

Momentum Strategies in Commodity Futures Markets

Joëlle Miffre* and Georgios Rallis
Cass Business School

Abstract

The article tests for the presence of short-term continuation and long-term reversal in commodity futures prices. While contrarian strategies do not work, the article identifies 13 profitable momentum strategies that generate 9.38% average return a year. A closer analysis of the constituents of the long-short portfolios reveals that the momentum strategies buy backwardated contracts and sell contangoed contracts. The correlation between the momentum returns and the returns of traditional asset classes is also found to be low, making the commodity-based relative-strength portfolios excellent candidates for inclusion in well-diversified portfolios.

Keywords: Commodity futures, Momentum, Backwardation, Contango, Diversification

JEL classification codes: G13, G14

This version: 5 August 2006

* *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 authors would like to thank Chris Brooks and two anonymous referees for helpful comments.

1. Introduction

Commodity futures are excellent portfolio diversifiers and, for some, an effective hedge against inflation (Bodie and Rosansky, 1980; Bodie, 1983). They also offer leverage and are not subject to short-selling restrictions. Besides, the nearby contracts are typically very liquid and cheap to trade. For all these reasons, commodity futures are good candidates for strategic asset allocation and have been proved to be useful tools for alpha generation (Jensen et al., 2002; Vrugt et al., 2004; Wang and Yu, 2004; Erb and Harvey, 2006).

This article examines the profitability of 56 momentum and contrarian strategies in commodity futures markets. The momentum strategies buy the commodity futures that outperformed in the recent past, sell the commodity futures that under-performed and hold the relative-strength portfolios for up to 12 months. The contrarian strategies do the opposite. They buy the commodity futures that underperformed in the distant past, sell the commodity futures that outperformed and hold the long-short portfolios for periods ranging from 2 to 5 years. To put this differently, the article investigates whether the short-term price continuation and the long-term mean reversion identified in equity markets by Jegadeesh and Titman (1993, 2001) and De Bondt and Thaler (1985) are present in commodity futures markets. The paper also builds on the research of Erb and Harvey (2006) who show that a momentum strategy with a 12-month ranking period and a 1-month holding period is profitable in commodity futures markets.

While contrarian strategies do not work, the article identifies 13 profitable momentum strategies in commodity futures markets. Tactically allocating wealth towards the best performing commodities and away from the worst performing ones generates an average return¹ of 9.38% a year. Over the same period, a long-only equally-weighted

¹ The term “return” is used loosely to refer to the performance of the momentum and contrarian strategies. It is noted that the term is improper in futures markets as, aside from the initial margins, no cash payment is made at the time the position is opened. It follows that a definition of returns that implicitly assumes that investors purchase the futures contract at the settlement price is, by definition, inaccurate. Note however that a definition that considers the initial margin as an investment is also incorrect since

portfolio of commodity futures lost 2.64%. In line with the analysis of Erb and Harvey (2006), this result suggests that active investment strategies have historically been profitable in commodity futures markets.

While they are not merely a compensation for risk, the momentum returns are found to be related to the propensity of commodity futures markets to be in backwardation or in contango. The results indeed suggest that the momentum strategies buy backwardated contracts and sell contangoed contracts. Therefore our analysis indicates that one can link the momentum profits in commodity futures markets to an economic rationale related to Keynes (1930) and Hicks (1939) theory of normal backwardation. Interestingly, the momentum returns are also found to have low correlations with the returns of traditional asset classes, making the commodity-based relative-strength strategies good candidates for inclusion in well-diversified portfolios.

There are strong rationales for implementing momentum strategies in commodity futures markets rather than in equity markets: Our commodity-based long-short strategies minimize transaction costs,² trade liquid contracts with nearby maturities, are not subject to the short-selling restrictions that are often imposed in equity markets and focus on 31 commodity futures only (as opposed to hundreds or thousands of stocks). It is therefore unlikely that the abnormal returns we identify will be eroded by the costs of implementing the momentum strategy or will be a compensation for a lack of liquidity (as in Lesmond et al., 2004).

the initial margin is just a good faith deposit (and not an investment) and is redeemed to the trader (along with accrued interests and marking-to-market profits or losses) at the time he/she enters a reversing trade. Based on this and in line with, among others, Dusak (1973) and Bessembinder (1992), the paper measures futures returns as the change in the logarithms of settlement prices. Had futures returns been measured relative to the margins and on a fully-collateralized basis, the momentum profits would have been further enhanced. Our definition of return is free of collateral and therefore more conservative.

² Transaction costs in futures markets range from 0.0004% to 0.033% (Locke and Venkatesh, 1997), which is much less than the conservative 0.5% estimate of Jegadeesh and Titman (1993) or the more realistic 2.3% estimate of Lesmond et al. (2004) for the equity market.

On a less positive note, institutional investors who implement momentum strategies in commodity futures markets have to post initial margins, monitor margin accounts on a daily basis, roll-over contracts before maturity and pay margin calls. As they are not born by equity asset managers, such costs have to be weighed against the benefits of implementing momentum strategies in commodity futures markets. The margin calls and roll-over risk, however, should not be overstated: As the momentum strategies buy backwardated contracts and sell contangoed contracts, little to no cash will be required for margin calls and the roll-over trades will be more often than not profitable.

The article proceeds as follows. Section 2 introduces the dataset. Section 3 outlines the methodology used to construct momentum and contrarian portfolios. It also presents the risk models that are employed to measure the abnormal returns of the strategies. Section 4 discusses the results from the momentum strategies. In particular, it highlights the relationship between momentum profits, backwardation and contango and the diversification properties of the momentum portfolios. Section 5 focuses on the contrarian strategies. Finally section 6 concludes.

2. Data

The data, obtained from Datastream International, comprises settlement prices on 31 US commodity futures contracts. We consider 13 agricultural futures (cocoa, coffee C, corn, cotton #2, milk, oats, orange juice, soybean meal, soybean oil, soybeans, sugar #11, wheat, white wheat), 4 livestock futures (feeder cattle, frozen pork bellies, lean hogs, live cattle), 6 metal futures (aluminum, copper, gold 100 oz, palladium, platinum, silver 1000 oz), 5 oil and gas futures (heating oil, light crude oil, natural gas, regular gas, unleaded gas) and the futures on diammonium phosphate, lumber and western plywood. The dataset spans the period January, 31 1979 to September, 30 2004. To avoid survivorship bias, we include contracts that started trading after January 1979 or were delisted before September 2004. We mitigate problems of low liquidity and high transaction costs by filtering out futures with average trading volume below 1,000 contracts over the period January, 31 1979 to September, 30

2004.³ The total sample size ranges from a low of 22 contracts at the beginning of the period to a peak of 27 contracts over the periods March 1996-July 1997 and July 1999-September 2004.⁴

The paper tests the sensitivity of the results to the technique employed to compute futures returns. Two approaches are used to compile time series of futures prices and, consequently, time series of futures returns. In both cases, futures returns are computed as the change in the logarithms of the settlement prices.

First, we collect the futures prices on all nearest and second nearest contracts. We hold the first nearby contract up to one month before maturity. At the end of that month, we roll our position over to the second nearest contract and hold that contract up to one month prior to maturity. The procedure is then rolled forward to the next set of nearest and second nearest contracts when a new sequence of futures returns is compiled. Second, we re-iterate this approach but, this time, we switch to the most distant (in place of the nearby) contract and use weekly⁵ (in place of monthly) settlement prices. To be more specific, we collect weekly settlement prices on all maturity contracts. We hold the first contract up to two weeks before maturity. At this time, we roll our long position to the contract whose maturity is the furthest away and hold it up to two weeks before it matures. The process is repeated throughout the dataset to generate a sequence of investable distant maturity futures returns.

³ The omitted contracts are for ammonia, boneless beef, broiler chickens, butter, cheddar cheese, cotton seed, fresh pork bellies, nonfat dry milk, potatoes, oriented strand board and white shrimp. It is noted that excluding these contracts introduces a look-ahead bias.

⁴ We use the Ljung-Box Q statistics to test for 1st and 12th order serial correlation in futures returns. The results, available on request, indicate presence of serial correlation in more than half of the series at the 10% level. This crude test suggests that today's returns depend on past values and is an indication that long-short strategies might be profitable in commodity futures markets.

⁵ We download Wednesday prices to ensure that the results are not driven by week-end effect.

This sensitivity analysis is interesting for two reasons. First, it enables us to test whether the profits of the trading rule depend on the choice of the roll-over date (as highlighted, among others, in Ma et al., 1992). Second, if the momentum profits are related to backwardation and contango, trading contracts whose maturity is the furthest away might generate superior profits. This potential benefit, however, has to be weighed against the liquidity risk that is involved in trading maturing contracts and contracts with far distant maturities. It could indeed be the case that, due to a lack of liquidity, the choice of i) a later roll-over date and ii) distant maturity contracts has a damaging impact on momentum profits. This point notwithstanding, the sensitivity of the results to the roll-over date is an empirical question that deserves attention as it is of interest to institutional investors.

At the roll-over date, one could adjust the price level *ex-post* to eliminate the price gap between the futures contract that is closed out and the futures contract that is entered into. We favor a correction-free approach instead. The reasons for using unadjusted price series are twofold. First, as real transaction prices are used in practice, momentum and contrarian strategies have to be implemented on unadjusted price series if they are to be meaningful to institutional investors. Second, if, as we argue, the momentum strategy buys backwardated contracts and sells contangoed contracts, part of the momentum profits will come from the profits generated on the roll-over trades. As a result, adjusting the price levels on the roll-over date might eliminate part of the momentum profits that institutional investors seek to earn.

3. Methodology

This study analyzes any combination of ranking periods of 1, 3, 6, 12, 24, 36 and 60 months and holding periods of 1, 3, 6, 12, 18, 24, 36 and 60 months. These permutations result in 32 short-term momentum strategies with four ranking periods (1, 3, 6 and 12 months) and eight holding periods (1, 3, 6, 12, 18, 24, 36 and 60 months) and in 24 long-term contrarian strategies with three ranking periods (24, 36 and 60 months) and eight holding periods (1, 3, 6, 12, 18, 24, 36 and 60 months).

At the end of each month, futures contracts are sorted into quintiles based on their average return over the previous R months (ranking period). The decision to form quintiles was based on the fact that our cross section is too small to accommodate deciles as is common in the literature on equity momentum. By adding more futures to the quintile portfolios, our approach enhances risk diversification at the cost of lowering the dispersion of returns between the best and worst performing futures and thus the profitability of the strategies. The futures contracts in each quintile are equally weighted.⁶ The performance of both the top and bottom quintiles is monitored over the subsequent H months (holding period) over which no rebalancing takes place. We call the resulting strategy the R - H momentum or contrarian strategy.

We follow the approach of Moskowitz and Grinblatt (1999) and Jegadeesh and Titman (2001) and form overlapping winner and loser portfolios. Taking, as an example, the 6-3 momentum strategy, the winner portfolio in, say, December is formed by equally weighting the top 3 quintile portfolios that were formed at the end of September, October and November. The same applies to the loser portfolio. Its return is equal to the average return in December of the 3 bottom quintiles that were formed at the end of September, October and November.⁷ The return of the momentum (contrarian) strategy is then simply defined as the difference in the December returns of the winner (loser) and loser (winner) portfolios. The procedure is rolled over to the next month, where another set of winner, loser, momentum and contrarian portfolios is formed.

⁶ A strategy that assumes equal-weighting might prove difficult to implement in illiquid markets. To mitigate problems related to lack of liquidity, we filter out futures with average trading volume below 1,000 contracts. Another approach would have been to adopt a weighting scheme that assigns higher weights to the contracts with higher open interests. In the light of recent evidence suggesting that trading activity enhances short-term contrarian profits in futures markets (Wang and Yu, 2004), a weighting scheme based on open interests might yield interesting results.

⁷ As the November winner and loser contribute towards only a third of the December momentum profits, it is reasonable to assume that the momentum profits are not driven by bid-ask bounce. As a result and following Moskowitz and Grinblatt (1999), we decided not to skip a month between the ranking and holding periods.

The following multifactor model is then used to measure the profitability of the strategy after accounting for risk

$$R_{Pt} = \alpha + \beta_B(R_{Bt} - R_{ft}) + \beta_M(R_{Mt} - R_{ft}) + \beta_C(R_{Ct} - R_{ft}) + \varepsilon_{Pt} \quad (1)$$

R_{Pt} is the return of the winner, loser, or momentum portfolio, R_{Bt} , R_{Mt} and R_{Ct} are the returns on Datastream government bond index, the S&P500 composite index and GSCI (Goldman Sachs Commodity Index) respectively, R_{ft} is the risk-free rate and ε_{Pt} is an error term.

As the possibility remains that the momentum profits are a compensation for time-varying risks (Chordia and Shivakumar, 2002), we estimate a conditional model that allows for the measures of risk and abnormal performance (β_B , β_M , β_C and α) in (1) to vary over time as a function of Z_{t-1} , a vector of pre-specified mean-zero information variables (Christopherson et al., 1998)

$$\begin{aligned} R_{Pt} = & \alpha_0 + \alpha_1 Z_{t-1} + \\ & \beta_{B0}(R_{Bt} - R_{ft}) + \beta_{B1}(R_{Bt} - R_{ft})Z_{t-1} + \\ & \beta_{M0}(R_{Mt} - R_{ft}) + \beta_{M1}(R_{Mt} - R_{ft})Z_{t-1} + \\ & \beta_{C0}(R_{Ct} - R_{ft}) + \beta_{C1}(R_{Ct} - R_{ft})Z_{t-1} + \varepsilon_{Pt} \end{aligned} \quad (2)$$

Z_{t-1} includes proxies for the business cycle such as the first lag in (i) the dividend yield on the S&P500 composite index, (ii) the term structure of interest rates and (iii) default spread.⁸ The first lag on the momentum returns is also used as a predictor of the abnormal performance of the momentum strategy one period ahead.

⁸ The term structure is measured as the difference between the yield on US Treasury bonds with at least 10 years to maturity and the US three-month Treasury-bill rate. Default spread is measured as the yield difference between Moody's Baa and Aaa-rated corporate bonds.

Insignificant estimates of α in (1) and α_0 in (2) indicate that the momentum returns are merely a compensation for risk and are therefore consistent with rational pricing in an efficient market.

4. Momentum Strategies

This section presents the results of our commodity-based relative-strength strategies. We focus on the profits that the strategies generate (Section 4.1), the risk factors that may drive the performance (Section 4.2), the constituents of the long-short portfolios and how they relate to the propensity of commodity markets to be in backwardation or contango (Section 4.3) and the ability of momentum portfolios to act as portfolio diversifiers and inflation hedge (Section 4.4).

4. 1. Momentum profits

Table 1 displays summary statistics of returns of short-term momentum strategies, where the rows represent the ranking periods and the columns the holding periods. It is clear from Table 1 that the winner portfolios typically outperform the loser portfolios over holding periods that range from 1 to 12 months. With only 3 exceptions out of 16 strategies (for the 6-12, 12-6 and 12-12 momentum strategies), the difference in returns between the winner and the loser portfolios is positive and significant at the 10% level. Across the 13 strategies that are profitable, one could earn an average return of 9.38% a year by consistently buying the best performing commodity futures and selling the worst performing ones. Over the same period, a long-only portfolio that equally weights the 31 commodities we considered lost 2.64% a year. The results in Table 1 are in line with Jegadeesh and Titman (1993, 2001) who identify short-term price continuation in equity markets. They are also consistent with Erb and Harvey (2006) who observe that a 12-1 momentum strategy is profitable in commodity futures markets.

[Insert Table 1 around here]

Across the 13 strategies that are profitable at the 10% level, the loser portfolios always yield negative and significant average return that range from a low of -10.83%

(for the 6-1 strategy) to a high of -5.16% (for the 3-12 strategy). The evidence from the 13 winner portfolios is less strong both in economic and statistical terms. The winner portfolios offer average returns that can, at times, be negative and range from a low of -1.75% (for the 1-12 strategy) to a high of 7.26% (for the 3-1 strategy). As in Hong et al. (2000), the price continuation in commodity futures markets is therefore mainly driven by the losers.

As the possibility remains that the momentum strategies pay off as a compensation for risk, Table 1 also reports the annualized standard deviations and the reward-to-risk ratios of the strategies. As expected, the most profitable strategies rank among the most risky. For example, the 12-1 momentum strategy offers the highest average return (14.60%) and, with a standard deviation of 25.57%, it is also the second most volatile. On the other hand, the 1-12 momentum strategy has the lowest level of risk (8.20%) and, subsequently, the lowest average return (5.27%).

Over the period March 1979 - September 2004, a portfolio that equally weights the 31 commodity futures considered in this study had a negative reward-to-risk ratio equal to -0.2442. Over the same period, the S&P500 composite index had an expected Sharpe ratio of 0.3101. Simultaneously, the 13 profitable momentum strategies in Table 1 had reward-to-risk ratios ranging from 0.3768 (for the 12-3 strategy) to 0.6681 (for the 1-6 strategy), with an average at 0.4978. This indicates that commodity-based relative-strength strategies perform better on a risk-adjusted basis than passive long-only strategies in equity and commodity futures markets.

Given the recent interest of institutional investors in commodity futures, one may question whether the momentum profits identified over the period March 1979 - September 2004 in Table 1 will be sustained in the future. Although the past is not necessarily a reliable guide to the future, we compare the momentum risk-adjusted returns in the later period (June 1998 – September 2004) to those earned in earlier periods (March 1979 – July 1985, August 1985 – December 1991, January 1992 – May 1998) and use this information to test whether the momentum profits have decreased recently due to a rising interest of institutional investors in commodity futures. If momentum profits have shrunk over time, it is likely that future profits will

also be compressed. The reward-to-risk ratios of the 16 momentum strategies are reported in Table 2 over four consecutive periods of equal duration. 10 out of 16 strategies generated their best risk-adjusted return in the later period. Over the same period, only one strategy (the 1-1 strategy) yielded its worst performance. As the recent interest of institutional investors has not shrunk the momentum profits, one can expect the profits of the long-short strategies to be sustainable in the near future too. It is also noted from Tables 1 and 2 that with relatively few exceptions (for the 3-6 and 6-3 strategies over the period January 1992 – May 1998 and the 1-1 strategy over the period June 1998 – September 2004), the 13 strategies that are profitable over the long run in Table 1 generate positive risk-adjusted returns in each of the four sub-periods.

[Insert Table 2 around here]

Figure 1 looks at the performance of the zero-cost winner minus loser portfolios over increasing holding periods. Consistent with Rouwenhorst (1998) and Jegadeesh and Titman (2001), the average return of the momentum portfolios for a given ranking period is U-shaped, suggesting that the initial positive relative strength (over horizon of up to 12 months as reported in Table 1) is followed by first a negative performance (over horizons of 18 to 24 months) and then a zero average return (beyond 24 months). This indicates that after the initial price continuation, a subsequent price correction takes place. This is consistent with the idea that transactions by short-term momentum traders temporarily move prices away from long-term equilibrium, eventually causing prices to overreact. Once the overreaction is acknowledged, the market is in for a correction (Barberis et al., 1998; Daniel et al., 1998; Hong and Stein, 1999). This adjustment occurs over horizons of 18 to 24 months. Note however that this interpretation should be treated with some caution, as the returns over holding periods of 18 and 24 months, though mostly negative, are insignificant.

[Insert Figure 1 around here]

Table 3 tests the sensitivity of the momentum results to the technique used to calculate futures returns. Relative to Table 1, Table 3 assumes that i) the roll-over date is set to the second last Wednesday before maturity (as opposed to the last trading day of the month before maturity), and ii) at the time of the roll-over, the contracts whose maturity is the furthest away is used (as opposed to the contract with the second

nearest maturity). The momentum strategies in Table 3 perform well at the 10% level for 8 combinations of ranking and holding periods. Across these 8 momentum strategies, the winners outperformed the losers by an average of 7.38% a year. The momentum profits in Table 3 are therefore less significant in both economic and statistical terms than those reported in Table 1. Although momentum persists, the profitability of the trading strategy is found to be sensitive to the way futures prices are compiled. It is likely also that the 7.38% average return is, at least in part, a compensation for the illiquidity of maturing contracts and contracts with far distant maturities. Net of liquidity risk, the profits of the relative-strength strategies are expected to further decrease.

[Insert Table 3 around here]

4. 2. Risk-based explanations

The remainder of Section 4 focuses on the 13 momentum strategies that are profitable at the 10% level in Table 1. This section tests whether the profits then identified are a compensation for risk. With this in mind, Table 4 displays the sensitivities of each portfolio returns to the bond, equity and commodity futures markets and, subsequently, the abnormal performance of the momentum strategies (α in (1)). The results indicate that both the winners and losers are sensitive to the risk factors. While the returns of 11 out of 13 momentum strategies follow the ups and downs of GSCI, the relative-strength portfolios are truly neutral to the risks present in the bond and equity markets. As a result, the adjusted- R^2 of the momentum regressions are very low.

[Insert Table 4 around here]

On average, the annualized abnormal returns of the 13 profitable momentum strategies equal 10.18%,⁹ ranging from a low of 5.77% for the 1-12 strategy to a high of 16.04% for the 12-1 strategy. The 13 profitable strategies of Table 1 have positive

⁹ The average abnormal performance in Table 4 (10.18%) is slightly higher than the average return reported in Table 1 (9.38%). The difference is due to the fact that (1) the momentum strategies have a positive commodity beta and (2) the commodity index offered a negative excess return over the period considered (-2.82%).

and significant α in Table 4. Therefore, the winner-loser profits cannot be described as a compensation for exposure to the risks we considered.¹⁰ As in Table 1, the momentum pattern is mainly driven by the losers: at the 10% level, all 13 losers have negative and significant alphas, while only 2 winners have positive and significant alphas. This result corroborates the conclusions of Hong et al. (2000) from equity markets.

As a robustness check, Table 5 investigates whether the average returns of Table 1 are a compensation for time-varying risks. The possibility indeed remains that the profitability of the momentum strategies is driven by the winners having higher systematic risks than the losers in up-markets and lower systematic risks than the losers in down-markets. If this is the case, the momentum profits identified in Table 1 could simply be a return for exposure to time-varying risks. To test this, model (2) conditions the measures of abnormal performance and risks on business cycle variables. For model (2) to be well-specified, the hypotheses that $\alpha_1 = 0$, $\beta_1 = \{\beta_{B1}, \beta_{M1}, \beta_{C1}\} = 0$ and $\alpha_1 = \beta_1 = 0$ have to be rejected. Table 5 reports the p -values of these tests and α_0 , the conditional abnormal performance of the momentum portfolios.

[Insert Table 5 around here]

The results indicate that, out of the 13 profitable strategies we consider, 2 have time-dependent measures of abnormal performance and 10 have time-dependent measures of risk at the 10% level. Additionally, the evidence suggests that α_1 and β_1 are jointly significant for 10 strategies at the 5% level. These results ultimately indicate that restricting the measures of risk and abnormal performance to be constant as in (1), instead of conditioning them on business cycle variables as in (2), might lead to poor conclusions on abnormal performance. The annualized conditional measures of abnormal performance (α_0) range from 5.86% for the 1-12 strategy to 16.76% for the

¹⁰ They are not compensation to the Fama and French (1993) *SMB* and *HML* factors either. Adding the momentum factor of Carhart (1997) to the sets of risk factors included in (1) reduces the size and significance of the abnormal return (α). This result is expected as both the momentum factor of Carhart and our relative-strength portfolios are formed by consistently buying recent winners and selling recent losers. The results from these models are available on request from the authors.

12-1 strategy, with an average at 9.97%. All 13 strategies have significant α_0 at the 10% level, an indication that the abnormal performance identified in Table 1 is not merely a compensation for time-varying risks.

4. 3. Backwardation and contango

This section analyzes in more details the characteristics of the futures contracts that the momentum strategies recommend trading. Following Erb and Harvey (2006), the article hypothesizes that the momentum strategies buy backwardated contracts and sell contangoed contracts. If hedgers are net short, the futures price has to rise as maturity approaches to entice speculators to open long positions. Conversely, if hedgers are net long, the futures price has to fall as maturity approaches to entice speculators to open short positions. The increase (decrease) in the futures price over the life of the contract is referred to as normal backwardation (contango) (for more on this, Keynes, 1930; Hicks, 1939; or, more recently, Miffre, 2000). This suggests that the momentum profits could be driven by long positions in backwardated contracts and short positions in contangoed contracts. To test this hypothesis, we relate the buy and sell recommendations of the trading rule first, to the roll-returns of commodity futures and second, to the term structure of average futures prices.

To measure whether a market is in backwardation or contango, roll-returns of each commodity futures are calculated by relating the futures price on the nearest contract to the futures price on the most distant contract as follows: $R_t = P_{Nearest,t} / P_{Distant,t} - 1$. A positive roll-return R_t indicates that the market is backwardated, as the time t futures price on the nearest contract then exceeds the time t futures price on the most distant contract. Conversely, a negative roll-return suggests that the market is in contango. For each momentum strategy, dummy variables that assign positive values to the commodity futures that are bought and negative values to the commodity futures that are sold are created. The actual values assigned to the dummy depend on the number of times the specific contract is bought or sold. For example, if in a given month the strategy buys (sells) 3 aluminum contracts, the aluminum dummy equals 3 (-3) for that specific month. Similarly, if the strategy ignores aluminum futures, the position dummy equals 0. For each commodity in each strategy, we then calculate the

correlation between the roll-returns and the position dummies. A positive and significant correlation indicates that the momentum strategy buys backwardated contracts and sells contangoed contracts, while a negative and significant correlation suggests the opposite.

The correlations between the roll-returns and the position dummies are reported in Table 6 for each of the 31 commodity futures and each of the 13 profitable momentum strategies. The last column reports the average correlations per commodity futures across strategies. The last row presents the average correlations per strategy across commodity futures. The mean correlation across both strategies and commodity futures equals 39.31%. 86.85% (85.61%) of the correlations are positive and significant at the 5% (1%) level.¹¹ These results indicate that the momentum strategies buy backwardated contracts and sell contangoed contracts. This proposition is strongly supported for light crude oil, lumber, oats, soybean oil and unleaded gas for which the average correlations across strategies exceed 55%. The adequacy of the hypothesis is also born out by the fact that the average correlations across commodities are positive, ranging from a low of 23.63% for the 1-1 strategy to a high of 45.68% for the 3-12 strategy.

[Insert Table 6 around here]

A closer look at the results in Table 6 reveals that the correlations between the roll-returns and the position dummies are negative and mainly significant for western plywood, suggesting that the momentum strategies buy western plywood in contangoed markets and sell it in backwardated markets. The correlations in Table 6 are insignificantly different from zero for the futures on aluminum, gold and regular gas, an indication that the momentum profits do not depend on whether these markets are in backwardation or contango. This suggests that dropping the futures on western plywood, aluminum, gold and regular gas from the set of contracts on which the

¹¹ Note that this result is not sensitive to the definition of roll-return. When roll-returns are measured as in Erb and Harvey (2006) as a function of the price differential between the nearest and second nearest contracts, 78.43% (74.40%) of the correlations between the position dummies and the roll-returns are positive and significant at the 5% (1%) level.

momentum strategies is implemented could further enhance the profitability of the trading rule.

The term structure of futures prices can also be used to reveal whether a market is backwardated or contangoed. A backwardated market has a downward-sloping term structure, as the time t futures prices of nearby contracts exceed that of more distant contracts. Conversely, a contangoed market has an upward-sloping term structure, as, in this case, prices of distant contracts exceed prices of nearby contracts. Figure 2 pictures the term structure of average futures prices of two commodities (unleaded gas and silver) as the average futures prices across contracts 1 to 12 months before maturity.¹² The plots clearly suggest that unleaded gas tend to be in backwardation over the period January 1979 – September 2004, while silver was contangoed more often than not. Figure 2 also presents $p(\omega > 0)$, $p(\omega < 0)$ and $p(\omega = 0)$, the percentages of times the 13 momentum strategies buy, sell or ignore each of the two commodity futures. In line with our hypothesis that the momentum strategies buy backwardated contracts and sell contangoed contracts, we bought unleaded gas futures, a backwardated contract, 52.14% of the times and sold silver futures, a contangoed contract, 45.88% of the times.

[Insert Figure 2 around here]

4. 4. Momentum, diversification and inflation hedge

Commodity futures are well-known for their properties as risk diversifiers. Table 7 reports the correlations between the momentum returns and the returns of traditional asset classes. Across the 13 profitable strategies, the average correlation between the momentum returns and the returns of the S&P500 composite index is -0.02, ranging from a low -0.06 (for the 12-1 and 12-3 strategies) to a high of 0.05 (for the 3-6 strategy). The correlations between the momentum returns and the Treasury-bill or Treasury-bond rates are equally low with averages at 0.03 and 0.04, respectively.

¹² Because most futures contracts do not trade for more than one year, the term structure of average prices is estimated with reference to the 12 months before maturity. Average prices on contracts with maturities exceeding 12 months are meaningless as then too few observations are considered.

None of the correlations with the S&P500 returns, the Treasury-bond or Treasury-bill rates are significant at the 5% level. These results corroborate the evidence in Table 4 on the lack of sensitivity of the momentum returns to equity and bond returns. This suggests that institutional investors may tactically add commodity futures to their asset mix not solely to earn abnormal returns but also to reduce the total risk of their equity and/or fixed-income portfolios.

[Insert Table 7 around here]

The correlations between the momentum returns and the GSCI excess returns are mainly positive and significant. This backs up the evidence in Table 4 of positive and significant loadings of the momentum returns on the GSCI excess returns. The positive correlations and loadings can in turn be explained by the relatively high weighting of GSCI towards energy derivatives (Erb and Harvey, 2006) and the long positions of momentum portfolios in backwardated energy markets (as evidenced, for example, in Figure 2).

Table 7 also reports the correlations between the momentum returns and the percentage change in the consumer price index (used as a proxy for short-term unexpected inflation). The correlations are insignificant and range from -0.06 to 0.04. This indicates that the strategies do not offer a hedge against short-term unexpected inflation. The incremental returns and the added benefits of diversification come at the cost of losing the inflation hedge that is naturally provided by commodities (Bodie and Rosansky, 1980; Bodie, 1983). This result corroborates the evidence in Erb and Harvey (2006) who question the ability of excess commodity futures returns to act as an inflation hedge.

5. Contrarian Strategies

Table 8 reports summary statistics of returns of long-term contrarian strategies. A contrarian strategy advocates that the losers (winners) in the ranking period will turn into winners (losers) in the holding period. As a result, a contrarian strategy that tactically allocates wealth towards the long-term underpriced losers and away from the long-term overpriced winners should be profitable.

[Insert Table 8 around here]

The results in Table 8 indicate that the systematic rebalancing of commodity futures using a contrarian approach is not a source of abnormal returns in commodity futures markets. There is no evidence that past winners turn into losers over ranking and holding periods that range from 2 to 5 years. In the meantime, past losers systematically keep losing (the average return of the loser portfolios ranges from -5.12% to -0.72% a year). As a result, none of the contrarian strategies is profitable. There is even evidence that a momentum strategy is profitable at the 10% level, if the ranking period is set to 5 years and the holding period to 3 or 5 years.

The contrarian pattern identified in stock markets over long-term horizons by De Bondt and Thaler (1985) is not present in commodity futures markets. For price reversals to occur in commodity futures markets, contracts would need to switch every 2 to 5 years from backwardation to contango. Then, the winners in the ranking period (namely, in backwardated markets) would become losers in the holding period (namely, in contangoed markets). Conversely, if markets switched every 2 to 5 years from contango to backwardation, the losers in the ranking period (namely, in contangoed markets) would become winners in the holding period (namely, in backwardated markets). In both cases, a contrarian strategy would be profitable. The lack of price reversals in commodity futures markets is therefore possibly due to the fact that commodity futures markets do not switch over horizons of 2 to 5 years from backwardation to contango (or, conversely, from contango to backwardation).

The absence of price reversals may also be due to the fact that many commodity futures have had negative average returns over the period considered, with an equally-weighted portfolio of the 31 futures yielding an average return merely equal to -2.64% a year. As a result, the loser portfolios keep losing not simply over the short run (as in Tables 1, 2 and 3) but also over longer horizons (in Table 8). Possibly for the same reason, we barely found any evidence of price continuation in the momentum winners in Tables 1, 2 and 3.

Figure 3 pictures the average returns of the contrarian strategies over increasing holding periods. For a given ranking period, the relationship between average contrarian return and holding period is n-shaped, suggesting that the contrarian strategies perform better for intermediate holding periods. The contrarian strategies with a 5-year ranking period offer the most negative returns, while the strategies with a 2-year ranking period perform relatively better. These contrarian returns are however insignificant at the 10% level, making even these strategies unprofitable.

[Insert Figure 3 around here]

6. Conclusions

The article looks at the performance of 56 momentum and contrarian strategies in commodity futures markets. We build on the research of Erb and Harvey (2006) who focus on one momentum strategy. While contrarian strategies do not work, 13 momentum strategies are found to be profitable in commodity futures markets over horizons that range from 1 to 12 months. Our tactical allocation in commodity futures markets generates an average return of 9.38% a year. Interestingly, a portfolio that equally weights the 31 commodity futures considered in the study lost 2.64% a year over the same period. The momentum returns are also found to have low correlations with the returns of traditional asset classes, making therefore our relative-strength portfolios good candidates for inclusion in well-diversified portfolios.

While the momentum profits are not a compensation for risk (whether it is constant or time-dependent), they are related to the backwardation and contango theories. The results indeed indicate that the momentum strategies buy backwardated contracts and sell contangoed contracts. This result implicitly suggests that a momentum strategy that consistently trades the most backwardated and contangoed contracts is likely to be profitable. We see this subject as an interesting avenue for further research.

The possibility remains that the momentum profits may be eroded by transaction costs or may be a compensation for thin trading and market frictions (as in Lesmond et al., 2004). These explanations seem unlikely for four reasons. First, transaction costs in futures markets range from 0.0004% to 0.033% (Locke and Venkatesh, 1997) and are

therefore much less than the conservative 0.5% estimate of Jegadeesh and Titman (1993) or the more realistic 2.3% estimate of Lesmond et al. (2004) for equity markets. Second, while short-selling restrictions are often imposed in equity markets, taking short positions in commodity futures is as easy as taking long positions. Third, the nearest or next nearest contracts, typically the most liquid ones, were used to form the long-short portfolios. Fourth, the strategies were implemented on only 31 commodity futures and are therefore much less trading intensive than the ones typically implemented in equity markets. These points notwithstanding, trading costs are not considered in this study and, as a result, we cannot draw final inferences on the magnitude of the net momentum profits. We leave this as a possible route for future research.

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Table 1 - Summary statistics of returns of momentum strategies

	Holding Period of 1 Month			Holding Period of 3 Months			Holding Period of 6 Months			Holding Period of 12 Months		
	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum
Panel A: Ranking Period of 1 Month												
Mean	0.0239 (0.60)	-0.0847 (-2.16)	0.1087 (2.13)	0.0126 (0.39)	-0.0688 (-2.32)	0.0814 (2.58)	0.0088 (0.30)	-0.0677 (-2.41)	0.0765 (3.35)	-0.0175 (-0.67)	-0.0702 (-2.74)	0.0527 (3.20)
Standard deviation	0.2016	0.1987	0.2584	0.1631	0.1496	0.1593	0.1454	0.1406	0.1145	0.1290	0.1274	0.0820
Reward-to-risk ratio	0.1187	-0.4265	0.4205	0.0772	-0.4598	0.5108	0.0608	-0.4811	0.6681	-0.1353	-0.5509	0.6435
Panel B: Ranking Period of 3 Months												
Mean	0.0726 (1.83)	-0.0655 (-1.78)	0.1380 (2.79)	0.0398 (1.08)	-0.0648 (-1.95)	0.1046 (2.47)	0.0121 (0.37)	-0.0643 (-2.15)	0.0764 (2.34)	0.0031 (0.11)	-0.0516 (-1.88)	0.0547 (2.23)
Standard deviation	0.2000	0.1853	0.2494	0.1853	0.1665	0.2130	0.1619	0.1493	0.1635	0.1341	0.1359	0.1214
Reward-to-risk ratio	0.3629	-0.3532	0.5535	0.2146	-0.3890	0.4911	0.0747	-0.4308	0.4674	0.0228	-0.3799	0.4503
Panel C: Ranking Period of 6 Months												
Mean	0.0104 (0.25)	-0.1083 (-2.72)	0.1188 (2.37)	-0.0001 (0.00)	-0.0869 (-2.40)	0.0868 (1.93)	0.0033 (0.10)	-0.0872 (-2.57)	0.0905 (2.30)	-0.0323 (-1.08)	-0.0528 (-1.76)	0.0205 (0.65)
Standard deviation	0.2060	0.1996	0.2515	0.1886	0.1810	0.2252	0.1667	0.1689	0.1961	0.1480	0.1474	0.1555
Reward-to-risk ratio	0.0506	-0.5427	0.4722	-0.0007	-0.4803	0.3854	0.0196	-0.5165	0.4614	-0.2183	-0.3582	0.1318
Panel D: Ranking Period of 12 Months												
Mean	0.0407 (1.01)	-0.1053 (-2.73)	0.1460 (2.84)	0.0085 (0.25)	-0.0758 (-2.10)	0.0843 (1.86)	-0.0306 (-0.94)	-0.0402 (-1.19)	0.0096 (0.23)	-0.0397 (-1.27)	-0.0097 (-0.31)	-0.0300 (-0.82)
Standard deviation	0.1993	0.1916	0.2557	0.1693	0.1786	0.2236	0.1610	0.1662	0.2072	0.1518	0.1520	0.1788
Reward-to-risk ratio	0.2041	-0.5495	0.5709	0.0499	-0.4246	0.3768	-0.1899	-0.2417	0.0463	-0.2613	-0.0635	-0.1679

The mean and standard deviation are annualized. The reward-to-risk ratio is measured as the ratio of the annualized mean to the annualized standard deviation. *t*-ratios for the significance of the mean are in parentheses. Our definition of returns assumes that we hold contracts up to one month before maturity, at which date the position is rolled over to the second nearest contract and held up to one month prior to maturity. Futures prices are collected at a monthly frequency.

Table 2 - Reward-to-risk ratios of momentum portfolios over time

	Mar 1979 - Jul 1985	Aug 1985 - Dec 1991	Jan 1992 - May 1998	Jun 1998 - Sep 2004	Mar 1979 - Sep 2004
Panel A: Ranking Period of 1 Month					
$H = 1$	0.6123	0.8360	0.6873	-0.4485	0.4205
$H = 3$	0.2803	0.5945	0.7646	0.5078	0.5108
$H = 6$	0.5463	0.6783	0.4763	0.9990	0.6681
$H = 12$	0.3338	0.8223	0.6393	0.7815	0.6435
Panel B: Ranking Period of 3 Months					
$H = 1$	0.5584	0.4094	0.7001	0.6047	0.5535
$H = 3$	0.6082	0.2333	0.3841	0.7166	0.4911
$H = 6$	0.4819	0.4064	-0.0404	0.9075	0.4674
$H = 12$	0.4067	0.3351	0.3117	0.7030	0.4503
Panel C: Ranking Period of 6 Months					
$H = 1$	0.7690	0.2625	0.0827	0.6772	0.4722
$H = 3$	0.4614	0.2922	-0.0175	0.7103	0.3854
$H = 6$	0.5157	0.3553	0.2027	0.7261	0.4614
$H = 12$	0.0363	0.1644	-0.1026	0.3487	0.1318
Panel D: Ranking Period of 12 Months					
$H = 1$	0.5425	0.4127	0.6148	0.7465	0.5709
$H = 3$	0.2603	0.2822	0.2651	0.6323	0.3768
$H = 6$	-0.0693	0.1234	-0.2640	0.2687	0.0463
$H = 12$	-0.0520	0.0475	-0.7817	-0.0757	-0.1679

The table reports the reward-to-risk ratios of the momentum portfolios over 4 consecutive sub-periods and over the whole sample. The reward-to-risk ratio is measured as the portfolio's annualized mean divided by its annualized standard deviation. H is the holding period of the momentum strategy.

Table 3 - Sensitivity of momentum profits to return definition

	Holding Period of 1 Month			Holding Period of 3 Months			Holding Period of 6 Months			Holding Period of 12 Months		
	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum
Panel A: Ranking Period of 1 Month												
Mean	0.0237 (0.70)	-0.0701 (-2.17)	0.0938 (2.23)	0.0040 (0.15)	-0.0537 (-2.09)	0.0577 (2.18)	-0.0100 (-0.43)	-0.0327 (-1.34)	0.0227 (1.13)	-0.0123 (-0.57)	-0.0456 (-2.03)	0.0333 (2.51)
Standard deviation	0.1705	0.1634	0.2136	0.1337	0.1300	0.1337	0.1176	0.1225	0.1009	0.1082	0.1120	0.0660
Reward-to-risk ratio	0.1387	-0.4290	0.4390	0.0298	-0.4134	0.4317	-0.0854	-0.2672	0.2249	-0.1139	-0.4072	0.5041
Panel B: Ranking Period of 3 Months												
Mean	0.0421 (1.24)	-0.0730 (-2.33)	0.1150 (2.61)	0.0040 (0.13)	-0.0583 (-2.05)	0.0623 (1.72)	-0.0120 (-0.46)	-0.0401 (-1.52)	0.0280 (0.98)	-0.0119 (-0.52)	-0.0552 (-2.28)	0.0433 (2.15)
Standard deviation	0.1718	0.1586	0.2225	0.1513	0.1435	0.1822	0.1315	0.1319	0.1435	0.1132	0.1204	0.1000
Reward-to-risk ratio	0.2449	-0.4601	0.5171	0.0266	-0.4061	0.3418	-0.0916	-0.3039	0.1954	-0.1051	-0.4584	0.4327
Panel C: Ranking Period of 6 Months												
Mean	0.0092 (0.27)	-0.0598 (-1.89)	0.0689 (1.62)	-0.0029 (-0.09)	-0.0478 (-1.56)	0.0449 (1.16)	-0.0184 (-0.65)	-0.0505 (-1.72)	0.0321 (0.95)	-0.0175 (-0.73)	-0.0426 (-1.62)	0.0251 (1.00)
Standard deviation	0.1718	0.1591	0.2137	0.1583	0.1534	0.1934	0.1421	0.1468	0.1693	0.1187	0.1300	0.1242
Reward-to-risk ratio	0.0533	-0.3758	0.3227	-0.0184	-0.3114	0.2320	-0.1295	-0.3441	0.1896	-0.1474	-0.3274	0.2018
Panel D: Ranking Period of 12 Months												
Mean	0.0289 (0.85)	-0.0815 (-2.44)	0.1105 (2.51)	0.0028 (0.09)	-0.0717 (-2.25)	0.0745 (1.89)	-0.0158 (-0.57)	-0.0430 (-1.39)	0.0272 (0.76)	-0.0362 (-1.33)	-0.0252 (-0.90)	-0.0110 (-0.35)
Standard deviation	0.1703	0.1664	0.2195	0.1559	0.1583	0.1962	0.1380	0.1532	0.1770	0.1337	0.1372	0.1557
Reward-to-risk ratio	0.1699	-0.4900	0.5031	0.0181	-0.4529	0.3798	-0.1144	-0.2805	0.1536	-0.2707	-0.1834	-0.0709

The mean and standard deviation are annualized. The reward-to-risk ratio is measured as the ratio of the annualized mean to the annualized standard deviation. *t*-ratios for the significance of the mean are in parentheses. The difference with Table 1 is that we switch to the most distant (in place of the nearby) contract and use weekly (in place of monthly) settlement prices. Our definition of returns assumes that we hold the first contract up to two weeks before maturity, at which time we roll our long position to the contract whose maturity is the furthest away.

Table 4 - Static risk model

	Holding Period of 1 Month			Holding Period of 3 Months			Holding Period of 6 Months			Holding Period of 12 Months		
	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum	Winners	Losers	Momentum
Panel A: Ranking Period of 1 Month												
α	0.0299 (0.83)	-0.0788 (-2.27)	0.1087 (2.10)	0.0214 (0.81)	-0.0674 (-2.69)	0.0889 (2.79)	0.0132 (0.58)	-0.0670 (-2.89)	0.0802 (3.48)	-0.0071 (-0.36)	-0.0648 (-3.12)	0.0577 (3.49)
β_B	-0.1470 (-1.55)	-0.0558 (-0.61)	-0.0912 (-0.67)	-0.0804 (-1.16)	-0.1387 (-2.10)	0.0583 (0.70)	-0.0608 (-1.03)	-0.1180 (-1.95)	0.0572 (0.95)	-0.0536 (-1.05)	-0.1059 (-1.94)	0.0524 (1.21)
β_M	0.0733 (1.07)	0.1552 (2.34)	-0.0819 (-0.83)	0.0920 (1.83)	0.1451 (3.03)	-0.0531 (-0.88)	0.1180 (2.74)	0.1189 (2.70)	-0.0010 (-0.02)	0.0926 (2.49)	0.1205 (3.05)	-0.0279 (-0.89)
β_C	0.5270 (8.83)	0.5452 (9.45)	-0.0181 (-0.21)	0.5552 (12.70)	0.4524 (10.86)	0.1028 (1.94)	0.5227 (13.85)	0.4551 (11.82)	0.0675 (1.76)	0.4978 (15.22)	0.4321 (12.42)	0.0657 (2.37)
\bar{R}^2	20.51%	23.49%	-0.50%	35.18%	29.93%	0.55%	39.97%	33.14%	0.35%	44.53%	35.72%	1.48%
Panel B: Ranking Period of 3 Months												
α	0.0832 (2.42)	-0.0668 (-1.94)	0.1500 (3.02)	0.0482 (1.59)	-0.0661 (-2.19)	0.1144 (2.70)	0.0215 (0.84)	-0.0613 (-2.34)	0.0828 (2.53)	0.0130 (0.63)	-0.0503 (-2.12)	0.0631 (2.58)
β_B	-0.0766 (-0.85)	-0.1503 (-1.66)	0.0737 (0.57)	-0.0297 (-0.37)	-0.1571 (-1.99)	0.1274 (1.15)	-0.0280 (-0.42)	-0.1183 (-1.73)	0.0903 (1.06)	-0.0376 (-0.69)	-0.1339 (-2.13)	0.0963 (1.49)
β_M	0.0827 (1.26)	0.1486 (2.26)	-0.0660 (-0.70)	0.1379 (2.39)	0.1292 (2.25)	0.0087 (0.11)	0.1368 (2.81)	0.1102 (2.21)	0.0266 (0.43)	0.0551 (1.39)	0.1132 (2.49)	-0.0581 (-1.24)
β_C	0.5961 (10.45)	0.3786 (6.61)	0.2175 (2.64)	0.6150 (12.24)	0.3992 (7.97)	0.2159 (3.08)	0.5730 (13.35)	0.4192 (9.56)	0.1538 (2.82)	0.5212 (14.93)	0.4068 (10.16)	0.1145 (2.77)
\bar{R}^2	26.52%	13.85%	1.45%	33.98%	18.75%	2.57%	38.38%	24.45%	2.16%	43.10%	27.14%	2.58%
Panel C: Ranking Period of 6 Months												
α	0.0209 (0.59)	-0.1085 (-2.98)	0.1294 (2.56)	0.0127 (0.40)	-0.0821 (-2.48)	0.0948 (2.09)	0.0134 (0.49)	-0.0820 (-2.72)	0.0954 (2.39)			
β_B	0.0039 (0.04)	-0.1065 (-1.12)	0.1104 (0.84)	0.0007 (0.01)	-0.1050 (-1.22)	0.1058 (0.90)	-0.0520 (-0.73)	-0.0836 (-1.07)	0.0316 (0.31)			
β_M	0.0925 (1.38)	0.1592 (2.31)	-0.0667 (-0.69)	0.1141 (1.92)	0.0982 (1.57)	0.0159 (0.19)	0.1113 (2.13)	0.1281 (2.24)	-0.0168 (-0.22)			
β_C	0.6327 (10.81)	0.4789 (7.93)	0.1538 (1.83)	0.6206 (11.84)	0.4481 (8.11)	0.1725 (2.28)	0.5616 (12.18)	0.4635 (9.19)	0.0981 (1.47)			
\bar{R}^2	28.09%	18.29%	0.40%	32.37%	18.34%	1.06%	33.89%	22.96%	-0.25%			
Panel D: Ranking Period of 12 Months												
α	0.0587 (1.70)	-0.1019 (-2.83)	0.1604 (3.11)	0.0222 (0.78)	-0.0757 (-2.25)	0.0978 (2.16)						
β_B	-0.0068 (-0.07)	-0.0857 (-0.91)	0.0789 (0.58)	-0.0066 (-0.09)	-0.1319 (-1.48)	0.1254 (1.04)						
β_M	0.0434 (0.66)	0.1612 (2.35)	-0.1178 (-1.20)	0.0235 (0.43)	0.1313 (2.03)	-0.1077 (-1.24)						
β_C	0.6177 (10.69)	0.4117 (6.82)	0.2060 (2.38)	0.5759 (12.00)	0.3940 (6.92)	0.1819 (2.38)						
\bar{R}^2	27.55%	14.49%	1.37%	32.51%	14.61%	1.62%						

Table 4 – Continued

The table reports coefficient estimates from (1). α measures abnormal performance, β_B , β_M and β_C measures the sensitivities of returns to the excess returns on Datastream government bond index, the S&P500 composite index and GSCI, respectively. t -ratios are in parenthesis. To facilitate comparison with Table 1, α has been annualized. \bar{R}^2 is the adjusted goodness of fit statistic.

Table 5 - Conditional risk model

	α_0		$p(\alpha_1 = 0)$	$p(\beta_1 = 0)$	$p(\alpha_1 = \beta_1 = 0)$
	Estimate	t -ratio			
Panel A: Ranking Period of 1 Month					
$H = 1$	0.0992	1.93	0.12	0.01	0.00
$H = 3$	0.0770	2.60	0.33	0.00	0.00
$H = 6$	0.0738	3.67	0.02	0.00	0.00
$H = 12$	0.0586	3.94	0.60	0.00	0.00
Panel B: Ranking Period of 3 Months					
$H = 1$	0.1303	2.74	0.45	0.00	0.00
$H = 3$	0.1093	2.95	0.18	0.00	0.00
$H = 6$	0.0834	2.94	0.75	0.01	0.03
$H = 12$	0.0704	3.12	0.06	0.10	0.01
Panel C: Ranking Period of 6 Months					
$H = 1$	0.1232	2.69	0.71	0.00	0.00
$H = 3$	0.0916	2.31	0.50	0.03	0.04
$H = 6$	0.1034	2.98	0.67	0.25	0.51
Panel D: Ranking Period of 12 Months					
$H = 1$	0.1676	3.38	0.93	0.04	0.12
$H = 3$	0.1079	2.53	0.61	0.26	0.14

α_0 measures the conditional abnormal performance of the momentum portfolio. To facilitate comparison with Table 1, α_0 has been annualized. $p(\alpha_1=0)$, $p(\beta_1=0)$ and $p(\alpha_1=\beta_1=0)$ are p -values associated with the hypotheses that the measures of abnormal performance and/or risk are constant. H is the holding period of the momentum strategy.

Table 6 - Correlations between roll-returns and position dummies: Backwardation and contango

	R = 1				R = 3				R = 6			R = 12		Average
	H = 1	H = 3	H = 6	H = 12	H = 1	H = 3	H = 6	H = 12	H = 1	H = 3	H = 6	H = 1	H = 3	
Aluminium	28% *	2%	2%	-18%	2%	4%	3%	-11%	3%	3%	1%	2%	1%	1.77%
Cocoa	28% *	44% *	54% *	59% *	37% *	44% *	47% *	51% *	43% *	44% *	42% *	51% *	54% *	45.89%
Coffee	29% *	44% *	55% *	59% *	40% *	47% *	55% *	63% *	50% *	52% *	53% *	56% *	58% *	50.78%
Copper	18% *	31% *	40% *	52% *	39% *	47% *	56% *	72% *	49% *	58% *	63% *	68% *	72% *	51.06%
Corn	23% *	42% *	57% *	65% *	44% *	54% *	64% *	67% *	56% *	61% *	64% *	55% *	58% *	54.70%
Cotton	26% *	41% *	48% *	53% *	37% *	44% *	46% *	49% *	46% *	45% *	43% *	52% *	50% *	44.61%
Diammonium Phosphate	17%	30% *	58% *	64% *	13%	32% *	64% *	65% *	50% *	66% *	67% *	60% *	61% *	49.76%
Feeder Cattle	20% *	27% *	27% *	22% *	40% *	41% *	45% *	45% *	37% *	34% *	28% *	32% *	38% *	33.49%
Frozen Pork Bellies	25% *	34% *	36% *	47% *	39% *	41% *	42% *	51% *	41% *	40% *	43% *	43% *	43% *	40.46%
Gold	3%	1%	0%	4%	3%	0%	-2%	7%	3%	3%	5%	4%	6%	2.71%
Heating Oil	25% *	33% *	42% *	53% *	28% *	32% *	44% *	56% *	40% *	43% *	49% *	48% *	50% *	41.86%
Lean Hogs	21% *	35% *	44% *	55% *	30% *	38% *	45% *	51% *	45% *	49% *	51% *	48% *	51% *	43.31%
Light Crude Oil	32% *	46% *	54% *	64% *	46% *	50% *	53% *	62% *	62% *	63% *	61% *	61% *	63% *	55.21%
Live Cattle	29% *	45% *	40% *	26% *	47% *	50% *	42% *	27% *	38% *	32% *	20% *	27% *	24% *	34.29%
Lumber	51% *	69% *	76% *	69% *	62% *	64% *	62% *	58% *	67% *	61% *	52% *	66% *	60% *	62.80%
Milk	29% *	41% *	48% *	45% *	53% *	54% *	51% *	45% *	60% *	55% *	47% *	51% *	48% *	48.18%
Natural Gas	39% *	53% *	58% *	64% *	53% *	51% *	57% *	56% *	52% *	51% *	47% *	54% *	50% *	52.67%
Oats	38% *	52% *	64% *	66% *	47% *	55% *	65% *	66% *	61% *	64% *	66% *	67% *	66% *	59.77%
Orange Juice	15% *	20% *	22% *	32% *	31% *	37% *	43% *	53% *	34% *	38% *	41% *	45% *	47% *	35.13%
Palladium	24% *	35% *	41% *	44% *	36% *	41% *	47% *	50% *	38% *	41% *	44% *	41% *	42% *	40.36%
Platinum	13% *	21% *	29% *	33% *	34% *	40% *	47% *	55% *	32% *	35% *	36% *	40% *	41% *	35.14%
Regular Gas	32% *	18%	2%	26% *	38% *	16%	-2%	12%	-2%	-10%	-3%	26%	24%	13.68%
Silver	13%	17% *	21% *	25% *	19% *	23% *	28% *	34% *	27% *	29% *	33% *	31% *	33% *	25.68%
Soybean Meal	29% *	50% *	60% *	63% *	44% *	52% *	55% *	56% *	52% *	56% *	56% *	58% *	58% *	52.88%
Soybean Oil	29% *	51% *	61% *	65% *	45% *	54% *	62% *	64% *	54% *	59% *	61% *	56% *	59% *	55.40%
Soybeans	16% *	31% *	37% *	47% *	35% *	44% *	53% *	52% *	47% *	54% *	52% *	46% *	49% *	43.39%
Sugar	31% *	46% *	58% *	71% *	46% *	54% *	60% *	67% *	52% *	54% *	54% *	58% *	59% *	54.70%
Unleaded Gas	44% *	55% *	56% *	65% *	51% *	47% *	53% *	58% *	57% *	57% *	60% *	62% *	60% *	55.78%
Western Plywood	-8%	-27% *	-28% *	-36% *	-19%	-36% *	-46% *	-51% *	-40% *	-55% *	-53% *	-42% *	-42% *	-36.98%
Wheat	18% *	28% *	41% *	51% *	30% *	37% *	42% *	56% *	46% *	49% *	53% *	56% *	62% *	43.91%
White Wheat	-7%	13%	37% *	35% *	8%	25% *	35% *	30% *	30% *	37% *	37% *	26% *	34% *	26.25%
Average	23.63%	33.13%	40.04%	44.21%	34.16%	38.08%	42.46%	45.68%	39.67%	40.93%	41.07%	43.50%	44.48%	39.31%

R is the ranking period, H is the holding period of the momentum strategy. The roll-return is measured as a function of the time t price differential between the nearest contract and the most distant contract. The position dummies assign positive values to the commodity futures that are bought, negative values to the commodity futures that are sold and a value of 0 to the commodity futures that are neither bought, nor sold. * indicates that the correlation is significant at the 5% level (using Pearson correlation test).

Table 7 - Diversification and inflation hedge

	US T-Bill	US T-Bond	S&P500	Commodity	Inflation
Panel A: Ranking Period of 1 Month					
$H = 1$	0.09	-0.04	-0.05	-0.01	0.03
$H = 3$	0.00	0.03	-0.04	0.11 **	-0.02
$H = 6$	0.01	0.06	0.02	0.10 **	-0.06
$H = 12$	0.00	0.06	-0.03	0.14 *	-0.05
Panel B: Ranking Period of 3 Months					
$H = 1$	0.00	0.03	-0.03	0.15 *	-0.01
$H = 3$	0.03	0.07	0.03	0.18 *	-0.04
$H = 6$	0.03	0.07	0.05	0.16 *	-0.04
$H = 12$	0.03	0.07	-0.05	0.16 *	0.02
Panel C: Ranking Period of 6 Months					
$H = 1$	0.07	0.05	-0.02	0.11 **	-0.01
$H = 3$	0.03	0.06	0.03	0.13 *	-0.03
$H = 6$	0.05	0.02	0.00	0.09	0.01
Panel D: Ranking Period of 12 Months					
$H = 1$	0.03	0.02	-0.06	0.14 *	0.02
$H = 3$	0.01	0.05	-0.06	0.14 *	0.04
Average	0.03	0.04	-0.02	0.12	-0.01

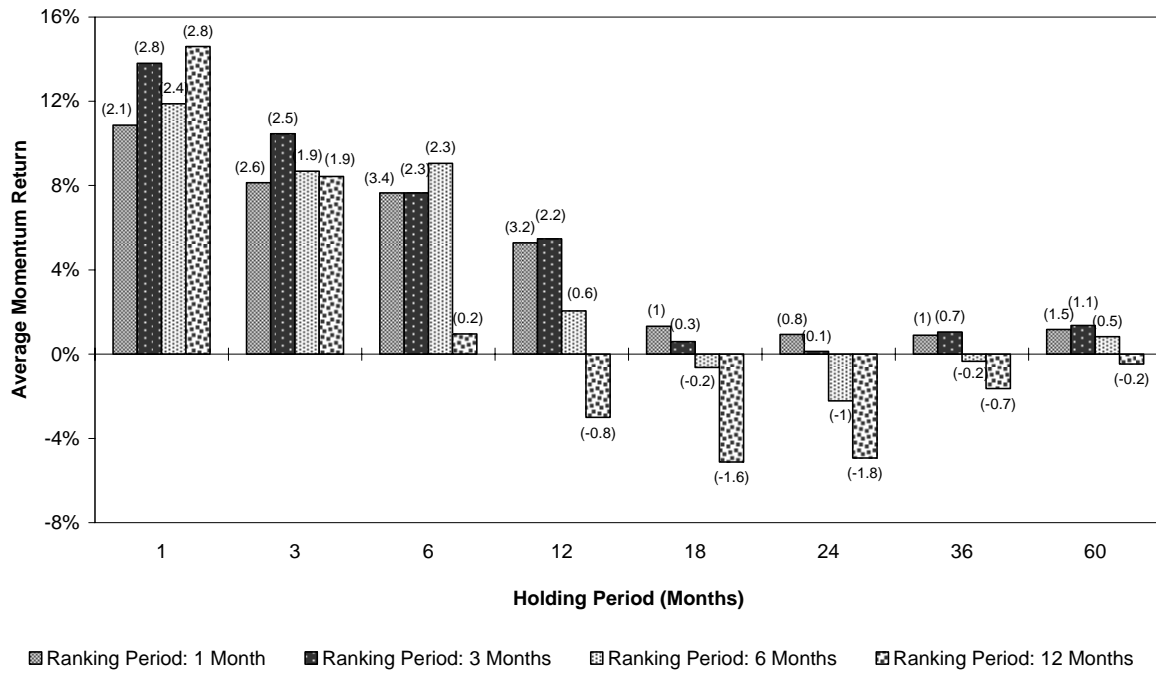
The table reports correlations between the returns of momentum portfolios and the returns of different asset classes. H is the holding period of the momentum strategy. * and ** indicate that the correlation is significant at the 1 and 10% level, respectively (using Pearson correlation test).

Table 8 - Summary statistics of returns of contrarian strategies

	Holding Period of 2 Years			Holding Period of 3 Years			Holding Period of 5 Years		
	Winners	Losers	Contrarian	Winners	Losers	Contrarian	Winners	Losers	Contrarian
Panel A: Ranking Period of 2 Years									
Mean	-0.0254 (-0.87)	-0.0072 (-0.24)	0.0182 (0.50)	-0.0130 (-0.46)	-0.0259 (-0.91)	-0.0129 (-0.41)	0.0037 (0.14)	-0.0186 (-0.66)	-0.0223 (-0.80)
Standard deviation	0.1366	0.1406	0.1680	0.1294	0.1299	0.1442	0.1177	0.1212	0.1206
Reward-to-risk ratio	-0.1856	-0.0513	0.1080	-0.1002	-0.1990	-0.0894	0.0315	-0.1531	-0.1846
Panel B: Ranking Period of 3 Years									
Mean	-0.0129 (-0.41)	-0.0407 (-1.24)	-0.0278 (-0.68)	0.0011 (0.04)	-0.0215 (-0.68)	-0.0226 (-0.59)	0.0214 (0.73)	-0.0314 (-1.00)	-0.0528 (-1.55)
Standard deviation	0.1438	0.1494	0.1867	0.1376	0.1408	0.1704	0.1240	0.1323	0.1436
Reward-to-risk ratio	-0.0893	-0.2723	-0.1490	0.0082	-0.1526	-0.1326	0.1726	-0.2376	-0.3679
Panel C: Ranking Period of 5 Years									
Mean	0.0353 (0.99)	-0.0239 (-0.68)	-0.0592 (-1.22)	0.0475 (1.34)	-0.0331 (-0.96)	-0.0806 (-1.72)	0.0354 (0.95)	-0.0512 (-1.58)	-0.0866 (-1.88)
Standard deviation	0.1548	0.1520	0.2106	0.1490	0.1461	0.1980	0.1481	0.1286	0.1829
Reward-to-risk ratio	0.2281	-0.1573	-0.2812	0.3188	-0.2269	-0.4073	0.2391	-0.3979	-0.4734

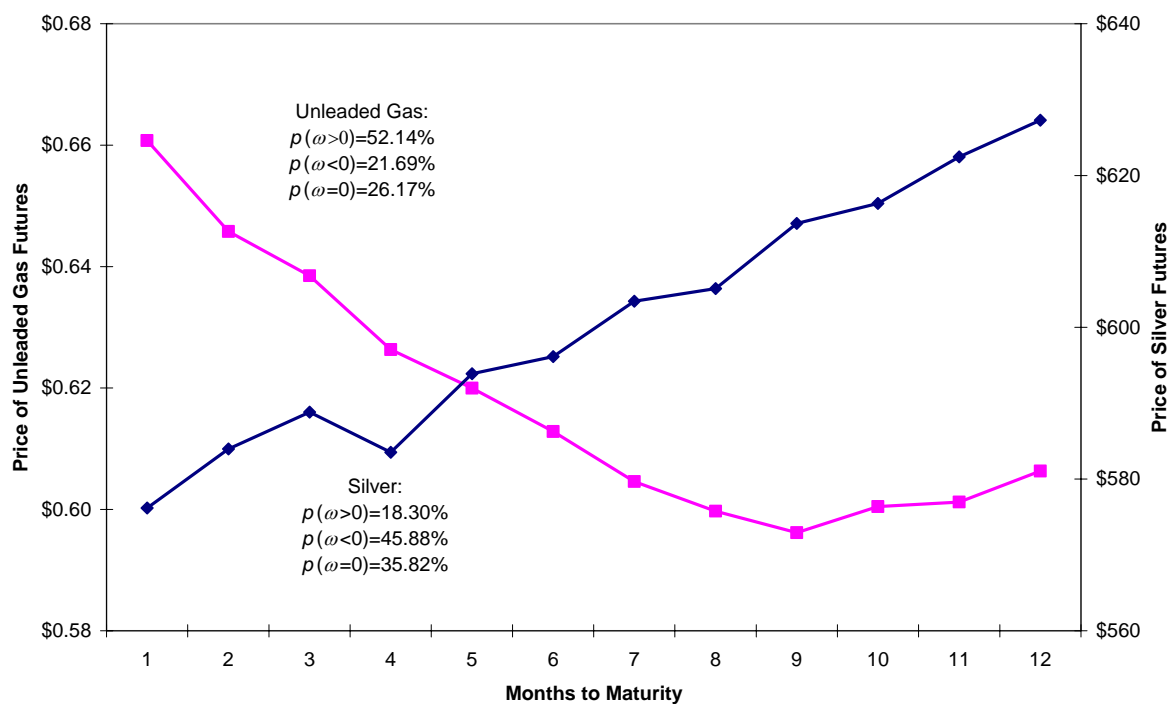
The mean and standard deviation are annualized. The reward-to-risk ratio is measured as the ratio of the annualized mean to the annualized standard deviation. *t*-ratios for the significance of the mean are in parentheses.

Figure 1 - Average momentum returns over different holding periods



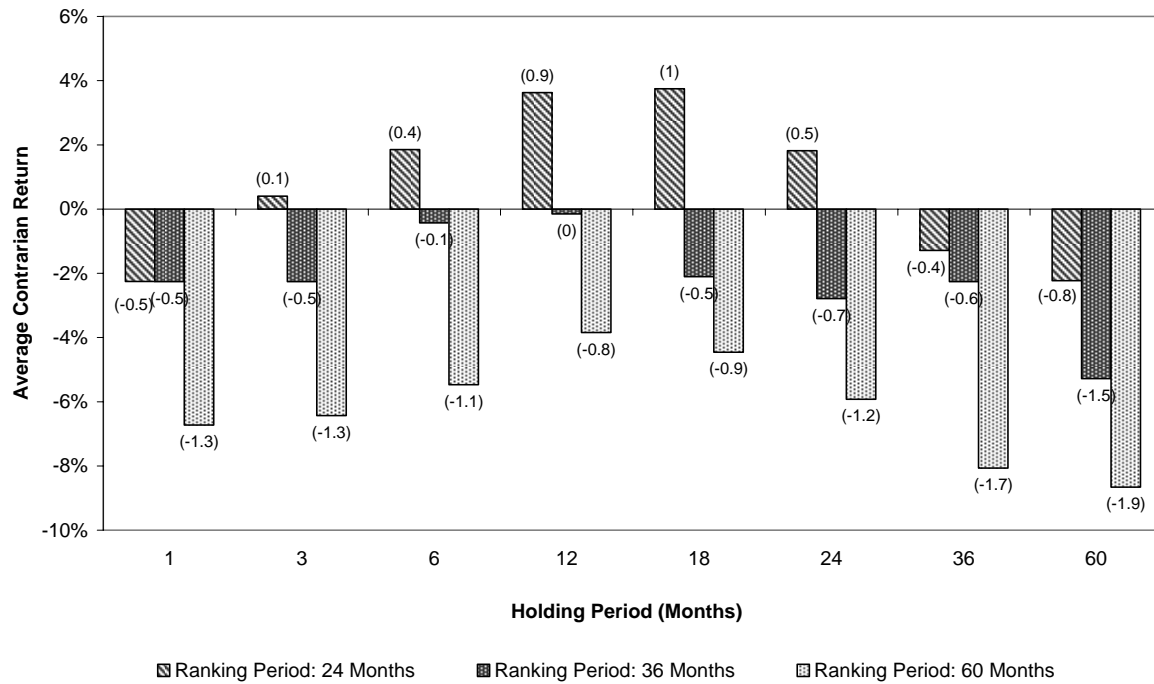
The figure presents the average returns of momentum portfolios for 4 ranking periods and for holding periods of increasing length. *t*-ratios for the significance of the mean are reported in parentheses.

Figure 2 - Term structure of average futures prices: Unleaded gas and silver



The figure presents the average prices of unleaded gas and silver futures 1 to 12 months before maturity. $p(\omega > 0)$ is the percentage of long positions across the 13 profitable momentum strategies, $p(\omega < 0)$ is the percentage of short positions across the 13 profitable momentum strategies and $p(\omega = 0)$ is the percentage of times the 13 momentum strategies disregard the commodity futures.

Figure 3 - Average contrarian returns over different holding periods



The figure presents the average returns of contrarian portfolios for 3 ranking periods and for holding periods of increasing length. *t*-ratios for the significance of the mean are reported in parentheses.