Commodity Based Momentum Strategies

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Abstract

This paper examines the profitability, diversification benefits and risks related to momentum strategies applied in the commodity futures markets during the sample period 1999 – 2013. The analysis is based individually on commodity momentum strategies as well as a comparison to momentum strategies applied in equity markets. The results suggest that it is possible to successfully execute momentum strategies on commodity markets and achieve substantial diversification benefits, but that investments in these strategies are subject to periods of relatively large drawdown risks. Furthermore, the results also indicate that momentum strategies applied to commodities are suitable complements to a portfolio already consisting of momentum strategies applied to equity markets.

Keywords: Momentum, commodities, alternative investments, investment strategies.

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1 Introduction

In the last decade investing in commodities and particularly commodity indices has become increasingly popular (Fabozzi 2008 and Tang & Xiong 2010). As Masters & White (2008) note, estimates show that commodity index investments increased from a level of 13 billion U.S. dollars in 2003 to 317 billion U.S. dollars just before the sharp decline in commodity prices in 2008. This trend is perhaps not surprising given the growing interest for investing in alternative assets. As an explanation of this trend, Eiling & Gerard (2007) examined a sample of 24 developed countries and 32 emerging markets and found that there has been an upward shift in correlation between equity markets around the world. This would suggest that investors all over the world are more actively looking for alternative assets to provide them with diversification benefits in order to increase risk-adjusted returns. Prior research supports the idea that commodities are able to realize substantial diversification benefits when included in traditional portfolios (Gorton & Rouwenhorst (2006), Kat & Oomen (2006)) which is why it is undoubtedly one of the most interesting so called alternative assets to look further into. The disadvantage of buy and hold strategies in commodities is that the correlation to equities increases in recessions due to a business cycle component inferred in especially energy commodities as found by Bhardwaj & Dunsby (2013).

Fund managers nowadays are more open to alternative investment strategies in their quest to "beat the market" in terms of risk-adjusted returns. When there are good opportunities in the market, those are arbitraged until the profitability is not attractive enough anymore. According to the McKinsey report (2012) "The Mainstream of Alternative Investments: Fueling the Next Wave of Growth in Asset Management", investments in alternative investments doubled from 2005 to 2011 ($6.5 trillion) globally. At an annual rate of 14 percent this outstripped traditional asset classes by far. Over all assets under management in the world, alternative investments stands for approximate one fourth of all investments. Alternatives are also moving more into retail portfolios because these assets are becoming easier to invest in.

Momentum is one of the most common alternative investment strategies and bases the investment decisions on previous returns by going long past winners and short losers, loading risk on further price diverging rather than converging (contrarian strategies). Momentum as an alternative investment strategy has traditionally mainly been used on equity markets because of 1) good liquidity, 2) many investable assets and 3) it is

easy and straightforward to rank historical returns. Momentum in equities is well developed by both academics and professionals (Jagadeesh & Titman 1993), while applying momentum strategies on commodities is a more recent idea (Miffre & Rallis 2007). One reason is that commodity markets have developed to well-functioning investment fields.

This paper evaluates different ways of applying momentum strategies on commodities motivated by the independency and attractive volatility profile of individual commodities. The analysis of momentum effects in commodity markets is additionally motivated by relatively low transaction costs and the fact that there are essentially no restrictions on holding short positions in commodity futures markets. To the best of knowledge this is the first study of commodity momentum strategies evaluated during the sample period 1999 – 2013 including the period between 2008 – 2009 were several financial markets experienced severe market stress and large declines in prices. The results indicate that it is profitable to execute momentum strategies on commodity markets but that the average performance is lower than those found by prior studies which did not include the recent financial crisis. Moreover, commodity based momentum strategies can be used to deliver substantial diversification benefits for investors holding traditional portfolios and, furthermore that it might be suitable to combine momentum strategies applied to equities with those applied in commodity markets.

1.1 Paper outline

The rest of this paper is organized as follows. Section 2 contains a background on commodity investments and momentum strategies as well as a further motivation on the purpose of this paper and the questions intended to be answered. In section 3, previous research on commodities and momentum strategies are discussed. Section 4 describes and discusses the data used in this paper. In section 5, the methodology of this paper is presented with a focus on how the momentum portfolios are constructed and evaluated. Section 6 presents the main findings from the empirical analysis and these are then subsequently analysed and discussed in section 7. Conclusions are presented in section 8 followed by suggestions for further research and practical use of the results in section 9 and 10 respectively.

2 Background

Commodity investments have increased a lot during the last decade due to many factors (Fabozzi et al. 2008 and Tang & Xiong 2010). An attractive correlation pattern to traditional investments like equities and bonds is probably the main reason, but also improvements of investment opportunities across commodities. The transition from non-standardized forward contracts on specific commodities and maturities to a futures market with standardized contracts on common commodities with rolling maturities has given the speculators and investors a new playground.

Commodities should not be seen as one asset since they are hugely independent and follow different fundamentals. This is also true for equities indeed, but 'supply & demand' is considered to be the main price driver in commodities, but only a part of the price in equities. A popular stock will be traded on a high price, but a good harvest for a certain commodity will be considered as supply surplus and therefore lower the price, everything else like. Seasonal effects within certain agriculture commodities will be more important for the price than the long-term view on the commodity itself.

A new way of pricing different assets in combination with a more accessible market to invest in has created a huge field for execution of new investment strategies. There are a lot of investment strategies originally developed for equities that contradict the 'weak market-efficiency', which means that historical information can explain future returns (Fama 1970). Two of the most common strategies are momentum and mean reversal, which only consider the return for a given period in the past for its holding during the following period. Momentum buys winners and sells losers, while mean reversal does it the opposite way. Since the two strategies only take into consideration past prices, these strategies are applicable to execute on commodity prices as well as stock prices. Due to the more volatile and diverse nature of commodity returns, these strategies may even be better to execute on commodity assets rather than equities.

An intuition behind good equity returns is that companies evolve, increase their profitability and grow more than the long-term inflation of around 2%. The risk is the short-term fluctuations in the market beta, and the idiosyncratic risk in certain stocks (which are eliminated in a well-diversified portfolio). An intuition behind commodity returns is harder to find, since the returns are rather negatively correlated to better technology and harvest that drives the companies in such. The commodity returns could be argued to be more 'inflation-like' in the long run, but still with a high short-term

volatility (see Table 2 under Data). This risk may not be that attractive to bear for an investor, since the returns are expected to be lower than for equities, with higher risk. An implementation of trading strategies in commodity prices could make this part of a portfolio more attractive and even less correlated to traditional asset such as stocks and bonds.

2.1 Research Question

This paper will examine whether it is profitable to invest in commodities through momentum strategies rather than buy and hold. Momentum is a zero-cost market neutral strategy with an aim to deliver positive risk-adjusted returns independent of the underlying market. Equity based momentum strategies have been used for a while, hence it would be interesting to see how well a commodity based momentum strategy can increase risk-adjusted returns to an already existing momentum strategy based on equities. This paper therefore investigates the following Research Question:

> **"Is the speculation force strong enough to make momentum strategies profitable on commodities, and can these strategies be used as efficient diversifiers to equity based strategies within a portfolio?"**

2.2 Hypothesis

Testing a momentum strategy on commodities has recently been done by some researches as the field of commodity investments have increased in terms of liquidity and professionalism. At a first sight it feels quite obvious that it is possible to execute a trading strategy based on historical price information on the commodity market with similar results as has been proved on the equity markets. Some highlights should anyhow be in mind when doing this in terms of driving forces for momentum (diverging prices) versus contrarian (converging prices) strategies based on commodities:

- **Market efficiency;** if markets were fully efficient, there should not be room to execute neither momentum nor contrarian strategies with riskless profitable results. However, profitable momentum strategies have been proved on equity markets and the grade of efficiency in markets could be questionable.

- **Fundamentals;** the intuition on equity markets is that previous winners beat losers since the companies will continue develop better than the market even in the future. Intuitively, a commodity with a high return one year will face trouble when consumers look for cheaper substitutes in the future, which rather support a contrarian strategy.
- **Re-balancing;** commodity indices re-balance their portfolios on a monthly, quarterly or yearly basis and will sell commodities with high returns and buy those with lower (if target weights are unchanged), which should affect prices towards a contrarian approach.
- **Speculation;** assets with exceptional returns attract investors in the same way huge price drops cause investors to sell. This is the main driving force and intuition for why a momentum strategy should work in general.

The profitability for contrarian versus momentum strategies will certainly vary over time regarding to different driving forces. This paper will examine whether the speculation force is strong enough to drive prices in a way that makes a momentum strategy profitable on commodities.

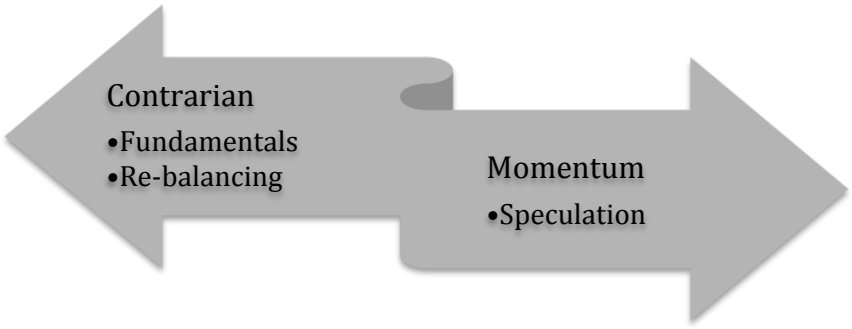

Figure 1: Contrarian and Momentum driving forces

3 Literature Review

In this section, prior research that has been done within the thesis topic area is presented. It begins with a discussion of the most relevant finance literature, moving on to discuss prior research done on the drivers of commodities pricing, momentum strategies in general and momentum strategies applied to commodities in particular.

3.1 Finance

Portfolio theory is a well-established paradigm and the economic theory underlying the investor's optimal portfolio choice, pioneered by Markowitz (1952, 1959), is well understood both by academia and by practitioners. The main conclusion is that combinations of assets that are not perfectly correlated can reduce investment risk without reducing expected returns in a portfolio. The Capital Asset Pricing Model (CAPM) was introduced by Treynor (1961, 1962), Sharpe (1964) and Mossin (1966) independently, building on the earlier work of Markowitz on diversification and modern portfolio theory.

Academics have for a long time tried to explain stock returns through patterns in historical information such as accounting numbers (Fama & French 1993) and by historical returns (Carhart 1997). Starting with the market as a benchmark, the returns where expressed as a Market Beta (β), sensitivity on a certain asset to the market ("M"). This is known as CAPM and explained returns well up to the findings of the model but then failed to explain the main part of future returns. Fama & French (1993) tried to find patterns in stock returns by explaining the "missing part". They came up with two other factors that explained the full picture better. One was the Size factor ("SMB", small companies seemed to outperform big companies) and the other was the Value factor ("HML", companies with high book-to-market value on equity seemed to outperform those with lower, i.e. mature companies outperformed growth companies in the long run). The Fama-French three Factor model explained returns much better than the CAPM and stayed in the market for a long time. Carhart (1997) tried to construct an even better model to explain stock returns by adding a Momentum factor (MOM) to the Fama-French three Factor model. The intuition behind the momentum factor is that winners beat losers when looking at a prior observation period and use the result to buy winners and sell losers into a following holding period. All three additional factors to the

Market (SMB, HML and MOM) build on zero-cost portfolio theory that implies a long leg and a short leg to achieve the relative return between those two over time. By adding SMB, HML and MOM to the CAPM, returns are better explained and the full model looks like equation 1, where ε is an error term and $\beta_{i,X}$ is the factor loading:

$$E(R_i) = R_f + \beta_{i,M}(R_M - R_f) + \beta_{i,SMB}R_{SMB} + \beta_{i,HML}R_{HML} + \beta_{i,MOM}R_{MOM} + \varepsilon \quad (1)$$

3.2 Commodities

Although investing in commodities has increased dramatically in recent years, it is still an open question in the existing literature whether and how investor's should include commodities in their portfolios. Among the first to systemically analyse commodities as an investable asset class were Bodie & Rosansky (1980) who analysed the performance of 23 commodity futures during the period 1950-1976. They found that investors could reduce their risk by 30% without reducing returns by holding a portfolio consisting of 60% stocks and 40% commodities as compared to holding a stock-only portfolio. However, this early research was based on an aggregate measure of commodity futures performance and did not consider the optimal allocations for individual commodities.

A more recent study is the one by Jensen et al. (2000) were an aggregate measure, the S&P Goldman Sachs Commodity Index, is used to analyse the effect of adding commodity futures to a portfolio consisting of stocks, bonds, T-Bills and real estate. They found that, over the period 1973-1997, those portfolios consisting to some degree of commodity futures outperformed the once that did not but that the effect varied depending on monetary policy.

With the growing interest in commodities in the recent decade, research has expanded vastly. Most of the more recent literature has investigated key issues such as whether the investment in commodities delivers a positive risk premium, how the returns of commodities co-varies with more traditional asset classes such as bond and stocks, and how well it hedges against inflation (Erb & Harvey (2006), Gordon & Rouwenhorst (2006) and Kat & Oomen (2007)). The existing literature provides somewhat mixed evidence: Gordon & Rouwenhorst use a dataset spanning 1959-2012 and finds stock-like historical returns for commodity futures whereas Erb & Harvey and Kat & Oomen did not find any evidence of time-persistent risk premiums for single commodities except for a few energy commodities. They do however find that portfolios consisting of

commodity futures can have equity-like returns if they are able to accomplish a high enough diversification return.

Various attempts on finding the drivers of commodity prices have been done and the current empirical literature can generally be divided into two camps. The first one has primarily focused on the development and testing of models based on the CAPM and C-CAPM (Consumption-CAPM). Evidence from these studies has been mixed at best (see Dusak 1973, Hodrick & Srivastava 1984 and Jagannathan 1985). The second set of literature has predominantly focused on how commodity specific factors, such as the commodity basis, can be used to explain the expected return. Fama & French (1987) found evidence that basis can be used to forecast returns for some types of commodities. A number of papers have found evidence that the net holdings of hedgers significantly affect future returns (see Carter et al. 1983; Bessembinder 1992; de Roon et al. 2000).

Hong and Yogo (2009) were the first to combine the two strands when they considered how the common and local factors jointly could be used to determine expected aggregate commodity returns. They found that well-known predicators of bond and stock markets, such as the short interest rate and yield spread, are also able to forecast commodity returns. Furthermore they compare the relative importance of common and local factors for predicting price movements. Daskalaki et al. (2013) builds further upon these results but finds that not only do equity-motivated tradable factors not price commodity future but also that there is no single commodity-specific factor which can explain the time series of returns of every single commodity future. This highlights the heterogeneous structure of the commodity market.

An extension of the paper by Daskalaki et al. is provided by Chevallier et al. (2013) who use the criterion proposed by Alessi et al. (2010) to determine the number of factors to be included in a factor model to price commodities. They find that there are common risk factors to different commodity sectors but also finds that the first factor of the commodity dataset explains a much lower proportion than the first factor for other asset classes such as bonds, equities and currencies. Another extension is one done by Karstanje et al. (2013) who, building on the framework proposed by Diebold et al. (2008), adopts a dynamic Nelson-Siegel model in order to decompose the commodities futures curves into level, slope and curvature factors. Their results show that around 75% of the individual level factor variation can be explained by global and sector components whereas for the slope and curvature factors this fraction is around 60%. The rest can be attributable to an idiosyncratic component for each commodity.

In a recently published paper by Lombardi & Ravazzolo (2013) the authors show that the correlation between commodity and equity returns, in particular those for oil commodities, has increased substantially after the recent financial crisis. Furthermore, they argue that in the most recent years it looks like both commodity and equity prices has become more sensitive to news about the global macroeconomic environment instead of idiosyncratic and local market shocks. Bhardwaj & Dunsby (2013) notes that over the last fifty years the stock-commodity and stock-bond correlations have both been close to zero but that the annual correlation coefficient between stocks and commodities has varied dramatically, ranging from -0.39 to 0.76. The authors find that the correlation within the commodities asset class and the correlation to stocks increase during bad economic times and argue that this is most likely due to a business cycle component. Another explanation for this pattern is proposed by Tang & Xiong (2010) who argue that the correlation between stocks and commodities has seen a permanent increase because of a higher investor involvement in the commodity markets. The authors also find that the correlation between prices of non-energy commodities and oil prices have become substantially more correlated and that this trend is particularly true for the commodities in the two most popular commodity indices: the S&P GSCI and the DJ-UBSCI.

3.3 Momentum

Jagadeesh & Titman (1993) documented momentum as stocks performed well in a prior period of three- to twelve-months also outperformed other stocks in the following period of three- to twelve-months. Grundy & Martin (2001) investigated the risks of the Jagadeesh & Titman approach and concluded that the Fama-French three Factor model could not explain the risk in a momentum strategy, but there must be other explanatory variables of risk exposure. Over the 1926-1995 period, a momentum strategy would have earned an average monthly return of 0.44% (t-statistics of 1.83) according to Grundy and Martin. The fully understanding of the risks in a risk-adjusted momentum strategy by controlling for Fama-French three factors, remain as an open question at this point in time. Moskowitz & Grinblatt (1999) argued that momentum returns are explained by industry momentum as an additional factor, beside the Fama-French three factor model. However, Grundy & Martin conclude that this result is observable but not telling the whole story and there is much more to explore to understand risk metrics in momentum strategies on the stock market. Jagadeesh & Titman (2001) confirmed the seasonality

effect in momentum returns that the historical returns are negative in January but significantly positive in every other month. This is in contrast to other factors like the size effect and the book-to-market effect, which are significantly stronger in January.

3.4 Momentum in Commodities

Miffre & Rallis (2007) concluded that momentum strategies are much more profitable than contrarian strategies when applying those on commodity futures. The data contained 31 US commodity contracts and the average annual return generated was 9.38% over the period 1979-2004, while a long-only equally weighted portfolio of commodity futures lost 2.45%. A ranking period of twelve months and a holding period of one month was the most profitable momentum strategy in the paper, and supported the thesis of long ranking period followed by a short holding period in momentum strategies. Active management in commodity futures markets have historically been profitable, in line with the analysis of Erb & Harvey (2006). Narayan et al. (2012) tested a moving average approach on gold, silver, oil and platinum on the futures and spot markets, compared to the classical momentum strategies based on *n*-month previous returns. The results were profitable for silver, oil and platinum but not for gold and were similar using futures and spot prices. Patterns across commodities tend to be clear when testing them quantitatively but hard to understand intuitively beforehand.

4 Data

Beginning with commodities, followed by equities and bonds, all data are presented and discussed in this section. The data used in this paper are gathered from Datastream.

4.1 Commodities

Since the market environment is constantly changing appearance and characteristics, this paper will examine whether commodity based momentum strategies have been profitable enough in modern time. Data is therefore ranging between 1999-2013 to cover the latest trends and price patterns of commodities, covering both bull and bear markets. All data is in U.S. Dollars and the individual commodities are the constituents of the Goldman Sachs Commodity Index (GSCI), which includes 24 individual commodities. For the purpose of this thesis Feeder Cattle is excluded because of limited availability of time series data for the full sample period. Furthermore, since the series behaves extremely similar as the series of Live Cattle it does not add much information for the purpose of this thesis. Therefore there are 23 commodities included in the research.

The GSCI is one of the most common and largest assets under management commodity indices, assumed to be $100 billion in November 4, 2011 according to a report by Credit Suisse (2011). The index is more weighted towards energy commodities, compared to most other commodity indices. However, since this paper covers the individual constituents of the index the strategies used will be completely independent of any weighting scheme. The Goldman Sachs Commodity Index used in this research paper only trades on front-month futures, which means that they buy and hold the closest maturity (often 3-month) in all commodities and roll over the contracts on a quarterly basis. The WTI contracts roll over every month due to higher liquidity. The paper is constrained to only use this type of trading in the front-month contracts in order to make sure that only trading in the most liquid contracts. Thus, the results may be conservatively affected since they will not capture any illiquidity premia. However, since the interest predominately is generating positive excess returns from the momentum strategies at the lowest possible cost, this is a suitable process for the purpose of this thesis.

The GSCI is published in three different forms: excess return, total return and spot return. For the purpose of this thesis the total return index is used, which represents

the returns accumulated from investing in fully collateralized nearby commodity futures contract. The total return measure is completely comparable to the returns one could earn from a regular equity investment where dividends are reinvested. Therefore, the total return measure is suitable for when comparing the returns earned by implementing momentum strategies on commodities to those earned on equities. Furthermore, as the total return index is commonly used in prior research on commodity momentum, making a meaningful comparison of the results to those results evaluated on earlier sample periods is possible.

Summary statistics for each individual commodity can be found in table 1. These summary statistics confirm prior research about the heterogeneous characteristic of the individual commodity assets. Large differences in average annual mean returns are observed, with the highest return realized by Unleaded Gas (17.2%) whereas the lowest return is realized by Natural Gas (-25.3%). Furthermore relatively high standard deviation is seen, at an average of 30% across all commodities, which confirms prior studies showing that a large portion of the risk in commodities is due to idiosyncratic risk. The sample period contains both periods of sharp declines in commodity markets in general as well as periods in where commodities have performed very well. Thus, the study cover a long enough period so it is at least able to discuss whether the results are expected to continue in the future even though they are not able to determine if the pattern identified will in fact continue. Prior research on commodity trading strategies has typically only evaluated strategies up until year 2006. This is why the sample period used in this paper is particularly interesting since this period include the large decline in commodity prices in recent years.

Table 1: Summary statistics of log returns for GSCI Total Return Index between 1999-2013

Commodity	Mean	Variance	St.Dev	Skewness	Excess Kurtosis	Min	Max	Observations
Crude Oil	9.6%	0.8%	35.0%	-0.33	3.33	-16.5%	13.3%	3907
Brent Crude Oil	16.3%	0.6%	32.1%	-0.30	3.27	-13.9%	12.9%	3907
Unleaded Gas	17.2%	0.8%	36.1%	-0.26	2.33	-12.8%	13.0%	3907
Heating Oil	11.8%	0.7%	33.6%	-0.16	1.97	-13.9%	9.9%	3907
Gas Oil	15.0%	0.6%	30.6%	-0.17	2.46	-14.4%	10.7%	3907
Natural Gas	-25.3%	1.5%	49.1%	0.04	2.31	-16.7%	18.8%	3907
Aluminum	-0.3%	0.3%	21.6%	-0.28	2.63	-8.2%	5.9%	3907
Copper	12.8%	0.5%	27.5%	-0.13	4.46	-10.4%	11.9%	3907
Lead	10.1%	0.7%	32.9%	-0.24	3.70	-13.1%	12.8%	3907
Nickel	11.0%	0.9%	37.5%	-0.15	3.75	-18.3%	13.2%	3907
Zinc	2.4%	0.6%	30.0%	-0.18	3.11	-11.1%	9.3%	3907
Gold	8.7%	0.2%	18.6%	-0.14	6.54	-9.8%	8.8%	3907
Silver	7.9%	0.6%	31.8%	-0.97	8.04	-19.5%	12.5%	3907
Wheat	-9.6%	0.6%	30.5%	0.07	2.19	-10.0%	8.8%	3907
Red Wheat	-3.8%	0.5%	27.4%	0.05	2.19	-9.0%	8.1%	3907
Corn	-6.3%	0.5%	27.7%	0.06	2.24	-8.1%	8.7%	3907
Soybeans	8.5%	0.4%	24.5%	-0.18	2.22	-7.3%	6.7%	3907
Cotton	-6.6%	0.5%	27.6%	-0.05	1.22	-7.1%	6.9%	3907
Sugar	3.0%	0.7%	33.3%	-0.28	2.02	-12.4%	8.4%	3907
Coffee	-12.9%	0.7%	34.0%	0.24	6.70	-13.4%	21.2%	3907
Cocoa	1.6%	0.6%	31.1%	-0.15	2.49	-10.0%	9.9%	3907
Live Cattle	0.2%	0.1%	13.9%	-0.21	2.34	-6.4%	3.7%	3907
Lean Hogs	-8.0%	0.3%	23.4%	-0.07	0.98	-6.4%	5.7%	3907

The table shows the summary statistics for the full sample period. Mean. standard deviation and variance are annualized figures.

Summarizing monthly standard deviations for all individual assets shows a pattern with similar volatility hikes for energy and metal commodities to those experienced by equities (January and October), while agriculture commodities have higher standard deviation during harvest periods (mainly in Jun - Aug). The independence and different driving forces for price changes of different commodities are shown in the volatility table below.

Table 2: Monthly standard deviation between 1999-2013. Individual relative color pattern

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Equity	4.3%	3.8%	5.3%	4.2%	4.1%	4.3%	4.3%	4.7%	5.5%	6.8%	5.7%	4.4%
Bonds	2.0%	1.7%	2.3%	1.9%	1.9%	2.1%	1.9%	1.9%	2.0%	1.8%	1.8%	2.1%
S&P GSCI	6.7%	6.4%	7.2%	6.0%	6.4%	6.6%	5.9%	6.0%	7.5%	7.7%	7.4%	7.4%
Crude Oil	10.4%	9.7%	10.9%	9.3%	9.3%	9.6%	8.4%	8.5%	10.9%	10.6%	11.2%	11.7%
Brent Crude Oil	9.1%	8.9%	10.1%	8.6%	8.5%	9.1%	7.5%	7.6%	9.9%	9.8%	10.6%	10.7%
Unleaded Gas	10.0%	10.5%	10.5%	9.4%	9.6%	9.7%	8.8%	9.9%	11.6%	11.3%	11.5%	11.6%
Heating Oil	9.7%	9.8%	10.8%	9.0%	9.2%	9.7%	8.0%	8.4%	10.5%	9.8%	10.0%	10.8%
Gas Oil	9.6%	8.5%	9.8%	8.2%	8.3%	8.4%	7.6%	7.4%	10.0%	9.3%	9.1%	9.1%
Natural Gas	16.6%	14.8%	12.7%	11.2%	12.2%	13.9%	13.4%	14.7%	14.7%	14.2%	14.2%	16.7%
Aluminium	6.6%	6.5%	6.0%	6.4%	6.7%	6.3%	6.2%	5.4%	6.0%	6.7%	6.4%	5.6%
Copper	8.2%	8.2%	7.2%	7.9%	8.8%	8.1%	6.5%	7.0%	7.2%	10.7%	7.9%	6.7%
Lead	9.5%	9.4%	8.6%	8.4%	9.7%	9.0%	8.7%	10.1%	9.8%	11.9%	9.7%	8.7%
Nickel	12.4%	9.7%	9.6%	9.8%	10.8%	11.5%	9.4%	10.0%	10.8%	13.4%	11.4%	10.2%
Zinc	9.0%	9.2%	8.0%	8.2%	9.1%	9.3%	8.2%	8.2%	8.4%	10.0%	9.2%	6.9%
Gold	4.9%	5.8%	5.1%	5.3%	5.0%	5.7%	4.6%	4.8%	6.7%	5.7%	5.3%	5.1%
Silver	8.1%	8.1%	8.6%	10.8%	9.4%	9.2%	7.5%	8.6%	11.3%	9.8%	9.2%	8.8%
Wheat	8.3%	8.3%	10.2%	8.2%	8.7%	9.5%	8.6%	9.2%	9.0%	9.9%	7.9%	7.2%
Red Wheat	7.7%	7.9%	9.2%	7.7%	7.6%	8.5%	7.3%	8.2%	8.1%	8.4%	7.5%	6.6%
Corn	7.6%	5.7%	7.7%	7.4%	7.8%	9.4%	9.9%	8.3%	8.3%	9.1%	6.9%	6.5%
Soybeans	6.6%	6.1%	7.3%	6.2%	6.4%	7.4%	8.8%	8.2%	7.2%	7.7%	6.6%	5.6%
Cotton	7.2%	8.1%	8.4%	7.3%	8.1%	8.6%	7.9%	8.0%	7.8%	8.7%	8.3%	7.1%
Sugar	9.6%	9.4%	11.1%	9.2%	9.4%	9.9%	9.5%	9.3%	9.6%	10.2%	9.2%	9.0%
Coffee	8.8%	7.8%	9.4%	8.7%	9.1%	9.0%	11.5%	9.1%	9.9%	12.7%	11.0%	9.5%
Cocoa	9.5%	9.0%	10.1%	8.6%	8.5%	9.4%	9.0%	8.3%	8.8%	8.8%	8.9%	8.8%
Live Cattle	3.6%	3.6%	4.2%	4.3%	4.0%	4.3%	3.7%	3.7%	3.7%	4.3%	3.8%	4.6%
Lean Hogs	6.3%	6.5%	6.2%	6.6%	5.8%	6.7%	7.1%	8.0%	7.0%	8.2%	6.0%	5.9%

4.2 Equities

For the purpose of this thesis, the Standard & Poor's 500 (S&P 500) is used as a measurement for a well-diversified equity portfolio. The S&P 500 is a market capitalization weighted index that includes 500 large companies, which are listed on the New York Stock Exchange or the NASDAQ. It is undoubtedly one of the most commonly followed equity indices and is particularly suitable for comparison purposes since it is an US based index and the commodities included in this thesis are typically denominated in U.S. dollars.

To compare the performance of commodity momentum strategies with strategies applied to equities, S&P 500 is used as a proxy for the equity investment universe. To avoid any survivorship bias in the data, the S&P 500 composition as of 1999 is the

starting point with adjustments for any additions and deletions in the index as time passes by.

4.3 Bonds

J.P. Morgan Global Government Bond Total Return Index is used as a proxy for the broad bond market. This is an U.S. dollar denominated index that consists of actively traded investment-grade issues and spans from developed to emerging markets and is thus a good proxy for the overall development of fixed income securities available to the common investor.

5 Methodology

In this section the methods employed in this thesis paper are discussed. Beginning by explaining how the returns are calculated for each asset included in the investment universe followed by how the returns for particular zero-cost momentum portfolios are defined. Subsequently, discussing how the momentum portfolios are constructed in this thesis and how these are successively evaluated across time.

5.1 Return definition

To evaluate the returns used in the research, the simple return from time t to t + T follows the standard definition in the current momentum literature:

$$r_{T,t} = \frac{V_T}{V_t} - 1 \tag{2}$$

where V_t and V_T represents the initial value at time t and the final value of the asset respectively. For the individual commodities this final value will include any collateral and roll return whereas for equities the final value will be adjusted for corporate actions such as splits and dividends. Consistent with this return definition, the return for the zero-cost momentum portfolios is defined as:

$$r_{T,t} = \left(\frac{V_T^{long}}{V_t^{long}} - 1\right) - \left(\frac{V_T^{short}}{V_t^{short}} - 1\right) \tag{3}$$

where V^{long} and V^{short} represents the value of the long and short leg of the momentum portfolio respectively.

5.2 Momentum portfolios

As stated previously, the logic behind the momentum theory is that those assets that have performed well in the past (winners) will continue to perform well in the future while those assets that have performed poorly in the past (losers) will continue to perform poorly in the future. To profit from this pattern one would want to buy (go

long) the previous winners and sell (go short) previous losers. To form the winner and loser portfolios all assets in the investment universe will be ranked in ascending order based on the asset's previous return for the relevant ranking period. Subsequently, the previous winners and losers are separated and sorted into portfolios.

To invest in the momentum portfolio described above one should short-sell the loser portfolio and use the proceeds from the short selling to invest in the winner portfolio. The frequency of this practice is once a month. Financing the long position in the winner portfolio with the proceeds from the short position in the loser portfolio, and ignoring any transaction costs or margin requirements, creates a zero net-investment portfolio.

In order to evaluate the persistency of the momentum effect in this thesis, several combinations of holding periods (H) and ranking periods (R) are tested. In the study of momentum profitability, ranking periods of 1, 3, 6 and 12 months in combinations with holding periods of 1, 3, 6 and 12 months are evaluated. Each month consists of 21 active trading days. All possible combinations result in 16 short-term momentum strategies. For example, the 1-1 momentum strategy will go long (short) the assets that performed best (worst) during the last month and consequently hold these assets for the next month. In the following presentation all portfolios will be classified as H-R momentum strategies where the H and R will represent the holding and ranking period respectively.

In the process to construct and evaluate the performance of the momentum strategies one needs to make a decision of whether the portfolios are to be non-overlapping or overlapping across time. A non-overlapping technique is undoubtedly the easiest technique to understand and apply. This process is based on some ranking period t – R and will take a position at time t and subsequently hold this investment until time t + H. Then, at time t + H, the process will repeat itself meaning that the next position will be based on the ranking period from t + H – R to t + K and will be held until t + H + H. Albeit very simple to use, this evaluation method comes with drawbacks such as that it is subject to the bid-ask bounce, which could potentially make the results somewhat biased as shown by Moskowitz and Grinblatt (1999).

For the purpose of this thesis, overlapping portfolios are used to avoid any bias in the results. More importantly, with this process the power of the tests conducted in this thesis is increased and it is possible evaluate shorter sub-samples of the full sample period. Furthermore, since prior research on momentum strategies applied to commodities has predominately used the technique of overlapping portfolios this makes

comparisons with earlier results easier to interpret. The main idea of the overlapping technique is to apply a set of overlapping sub-portfolios. In this process the chosen investment strategy will be followed every month so that at any month t in the sample, positions corresponding to a series of momentum portfolios held from the preceding H-1 months will be active. Practically, this means that for every month t the strategy will go long the winner portfolio and short the loser portfolio and at the same time close out the portfolio which was initiated in month t – H. Within each momentum strategy, all individual momentum portfolios are equally weighted. In figure 2 an illustrative example of the overlapping technique applied in this paper is provided where R = 3 months and H = 6 months. The figure is a generalization of the technique and will differ depending on the particular ranking and holding period used. The number of portfolios for an individual momentum strategy at any point in time will correspond to the number of months in the holding period (H).

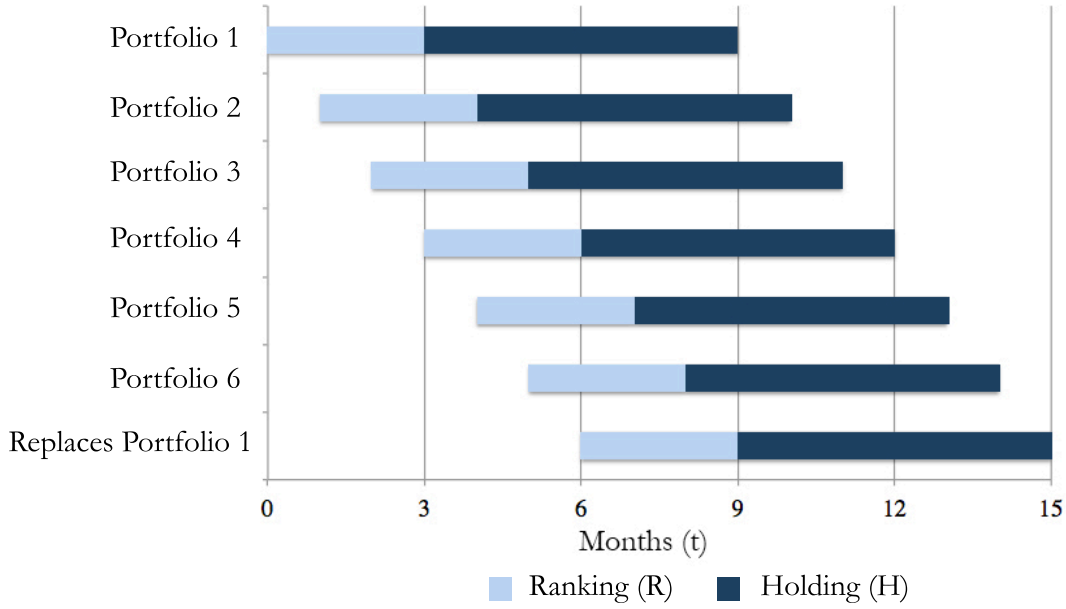

Figure 2: Overlapping portfolio methodology with R = 3 months, H = 6 months

5.2.1 Commodities

At the end of each month the total returns of the individual commodities are ranked and sorted into quintiles based on their average return over the previous R months (ranking period). In this paper this means that long 5 positions and short 5, out of the sample of 23 commodities. Earlier studies that have evaluated momentum in equities (see

Moskowitz & Grinblatt 1999 and Jagadeesh & Titman 2001) typically sort the prior returns into deciles and not quintiles. This paper's investment universe is limited to 23 commodities the procedure of using quintiles is chose, since it has been a common practice when evaluating momentum strategies for smaller cross sections, see for example Miffre & Rallis (2007). By using quintiles instead of deciles the portfolios will experience increased risk diversification across the investment universe. However, this will be done at the cost of decreasing the dispersion between the returns of the winner and loser portfolios, which subsequently will reduce the total profitability of the strategies. Therefore, the use of quintiles will result in more conservative results in terms of average returns but will enhance the stability of the portfolios over time.

5.2.2 Equities

The process for creating momentum portfolios for equities will follow the same process as outlined above with the exception that equities have such a large sample and are ranked as top and bottom deciles instead of quintiles. Prior studies on equity momentum (see for example Jegadeesh & Titman 2001) sometimes screen out those stocks with low market capitalization in order to avoid illiquid stocks. The equity investment universe in this paper consists of the S&P 500 Index, which is composed of mostly very liquid stocks and no exclusions are used.

5.2.3 Risk evaluation

To measure the profitability of the momentum portfolios after accounting for risk the following multifactor model is constructed:

$$R_{Pt} = \alpha + \beta_B\left(R_{Bt} - R_{ft}\right) + \beta_M\left(R_{Mt} - R_{ft}\right) + \beta_C\left(R_{Ct} - R_{ft}\right) + \varepsilon_{Pt} \quad (4)$$

where R_{Pt} is the return of the momentum portfolio, R_{Bt}, R_{Mt} and R_{Ct} are the returns on J.P Morgan Global Government Bond Index, the S&P500 Index and Goldman Sachs Commodity Index respectively, R_{ft} is the risk-free rate and ε_{Pt} is an error term. The 3-month US Treasury Bill middle rate gathered from Datastream is used as a proxy for the risk-free rate.

To compare individual momentum strategies with each other, both within the commodities asset class but also for the purpose of comparisons with momentum strategies applied on equities, one measure to capture large and unusual losses is used as

well as one to compare risk-adjusted returns. These measures are the maximum drawdown and the Sharpe ratio, which are discussed in further detail below.

5.2.3.1 Maximum Drawdown

Maximum drawdown is a relatively new risk measure, which has its origins in the finance literature paper by Grossman & Zhou (1993) and is often described as a risk measure suitable for real-world investors.

The maximum drawdown represents the maximum loss incurred from a peak to a bottom during a certain time period. Two of the most important moments of a return distribution are the mean and the standard deviation and many investors focus on these two parameters when they evaluate their portfolio. However for volatile time series, such as for commodities, the portfolio risk will be masked when skewness and kurtosis are ignored or when the return distribution exhibits a strong positive serial correlation (Pederson & Rudholm-Alfvin 2003). In these cases, the maximum drawdown is a common and useful tool to evaluate the worst-case scenario. The maximum drawdown can be calculated as an arithmetic or geometric Brownian motion with drift or in terms of the maximum percentage drop from a peak. For the purposes in this paper, the last alternative is most suitable and will be applied throughout the paper by using the following formula:

$$Maxmimum\ Drawdown = \frac{(bottom\ value - peak\ value)}{peak\ value} \tag{5}$$

Figure 3 is an illustration of the maximum drawdown measure, which will be used in this paper.

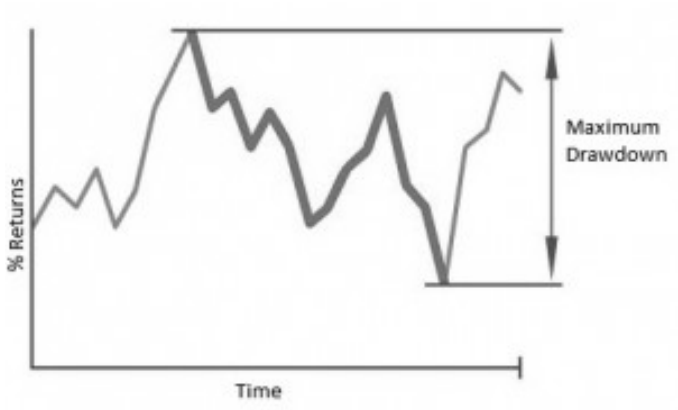

Figure 3: Maximum Drawdown illustration

5.2.3.2 Sharpe Ratio

Sharpe Ratio (SR) is a measure for risk-adjusted returns in terms of excess returns (returns above the risk-free rate, "$E(R_p) - Rf$") and standard deviation ("Std_p") and will be used to measure the risk-adjusted performance of the momentum strategies within this paper using the following formula:

$$SR_p = \frac{E(R_p) - Rf}{Std_p} \tag{6}$$

6 Results

The empirical results from the momentum portfolios evaluated over the time period 1999 – 2013 are presented in this section. Firstly the returns realized by the individual momentum portfolios, followed by discussing the risks and finally a discussion of the portfolios' ability to act as diversifiers in the context of a traditional portfolio.

6.1 Momentum profits

The results from the momentum strategies applied to commodities over the period from 1999 to 2013 are shown in table 3. All of the 16 different combinations of holding and ranking periods are able to deliver positive returns for the full sample period. Across all combinations, the momentum strategies deliver an average annual return of 3.02%.

The possibility remains that the returns realized on these strategies pay off as a compensation for risk. Therefore, the annualized standard deviations and the Sharpe ratios are reported for all strategies. Not surprisingly, the most profitable strategies are also among the most risky. The highest return for an individual strategy is 7.21% achieved by the 1-12 strategy (one month holding period based on 12 months ranking period). However, this is also the strategy that has the highest standard deviation in the sample, 14.76%. That being said, the 1-12 strategy has the highest Sharpe ratio, representing the highest risk-adjusted return.

Table 3: Momentum profits commodities 1999-2013

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	1.23%	5.50%	5.04%	7.21%
	(0.46)	(1.77)	(1.57)	(1.93)
Standard deviation	10,48%	12.22%	12.70%	14.76%
Sharpe Ratio	0.12	0.45	0.40	0.49
Holding period of 3 Months				
Mean	2.34%	3.89%	2.95%	4.33%
	(1.27)	(1.45)	(0.92)	(1.22)
Standard deviation	7.30%	10.48%	11.59%	13.97%
Sharpe Ratio	0.32	0.37	0.35	0.31
Holding period of 6 Months				
Mean	1.95%	2.95%	1.73%	1.19%
	(1.42)	(1.37)	(0.68)	(0.43)
Standard deviation	5.40%	8.41%	10.00%	10.79%
Sharpe Ratio	0.36	0.35	0.17	0.11
Holding period of 12 Months				
Mean	2.19%	2.99%	2.22%	0.66%
	(2.21)	(1.83)	(1.08)	(0.28)
Standard deviation	3.97%	6.51%	8.10%	9.37%
Sharpe Ratio	0.56	0.46	0.27	0.07
Average of all holding and ranking periods				
Mean	3.02%			
Sharpe Ratio	0.32			

Figure 4 shows the performance of the zero-cost momentum portfolios applied to commodities over increasing holding periods. The results on commodities are consistent with those reported by Rouwenhorst (1998) and Jegadeesh & Titman (2011) who found that the average return for portfolios of momentum strategies applied to equities for a given ranking period is declining in the length of holding period. Intuitively this indicates that after a period of an initial price continuation, the market will experience a subsequent price correction. This is also consistent with the thought presented by Barberis et al (1998) and Hong & Stein (1999) that short-term investors are able to momentarily move prices away from the long-run equilibrium, which eventually will lead

prices to overreact. Once the market has recognized the overreaction, the prices will adjust back to their equilibrium level.

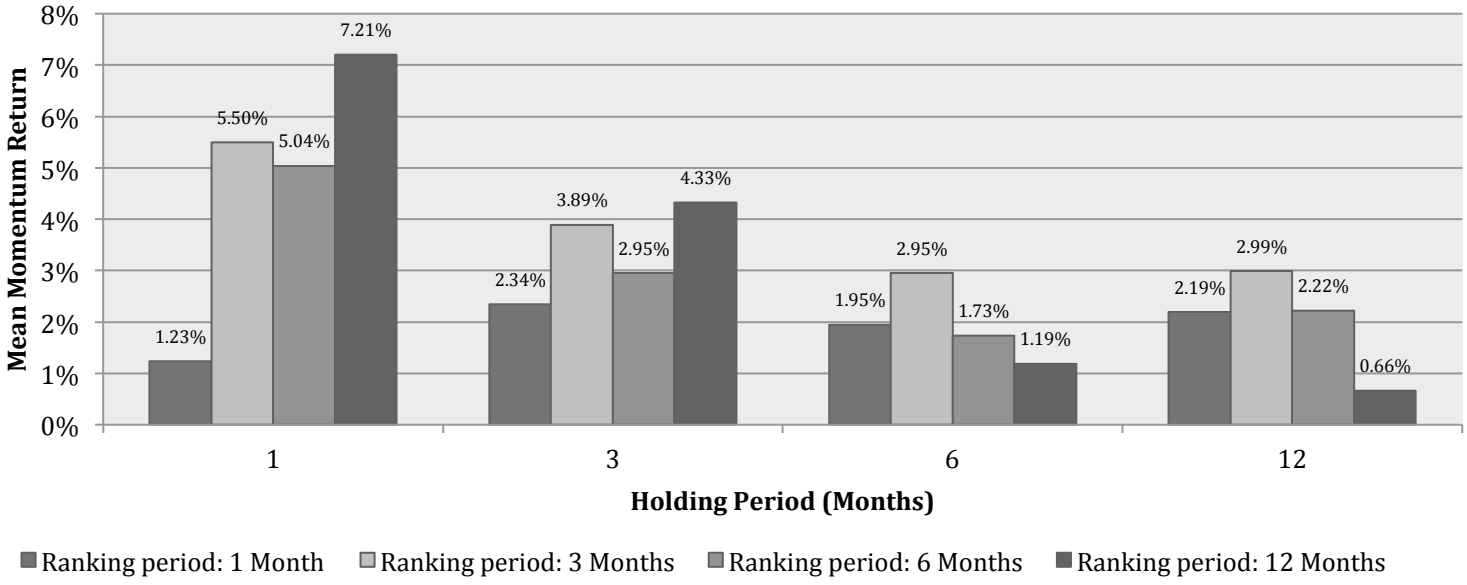

Figure 4: Returns realized between 1999-2013 across different holding and ranking periods for the commodity momentum strategies

Table 4 shows the results from momentum strategies applied to the equity market over the period 1999 to 2013. Again, all of the 16 different combinations of holding and ranking periods are able to deliver positive returns for the full sample period. Across all combinations, the momentum strategies deliver an average annual return of 4.95% and a corresponding average Sharpe ratio of 0.60. Furthermore, the holding and ranking periods combinations associated with the highest returns (1-12 and 3-12) of 9.73% and 9.51% are also those that show the highest standard deviations at 10.79% and 10.48% but also the largest Sharpe ratios. This is consistent with the results from the commodity momentum strategies.

Table 4: Momentum profits equities 1999-2013

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	-0.59%	0.93%	6.37%	9.73%
	(-0.33)	(0.43)	(2.62)	(3.56)
Standard deviation	6.98%	8.57%	9.52%	10.79%
Sharpe Ratio	-0.08	0.11	0.66	0.9
Holding period of 3 Months				
Mean	0.15%	3.63%	7.27%	9.51%
	(0.11)	(1.83)	(3.17)	(3.58)
Standard deviation	5.40%	7.78%	9.05%	10.48%
Sharpe Ratio	0.03	0.46	0.81	0.91
Holding period of 6 Months				
Mean	1.53%	4.58%	7.01%	8.53%
	(1.31)	(2.67)	(3.34)	(3.41)
Standard deviation	4.60%	6.83%	8.25%	9.84%
Sharpe Ratio	0.33	0.68	0.85	0.853
Holding period of 12 Months				
Mean	1.87%	4.45%	6.28%	7.91%
	(1.91)	(3.12)	(3.43)	(3.55)
Standard deviation	3.81%	5.56%	7.14%	8.73%
Sharpe Ratio	0.49	0.79	0.87	0.90
Average of all holding and ranking periods				
Mean	4.95%			
Sharpe Ratio	0.60			

Figure 5 shows the performance of zero-cost momentum portfolios over increasing holding periods. Again, some evidence of the pattern of decreasing average returns as holding period increase is observable. This is particularly true for those strategies that have a relatively long ranking (12 months) period whereas the opposite seems to be true for those strategies that have a very short ranking period (1 month).

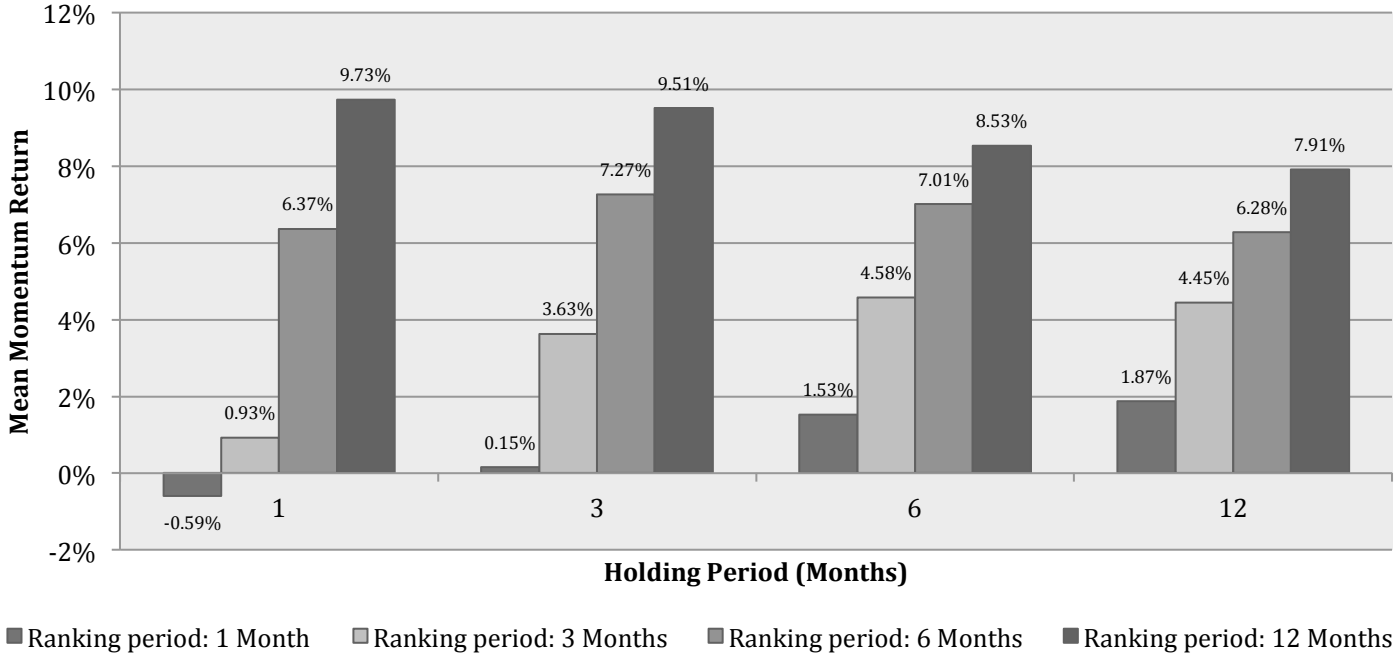

Figure 5: Return realized between 1999-2013 across different holding and ranking periods for the equity momentum strategies

In figure 6, the average cumulative returns across all individual holding and ranking periods for the momentum strategies for both commodities and equities are shown. Furthermore, the cumulative returns of a buy and hold investment in the S&P 500 and the GSCI respectively are included. This figure once again highlights the excessive returns generated by the momentum strategies above their corresponding buy and hold benchmark, applied both to equities and commodities. Moreover, it is also clear that while the equity momentum strategy has been the most successful during this period in terms of total return it has also been subject to some period of very large drawdowns. The figure also highlights the large market shifts that have occurred in both of the underlying assets. The S&P 500 and the GSCI have during the sample period experienced sharp declines as well as relatively stable performance.

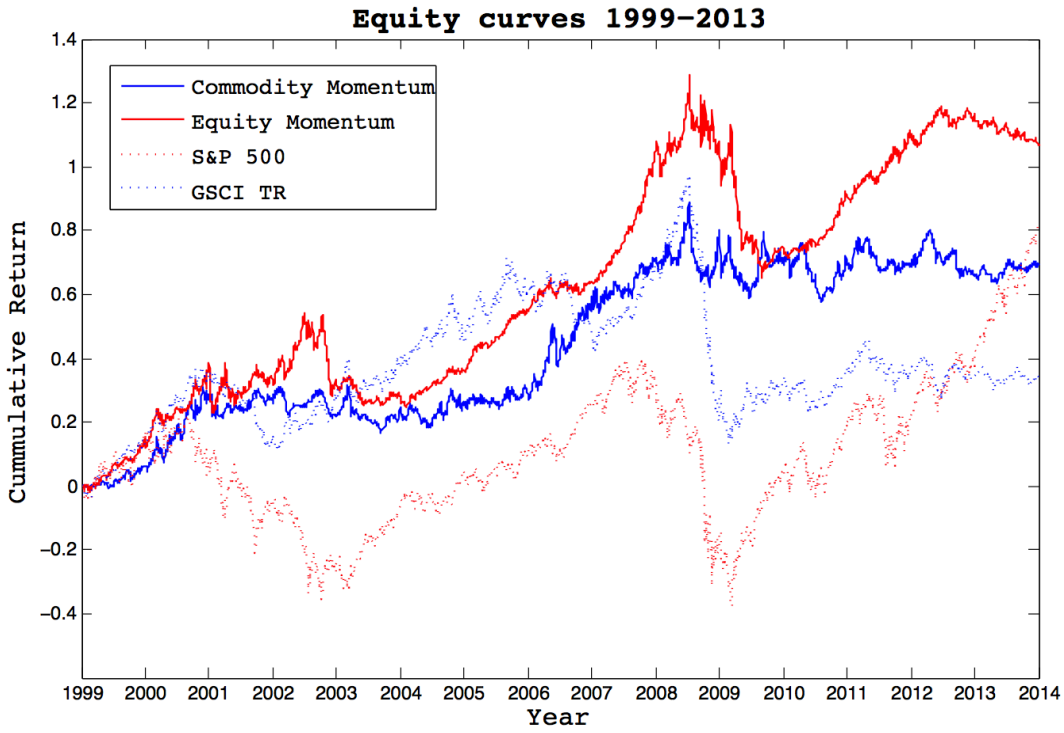

Figure 6: Average cumulative returns between 1999-2013 for the commodity and equity momentum strategies (solid lines) as well as the buy and hold strategies applied to GSCI and the S&P 500 (dotted lines)

In figure 7, the 16 individual momentum strategies for commodities in the standard mean return and standard deviation space are shown. For reference, the numbers of index investments in bonds, equities and commodities are also illustrated. Not surprisingly the results show that there exists a large dispersion in the returns achieved by the individual momentum strategies. As a general tendency, several of the momentum strategies are able to deliver returns similar to traditional investments but at a lower risk as measured by the standard deviation. However, for some of the momentum strategies disappointing returns well below those generated by the traditional assets are experienced.

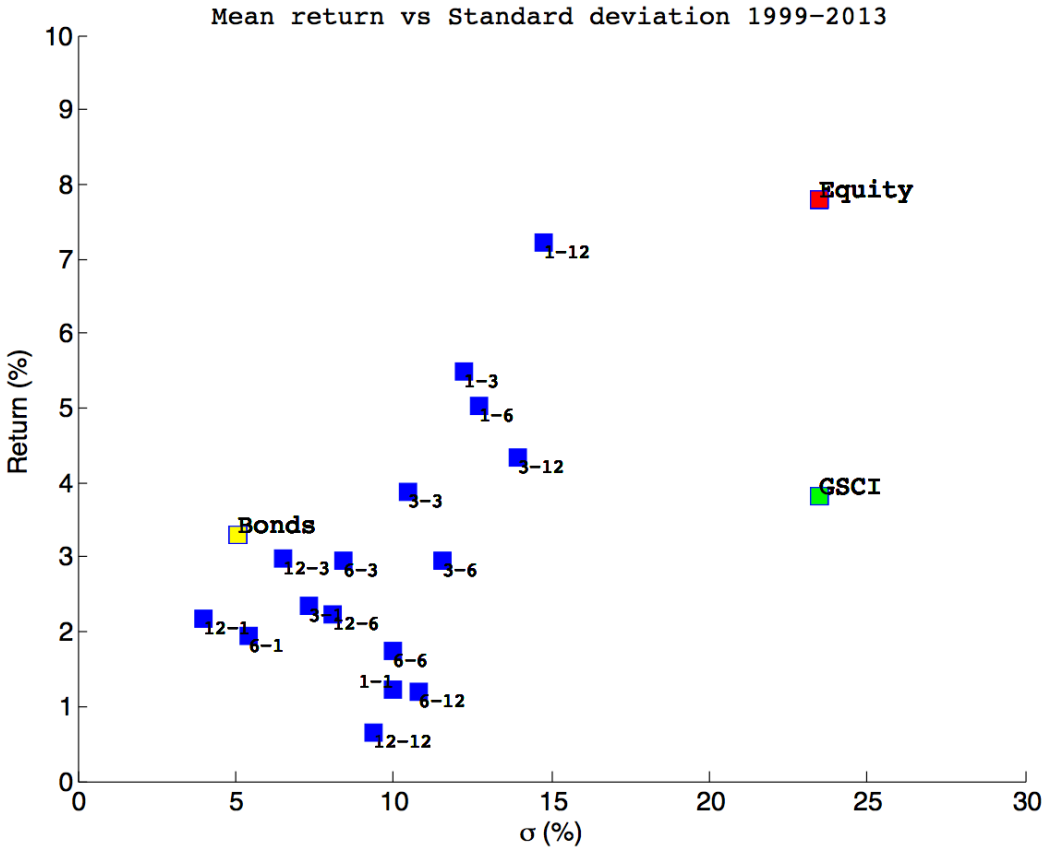

Figure 7: Annual mean return and standard deviation for each individual commodity momentum strategy as well as the figures for buy and hold investments in bonds, equity and commodities (GSCI) over the period 1999-2013. Momentum strategies are reported as H-R where H and R represent holding and ranking period

In the most recent momentum literature, there has been a strong focus on momentum crashes – periods when momentum strategies perform extremely poorly. In the results above, the equity momentum strategy experienced time-periods where it on average performed very poorly. Therefore, it is interesting to evaluate momentum portfolios during different sub-periods. Aside from the full sample period between 1999 and 2013 a split has been made between "pre-crisis" from 1999 – 2007 as well as the crisis period 2008 – 2009.

For the pre-crisis period (1999-2007), panel A in table 5, the average return for the commodity momentum strategies are 5.53% with an average Sharpe ratio of 0.56. The corresponding figures for the equity momentum strategies for the same sample period is 7.92% and 1.07. Interestingly, both the commodity and the equity momentum strategies deliver positive returns for all combinations of ranking and holding periods during this period. The full results for all individual strategies can be found in Table 15 and 16 in the Appendix. In table 5 the average maximum drawdown experienced by the

momentum strategies are shown. During the pre-crisis period the average maximum drawdown for the commodities strategies are lower than for the strategies applied to equities, at -17.51% and -20.75% respectively. For the crisis period, shown in Panel B in table 5, measured between 2008 – 2009 the average return for the commodity momentum is -0.12% with an average Sharpe ratio of -0.05. The corresponding figures for the equity momentum strategies are -6.66% and -0.53. Results for each individual strategy can be found in Table 17 and 18 in the Appendix.

Table 5: Momentum profits during sub periods

Average across all combinations of holding and ranking periods.

	Panel A: 1999-2007			**Panel B: 2008-2009**	
	Commodities	Equities		Commodities	Equities
Mean	5.53%	7.92%	Mean	-0.12%	-6.66%
Sharpe Ratio	0.56	1.07	Sharpe Ratio	-0.05	-0.53
Max Drawdown	-17.51%	-20.75%	Max Drawdown	-20.98%	-28.22%

During the crisis period all 16 combinations of holding and ranking periods applied to equities realized negative returns. For the commodity strategies the results were that 5 out of the 16 strategies realized a positive return for the same period. Furthermore, the maximum drawdown for the commodity strategies is, on average, significantly lower than for the equity strategies. Across all strategies, the commodities experienced a maximum drawdown of -20.98% whereas the corresponding figure for the equity strategies is -28.22%. Each strategy's individual maximum drawdown during the sub samples is presented in Table 19 and 20 in the Appendix.

Those commodity strategies that performed poorly generally have a long holding period, typically those with a holding period of 12 months. The results are not surprising given the earlier results showing that those strategies have been shown to have a risk indicated by the higher standard deviation. The commodity market declined substantially in 2008 – 2009, as evident in figure 6, and it is perhaps not unreasonable to believe that the strategies with a long holding period combined with a long ranking period would be slow to react to these volatile and changing markets.

6.2 Risk Evaluation

A risk evaluation of the commodity momentum strategies is done to evaluate whether the profits identified earlier are simply a compensation for risk. In table 6, formula 4 is used to show the factor loadings of each momentum portfolio returns to the commodity, bond and equity markets as well as the abnormal performance of these strategies. Consistent with the results of Miffre & Rallis (2007) the momentum portfolios are fairly neutral to the risks present in the equity, bond and the commodity market. Consequently, the reported R^2 are very low.

Table 6: Regression risk factors
$R_{Pt} = \alpha + \beta_B(R_{Bt} - R_{ft}) + \beta_M(R_{Mt} - R_{ft}) + \beta_C(R_{Ct} - R_{ft}) + \varepsilon_{Pt}$. Reported alphas are annualized for ease of comparison. T-statistics shown in parentheses. 1999-2013.

	Ranking Period			
	1 Month	**3 months**	**6 months**	**12 months**
Panel A: Holding period of 1 month				
α	0.0108	0.0544	0.0494	0.0709
	(0.40)	(1.70)	(1.49)	(1.83)
β_C	0.0128	0.0023	0.0185	0.0369
	(0.46)	(0.07)	(0.55)	(0.95)
β_B	0.0075	-0.0022	0.0155	0.0328
	(0.27)	(-0.07)	(0.46)	(0.84)
β_M	0.0009	0.0027	-0.0015	-0.0154
	(0.10)	(0.27)	(-0.14)	(-1.28)
R^2	0.017%	0.012%	0.012%	0.108%
Panel B: Holding period of 3 months				
α	0.0230	0.0389	0.0259	0.0408
	(1.23)	(1.42)	(0.87)	(1.13)
β_C	-0.0001	-0.0004	0.0087	0.0286
	(0.00)	(-0.01)	(0.28)	(0.77)
β_B	-0.0004	0.0010	0.0061	0.0202
	(-0.02)	(0.04)	(0.20)	(0.54)
β_M	0.0010	-0.0013	-0.0090	-0.0185
	(0.17)	(-0.15)	(-0.95)	(-1.62)
R^2	0.001%	0.002%	0.037%	0.128%
Panel C: Holding period of 3 months				
α	0.01909	0.02916	0.01651	0.00943
	(1.37)	(1.34)	(0.64)	(0.34)
β_C	0.00606	0.00233	0.00155	0.01234
	(0.42)	(0.10)	(0.06)	(0.43)
β_B	0.00447	-0.00243	-0.00396	0.00473
	(0.31)	(-0.11)	(-0.15)	(0.16)
β_M	-0.00116	-0.00549	-0.01326	-0.01501
	(-0.26)	(-0.79)	(-1.61)	(-1.69)
R^2	0.012%	0.029%	0.083%	0.112%
Panel D: Holding period of 12 month				
α	0.02156	0.02922	0.02086	0.00460
	(2.14)	(1.76)	(1.00)	(0.19)
β_C	0.00151	0.00130	-0.00107	0.00047
	(0.15)	(0.08)	(-0.05)	(0.02)
β_B	-0.00224	-0.00580	-0.00848	-0.00874
	(-0.22)	(-0.34)	(-0.39)	(-0.35)
β_M	-0.00481	-0.00986	-0.01270	-0.01602
	(-1.50)	(-1.87)	(-1.91)	(-2.09)
R^2	0.094%	0.135%	0.122%	0.148%

The annualized abnormal return (α) for the momentum strategies after accounting for risk factors is on average 2.90% and range from 0.46% to 7.09%. Five (seven) of the momentum strategies show abnormal returns that are significant at the 5% (10%) level. Therefore, for some of the strategies one can not conclude that the abnormal returns are not compensation for the risk exposures included in the regression.

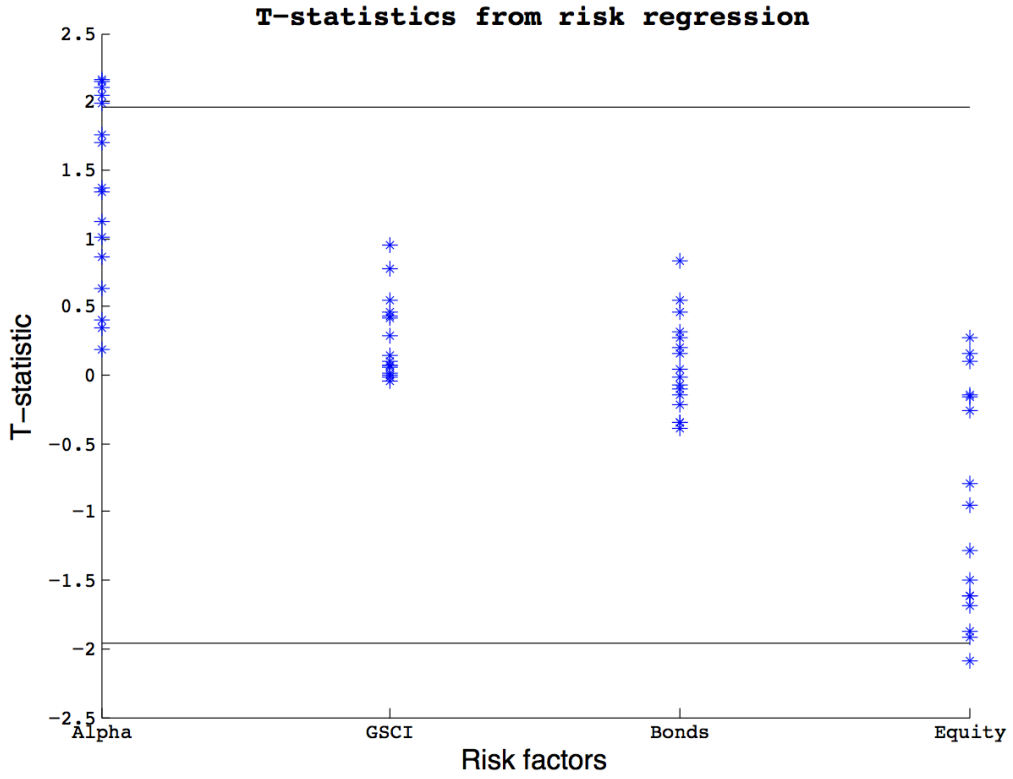

Figure 8: T-statistics for the alphas and each risk factor from the regression. Horizontal lines represent 5% significance level (1.96)

In figure 8 the t-statistics from the regressions are shown graphically. The results show that one (five) of the commodity momentum strategies show a negative loading to the equity market at 5% (10%) significance. This can be seen as some indication that at least the commodity momentum strategies may act as good diversifiers for portfolios consisting of large portions of equities. In general, practically all momentum strategies are truly neutral to the broad movements in the bond, equity and commodity markets.

Even though the maximum drawdown during both sub periods were lower for the momentum strategies applied to commodities, the maximum drawdowns experience during the full period 1999-2013 needs to be evaluated in order to fully understand the risks in each strategy. In table 7, the maximum drawdowns experienced for each individual momentum strategy are shown, applied both to commodities and equities for

the full sample period 1999-2013. On average the maximum drawdowns for equities are higher, at -29%, than those for commodities at -22%. However, this also shows that even though the prior results showed that the commodity momentum strategies fare relatively well during the crisis period of 2008 – 2009, they are also subject to periods of high drawdowns. For both commodity and equity momentum strategies, a combination of short ranking period and long holding period is most resistant to large losses.

Table 7: Maximum Drawdowns 1999-2013

	Commodity	Equity
Panel A: Holding period of 1 month		
R = 1	-31%	-26%
R = 3	-30%	-30%
R = 6	-22%	-43%
R = 12	-30%	-38%
Panel B: Holding period of 3 months		
R = 1	-18%	-24%
R = 3	-25%	-27%
R = 6	-16%	-36%
R = 12	-17%	-36%
Panel C: Holding period of 6 months		
R = 1	-10%	-19%
R = 3	-16%	-23%
R = 6	-30%	-29%
R = 12	-31%	-35%
Panel D: Holding period of 12 months		
R = 1	-11%	-16%
R = 3	-17%	-20%
R = 6	-24%	-27%
R = 12	-31%	-34%
Average	-22%	-29%

These results motivate further research in order to try to understand how and when the commodity momentum strategies experience large drawdowns. Therefore, the equity curve for each individual momentum strategy applied to commodities will be evaluated. This is presented in figure 9 where a reference line in red marking the end of year 2007 also is included. Evidently, some of the strategies show a strong performance in the midst of the crisis period (1-1, 1-3, 1-6, 3-1 and 3-3) whereas some strategies show signs

of very weak performance (3-12, 6-6, 6-12 and 12-12). Notable is also that commodity momentum strategies have not yet recovered significantly in the last few years. As seen in figure 6 the equity momentum strategies has shown a strong performance in the period since the crisis but this does not seem to be the case for the commodity momentum strategies.

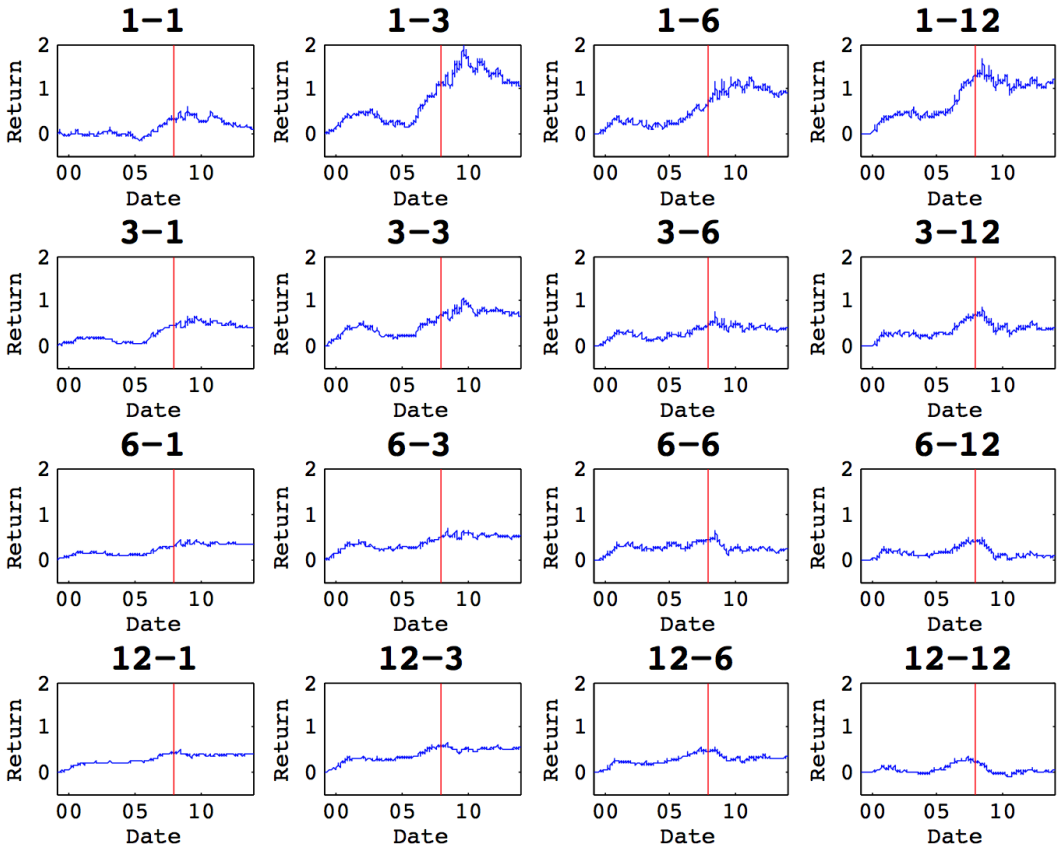

Figure 9: Cumulative return for each individual commodity momentum strategy between 1999-2013 classified according to H-R. Vertical red line marks the end of 2007

6.3 Diversification and inflation hedge properties

Commodities are known for their superior properties to act as risk diversifiers when included in traditional portfolios. In table 8 the correlations between the returns generated by the commodity momentum strategies and the returns of traditional asset classes during full sample period 1999 – 2013 are reported.

Table 8: Correlations commodity momentum with traditional assets.
During the full sample period 1999-2013.

	US T-Bill	Bonds	Equities	Commodities	Inflation
Panel A: Holding period of 1 month					
R = 1	0.00	-0.04*	-0.08*	0.04*	-0.14**
R = 3	-0.02	-0.05*	-0.11*	0.05*	-0.11
R = 6	-0.01	-0.05*	-0.10*	0.09*	-0.08
R = 12	0.01	-0.07*	-0.06*	0.15*	-0.02
Panel B: Holding period of 3 months					
R = 1	-0.02	-0.06*	-0.11*	0.08*	-0.12
R = 3	-0.02	-0.06*	-0.10*	0.07*	-0.08
R = 6	0.01	-0.05	-0.06*	0.15*	-0.03**
R = 12	0.03**	-0.07	-0.03*	0.19*	0.04
Panel C: Holding period of 6 months					
R = 1	0.00	-0.06*	-0.08*	0.12*	-0.07
R = 3	0.01	-0.05	-0.06*	0.15*	-0.03
R = 6	0.04*	-0.04**	-0.03	0.22*	-0.04
R = 12	0.04*	-0.06	0.00	0.24*	0.04
Panel D: Holding period of 12 months					
R = 1	0.02	-0.06*	-0.03**	0.28*	-0.01
R = 3	0.03**	-0.05	-0.01	0.28*	-0.03
R = 6	0.04*	-0.05	0.02	0.32*	0.03**
R = 12	0.03**	-0.06	0.03*	0.29*	0.05**
Average	0.012	-0.055	-0.051	0.17	-0.036

* and ** indicates significance at the 5% and 10% level using the Pearson's correlation test

The table shows that the commodity momentum strategies have very low correlations to all traditional asset classes. In fact, the correlation with equities is, on average, -0.051 and ranging from a low of -0.11 to a high of 0.03. The correlations between the momentum strategies to US T-bills and bonds are also very low at an average of 0.012 and -0.055 respectively. These results are in line with the regression results in table 6, which showed that the momentum returns did not load up significantly on either the equity or bond returns.

In table 8, the correlations between momentum returns and unexpected inflation, measured as the percentage change in US CPI, are low with an average of -0.036. These results indicate that the momentum strategies are not able to hedge against short-term unexpected inflation as well as prior studies on buy and hold commodities portfolios have shown (Erb & Harvey 2006, Bodie and Rosansky 1980, Bodie 1983).

In table 9, the correlations between momentum returns applied to equities and traditional asset classes as well as inflation are shown. The equity momentum strategies show positive, although relatively low, correlations with all the traditional asset classes. The most striking difference between the results from the commodity momentum strategies and the equity momentum strategies is that the equity strategies show a relatively high correlation with unexpected inflation. On average the correlation with inflation is 0.198 with a high of 0.25 and a low of 0.13.

Table 9: Correlations equity momentum with traditional assets 1999-2013

	US T-Bill	Bonds	Equities	Commodities	Inflation
Panel A: Holding period of 1 month					
R = 1	0.02	0.07*	-0.02*	-0.03**	0.20*
R = 3	0.04*	0.08*	-0.04**	-0.02	0.23*
R = 6	0.04*	0.09*	-0.01**	-0.01	0.25*
R = 12	0.05*	0.11**	-0.02	0.00	0.15*
Panel B: Holding period of 3 months					
R = 1	0.03**	0.10*	-0.08*	-0.05*	0.24*
R = 3	0.04*	0.09**	-0.04*	-0.02	0.25**
R = 6	0.05*	0.10	0.01	0.01	0.23*
R = 12	0.05*	0.11**	0.01	0.01	0.13*
Panel C: Holding period of 6 months					
R = 1	0.04*	0.10*	-0.04*	-0.02**	0.24*
R = 3	0.05	0.10*	-0.01*	0.01	0.23*
R = 6	0.04*	0.10**	0.03**	0.02	0.17**
R = 12	0.05**	0.11**	0.06	0.02	0.15
Panel D: Holding period of 12 months					
R = 1	0.03**	0.09*	0.07*	0.02	0.20*
R = 3	0.03*	0.10**	0.08**	0.04*	0.18*
R = 6	0.04*	0.10	0.12**	0.05*	0.17**
R = 12	0.04*	0.10	0.13**	0.04*	0.14**
Average	0.04	0.10	0.017	0.004	0.198

* and ** indicates significance at the 5% and 10% level using the Pearson's correlation test

Prior studies on diversification benefits of commodities have argued that these are limited in periods of market panic since correlations have increased dramatically during these periods. Therefore, it is interesting to study the correlations of the commodity momentum strategies during the period of 2008 – 2009. The results are presented in

table 10 whereas the full results for each individual strategy are presented in Table 21 in the Appendix.

Table 10: Correlations between commodity momentum strategies and traditional assets 2008-2009, averaged across all H-R strategies

	US T-Bill	Bonds	Equities	Commodities
Average	0.020	0.061	-0.133	-0.150

The results show that on average the correlations with short and long term interest rate instruments both increase from 0.012 and -0.055 to 0.02 and 0.061 during the crisis period. Furthermore the results show that the correlations with equities and commodities decrease from -0.051 and 0.17 to -0.133 and -0.15.

In table 11, the monthly average returns for the momentum strategies applied both to commodities and equities are shown. Interestingly, the pattern of seasonality in equity returns identified by Jagadeesh & Titman (2001), negative in January, are shown also in this sample. However, for commodities on average they delivered a monthly return in January of 7.03%. Again, this shows that the return patterns of momentum strategies applied to commodities and equities respectively are different which may motivate why a combination of the two may be beneficial for investors. Admittedly, the results on monthly returns are highly dependent on the sample period used. For example, the return on equity momentum in September is -5.65% which is perhaps not surprising as the sample period includes the day when Lehman Brothers filed for Chapter 11 bankruptcy protection, namely September 15 in 2008.

Table 11: Monthly average returns momentum strategies 1999-2013

Month	**Commodities**	**Equities**
January	7,03%	-5,10%
February	-7,32%	5,79%
March	-4,81%	-1,93%
April	18,50%	3,93%
May	7,24%	6,79%
June	-5,73%	2,58%
July	8,16%	-0,85%
August	-5,30%	11,48%
September	6,76%	-5,65%
October	0,41%	2,07%
November	2,38%	6,14%
December	-10,87%	-2,01%

As identified earlier, the momentum strategies applied to equities and commodities respectively behave somewhat different and perform well (poorly) during different periods. The overall correlation between the momentum strategies is evaluated to see if it would be suitable to combine them in a portfolio. This is particularly interesting since it has been shown that correlations between equities and commodities in general have increased in recent years.

In table 12, correlations between all individual equity strategies (16 combinations) with those of the individual commodity strategies (16 combinations) are shown. Correlations between the strategies are low across all combinations and on average the correlation is 0.09. These results indicate once again that it may be beneficial for investors, who allocate a portion of their portfolio to alternative investments such as momentum, to apply these strategies not only to equities but also to commodities.

Table 12: Correlations between commodity and equity momentum strategies during the period 1999 to 2013. Strategies are classified according to their holding and ranking period denote by H/R.

		COMMODITY MOMENTUM															
		1/1	**1/3**	**1/6**	**1/12**	**3/1**	**3/3**	**3/6**	**3/12**	**6/1**	**6/3**	**6/6**	**6/12**	**12/1**	**12/3**	**12/6**	**12/12**
EQUITY MOM	**1/1**	0.14	0.13	0.10	0.06	0.13	0.11	0.07	0.03	0.10	0.07	0.03	-0.01	0.06	0.04	-0.01	-0.05
	1/3	0.10	0.14	0.13	0.08	0.13	0.14	0.11	0.05	0.13	0.11	0.08	0.02	0.08	0.06	0.02	-0.03
	1/6	0.08	0.12	0.14	0.10	0.11	0.13	0.13	0.08	0.14	0.13	0.11	0.05	0.11	0.09	0.05	0.00
	1/12	0.07	0.11	0.12	0.11	0.11	0.12	0.11	0.09	0.12	0.11	0.10	0.07	0.11	0.09	0.06	0.01
	3/1	0.11	0.15	0.13	0.08	0.15	0.14	0.11	0.06	0.13	0.10	0.07	0.01	0.08	0.06	0.01	-0.03
	3/3	0.08	0.14	0.14	0.09	0.13	0.15	0.12	0.07	0.14	0.12	0.09	0.03	0.10	0.08	0.03	-0.01
	3/6	0.07	0.11	0.13	0.11	0.11	0.13	0.13	0.09	0.13	0.13	0.12	0.07	0.12	0.10	0.07	0.02
	3/12	0.05	0.10	0.12	0.11	0.10	0.11	0.11	0.10	0.11	0.11	0.10	0.07	0.11	0.09	0.07	0.02
	6/1	0.09	0.14	0.14	0.10	0.14	0.15	0.13	0.08	0.15	0.13	0.10	0.05	0.11	0.09	0.05	0.00
	6/3	0.08	0.13	0.14	0.11	0.13	0.14	0.13	0.09	0.14	0.13	0.11	0.06	0.12	0.10	0.06	0.02
	6/6	0.06	0.11	0.13	0.11	0.11	0.12	0.12	0.10	0.13	0.12	0.12	0.08	0.12	0.11	0.08	0.03
	6/12	0.04	0.09	0.11	0.11	0.09	0.10	0.10	0.10	0.11	0.10	0.10	0.08	0.10	0.09	0.07	0.03
	12/1	0.07	0.11	0.11	0.10	0.11	0.12	0.11	0.09	0.12	0.11	0.09	0.07	0.11	0.09	0.06	0.03
	12/3	0.05	0.10	0.12	0.11	0.11	0.12	0.12	0.10	0.12	0.12	0.11	0.08	0.12	0.10	0.08	0.04
	12/6	0.04	0.08	0.10	0.11	0.08	0.10	0.11	0.11	0.11	0.11	0.11	0.09	0.11	0.11	0.09	0.05
	12/12	0.02	0.07	0.09	0.11	0.07	0.09	0.10	0.10	0.09	0.09	0.10	0.09	0.10	0.09	0.08	0.05
	Average	0.07	0.12	0.12	0.10	0.11	0.12	0.11	0.08	0.12	0.11	0.10	0.06	0.10	0.09	0.05	0.01
	Average across all strategies				0.09												

7 Analysis

The results show that commodity momentum strategies are able to deliver positive returns across a relatively long time period but they are also able to potentially realize substantial diversification benefits when included in a traditional portfolio. That being said, the best performance was realized in the pre-crisis period between 1999-2007 and the performance measured as average returns have been lower in the post-crisis period. Therefore, it is not possible to conclude that the profits identified in this paper will be as profitable going forward. The results may be negatively affected by structural changes in the commodity markets, such as for example the decreased demand for industrial commodities from China. However, since commodities are such a heterogeneous asset class it seems unlikely that any changes will affect all individual commodities in the same manner.

To evaluate if the commodity momentum strategies use some commodities more than others, the average months each commodity has been held in the long and short leg respectively are calculated, as well as how many months the commodity were excluded from the momentum portfolios. This is interesting to know if the momentum portfolios seem to be loading up particularly to some commodities that could imply that they are exposed to high idiosyncratic risks. In Table 13 the summary statistics of positions held are presented as the average across all 16 combinations of holding and ranking periods. The full statistics for each commodity can be found in Table 22 in the Appendix.

The results show that all commodities are used to some extent in the portfolios on both short and long legs, however it is also clear that some commodities have been used more frequently than others. For example the results show that, on average, the momentum portfolios have held long positions frequently in Unleaded Gas (70 months), Brent Oil (60 months) and Crude Oil (55 months) whereas short positions have been held frequently in Natural Gas (90 months), Coffee (70 months) and Wheat (65 months).

Table 13: Average number of months each commodity has been held long, short or been excluded from the portfolio during the period 1999-2013. Average across all combinations of H and R

	Long	**Short**	**Excluded**
Crude	55	38	94
Brent	60	20	107
Unleaded Gas	70	24	92
Heating Oil	26	18	144
Gas Oil	51	29	107
Natural Gas	41	90	56
Aluminum	11	22	155
Copper	43	15	129
Lead	54	35	99
Nickel	57	43	87
Zinc	33	40	114
Gold	30	15	142
Silver	44	28	115
Wheat	26	65	96
Red Wheat	29	44	114
Corn	33	56	98
Soybeans	49	23	115
Cotton	30	52	105
Sugar	51	49	88
Coffee	26	70	91
Cocoa	43	49	95
Live Cattle	18	27	142
Lean Hogs	30	56	101

Above results are consistent with mean returns for the commodities during the sample period as shown by the summary statistics in Table 1. Commodities that have had the best (worst) performance during the sample period also have been held most frequently as long (short) positions. Also, commodities that have been shown to have a large standard deviation during the sample period seems to be more regularly used in the momentum portfolios, both as long and short positions, see figure below.

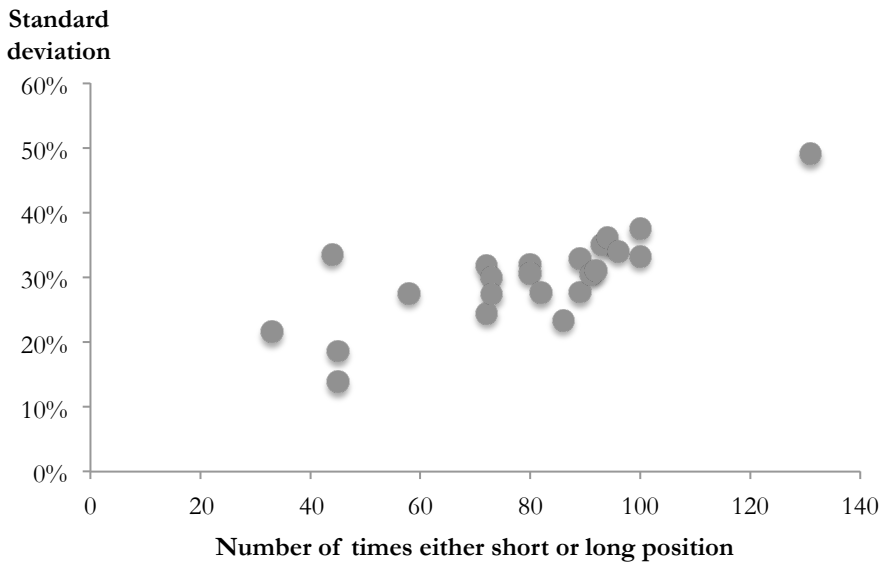

Figure 10: The relationship between standard deviation of individual commodities and their frequency of activity in the momentum portfolio.

That being said, standard deviations of the individual momentum portfolios are substantially lower than the standard deviations of the underlying assets. Therefore, it seems that the momentum strategies are able to effectively diversify most of the idiosyncratic risks of the individual portfolios.

The results show that the correlations of the commodity momentum strategies increase to short and long term fixed income instruments in crisis times. On the other hand, the correlations to both equities and commodities will actually decrease substantially during crisis periods. A possible explanation for this pattern is that some commodities, such as gold, will be used as a safe haven asset in crisis times, which could imply that correlations with safe-haven fixed income assets would increase in crisis times. By evaluating the average positions over the crisis period of 2008 – 2009, presented in table 14, commodities that were predominantly held as long positions were in fact sugar (10 months) cocoa (10 months) and gold (9 months). On the short leg commodities that were held for the most months were natural gas (12 months), lean hogs (11 months) and nickel (10 months).

Table 14: Average number of months each commodity has been held long, short or been excluded from the portfolio during the period 2008-2009

	Long	**Short**	**Excluded**
Crude	6	8	10
Brent	6	7	11
Unleaded Gas	6	5	13
Heating Oil	4	5	15
Gas Oil	6	6	12
Natural Gas	3	12	9
Aluminum	2	3	20
Copper	6	3	16
Lead	8	7	9
Nickel	5	10	10
Zinc	6	8	11
Gold	9	1	14
Silver	7	2	15
Wheat	3	8	14
Red Wheat	3	7	15
Corn	5	4	15
Soybeans	6	1	17
Cotton	2	2	21
Sugar	10	2	12
Coffee	4	1	19
Cocoa	10	1	13
Live Cattle	3	7	14
Lean Hogs	3	11	10

Although the results provide some evidence of safe-haven theory, since one third of all long positions in gold are during the crisis period, the causality cannot be proven and most likely other factors in the particular data sample should be accounted for. Furthermore, such a pattern should not be expected to be valid because of the heterogeneous characteristics of commodities as an asset class.

The decreased correlations of the commodity momentum strategies to traditional assets such as equities and commodities are particularly interesting from a diversification perspective. As prior studies have shown that correlations between commodities and equities typically increase in times of high market stress, perhaps due to a business cycle component, one could argue that the diversification benefits of commodities are lost when you need them the most. Therefore, the results in this paper motivate why it could be a wise idea to include a commodity momentum strategy to a traditional asset allocation portfolio.

This paper has ignored the effects of transaction costs, as is consistent with prior literature on momentum strategies. Naturally, the possibility exists that transaction costs or other market frictions could potentially erode the momentum profits. However, this seems questionable for the commodity markets for several reasons. Firstly, as Locke & Venkatesh (1997) showed, transaction costs in the commodity futures markets are very small and range from 0.0004% to 0.033%. This must considered to be very low in relation to the figures for transaction costs found in equity markets, 0.5% by Jegadeesh & Titman (1993) and 2.3% for Lesmond et al. (2004). Secondly, the commodity momentum strategies were implemented on only 23 commodity futures which mean that they require much less trading that those typically implemented in the equity markets which usually deal with several hundreds or even thousands of assets. Finally, short-selling constraints in commodity markets are practically non-existent whereas severe short-selling restrictions are typically imposed in equity markets, particularly in times of high market stress. However, one possible drawback of using commodities in momentum strategies is that investor who use commodity futures would be required to post initial margins and monitor their margin accounts on a daily basis. Nevertheless, the development of the commodity markets in the latest decade has progressed into an extremely effective and developed market.

8 Conclusions

This paper evaluates the profitability, diversification benefits and risks of momentum strategies applied in the commodity futures markets. Data on the GSCI futures contracts for the full sample period ranging from 1999 to 2013 has been used combined with a common research design to evaluate momentum effects in stock returns. The analysis of momentum effects in commodity markets are motivated by relatively low transaction costs and the fact that generally no restrictions on short positions exists in commodity futures markets.

The main findings of this paper indicate that some of the momentum strategies applied to commodities are able to generate significant abnormal returns when evaluated over short and intermediate time horizons. Hence, the speculation force in markets was strong enough during the sample period to generate momentum profits. For the period 1999-2007 the returns generated on the momentum strategies were on average 5.53% with a Sharpe ratio of 0.56. However, when evaluated over the full sample period between 1999-2013 the average return and Sharpe ratio was reduced to 3.02% and 0.32 respectively. Moreover, lower maximum drawdowns for momentum strategies applied to commodities were observed compared to those applied to equities. This was true in both bear and bull markets.

Furthermore, it was documented that the commodity momentum strategies are found to have low correlations with traditional assets such as stocks and bonds and are able to realize superior returns in periods of stock market downturns. The results showed that the correlations with both the stock market and the commodity market itself decreased in times of market stress. This shows that the commodity based momentum strategies can be a very good complement to a traditional portfolio since it is able to deliver substantial diversification benefits, when they are needed the most. Combining these results with those showing that commodity momentum strategies on average have a very low correlation to the momentum strategies applied to equities, the commodity momentum strategies can be a good source of diversification within an alternative asset portfolio, already consisting of an equity momentum strategy. Both commodity and equity momentum strategies also shown independency in specific monthly returns over the full sample period which makes the potential diversification benefits even greater.

9 Further Research

Through the results from this paper, one can elaborate on interesting questions to use the results for further research.

Firstly, equity momentum and commodity momentum strategies show different return patterns over the sample period. Both strategies returned independent returns in bull and bear periods, which is an evidence of the diversification benefits that can be gained from using both strategies in a portfolio. What are more interesting are the driving forces and factors that can predict which momentum strategy that will be profitable in the short-run. Through this, one can optimize the use of the two strategies and time the switch between them in order to achieve higher risk-adjusted returns.

Secondly, in equity momentum research there is a vast literature of papers trying to explain and forecast momentum crashes. This has not yet been discussed that much in regards to commodity momentum research, and it would therefore be an interesting topic to further research in order to understand the return profile and driving forces behind commodity momentum crashes. Furthermore, if one was able to predict these momentum crashes with some degree of certainty it would be interesting to see how it might be able to combine momentum strategies on different assets and apply a shifting regime in order to enhance the risk-adjusted return of the overall momentum portfolio.

Finally, since the risk factor analysis on commodity based momentum strategies did not show significant results, there is a room for further research to investigate what driving forces that can be drawn to the return pattern in order to fully understand the underlying risks of momentum strategies.

10 Practical Use of the Results

Academia and practitioners have tried to explain returns and risk premium for a long time. Momentum is a quite new phenomenon in the research and still shows positive returns in markets, which contradicts with finance theory about efficient markets.

Fund managers scan markets to find alpha and excess returns and at the same time tries to find new ways of decreasing risk for their investors. Alternative investments in general have attractive diversification benefits to portfolios consisting of stocks and bonds. Momentum strategies have increased since positive returns have been proved on equity markets for long sample periods with different combinations of ranking and

holding periods. Crashes in equity momentum strategies have historically been hard to predict. By analysing commodity-based strategies, this thesis has proved attractive returns and low correlations to equity based momentum strategies. This can improve risk-adjusted returns in alternative investment portfolios, which have increased its popularity among portfolio managers and investors across the world.

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Appendix

Table 15 (Appendix): Momentum profit commodities
During the period 1999-2007.

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	3.53%	9.02%	8.28%	11.41%
	(1.04)	(2.28)	(1.66)	(2.44)
Standard deviation	10.48%	12.06%	15.24%	14.29%
Sharpe Ratio	0.34	0.75	0.55	0.81
Holding period of 3 Months				
Mean	4.38%	6.31%	5.87%	7.46%
	(1.86)	(1.82)	(1.29)	(1.66)
Standard deviation	7.14%	10.64%	13.97%	13.49%
Sharpe Ratio	0.61	0.6	0.42	0.55
Holding period of 6 Months				
Mean	2.91%	4.63%	4.35%	4.76%
	(1.62)	(1.63)	(1.31)	(1.15)
Standard deviation	5.56%	8.73%	10.16%	10.79%
Sharpe Ratio	0.53	0.53	0.43	0.38
Holding period of 12 Months				
Mean	3.81%	5.07%	4.27%	2.44%
	(2.75)	(2.24)	(1.56)	(0.78)
Standard deviation	4.29%	6.83%	8.41%	9.52%
Sharpe Ratio	0.9	0.74	0.51	0.26
Average of all holding and ranking periods				
Mean	5.53%			
Sharpe Ratio	0.56			

Table 16 (Appendix): Momentum profit equities
During the period 1999-2007.

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	0.82%	3.11%	11.53%	13.71%
	(0.38)	(1.16)	(3.89)	(4.37)
Standard deviation	6.67%	8.10%	9.05%	9.52%
Sharpe Ratio	0.12	0.38	1.28	1.43
Holding period of 3 Months				
Mean	1.99%	6.62%	11.91%	12.81%
	(1.19)	(2.75)	(4.25)	(4.28)
Standard deviation	5.08%	7.30%	8.57%	9.21%
Sharpe Ratio	0.39	0.9	1.39	1.4
Holding period of 6 Months				
Mean	3.58%	7.56%	10.42%	11.81%
	(2.49)	(3.57)	(4.07)	(4.25)
Standard deviation	4.44%	6.51%	7.78%	8.41%
Sharpe Ratio	0.82	1.17	1.33	1.4
Holding period of 12 Months				
Mean	3.70%	6.66%	8.98%	11.43%
	(2.99)	(3.75)	(4.12)	(4.64)
Standard deviation	3.81%	5.40%	6.67%	7.46%
Sharpe Ratio	0.98	1.23	1.35	1.52
Average of all holding and ranking periods				
Mean	7.92%			
Sharpe Ratio	1.07			

Table 17 (Appendix): Momentum profit commodities
During the period 2008-2009.

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	-1.21%	11.78%	11.77%	-1.23%
	(-0.12)	(1.01)	(0.94)	(-0.11)
Standard deviation	13.97%	16.83%	22.86%	15.72%
Sharpe Ratio	-0.09	0.7	0.65	-0.08
Holding period of 3 Months				
Mean	3.83%	7.09%	1.90%	-7.45%
	(0.53)	(0.69)	(0.17)	(-0.72)
Standard deviation	10.32%	14.92%	16.03%	14.92%
Sharpe Ratio	0.37	0.48	0.12	-0.5
Holding period of 6 Months				
Mean	2.74%	3.79%	-5.51%	-10.58%
	(0.52)	(0.48)	(-0.60)	(-1.11)
Standard deviation	7.62%	11.43%	13.18%	13.65%
Sharpe Ratio	0.36	0.33	-0.42	-0.77
Holding period of 12 Months				
Mean	-1.22%	-1.60%	-5.03%	-10.93%
	(-0.39)	(-0.32)	(-0.78)	(-1.40)
Standard deviation	4.44%	7.14%	9.37%	11.27%
Sharpe Ratio	-0.27	-0.22	-0.54	-0.97
Average of all holding and ranking periods				
Mean	-0.12%			
Sharpe Ratio	-0.05			

Table 18 (Appendix): Momentum profit equities
During the period 2008-2009.

	Ranking Period			
	1 Month	**3 Months**	**6 Months**	**12 Months**
Holding period of 1 Month				
Mean	-6.80%	-9.11%	-13.09%	-8.92%
	(-0.85)	(-0.94)	(-1.20)	(-0.66)
Standard deviation	11.59%	13.97%	15.72%	19.53%
Sharpe Ratio	-0.59	-0.65	-0.83	-0.46
Holding period of 3 Months				
Mean	-8.07%	-7.11%	-8.86%	-6.63%
	(-1.28)	(-0.79)	(-0.86)	(-0.50)
Standard deviation	9.05%	13.02%	14.76%	19.21%
Sharpe Ratio	-0.89	-0.55	-0.6	-0.35
Holding period of 6 Months				
Mean	-5.36%	-4.45%	-3.66%	-6.78%
	(-1.04)	(-0.57)	(-0.38)	(-0.53)
Standard deviation	7.46%	11.11%	13.65%	18.26%
Sharpe Ratio	-0.73	-0.4	-0.27	-0.37
Holding period of 12 Months				
Mean	-3.85%	-2.79%	-4.21%	-6.84%
	(-0.95)	(-0.44)	(-0.49)	(-0.61)
Standard deviation	5.87%	9.05%	12.38%	16.19%
Sharpe Ratio	-0.66	-0.31	-0.34	-0.42
Average of all holding and ranking periods				
Mean	-6.66%			
Sharpe Ratio	-0.53			

Table 19 (Appendix): Maximum drawdowns 2008-2009

	Commodity	Equity
Panel A: Holding period of 1 month		
R = 1	-21%	-38%
R = 3	-12%	-44%
R = 6	-9%	-27%
R = 12	-11%	-20%
Panel B: Holding period of 3 months		
R = 1	-16%	-35%
R = 3	-15%	-36%
R = 6	-16%	-27%
R = 12	-17%	-21%
Panel C: Holding period of 6 months		
R = 1	-18%	-35%
R = 3	-26%	-29%
R = 6	-33%	-23%
R = 12	-22%	-19%
Panel D: Holding period of 12 months		
R = 1	-27%	-34%
R = 3	-33%	-27%
R = 6	-33%	-20%
R = 12	-27%	-16%
Average	-20.98%	-28.22%

Table 20 (Appendix): Maximum drawdowns 1999-2007

	Commodity	Equity
Panel A: Holding period of 1 month		
R = 1	-26%	-27%
R = 3	-15%	-20%
R = 6	-10%	-29%
R = 12	-5%	-26%
Panel B: Holding period of 3 months		
R = 1	-27%	-25%
R = 3	-27%	-21%
R = 6	-16%	-23%
R = 12	-8%	-17%
Panel C: Holding period of 6 months		
R = 1	-22%	-24%
R = 3	-21%	-20%
R = 6	-14%	-18%
R = 12	-13%	-14%
Panel D: Holding period of 12 months		
R = 1	-21%	-21%
R = 3	-16%	-19%
R = 6	-19%	-15%
R = 12	-20%	-11%
Average	-17.51%	-20.75%

Table 21 (Appendix): Correlations commodity momentum with traditional assets 2008-2009

	US T-Bill	Bonds	Equities	Commodities
Panel A: Holding period of 1 month				
R = 1	-0.065	0.078*	-0.17*	-0.295*
R = 3	-0.067	0.116*	-0.224*	-0.329*
R = 6	-0.058	0.124*	-0.225*	-0.330*
R = 12	0.029	0.153*	-0.199*	-0.251**
Panel B: Holding period of 3 months				
R = 1	-0.063	0.101*	-0.216*	-0.326*
R = 3	-0.071	0.064*	-0.231*	-0.326**
R = 6	0.014	0.021*	-0.162*	-0.222**
R = 12	0.078**	0.017*	-0.12)*	-0.141**
Panel C: Holding period of 6 months				
R = 1	-0.045	0.060*	-0.214*	-0.279*
R = 3	0.002	0.022*	-0.166**	-0.180*
R = 6	0.094*	0.050*	-0.1029*	-0.064
R = 12	0.113*	0.023**	-0.033	0.024
Panel D: Holding period of 12 months				
R = 1	0.054	0,073**	-0.125*	-0.023
R = 3	0.086*	0,043**	-0.065	0.049
R = 6	0.134*	0.028	0.019	0.142*
R = 12	0.091**	0,009	0.100*	0.153**
Average	0.020	0.061	-0.133	-0.150

* and ** indicates significance at the 5% and 10% level using the Pearson's correlation test

Table 22 (Appendix): Average number of months each commodity has been held long, short or been excluded. During the time period 1999-2013. Each strategy classified according to its holding and ranking period

	Crude	Brent	Un. Gas	Heating Oil	Gas Oil	Natural Gas	Aluminium	Copper	Lead	Nickel	Zinc	Gold	Silver	Wheat	Red Wheat	Corn	Soybeans	Cotton	Sugar	Coffee	Cocoa	L. Cattle	Hogs
H=1 R=1																							
Long	50	52	63	27	47	52	18	36	51	56	36	25	45	34	34	36	40	39	52	36	44	20	37
Short	40	25	37	21	35	76	25	24	37	47	37	24	39	53	43	44	32	54	52	61	47	29	48
Exduded	97	110	88	139	105	58	144	128	99	84	114	138	103	100	109	107	115	94	83	91	95	138	102
H=1 R=3																							
Long	56	64	70	31	50	47	11	42	56	59	32	28	42	25	26	30	46	29	52	24	40	22	38
Short	39	25	29	21	30	88	23	17	34	43	38	17	31	59	41	55	26	48	52	71	48	30	54
Exduded	92	99	88	135	107	52	153	128	97	85	117	142	114	102	119	101	115	109	83	92	99	135	95
H=1 R=6																							
Long	59	65	77	28	54	37	9	50	49	59	33	28	40	24	28	30	51	24	47	20	45	19	29
Short	34	16	20	19	25	93	19	13	33	43	39	12	24	74	50	61	21	49	49	74	50	28	58
Exduded	94	106	90	140	108	57	158	124	104	85	114	147	123	88	110	96	115	115	91	92	91	140	100
H=1 R=12																							
Long	55	59	72	17	54	27	5	45	59	55	29	39	48	21	26	34	58	26	51	23	43	12	17
Short	40	13	11	9	27	105	19	5	34	38	47	7	18	72	42	63	14	57	43	75	50	22	64
Exduded	92	115	103	161	107	55	163	137	95	94	111	141	120	94	119	89	115	103	94	89	94	153	106
H=3 R=1																							
Long	50	52	63	27	47	52	18	36	51	56	36	25	45	34	34	36	40	39	52	36	44	20	37
Short	40	25	37	21	35	76	25	24	37	47	37	24	39	53	43	44	32	54	52	61	47	29	48
Exduded	97	110	88	139	105	58	144	128	99	84	114	138	103	100	109	107	115	94	83	91	95	138	102
H=3 R=3																							
Long	56	64	70	31	50	47	11	42	56	59	32	28	42	25	26	30	46	29	52	24	40	22	38
Short	39	25	29	21	30	88	23	17	34	43	38	17	31	59	41	55	26	48	52	71	48	30	54
Exduded	92	99	88	135	107	52	153	128	97	85	117	142	114	102	119	101	115	109	83	92	99	135	95
H=3 R=6																							
Long	59	65	77	28	54	37	9	50	49	59	33	28	40	24	28	30	51	24	47	20	45	19	29
Short	34	16	20	19	25	93	19	13	33	43	39	12	24	74	50	61	21	49	49	74	50	28	58
Exduded	94	106	90	140	108	57	158	124	104	85	114	147	123	88	110	96	115	115	91	92	91	140	100
H=3 R=12																							
Long	55	59	72	17	54	27	5	45	59	55	29	39	48	21	26	34	58	26	51	23	43	12	17
Short	40	13	11	9	27	105	19	5	34	38	47	7	18	72	42	63	14	57	43	75	50	22	64
Exduded	92	115	103	161	107	55	163	137	95	94	111	141	120	94	119	89	115	103	94	89	94	153	106
H=6 R=1																							
Long	50	52	63	27	47	52	18	36	51	56	36	25	45	34	34	36	40	39	52	36	44	20	37
Short	40	25	37	21	35	76	25	24	37	47	37	24	39	53	43	44	32	54	52	61	47	29	48
Exduded	97	110	88	139	105	58	144	128	99	84	114	138	103	100	109	107	115	94	83	91	95	138	102
H=6 R=3																							
Long	56	64	70	31	50	47	11	42	56	59	32	28	42	25	26	30	46	29	52	24	40	22	38
Short	39	25	29	21	30	88	23	17	34	43	38	17	31	59	41	55	26	48	52	71	48	30	54
Exduded	92	99	88	135	107	52	153	128	97	85	117	142	114	102	119	101	115	109	83	92	99	135	95
H=6 R=6																							
Long	59	65	77	28	54	37	9	50	49	59	33	28	40	24	28	30	51	24	47	20	45	19	29
Short	34	16	20	19	25	93	19	13	33	43	39	12	24	74	50	61	21	49	49	74	50	28	58
Exduded	94	106	90	140	108	57	158	124	104	85	114	147	123	88	110	96	115	115	91	92	91	140	100
H=6 R=12																							
Long	55	59	72	17	54	27	5	45	59	55	29	39	48	21	26	34	58	26	51	23	43	12	17
Short	40	13	11	9	27	105	19	5	34	38	47	7	18	72	42	63	14	57	43	75	50	22	64
Exduded	92	115	103	161	107	55	163	137	95	94	111	141	120	94	119	89	115	103	94	89	94	153	106
H=12 R=1																							
Long	50	52	63	27	47	52	18	36	51	56	36	25	45	34	34	36	40	39	52	36	44	20	37
Short	40	25	37	21	35	76	25	24	37	47	37	24	39	53	43	44	32	54	52	61	47	29	48
Exduded	97	110	88	139	105	58	144	128	99	84	114	138	103	100	109	107	115	94	83	91	95	138	102
H=12 R=3																							
Long	56	64	70	31	50	47	11	42	56	59	32	28	42	25	26	30	46	29	52	24	40	22	38
Short	39	25	29	21	30	88	23	17	34	43	38	17	31	59	41	55	26	48	52	71	48	30	54
Exduded	92	99	88	135	107	52	153	128	97	85	117	142	114	102	119	101	115	109	83	92	99	135	95
H=12 R=6																							
Long	59	65	77	28	54	37	9	50	49	59	33	28	40	24	28	30	51	24	47	20	45	19	29
Short	34	16	20	19	25	93	19	13	33	43	39	12	24	74	50	61	21	49	49	74	50	28	58
Exduded	94	106	90	140	108	57	158	124	104	85	114	147	123	88	110	96	115	115	91	92	91	140	100
H=12 R=12																							
Long	55	59	72	17	54	27	5	45	59	55	29	39	48	21	26	34	58	26	51	23	43	12	17
Short	40	13	11	9	27	105	19	5	34	38	47	7	18	72	42	63	14	57	43	75	50	22	64
Exduded	92	115	103	161	107	55	163	137	95	94	111	141	120	94	119	89	115	103	94	89	94	153	106
Average:																							
Long	55	60	70	26	51	41	11	43	54	57	33	30	44	26	29	33	49	30	51	26	43	18	30
Short	38	20	24	18	29	90	22	15	35	43	40	15	28	65	44	56	23	52	49	70	49	27	56
Exduded	94	107	92	144	107	56	155	129	99	87	114	142	115	96	114	98	115	105	88	91	95	142	101