the time trend are reported in Table 6. The decrease in correlation between Treasury-bonds and commodity futures returns in Table 6 is less widespread than reported for equities in Table 4. Indeed, 10 commodity futures in Table 6, versus 18 in Table 4, demonstrate significant drops in correlations over time. Similarly, while none of the correlations between commodity futures and S&P500 returns rose in Table 4, correlation between US Treasury-bonds and 5 commodity futures returns increased over the period analyzed at the 1% level.

In contrast to the S&P500 index, the slope coefficient from regressions of conditional correlations on conditional bond volatilities (β_B in (4)) is positive on the whole at 7.5611.[12] That is, when bond volatility increases, correlation between Treasury-bond and commodity futures returns on average tends to rise. At the 5% level, β_B is negative for 7 commodity futures and positive for 13 commodity futures. This suggests that for 7 (13) commodity futures the benefits of diversification have increased (diminished) during periods of high interest rate volatility. While the split between positive and negative β_B coefficients is about even for agricultural and livestock commodities, all metal/other commodities possess positive β_B coefficients, with lumber and gold displaying the strongest co-movements with Treasury-bonds in their category. On the other hand, lean hogs (with a statistically significant β_B coefficient of -4.7442), orange juice (-3.5501) and frozen pork bellies (-2.9866) are good candidates for inclusion in a Treasury-bond portfolio in periods of high interest rate volatility.

[12] Note that, if we exclude soybean oil, treating it as an outlier, the average β_B coefficient across commodity futures is still high and positive at 4.1653.

5. Conclusions

In this paper, we study the conditional risk premia of commodity futures and the way their returns vary over time with those of traditional asset classes (S&P500 stocks and US T-bonds). We draw the following two conclusions.

First, we find that historically investors earned significant risk premia on 19 of the 21 commodity futures markets we studied. The risk premium claimed by speculators for undertaking price risk is negative for 12 commodities and positive for 7 commodities. This suggests that the contango theory has some merits in describing the pricing of 12 commodity futures, while the normal backwardation theory is supported empirically for 7 commodity futures markets. Our analysis of the size and sign of the commodity futures risk premia over two consecutive sub-samples of equal duration reveals that the past is not a definite guide to the future. The positive return earned over the period 1979-1991 by shorting 6 contangoed commodity futures does not necessarily equate that a short position in these markets was profitable over the period 1992-2004. Indeed, these 6 markets clearly switched from contango to normal backwardation. Vice versa, lean hog switched from normal backwardation in 1979-1991 to contango in 1992-2004. Caution should thus be exercised while extrapolating the size and sign of commodity risk premia from the past into the future. Taking long positions in markets that were historically backwardated and short positions in markets that were contangoed in the past might prove to be a loss-making strategy in the future.

Second, we find that the conditional correlations between equity and commodity futures returns fell over time. This suggests that commodity futures and equity markets have become more segmented and, thus, that commodity futures have become over time a better tool for strategic asset allocation. We also observe that the conditional correlations between commodity futures and equity returns fell in periods of market turbulence. We see this as good news to institutional investors with long positions in equities and commodity futures. Indeed, it is precisely when stock market volatility is high that benefits of diversification are most appreciated. We offer two hypotheses as possible explanations for this finding: i) that institutional investors treat commodity futures (such as gold) as refuge assets in periods of high market volatility and ii) the differing effects that major events have on the skewness and the prices of commodity futures and equities.

The findings from the bond market differ from those reported for the S&P500 index. For example, the decrease over time in correlations between Treasury-bond and commodity futures returns is less pronounced than was reported for equities. The conditional correlations with the Treasury-bond are also found to rise with interest rate volatility. This suggests that, unlike stocks, adding commodity futures to a US Treasury-bond portfolio does not reduce risk further in periods of high volatility in bond markets.

Our analysis could be further refined. Institutional investors do not just hold S&P500 stocks, US Treasury-bonds and commodity futures. To a large extent, their asset mix includes value and growth stocks, small, medium and large capitalization stocks, Treasury-bonds and Treasury-bills, corporate bonds of different grades and maturities and international assets. Their asset allocation could even consist of real estate, artwork or hedge funds. A thorough analysis of the temporal variations between commodity futures and a much broader range of assets is therefore warranted. We offer this as an interesting avenue for future research.

References

Andersen, T. G., Bollerslev, T., Christoffersen, P. F., Diebold, F. X., 2006. Volatility and correlation forecasting. In G. Elliott, C. W. J. Granger, & A. Timmermann (Eds.), Handbook of economic forecasting, 778-878. Amsterdam: North-Holland.

Bauwens, L., Laurent, S., Rombouts, J. V. K., 2006. Multivariate GARCH models: A survey. Journal of Applied Econometrics 21, 79-109.

Baxter, J., Conine, T. E., Tamarkin, M., 1985. On commodity market risk premiums: Additional evidence. Journal of Futures Markets 5, 121-125.

Bodie, Z., 1983. Commodity futures as a hedge against inflation. Journal of Portfolio Management Spring, 12-17.

Bodie, Z., Rosansky, V, 1980. Risk and returns in commodity futures. Financial Analysts Journal May/June, 27-39.

Bollerslev, T., Engle, R. F., Wooldridge, J. M., 1988. A capital asset pricing model with time-varying covariances. Journal of Political Economy 96, 116-131.

Conrad, J., Gultekin, M. N., Kaul, G., 1991. Asymmetric predictability of conditional variances. Review of Financial Studies 4, 597-622.

De Roon, F. A., Nijman, T. E., Veld, C., 2000. Hedging pressure effects in futures markets. Journal of Finance 55, 1437-1456.

Dusak, C., 1973. Futures trading and investor returns: An investigation of commodity market risk premium. Journal of Political Economy 81, 1387-1406.

Ehrhardt, M. C., Jordan, J. V., Walkling, R. A., 1987. An application of arbitrage pricing theory to futures markets: Tests of normal backwardation. Journal of Futures Markets 7, 21-34.

Engle, R. F., 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of UK inflation. Econometrica 50, 987-1008.

Engle, R. F., 2002. Dynamic conditional correlation: A simple class of multivariate generalized autoregressive conditional heteroscedasticity models. Journal of Business and Economic Statistics 20, 339-350.

Engle, R. F., Kroner, K. F., 1995. Multivariate simultaneous generalized GARCH. Econometric Theory 11, 122-150.

Erb, C., Harvey, C., 2006. The strategic and tactical value of commodity futures. Financial Analysts Journal 62, 2, 69-97.

Fama, E. F., French, K., 1989. Business conditions and expected returns on stocks and bonds. Journal of Financial Economics 25, 23-49.

Fama, E. F., French, K., 2002. The equity premium. Journal of Finance 57, 637-659.

Gorton, G., Rouwenhorst, K., 2006. Facts and fantasies about commodity futures. Financial Analysts Journal 62, 4, 86-93.

Hicks, J., 1939. Value and capital: An inquiry into some fundamental principles of economic theory. Cambridge: Oxford University Press.

Hunter, D., Simon, D., 2005. A conditional assessment of the relationships between the major world bond markets. European Financial Management 11, 463-482.

Keynes, M., 1930. A treatise on money, II: The applied theory of money. Macmillan and Co.

Kolb, R., 1992. Is normal backwardation normal? Journal of Futures Markets 12, 75-91.

Jensen, G., Johnson, R., Mercer, J., 2000. Efficient use of commodity futures in diversified portfolios. Journal of Futures Markets 20, 489-506.

Jensen, G., Johnson, R., Mercer, J., 2002. Tactical asset allocation and commodity futures. Journal of Portfolio Management Summer, 100-111.

Longin, F., Solnik, B., 2001. Extreme correlation in international equity markets. Journal of Finance 56, 649-676.

Miffre, J., 2000. Normal backwardation is normal. Journal of Futures Markets 20, 803-821.

Miffre, J., Rallis, G., 2006. Momentum strategies in commodity futures markets. Cass Business School Working Paper.

Park, H., Wei, J., Frecka, T., 1988. A further investigation of the risk-return relation for commodity futures. Advances in Futures and Option Research 3, 357-377.

Poon, S. H., Granger, C. W. J., 2003. Forecasting volatility in financial markets: A review. Journal of Economic Literature 41, 478-539.

Solnik, B., Boucrelle, C., Le Fur, Y., 1996. International market correlation and volatility. Financial Analysts Journal 52, 17-34.

Taylor, N., 2004. Modeling discontinuous periodic conditional volatility: Evidence from the commodity futures market. Journal of Futures Markets 24, 805-834.

Vrugt, E. B., Bauer, R., Molenaar, R., Steenkamp, T., 2004. Dynamic commodity timing strategies. Maastricht University Working Paper.

Wang, C., Yu, M., 2004. Trading activity and price reversals in futures markets. Journal of Banking and Finance 28, 1337-1361.

Table 1 - Descriptive Statistics of Returns

	Mean	Standard Deviation	Reward-to-Risk Ratio	Skewness	Excess Kurtosis	Jarque-Bera Test	Correlation with T-Bond	Correlation with S&P500
Panel A: Traditional Asset Classes								
Treasury-Bond	-0.0411	0.0518	-0.7933	0.3326	3.5590	612.87		
	(-4.09)			(4.54)	(24.27)	[0.00]		
S&P500	0.0333	0.1490	0.2233	-0.3089	3.3731	548.47		
	(1.10)			(-4.21)	(22.99)	[0.00]		
Panel B: Agricultural Commodities								
Cocoa	-0.0598	0.2680	-0.2232	0.4213	1.3941	127.80	-0.0030	0.0194
	(-1.16)			(5.84)	(9.66)	[0.00]	(-0.10)	(0.66)
Coffee	-0.0182	0.3529	-0.0515	1.2319	10.4187	5520.83	-0.0281	0.0206
	(-0.26)			(17.07)	(72.18)	[0.00]	(-0.96)	(0.70)
Corn	-0.0623	0.1883	-0.3307	0.9778	6.3044	2053.25	-0.0129	0.0597
	(-1.72)			(13.41)	(43.22)	[0.00]	(-0.44)	(2.01)
Cotton	-0.0156	0.2134	-0.0731	0.2750	1.2478	89.57	-0.0340	0.0505
	(-0.37)			(3.81)	(8.65)	[0.00]	(-1.15)	(1.72)
Oats	-0.0939	0.2721	-0.3449	0.7871	4.8552	1254.81	0.0240	0.0474
	(-1.83)			(10.91)	(33.64)	[0.00]	(0.81)	(1.61)
Orange Juice	-0.0280	0.2491	-0.1124	0.7297	5.4576	1504.03	0.0000	0.0255
	(-0.58)			(10.01)	(37.42)	[0.00]	(0.00)	(0.86)
Soybean Meal	0.0343	0.1992	0.1721	0.3408	1.5670	131.77	0.0527	0.0704
	(0.85)			(4.57)	(10.51)	[0.00]	(1.74)	(2.32)
Soybean Oil	-0.0252	0.2060	-0.1225	0.2041	1.5433	114.99	0.0428	0.0849
	(-0.63)			(2.74)	(10.35)	[0.00]	(1.41)	(2.80)
Soybeans	-0.0286	0.1826	-0.1565	0.1168	2.3529	257.88	0.0495	0.1060
	(-0.80)			(1.58)	(15.96)	[0.00]	(1.65)	(3.54)
Sugar	0.0259	0.3932	0.0658	0.8293	6.6477	2308.03	-0.0304	0.0336
	(0.33)			(11.61)	(46.53)	[0.00]	(-1.04)	(1.15)
Wheat	-0.0098	0.1794	-0.0546	0.6585	4.6047	1104.82	-0.0037	0.0456
	(-0.28)			(9.12)	(31.90)	[0.00]	(-0.13)	(1.55)
Panel C: Livestock Commodities								
Feeder Cattle	0.0043	0.1309	0.0329	-0.4819	4.8972	1125.16	0.0452	0.1146
	(0.17)			(-6.47)	(32.85)	[0.00]	(1.49)	(3.79)
Frozen Pork Bellies	-0.0290	0.3384	-0.0857	0.2703	2.2673	261.46	0.0147	-0.0310
	(-0.44)			(3.75)	(15.71)	[0.00]	(0.50)	(-1.05)
Lean Hog	0.0358	0.2098	0.1706	-0.3253	2.3262	263.03	0.0425	0.0371
	(0.85)			(-4.36)	(15.60)	[0.00]	(1.40)	(1.22)
Live Cattle	0.0370	0.1410	0.2622	-0.5072	5.8339	1653.85	0.0385	0.0897
	(1.30)			(-6.95)	(40.00)	[0.00]	(1.30)	(3.03)
Panel D: Metal and Other Commodities								
Gold	-0.0299	0.1621	-0.1843	1.3220	12.5318	6732.28	0.1217	0.0617
	(-0.94)			(16.93)	(80.24)	[0.00]	(3.84)	(1.94)
Heating Oil	0.1451	0.2746	0.5283	0.4985	5.2997	1193.52	-0.0425	-0.0109
	(2.50)			(6.38)	(33.93)	[0.00]	(-1.33)	(-0.34)
Lumber	-0.0631	0.2721	-0.2321	0.2305	0.5719	25.45	0.0959	0.1678
	(-1.21)			(3.16)	(3.92)	[0.00]	(3.24)	(5.72)
Palladium	0.0522	0.3164	0.1650	0.4224	4.1646	888.60	0.0281	0.0757
	(0.81)			(5.91)	(29.15)	[0.00]	(0.97)	(2.61)
Platinum	0.0376	0.2537	0.1481	0.4662	6.2809	1984.06	0.0783	0.1367
	(0.73)			(6.53)	(43.97)	[0.00]	(2.70)	(4.74)
Silver	-0.0612	0.2731	-0.2242	0.3600	5.2166	1307.98	0.0518	0.0979
	(-1.17)			(4.94)	(35.76)	[0.00]	(1.74)	(3.31)
Commodity Average	-0.0073	0.2417	-0.0310	0.4204	4.5611	1423.96	0.0253	0.0621

Note: The mean and standard deviation are annualized using the formulae $\left(1+\overline{R}_P\right)^n-1$ and $\sqrt{n}\sigma_P$, where $\overline{R}_P$ and σ_P are the de-annualized mean and standard deviation, respectively and n is the average number of weeks in a given year. The reward-to-risk ratio is measured as the ratio of the annualized mean to the annualized standard deviation. Pearson correlation test is used to measure the significance of correlation. t-statistics are reported in parentheses, p-values are in brackets. The sample covers the period 1979-2004.

Table 2 - Normal Backwardation and Contango Theories

	Whole Sample: 1979 - 2004				**First Half of Sample: 1979 - 1991**				**Second Half of Sample: 1992 - 2004**			
	S&P500		Commodity futures		S&P500		Commodity futures		S&P500		Commodity futures	
	Estimate	*t*-ratio	Estimate	*t*-ratio	Estimate	*t*-ratio	Estimate	*t*-ratio	Estimate	*t*-ratio	Estimate	*t*-ratio
Panel A: Agricultural Commodities												
Cocoa	0.0594	45.93	-0.0809	-42.40	0.0660	23.91	-0.1104	-34.78	0.0821	13.85	-0.0683	-18.76
Coffee	0.0598	43.54	-0.0490	-13.30	0.0651	23.36	-0.0598	-7.79	0.0714	11.47	-0.0422	-3.98
Corn	0.0539	42.39	-0.0506	-27.16	0.0435	13.87	-0.0693	-15.24	0.0708	12.49	-0.0496	-13.90
Cotton	0.0511	37.57	-0.0392	-60.10	0.0650	14.10	-0.0175	-3.59	0.0581	9.31	-0.0303	-6.01
Oats	0.0588	45.36	-0.1441	-59.33	0.0636	20.51	-0.1765	-31.03	0.0690	11.00	-0.1011	-19.64
Orange Juice	0.0478	60.32	-0.0380	-23.47	0.0353	9.77	-0.0625	-8.32	0.0606	11.69	-0.0984	-20.48
Soybean Meal	0.0493	51.41	0.0178	3.56	0.0395	8.78	-0.0972	-15.27	0.0788	18.08	0.1474	51.95
Soybean Oil	0.0452	43.90	-0.0338	-8.45	0.0431	9.51	-0.0799	-16.78	0.0757	16.64	0.0115	1.60
Soybeans	0.0421	36.81	-0.0323	-9.66	0.0280	8.68	-0.1119	-24.96	0.0722	13.52	0.0392	13.43
Sugar	0.0586	53.16	0.0190	4.64	0.0670	18.81	-0.1063	-10.36	0.0707	11.97	0.0337	8.09
Wheat	0.0589	45.83	-0.0147	-7.18	0.0675	25.03	0.0069	1.54	0.0724	11.66	-0.0502	-11.49
Panel B: Livestock Commodities												
Feeder Cattle	0.0423	35.47	0.0276	17.75	0.0331	9.29	0.0244	6.94	0.0763	17.33	0.0181	5.85
Frozen Pork Bellies	0.0545	35.34	-0.0134	-4.51	0.0565	20.17	-0.1142	-31.24	0.0760	10.52	0.0754	15.97
Lean Hog	0.0480	36.38	0.0324	8.17	0.0412	6.56	0.0807	14.03	0.0796	14.77	-0.0131	-2.57
Live Cattle	0.0494	34.91	0.0548	47.86	0.0399	7.94	0.0752	43.01	0.0811	15.25	0.0407	14.06
Panel C: Metal and Other Commodities												
Gold	0.0276	33.04	-0.0296	-19.87	0.0154	3.56	-0.0513	-10.91	0.0555	16.65	-0.0206	-7.99
Heating Oil	0.0311	30.89	0.0666	152.34	0.0147	3.32	0.0663	13.43	0.0521	15.29	0.1249	26.28
Lumber	0.0532	61.59	0.0022	0.42	0.0541	23.41	-0.0676	-6.47	0.0626	11.96	0.0021	0.20
Palladium	0.0553	34.58	0.0174	3.27	0.0523	22.80	-0.0644	-7.42	0.0698	10.38	0.1164	12.98
Platinum	0.0639	52.91	-0.0046	-0.82	0.0441	9.66	-0.0719	-10.59	0.0958	20.27	0.0440	5.75
Silver	0.0582	42.51	-0.0888	-32.84	0.0490	19.39	-0.1176	-29.54	0.0805	13.30	-0.0183	-4.93
Panel D: Average Risk Premia												
Market	5.09%				4.69%				7.20%			
Contango			-5.12%				-8.61%				-4.92%	
Normal Backwardation			3.36%				6.16%				7.11%	

Table 2 - Continued

Note: The risk premia are annualized and measured as $\alpha_0 + \alpha_1 Z_{t-1}$ for the S&P500 composite index and $\beta_0 + \beta_1 Z_{t-1}$ for commodity futures. $\alpha_0 + \alpha_1 Z_{t-1}$ and $\beta_0 + \beta_1 Z_{t-1}$ are average fitted returns from regressions (1a): $R_{S,t} - R_{f,t} = \alpha_0 + \alpha_1 Z_{t-1} + u_{S,t}$ and (1b): $R_{F,t} = \beta_0 + \beta_1 Z_{t-1} + u_{F,t}$. $R_{S,t}$, $R_{f,t}$ and $R_{F,t}$ are the return on the S&P500 index, the risk-free rate and the return on the commodity futures under review, respectively. Z_{t-1} is a $L-$vector of information variables.

Table 3 - Specification of the Conditional Covariance Matrix with the S&P500

	c_S	c_{SF}	c_F	a_S	a_{SF}	a_F	b_S	b_{SF}	b_F
Panel A: Agricultural Commodities									
Cocoa	0.0000	0.0000	0.0000	0.8147	0.9830	0.9197	0.1435	0.0000	0.0606
	(1.43)	(-0.59)	(0.87)	(9.95)	(1063.78)	(14.41)	(2.30)	(0.01)	(1.38)
Coffee	0.0000	0.0000	0.0001	0.8106	0.9801	0.8481	0.1459	0.0000	0.1498
	(1.35)	(0.60)	(0.74)	(9.28)	(38.79)	(9.06)	(2.22)	(0.90)	(1.86)
Corn	0.0000	0.0000	0.0001	0.8017	0.9812	0.7767	0.1482	0.0062	0.1584
	(1.42)	(0.54)	(2.26)	(9.01)	(46.66)	(16.68)	(2.22)	(0.81)	(3.86)
Cotton	0.0000	0.0000	0.0000	0.8475	0.5947	0.8952	0.1200	0.0767	0.0924
	(2.45)	(0.95)	(1.88)	(21.24)	(4.71)	(31.64)	(3.95)	(2.91)	(3.73)
Oats	0.0000	0.0000	0.0002	0.8167	0.9633	0.6495	0.1422	0.0098	0.2181
	(1.47)	(0.87)	(2.25)	(10.78)	(34.74)	(5.51)	(2.44)	(1.03)	(2.13)
Orange Juice	0.0000	0.0000	0.0001	0.8033	0.9882	0.8246	0.1478	0.0037	0.0883
	(1.35)	(0.21)	(0.51)	(8.17)	(75.33)	(2.98)	(1.98)	(0.74)	(0.75)
Soybean Meal	0.0000	0.0000	0.0001	0.8143	0.9850	0.8276	0.1407	0.0061	0.1053
	(1.41)	(0.00)	(1.66)	(10.58)	(135.36)	(13.64)	(2.38)	(0.89)	(3.88)
Soybean Oil	0.0000	0.0000	0.0000	0.8176	0.9400	0.8921	0.1388	0.0236	0.0597
	(1.59)	(0.97)	(1.05)	(11.67)	(26.91)	(11.34)	(2.58)	(1.39)	(1.63)
Soybeans	0.0000	0.0000	0.0001	0.7952	0.9614	0.7976	0.1532	0.0166	0.1297
	(1.70)	(0.69)	(2.73)	(9.17)	(39.31)	(18.91)	(2.06)	(1.39)	(4.71)
Sugar	0.0000	0.0000	0.0000	0.8491	0.9297	0.9285	0.1255	0.0291	0.0688
	(1.07)	(-1.05)	(1.21)	(16.14)	(82.84)	(36.17)	(2.78)	(2.84)	(2.57)
Wheat	0.0000	0.0000	0.0001	0.8127	0.9874	0.6715	0.1440	0.0045	0.2216
	(1.39)	(0.47)	(3.36)	(9.71)	(62.14)	(10.04)	(2.33)	(0.80)	(3.57)
Panel B: Livestock Commodities									
Feeder Cattle	0.0000	0.0000	0.0000	0.8198	0.8407	0.8377	0.1328	0.0375	0.1407
	(1.99)	(0.33)	(2.58)	(14.29)	(2.18)	(21.63)	(2.98)	(0.55)	(4.30)
Frozen Pork Bellies	0.0000	0.0000	0.0003	0.8444	0.9278	0.7792	0.1242	0.0069	0.1016
	(1.63)	(0.05)	(3.18)	(17.53)	(29.71)	(14.46)	(2.98)	(0.75)	(3.53)
Lean Hogs	0.0000	0.0000	0.0000	0.8655	0.4293	0.8999	0.1083	0.0595	0.0680
	(2.07)	(1.36)	(2.13)	(24.18)	(3.23)	(34.60)	(3.71)	(1.92)	(3.88)
Live Cattle	0.0000	0.0000	0.0000	0.8645	0.9130	0.8755	0.1037	0.0186	0.1033
	(2.35)	(1.06)	(2.02)	(29.33)	(17.83)	(30.77)	(4.12)	(0.99)	(4.09)
Panel C: Metal and Other Commodities									
Gold	0.0000	0.0000	0.0000	0.8304	0.9256	0.8829	0.1209	0.0376	0.1019
	(2.04)	(-1.13)	(0.96)	(15.17)	(30.27)	(12.31)	(2.76)	(1.86)	(1.55)
Heating Oil	0.0000	0.0000	0.0001	0.7940	0.8373	0.7046	0.1455	0.0486	0.2626
	(1.10)	(0.69)	(4.13)	(6.30)	(9.46)	(55.82)	(1.79)	(1.84)	(7.62)
Lumber	0.0000	0.0000	0.0000	0.7959	0.8388	0.8881	0.1480	0.0307	0.1008
	(1.45)	(0.77)	(1.54)	(8.49)	(4.43)	(25.04)	(2.18)	(1.05)	(3.06)
Palladium	0.0000	0.0000	0.0000	0.8157	0.9508	0.9002	0.1370	0.0212	0.0773
	(1.52)	(0.28)	(1.21)	(9.56)	(23.92)	(17.40)	(2.09)	(1.23)	(2.19)
Platinum	0.0000	0.0000	0.0000	0.8698	0.9395	0.8992	0.1032	0.0301	0.0932
	(1.94)	(0.00)	(1.79)	(25.91)	(2014.22)	(45.76)	(3.63)	(3.31)	(4.74)
Silver	0.0000	0.0000	0.0001	0.8002	0.9002	0.8615	0.1479	0.0196	0.1034
	(1.20)	(-0.20)	(2.25)	(7.64)	(70.93)	(34.13)	(1.97)	(1.36)	(4.83)

Note: Returns and (co)variances are jointly modeled as: $R_{S,t} - R_{f,t} = \alpha_0 + \alpha_1 Z_{t-1} + u_{S,t}$, $R_{F,t} = \beta_0 + \beta_1 Z_{t-1} + u_{F,t}$, $h_{S,t}^2 = c_S + a_S h_{S,t-1}^2 + b_S u_{S,t-1}^2$, $h_{F,t}^2 = c_F + a_F h_{F,t-1}^2 + b_F u_{F,t-1}^2$, $h_{SF,t} = c_{SF} + a_{SF} h_{SF,t-1} + b_{SF} u_{S,t-1} u_{F,t-1}$. $R_{S,t}$, $R_{f,t}$ and $R_{F,t}$ are the return on the S&P500 index, the risk-free rate and the return on the commodity futures under review, respectively, Z_{t-1} is a $L-$vector of information variables, $u_{S,t}$ and $u_{F,t}$ are the residuals on the S&P500 index and the commodity futures, $h_{S,t}^2$ and $h_{F,t}^2$ are conditional variances, $h_{SF,t}$ is a conditional covariance. *t*-ratios are in parentheses. The sample covers the period 1979-2004.

Table 4 - Summary Statistics of Conditional Correlations

	Average		Standard Deviation	Trend (*1,000)	*t*-ratio	$\Delta\rho_{SF}$
Panel A: Agricultural Commodities						
Cocoa	-0.0155		0.0079	-0.0078	-9.47	-0.90%
Coffee	0.0347		0.0149	-0.0141	-10.73	-1.63%
Corn	0.0720	*	0.0538	-0.1044	-27.81	-11.80%
Cotton	0.0336		0.0811	-0.0142	-1.90	-1.64%
Oats	0.0542	***	0.0499	-0.0605	-17.53	-6.99%
Orange Juice	0.0268		0.0314	-0.0134	-6.48	-1.51%
Soybean Meal	0.0358		0.0507	-0.0897	-20.77	-9.70%
Soybean Oil	0.0784	*	0.0724	-0.0469	-6.15	-5.07%
Soybeans	0.0822	*	0.0767	-0.0997	-14.25	-11.02%
Sugar	-0.0345		0.0967	-0.1164	-15.07	-13.73%
Wheat	0.0364		0.0387	-0.0718	-27.64	-8.29%
Panel B: Livestock Commodities						
Feeder Cattle	0.0775	*	0.0646	-0.0003	-0.06	-0.04%
Frozen Pork Bellies	-0.0009		0.0167	-0.0036	-2.35	-0.42%
Lean Hog	0.0439		0.0588	-0.0132	-2.26	-1.42%
Live Cattle	0.0600	**	0.0439	0.0054	1.45	0.62%
Panel C: Metal and Other Commodities						
Gold	-0.0521		0.1512	-0.2966	-20.58	-29.19%
Heating Oil	0.0319		0.0858	-0.0062	-0.67	-0.61%
Lumber	0.1347	*	0.0552	-0.0376	-8.34	-4.25%
Palladium	0.0274		0.0846	-0.1309	-20.33	-15.45%
Platinum	0.0420		0.1095	-0.1563	-18.55	-18.45%
Silver	0.0041		0.0515	-0.0760	-16.58	-8.60%
Commodity Average	0.0368		0.0617	-0.0645		-7.15%

Note: "Trend" is the slope coefficient of a regression of conditional correlations $\rho_{SF,t}$ on a constant and a time trend. $\Delta\rho_{SF}$ is the difference between the last and first fitted values of a regression of conditional correlations on a constant and a zero-mean time trend. *, ** and *** indicate significance at the 1, 5 and 10% levels, respectively. The sample covers the period 1979-2004.

Table 5 - The Relation between Conditional Correlation and Conditional Market Volatility

	Intercept		Market Volatility: $h_{S,t}$		Futures Volatility: $h_{F,t}$		$\overline{R}^2$
	α	$t(\alpha)$	β_S	$t(\beta_S)$	β_F	$t(\beta_F)$	
Panel A: Agricultural Commodities							
Cocoa	-0.0448	-46.61	0.5414	18.55	0.4404	24.76	0.4047
Coffee	0.0861	43.75	-1.2360	-20.85	-0.4717	-18.36	0.7374
Corn	0.1961	26.71	-3.4539	-13.84	-1.7664	-8.62	0.2963
Cotton	0.0559	4.41	0.7182	1.54	-1.2235	-4.24	0.0160
Oats	0.1402	19.26	-2.3895	-10.58	-0.8460	-5.62	0.1585
Orange Juice	0.0680	12.95	-1.9153	-12.11	0.0150	0.15	0.1608
Soybean Meal	0.0812	11.70	-1.2531	-7.40	-0.6121	-3.26	0.0358
Soybean Oil	0.1088	7.88	-0.9168	-2.66	-0.3345	-0.99	0.0054
Soybeans	0.1284	13.61	-2.3392	-7.89	0.1759	0.77	0.0401
Sugar	-0.2255	-23.89	2.9632	7.67	2.2832	21.74	0.2803
Wheat	0.1098	24.15	-1.7521	-12.08	-1.3189	-11.30	0.1970
Panel B: Livestock Commodities							
Feeder Cattle	0.0795	10.13	1.4763	5.25	-1.7426	-6.75	0.0524
Frozen Pork Bellies	0.0168	4.97	-0.3292	-4.24	-0.2109	-3.59	0.0262
Lean Hog	0.0933	9.70	-0.8051	-2.40	-1.0238	-3.41	0.0299
Live Cattle	0.0684	14.73	0.8381	5.69	-1.3050	-7.79	0.0481
Panel C: Metal and Other Commodities							
Gold	-0.1424	-12.45	-4.2479	-9.09	7.9431	19.97	0.3814
Heating Oil	0.0954	7.93	-0.8999	-1.86	-1.0367	-4.50	0.0603
Lumber	0.2597	34.93	-1.5186	-6.57	-2.3172	-18.57	0.2289
Palladium	-0.0780	-9.71	0.5799	1.98	2.1502	12.55	0.1413
Platinum	-0.0832	-9.79	-0.3236	-0.90	3.8797	23.34	0.3072
Silver	-0.0642	-11.65	0.1777	0.96	1.7252	14.87	0.2424
Commodity Average	0.0452		-0.7660		0.2097		0.1833

Table 5 - Continued

Note: The results are derived by estimating the regression $\rho_{SF,t} = \alpha + \beta_S h_{S,t} + \beta_F h_{F,t} + \varepsilon_t$. The conditional volatilities ($h_{S,t}$ and $h_{F,t}$) and covariances ($h_{SF,t}$) are calculated as the fitted values from equations (1c), (1d) and (1e), respectively. The conditional correlations are measured as the ratio of the conditional covariances to the product of the conditional volatilities; namely, $\rho_{SF,t} = h_{SF,t} / (h_{S,t} h_{F,t})$. $\bar{R}^2$ is the adjusted coefficient of determination statistic. The sample covers the period 1979-2004.

Table 6 - Conditional Correlation and Conditional Bond Volatility

	Risk Premia		**Conditional Correlation: $\rho_{BF,t}$**				
	Estimate	t-ratio	$\Delta\rho_{BF}$	Trend	t-ratio	β_B	$t(\beta_B)$
Panel A: Agricultural Commodities							
Cocoa	-0.0888	-36.36	-4.37%	-0.0379	-23.46	3.6152	13.36
Coffee	-0.0569	-14.52	-0.30%	-0.0026	-3.27	0.2861	2.12
Corn	-0.0664	-62.61	-0.20%	-0.0018	-0.47	2.4394	4.11
Cotton	-0.0371	-59.67	-0.39%	0.0016	4.67	-0.2184	-7.37
Oats	-0.1400	-53.77	0.44%	0.0038	6.95	-1.8568	-34.23
Orange Juice	-0.0563	-42.09	1.48%	0.0131	3.63	-3.5501	-6.00
Soybean Meal	0.0149	2.90	0.52%	0.0048	6.90	-1.9225	-27.22
Soybean Oil	-0.0282	-7.51	-4.39%	-0.0406	-13.92	75.4775	8.09
Soybeans	-0.0359	-9.69	0.09%	0.0009	1.46	-1.1161	-14.68
Sugar	0.0132	2.92	0.38%	0.0032	0.60	4.5417	6.67
Wheat	-0.0197	-9.85	-0.13%	-0.0011	-0.33	0.5401	0.91
Panel B: Livestock Commodities							
Feeder Cattle	0.0261	17.78	-13.81%	-0.1276	-31.88	12.8731	14.77
Frozen Pork Bellies	-0.0111	-3.69	1.19%	0.0103	3.59	-2.9866	-6.19
Lean Hogs	0.0307	8.18	0.59%	0.0055	1.04	-4.7442	-5.45
Live Cattle	0.0545	49.66	-11.58%	-0.1024	-39.51	11.7232	24.19
Panel C: Metal and Other Commodities							
Gold	-0.0299	-14.99	-1.70%	-0.0173	-1.14	17.9828	9.09
Heating Oil	0.0666	152.34	-1.71%	-0.0173	-3.94	8.0515	10.49
Lumber	0.0063	1.17	-34.53%	-0.3053	-47.98	18.0667	12.71
Palladium	0.0030	0.55	-7.40%	-0.0627	-13.75	4.7553	6.23
Platinum	-0.0074	-1.39	-15.39%	-0.1304	-22.83	4.7499	4.41
Silver	-0.0897	-32.11	-7.49%	-0.0662	-5.86	10.0755	4.94
Commodity Average	-0.0215		-4.70%	-0.0414		7.5611	

Table 6 - Continued

Note: The commodity futures risk premia are annualized and measured as $\beta_0 + \beta_1 Z_{t-1}$, the average fitted returns from regression (1b): $R_{F,t} = \beta_0 + \beta_1 Z_{t-1} + u_{F,t}$. $R_{F,t}$ is the return on the commodity futures under review and Z_{t-1} is a $L-$vector of information variables. $\Delta\rho_{BF}$ is the difference between the last and first fitted values of a regression of conditional correlations on a constant and a zero-mean time trend. "Trend" is 1,000 times the slope coefficient of a regression of conditional correlations $\rho_{BF,t}$ on a constant and a time trend. The coefficient β_B is estimated from regressions of conditional correlations on bond and commodity futures volatilities. $t(\beta_B)$ is the associated *t*-statistics. The sample covers the period 1979-2004.

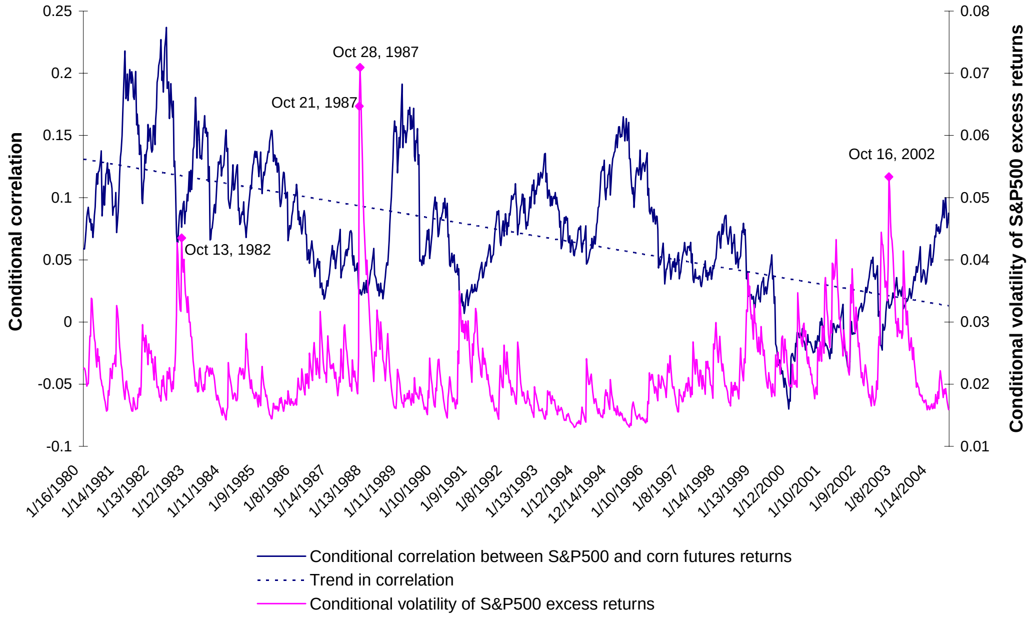

Figure 1 - The negative relation between conditional correlations and conditional market volatilities: The case of corn futures