Market Strategy
J.P. Morgan Securities Ltd.
London
September 19, 2006

JPMorgan

Momentum in Commodities

INVESTMENT STRATEGIES: NO. 25

- **Active momentum-based strategies in commodities offer high returns to risk and outperform passive investment in the asset class**
- **There are strong economic forces for momentum to exist in commodities**
- **Relative momentum of one commodity against the other forms the backbone of profitable momentum strategies in commodities**
- **The strategies are robust to many variations and perform well in both bull and bear commodity markets**
- **Momentum strategies in commodities should capture not only price trends but also the effects of contango and backwardation in the futures market**
- **JPMorgan markets various strategies that follow combinations of the rules presented here through a family of structured products named Commodity IGAR**

Ruy M. Ribeiro[AC]
(44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

Jan Loeys
(44-20) 7325-5473
jan.loeys@jpmorgan.com

John Normand
(44-20) 7325-5222
john.normand@jpmorgan.com
J.P. Morgan Securities Ltd.

Profiting from momentum in commodities

Investors have heavily invested in commodities over the past few years, and have earned fantastic returns. But the recent fall in commodity prices and signs they may be in a bubble are raising demand for less directional ways to be involved in the asset class (See Loeys and Panigirtzoglou, *Are alternatives the next bubble?* Sep 8). We show in this paper that a dynamic trading strategy based on **momentum in commodities is very profitable, robust and little correlated to the overall direction of commodity prices.**

A simple momentum strategy, shown in Chart 1, **invests in the top performing individual commodity indices over the past year and shorts the bottom performers** with monthly rebalancing. It delivers an excess return of 12.2%

We are grateful to Eynour Boutia, Declan Canavan, Jose Cogolludo, Yuli Gu, Ioannis Katsikas, Tim Owens, Nicolas Robin, Lionel Semonin, Julian Schillinger, Alvin Ying and particularly Rudy Andraous for their valuable comments and discussion.

The certifying analyst is indicated by an [AC]. See last page for analyst certification and important legal and regulatory disclosures.

Contents

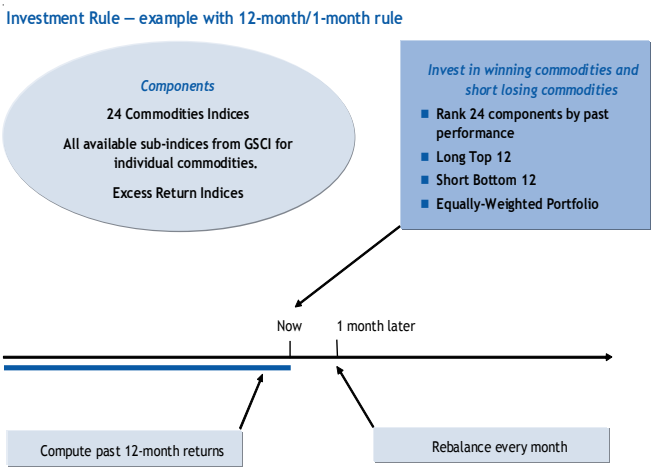
www.morganmarkets.com

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

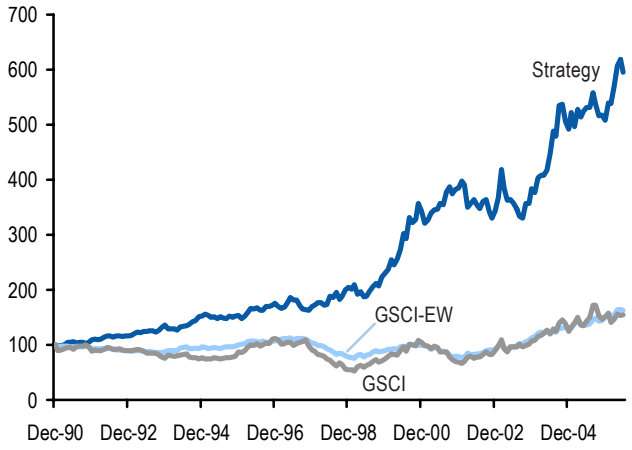
JPMorgan

Chart 1: Benchmark strategy – A simple long-short momentum rule



Source: JPMorgan

Chart 2: Benchmark strategy – cumulative excess return



Source: JPMorgan

with volatility of 13.6% since 1991, producing a Sharpe ratio that matches the one delivered by hedge funds. In comparison, the commodity asset class, represented by GSCI, the most popular index in the market, has delivered only 2.9% in excess returns over cash with higher volatility, 18.6 % since 1991.

This simple momentum strategy has value as **an outright "alpha" strategy** that exploits the market inefficiency of momentum. Chart 2 shows it is uncorrelated to the overall commodities market and outperforms a pure long-only investment in commodities. The strategy can also be used as an **enhancement to pure index exposures** to the commodity asset class, but its low correlation to the direction of prices implies it should not be seen as a substitute to such "beta" exposures.

The objective of this paper is to understand which types of momentum exist in commodities and how robust they are[1]. Hence, we test many different strategies that capture different types of momentum using tradable commodities indices. We introduce a number of **refinements to ameliorate the almost inevitable negative effect of turning points** without penalizing the profitability of the strategy.

The robustness of the strategy is tested in many ways to confirm that **profitability is not dependent on a particular choice** of indices/futures, time period, strategy rules, roll assumptions and other possible variations of the basic strategies.

The organization of the paper is as follows. First, this article discusses the types of momentum that can be found in commodities and the reasons why momentum is pervasive in commodities. We then test different strategies starting from the simple relative momentum strategy described above. Later, the article analyzes other types of momentum, introduces refinements and checks the robustness of the corresponding strategies. Finally, we relate these momentum strategies to other active rules in commodities and show the contribution to portfolio allocation of a momentum-based active investment in commodities.

Where is momentum in commodities?

Momentum is pervasive in commodities and has multiple manifestations. It shows up in two different dimensions[2]. Momentum can be present at the individual commodity level and at the aggregate level. And it can show up in outright returns (versus cash) and in relative returns versus other assets. There are four resulting combinations of these

1 This paper concentrates on the benefits of momentum strategies, avoiding detailed discussion of other inefficiencies in the commodity space but highlighting the main relations between momentum and other opportunities within commodities. This article confirms and extends the analysis of these recent papers, showing additional alternatives for active investors. For additional information on investing in commodities, Gorton and Rouwenhorst review the performance of commodity investment (see Facts and Fantasies about Commodity Futures, Financial Analysts Journal, 2006). For different views, see also Erb and Harvey (The Tactical and Strategic Value of Commodity Futures, Financial Analyst Journal, 2006). They show that a 12-1 momentum rule provides high returns. Another recent paper shares some results with ours. Miffre and Rallis (2006, Momentum in Commodity Futures Markets, working paper) also shows that momentum strategies tend to overweight backwardated commodities and underweight contangoed ones. See also A Note on Erb and Harvey (2005) by Gorton and Rouwenhorst available on SSRN for clarifications on the effect of equally-weighting and frequent rebalancing.

2 Momentum is an empirical phenomenon that contradicts market efficiency. In an efficient market, it should not be possible to build a profitable trading strategy using only information about past returns without moving into riskier assets. Even well-known guardians of the Efficient Market Hypothesis, such as Eugene Fama, recognize the possibility that momentum profits could be due to market inefficiency. See Fama, E. and K. French, *Multifactor Explanations of Asset Pricing Anomalies*, Journal of Finance, January 1996.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

Jan Loeys (44-20) 7325-5473
jan.loeys@jpmorgan.com

Box 1. Decomposition of commodity returns

An investment in an individual commodity index is a long position in a futures contract. Since the cost of a futures contract is zero, the notional is invested in cash (collateral). When the contract gets close to maturity, the initial position is closed and another is opened with a longer-dated contract. Therefore, the total returns of an investment in commodities indices and their corresponding futures contracts can be decomposed into:

- cash (collateral)
- spot return (change in spot price of commodities)
- roll returns (shape of futures curve)

When the curve is positively sloped (contango), the futures price rolls down the curve towards the spot price, and creates a loss. If the slope is negative (backwardation), rolling contracts generate positive returns, since the longer-dated contract is sold at a higher price as it nears maturity. Commodity futures curves are unstable over time, but historically are negatively sloped for oil and positive for most of the other commodities.

"Excess" returns over cash correspond to the sum of

- roll returns
- spot returns

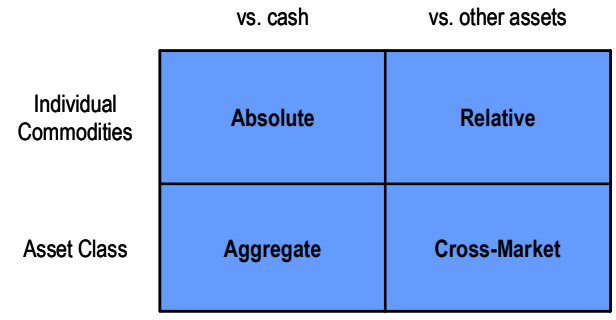
The strategies considered here are based on excess returns. Therefore, the strategies use both the average shape of the curve over the recent months and spot price performance to select which commodities to hold.

dimensions that can be used to construct strategies as depicted in Chart 3:

- **absolute momentum** – in the excess returns of a single commodity versus cash.
- **relative momentum** – one commodity vs. another.
- **aggregate momentum** – in the excess return of commodities as an asset class.
- **cross-market momentum** – commodities vs. other asset classes. We discussed the latter in detail in *Exploiting Cross-Market Momentum* and will thus focus here on the other three.

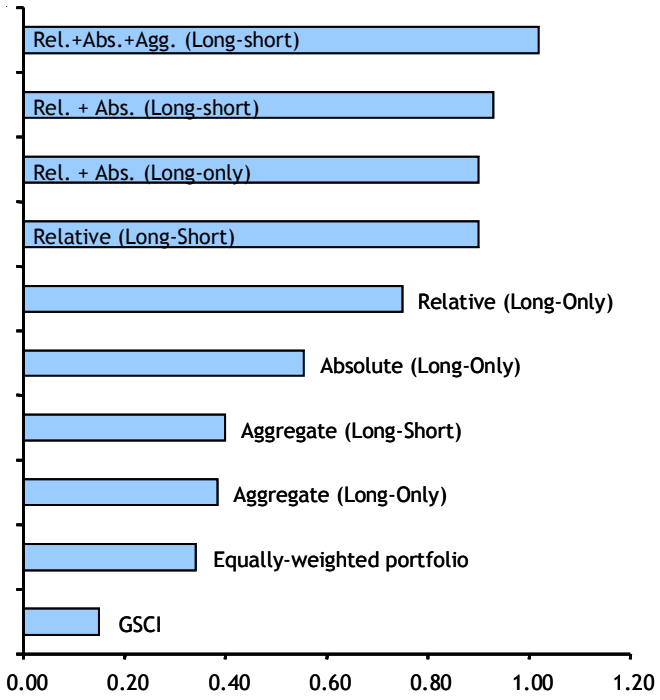
We find that all these momentum strategies provide positive and significant alphas, but **relative momentum is more profitable** than absolute and aggregate momentum. Moreover, combinations of these rules can deliver even better performance, as seen in Chart 4. The strategy is based on past excess returns instead of past spot returns as we find that both spot and roll returns provide relevant information for the strategy. (see Box 1 for definitions).

Chart 3: Types of momentum (based on total returns)



Source: JPMorgan

Chart 4: Sharpe Ratio for different types of momentum



Source: JPMorgan

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

Why momentum in commodities?

Momentum in commodities derives from basic economic forces. They explain why we see momentum in aggregate and individual commodities in both absolute and relative terms. At the same time, they explain why both roll and spot return should produce momentum and why these two types of momentum are intrinsically related. Momentum is due to:

- **behavioural biases;**
- **business cycle;**
- **sectoral cycles;** and
- **inelastic supply and demand**

In most markets, momentum can be simply explained by behavioural biases that create autocorrelation in prices. In the case of commodities, there are reasons for momentum that come also from demand and supply conditions that move only slowly over time. Commodities are not pure financial assets, even though we use futures markets to transact them. Commodities are also real products that have spot markets. The changes in demand and supply conditions in the product market drive most of the returns in commodities futures through their effect on spot prices or the size of roll yields. Demand and supply also suffer persistent shocks that can last for years as analyzed in the commodity cycle literature.

Overall, we find that the momentum force is **stronger in commodities than in many other financial markets**. Commodities are affected by the same behavioral biases that create momentum in many financial markets, but they are also real assets that are greatly affected by business and production cycles that thus create persistence[3].

Behavioral biases

In *Exploiting Cross-Market Momentum,* Feb 2006, we discuss two basic behavioural forces that can create momentum in markets — underreaction and overreaction to information. In the former, investors are unable to process available information in a timely fashion, and prices adjust to new information only slowly. The overreaction story is also based on other investors' cognitive biases that lead to extrapolation of past performance into the future. Both behavioural biases will make prices deviate persistently from intrinsic value. The behavioral biases can affect both the spot and futures markets as investors and hedgers react to underlying market information.

Business cycle

The business cycle itself tends to create cycles in the aggregate level of commodity prices. The boom and bust cycles in aggregate GSCI have averaged roughly three years in duration and exhibit price movements of some 40%. By historical standards (see *The Commodity Price Cycles: Has Anything Changed?,* J. Normand, 2005), the current rally is atypical, both for its duration and magnitude. From its trough in Feb 2002, the GSCI composite and the energy sub-index have rallied for longer and by far more than average.

The common driver of demand growth is the underlying cyclical condition during a four-year economic expansion. As production inputs, crude and base metals show a reasonable correlation with underlying global industrial production. The correlation between demand growth and global industrial production growth over the past decade has been approximately 0.6 for crude, and 0.9 for base metals.

Sectoral cycles

Commodity cycles are not all the same and they do not coincide (see Chart 5). An analysis of spot price cycles shows that some of them are clearly longer (see Table 1). Individual commodity cycles tend to last around 3 years and are rarely shorter than one year. This difference in cycles make strategies based on relative momentum interesting. All major sub-indices have posted sharp run-ups in prices over 2-to-3-year periods followed by equally strong and extended price declines. With the exception of energy, there has been no trend in price appreciation over the past 35 years, and energy and metals' apparent trend rise is due solely to the rally since 2002.

A first reason for the difference in cycle length and timing is that the different phases of the business cycle may have a different impact on various commodities. These differences in cycles are also due to changes in demand and supply that alter the required inputs in production. Growing industries can be more or less commodity-intensive with differing requirements in terms of types of commodities for production. Changes in consumer tastes can also affect the relative demand of particular commodities.

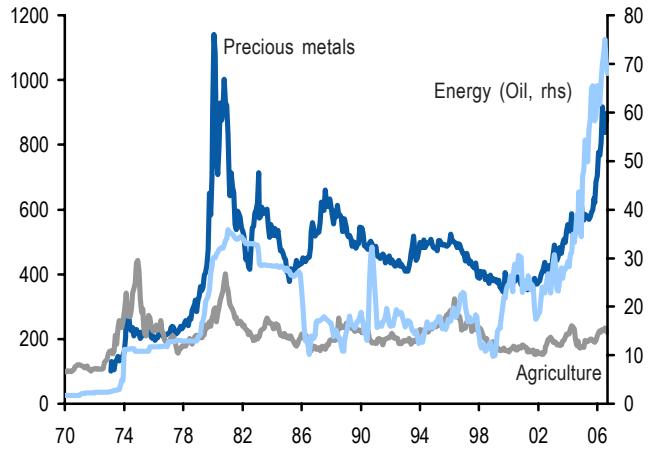
3 It is not worth spending too much time reviewing previous studies since some readers may be aware of the existence of cycles in commodity spot prices. There are various and comprehensive studies of commodity cycles (for example, see IMF web page for a long list of IMF papers on commodities and cycles in particular, http://www.imf.org/external/np/res/commod/bib.htm). In effect, the economic literature on cycles was partially motivated by the existence of cycles in commodity prices. There are also many accounts of the relation between commodity and business cycles due to their mutual dependence. First, commodities cycles will be related to changes in industry composition as most of the commodities are inputs in industrial production. Second, changes in commodities prices, e.g. oil, can affect the business cycle.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

Jan Loeys (44-20) 7325-5473
jan.loeys@jpmorgan.com

JPMorgan

Chart 5. Commodity spot price cycles



Source: JPMorgan

Supply and demand shocks

Commodity markets share one characteristic which tends to generate boom-bust cycles: low price elasticity in the short run. Elasticity is a structural characteristic driven on the demand side by the availability of substitutes. The presumption is that energy and base metals should exhibit low price elasticity over short- to medium-term horizons, since retooling to use alternative fuels or production inputs is expensive and/or time consuming. Price elasticity of supply is driven by the production cycle's length and the ease of holding inventory. This cycle varies widely by sector: several years for oil extraction and refining, two to three years for metals, two years for livestock and a year for agricultural products. Hence the presumption that short-term supply elasticity is also quite low. Regardless of the source of the shock, unanticipated changes in demand or supply may generate a large price response.

How to exploit momentum

To be interesting to investors, the strategy should focus on

- a **high return to risk** (high Sharpe ratio), which requires a large and diverse set of commodities;
- **transactability**, which requires focusing on tradable and low-cost indices; and
- **robustness**, which requires simplicity.

All strategies described here are designed to achieve these objectives as we use only simple strategies applied to a large set of commodities via low-cost tradable indices and futures.

We use the standard approach to trading momentum that has been developed in the equities literature. This relies on the idea that stocks that were recent winners will tend to perform better in the near future than recent losers. These rules divide stocks in groups based on their performance over, say, the past 3 to 12 months. After ranking and grouping the individual stocks, the investment rule overweights recent winners and underweights losers. Here we follow the same approach, but apply it across different commodities (Erb and Harvey (2006) also use the same methodology for commodities but only show one particular application). The performance of both equities and commodities strategies share a surprising resemblance.

Chart 6 describes our decision process and the variations that can be implemented. In following sections, these variations are introduced to test alternative interpretations of momentum and the robustness of the strategies. The analysis considers among others the following variations:

Table 1. Characteristics of Commodity Price Cycles – 1970-2006

		Commodity price booms		Commodity price slumps		Current phase		
	No. of completed cycles	Average duration (months)	Average increase (%)	Average duration (months)	Average loss (%)	Current duration (months)		Amplitude (%)
All commodities	5	37	45	36	-42	Boom (since Feb-02)	55	169
Energy	3	36	58	27	-54	Boom (since Feb-02)	55	232
Base metals	4	28	48	47	-43	Boom (since Nov-01)	58	249
Precious metals	5	30	47	43	-42	Boom (since Sep-99)	84	154
Agriculture	6	35	48	34	-45	Boom (since Nov-04)	22	27
Livestock	5	41	35	34	-30	Boom (since Sep-02)	46	53

Source: JPMorgan. Data until August 2006. *The Commodtity Price Cycles: Has Anything Changed?*, J. Normand, 2006.

Types of Momentum

- Relative momentum in return differences across individual commodities;
- Absolute momentum in excess return of individual commodities;
- Aggregate momentum in an overall index such as GSCI or GSCI Equally-weighted;
- Combinations of the above rules.

Positioning

- Long-only: long commodities with positive momentum;
- Long-short: long commodities with positive momentum and short those with negative momentum;
- Long with conditional shorts: long commodities with positive momentum and short those with negative momentum only when certain conditions are met.

Refinements

These refinements are additional restrictions that can be imposed on a basic momentum selection rule. The refinements can drop commodities that do not satisfy these restrictions. Other refinements are just different ways of computing past performance or taking risk into account. We will define them in more detail later on.

- Consistency check;
- Exponentially-weighted consistency check;
- Stop-loss rule;
- Additional shorter-term rules;
- Smoothed data;
- Moving average filters;
- Sorting by Sharpe ratios.

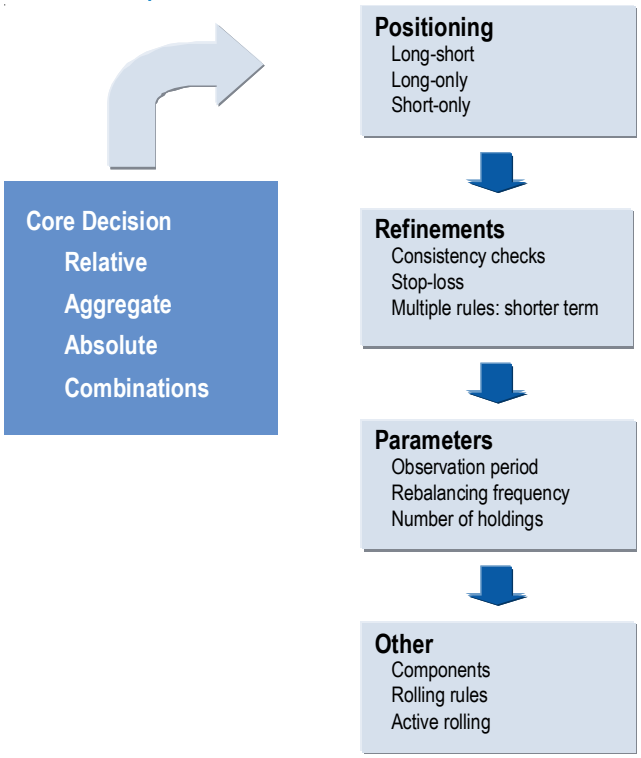
Parametrization

- Observation period: since the focus is on medium-term momentum, the observation period should remain in the 3-18 month range.
- Rebalancing frequency: monthly, bi-monthly and quarterly, and even less frequent.
- Number of assets: 1 to 12 commodities for each potential side of the position.

4 The benchmark strategy applies a standard methodology that has been used previously in equity research. Erb and Harvey (2006) apply a very similar rule to the commodities case. The differences to our base case are the underlying data and the number of assets in the long and short positions. They also show that a long-short strategy based on the past 12-month returns with monthly rebalancing is profitable.

5 In the academic literature, studies are inclined to focus on the behaviour of assets with extreme performers looking at first and last quintiles. We find that in some cases part of the performance derives from the commodities that had extreme performance in the past months, but we decide to trade all of them. Focusing on the extreme would increase substantially the volatility of the portfolio. The robustness analysis considers the effect of reducing the number of positions.

Chart 6. Concepts and refinements



We start with a simple strategy. After this benchmark strategy is introduced, the analysis will move to the effect of each of these variations.

Benchmark relative momentum strategy

Our **benchmark strategy**[4] is not the optimal strategy based on backtesting, but it is a good starting point (data used in this paper are described in Appendix A).

Our initial choice is to implement a rule with:

- **type of momentum:** relative
- **refinements:** none
- **positioning:** long-short
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: 12 assets each side[5]

This strategy goes long the 12 best performers in the previous 12 months and short the 12 worst performers, rebalancing every month with equal weights. The choice of a long-short strategy is to emphasize the effect of the selection rule based on relative momentum, getting a clear picture of the alpha being generated by momentum. The long-only version presents a similar but lower alpha, and it adds a beta exposure that is not essential.

Table 2 presents basic statistics for the strategy as well as two long-only benchmarks, GSCI and an equally-weighted portfolio of GSCI individual components (defined as GSCI Equally-weighted or GSCI-EW). The strategy has a higher return than both long-only exposures with standard deviation in between the two passive benchmarks, even though it focuses on the alpha in commodities. Due to the low beta to GSCI, the regression-based alpha remains about 10% a year. The strong performance was also seen earlier in Chart 2.

Observation period (ranking): 12 months

The strategy ranks these commodity indices using the past 12-month returns. This is common for similar strategies in the equities market and also a reasonable range for commodities due to their long cycles. The observation period should be long enough to eliminate the effect of short-term volatility. But it should not be too long either because at some point prices may turn around.

Many commodities have annual production cycles, making price cycles last at least that long. Many studies have shown that the half-life of price shocks tend to be at least one year for most commodities.

Seasonality in individual commodities is another economic reason to use 12 months or other multiples of 12 months. Anything longer or shorter than multiples of 12 could induce decisions that are not based on trends but on seasonal movements.

Rebalancing frequency: monthly

There is no particular reason to favor monthly rebalancing. As seen later on, results are robust to less frequent rebalancing. Monthly rebalancing will make us focus on the medium-term momentum and minimize the effect of short-term momentum. Less frequent rebalancing would make the portfolio more concentrated on the recent winners and losers, as the performance between the rebalancing periods determines how portfolio weights evolve between rebalancing dates.

Number of assets: 50/50

The benchmark strategy divides the available indices in two halves and uses the top half for the long position and the bottom half for the shorts. This is done for simplicity and to avoid arbitrary choices.

Table 2. Performance – Benchmark Strategy and GSCI

	Strategy	GSCI-EW	GSCI
Geometric mean	12.2%	3.2%	2.9%
Standard deviation	13.6%	9.5%	18.6%
Sharpe ratio	0.90	0.34	0.15
Correlation (GSCI)	0.29	0.83	1.00
Beta (GSCI)	0.22	0.42	1.00
Alpha (GSCI)	11.5%	1.7%	-
Alpha t-stat (GSCI)	3.48	1.25	-

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

Adding aggregate and absolute momentum

This section shows that **adding other momentum strategies can improve performance**. The following variations target different types of momentum. Positioning is changed only to make clear the contribution of the strategy. Both observation period and rebalancing frequency are kept the same for better comparison.

Aggregate commodities momentum

- **sources of momentum:** aggregate
- **refinements:** none
- **positioning:** long-short or long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 1 asset (GSCI aggregate)

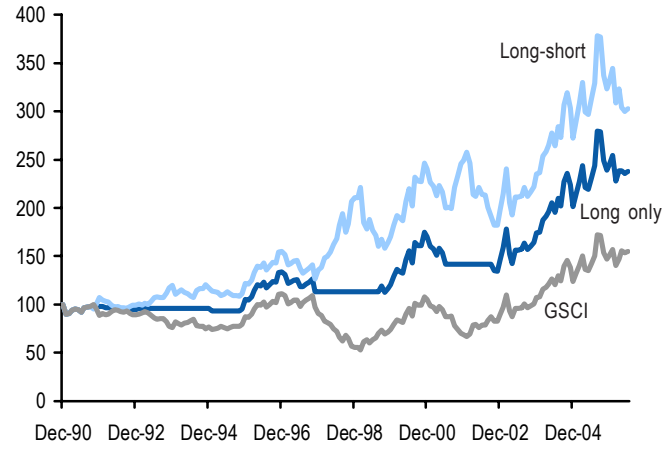
We can interpret this particular strategy as a simple dynamic beta allocation, since we change the exposure to the overall commodities group over time depending on its past performance. Therefore, we only choose whether to have a positive beta to commodities or a zero beta (and even negative) over time depending on the performance of the chosen aggregate commodities index.

There are two simple alternatives that we consider. In the first case, the strategy is either long commodities or stays neutral (long-only). In the second, the strategy is long commodities or short commodities (long-short). In terms of betas, the first switches between zero and one depending on past performance, while the second switches between +1 and -1.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

Chart 7: Aggregate Momentum – cumulative excess return



Source: JPMorgan

Table 3. Performance – Aggregate Momentum

	Long-only	Long-Short	GSCI
Geometric mean	5.7%	7.4%	2.9%
Standard deviation	15.0%	18.5%	18.6%
Sharpe ratio	0.38	0.40	0.15
Correlation (GSCI)	0.81	0.30	1.00
Beta (GSCI)	0.65	0.30	1.00
Alpha (GSCI)	3.8%	7.5%	-
Alpha t-stat (GSCI)	1.68	1.68	-

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

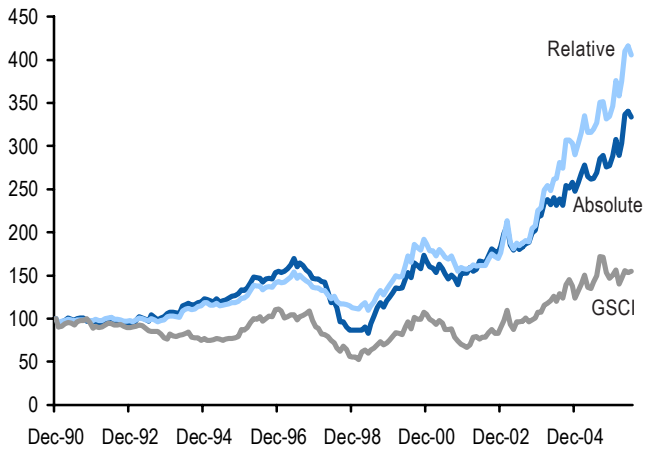
Chart 7 and Table 3 show the performance of both long-only and long-short plus the aggregate GSCI, based on monthly rebalancing and the past 12-month return. Relative to a passive long-only strategy, an aggregate momentum strategy will avoid periods with long-lasting downtrend. These downtrends will even turn into positive returns if short positions in commodities are taken.

Absolute commodities momentum

- **sources of momentum:** absolute
- **refinements:** none
- **positioning:** long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: potentially all

This variation takes long positions in individual commodities that had positive excess returns over the past 12 months. For a fair comparison, we analyze this strategy against the performance of a long-only relative momentum strategy.

Chart 8: Absolute Momentum – cumulative excess return – long-only



Source: JPMorgan

Table 4. Performance – Absolute Momentum – long-only

	Absolute	Relative	GSCI
Geometric mean	8.1%	9.5%	2.9%
Standard deviation	14.6%	12.6%	18.6%
Sharpe ratio	0.55	0.75	0.15
Correlation (GSCI)	0.66	0.78	1.00
Beta (GSCI)	0.51	0.53	1.00
Alpha (GSCI)	6.5%	7.4%	-
Alpha t-stat (GSCI)	2.33	3.75	-

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

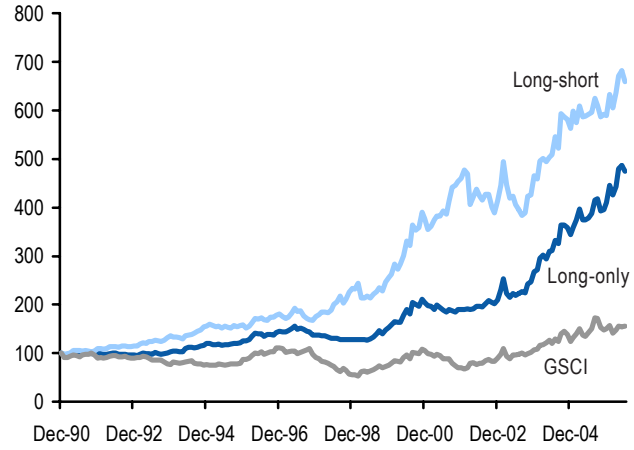
Chart 8 and Table 4 show the performance of these two strategies. It is clear that absolute momentum provides high returns, but the performance is less impressive than the relative momentum strategy.

Combining absolute and relative momentum

- **source of momentum:** relative and absolute
- **refinements:** none
- **positioning:** long-short or long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 assets each side

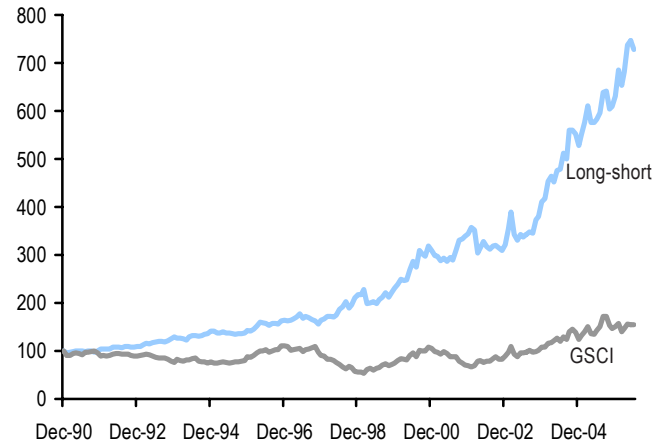
This variation selects only positive performers for the long side and negative performers for the short side, but reintroduces a limit to the number of longs and shorts. Hence, it is a relative momentum strategy that also uses information about absolute performance. This additional restriction will generate potential imbalance in the allocations, as we can have more commodities on the long or short side. Therefore, the beta to commodities will fluctuate over time.

Chart 9: Relative plus Absolute – cumulative excess return



Source: JPMorgan

Chart 10: Relative,Absolute and Aggregate – cumulative exc. return



Source: JPMorgan

Table 5. Performance – Relative plus Absolute

	Long-only	Long-short	GSCI
Geometric mean	10.6%	12.9%	2.9%
Standard deviation	11.7%	14.0%	18.6%
Sharpe ratio	0.90	0.93	0.15
Correlation (GSCI)	0.73	0.22	1.00
Beta (GSCI)	0.46	0.17	1.00
Alpha (GSCI)	8.7%	12.4%	-
Alpha t-stat (GSCI)	4.22	3.59	-

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

Table 6. Performance – Relative, Absolute and Aggregate

	Long-short	GSCI
Geometric mean	13.7%	2.9%
Standard deviation	13.4%	18.6%
Sharpe ratio	1.02	0.15
Correlation (GSCI)	0.32	1.00
Beta (GSCI)	0.23	1.00
Alpha (GSCI)	12.7%	-
Alpha t-stat (GSCI)	3.94	-

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

For example, if all commodities have positive excess returns, this version of the strategy becomes a simple long-only allocation with only 12 positions. Chart 9 and Table 5 show the basic statistics.

Combining aggregate, absolute and relative momentum: a conditional short rule

- **source of momentum:** relative and aggregate
- **refinements:** none
- **positioning:** long-conditional short
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 assets each side

There are other, more complex combinations of the three basic types of momentum. One of these is to only use short positions when the past performance of the commodities market (measured by GSCI-EW) is negative in excess returns. The conditional shorts make the portfolio "market-neutral" when the market is in a bearish mode.

Table 6 shows the basic statistics. Chart 10 shows this variation has a significant impact in performance. It benefits from the selective approach in relative momentum and also the effect of aggregate momentum. The addition of absolute momentum also has an additional positive impact, reinforcing the idea that these different types of momentum are complementary.

Adding refinements

Simple momentum strategies deliver strong performance, but the robustness of the strategy could be improved with additional refinements. These are not necessarily more efficient than the simple version described above, but address some of the concerns that investors may have with momentum-based strategies.

To make the discussion clear, the analysis returns to the benchmark strategy, focusing on the long-only version, and considers these refinements individually, even though some

Table 7. Adding refinements to Relative momentum - long-only

	Geom. mean	St. deviation	Sharpe Ratio
No refinements	9.5%	12.6%	0.75
Consistency	10.7%	11.4%	0.93
ExpW consistency	10.8%	10.8%	1.00
Stop-loss	7.7%	9.4%	0.83

Source: JPMorgan.

could be used simultaneously. Table 7 shows the basic statistics. The consistency check adds value to the benchmark strategy, even though part of this benefit could also be obtained with the addition of an absolute momentum rule instead.

Consistency Check

- **source of momentum:** relative
- **refinements:** consistency check
- **positioning:** long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 each side

This investment rule borrows one idea that has been proposed for equity momentum strategies by Grinblatt and Moskowitz (2004)[6]. In this paper, they found that stocks with *consistent* past performance are more likely to present momentum. Consistent returns are those that are delivered steadily and not just through a few large price movements. This idea can address concerns on the effect of sudden changes in commodity prices due to demand/supply shocks.

A certain commodity can have high excess returns over a certain period, but these high returns may result from only a few events. A one-off drastic change in a commodity price may even increase the likelihood of a mean-reversion process that can drive prices in the opposite direction.

Grinblatt and Moskowitz proposed a simple way of measuring consistency in positive momentum based on the proportion of months with positive performance, and vice-versa. If this proportion is higher than a specified cut-off point such as one half, then we can conclude that momentum is consistent and more likely to persist. In their analysis, they found that individual stocks that present consistent performance are more likely to present momentum. Therefore, the variation analyzes a strategy that only chooses commodities with consistent momentum, i.e. more than half of the months in the right direction.

Box 2. Consistency check

At a certain month t, we assign a weight, w_i, for each month t-i such that the sum of all weights is equal to one. In our base case, i varies from 1 to 12.

Additionally, if month i has positive performance, then x_i is equal to 1, otherwise 0.

A certain asset has consistent performance if cumulative returns are positive (negative) and the sum of all terms $w_i \times x_i$ is larger (smaller) than 0.5.

In the case of the simple consistent check, all weights are equal to one. In exponential-decaying case, w_i is equal to $A \times \exp(-r \times i)$. A is such that the sum of all weights is one for a certain r.

In the reported cases, we calibrate r to make the ratio of the weight of the most recent month to the weight of the least recent month equal to 5. In the regular consistency check, this ratio is one. In the stop-loss rule, the ratio is infinite.

Exponentially-weighted Consistency Check

- **source of momentum:** relative
- **refinements:** consistency check (exponential decay)
- **positioning:** long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 assets each side

The above consistency check will give the same weight to all months. Therefore, the most recent and most distant months are equally important. We can, however, give more weight to the most recent observations using exponentially-decaying weights. The only required information to calibrate the model is how higher the weight of the most recent month is relative to the most distant (see Box 2).

The consistency check is designed to consider the path of the returns over the observation period and not only the overall performance. The exponentially-weighted version will give more weight to the recent past.

6 *Predicting Stock Price Movements from Past Returns: The Role of Consistency and Tax-Loss Selling*, 2004, Journal of Financial Economics Vol. 71 No. 3, 541-579.

"Stop-Loss" Rule

- **source of momentum:** relative
- **refinements:** "stop-loss" rule
- **positioning:** long-short or long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 assets each side

If the decay in the previous rule is infinite, the consistency check only looks at the most recent observation. The rule becomes a "stop-loss" rule, because it is long (short) commodities with positive (negative) momentum over the past 12 months but only if returns are also positive (negative) in the most recent month.

This strategy is not the best performer in the range of exponentially-weighted consistent rules. Moreover, there are other "stop-loss" rules that perform better, but these rules should allow losses in the last month up to higher levels such as -5% or -10% instead of 0% before ruling out the likelihood of momentum. These rules seem, however, excessively arbitrary.

We find that excessive emphasis on the recent performance can damage the overall performance of medium-term momentum strategies. Therefore, very recent performance should be used only as additional information and should not drive the allocation decision.

Additional Shorter-Term Rules

- **source of momentum:** relative
- **refinements:** 12, 6, 3 month returns check
- **positioning:** long-short or long-only
- **observation period**: 12 months
- **rebalancing frequency**: monthly
- **number of assets**: up to 12 assets each side

Instead of using just one rule to measure consistency, we could also check multiple ranges, while the ranking is still based on the past 12 months. Additional checks can reduce significantly the number of commodities that are selected. Performance remains strong.

Other refinements

- **Smoothed Data**
  The rule could also be based on smoothed versions of the original excess return series in order to minimize of the effect of high daily volatility on month-to-month returns. Instead of using end-of-month information, we can use a moving average of the last days of the months. This can be used to improve the performance of rules based on shorter horizons but make no difference for longer horizons.

- **Moving-Average Filters**
  Moving-average filters are also very common in technical analysis. They provide similar results as they can be interpreted as combinations of the simple look-back rules used here and in most academic research. A moving-average rule will give more weight to recent returns compared to the ones used here. For the sake of completeness, we also tested rules where different look-back periods are aggregated using exponentially-decaying weights. Results are positive in all cases.

- **Sorting by Realized Sharpe Ratios**
  The rule could also take into account the volatility of the commodity when we rank commodities. Instead of sorting by past performance, it could sort by realized Sharpe ratio. There is no reason to claim that this is a superior rule, since momentum could be driven by the more volatile assets (as it is true in the case of other asset classes). We also tested this variation with similar results.

Parameters – robustness analysis

It is an easy task to create complicated rules that generate high alphas with past data. It is a lot more difficult to do the same with simple strategies that are robust to changes in parameters, such as ranking and rebalancing period. This section focuses on the robustness of the results to variations in the rules.

For the sake of conciseness, we test the robustness for variations in four particular parameters. Therefore, testing concentrates on:

- **source of momentum:** relative
- **refinements:** none
- **positioning:** long-short
- **observation period**: variable to test robustness
- **rebalancing frequency**: variable to test robustness
- **number of assets**: variable to test robustness

Table 8 reports the effect on the benchmark strategy of variations in three basic parameters: observation or ranking

Table 8. Robustness analysis for Relative momentum - long-short

Observation (Ranking)	Rebalancing	Assets	Average Excess Return	Standard Deviation	Sharpe Ratio	Alpha (GSCI)	t-stat	Beta (GSCI)
10	1	12	6.73%	13.05%	0.52	6.65%	2.10	0.19
11	1	12	10.22%	13.17%	0.78	9.72%	3.05	0.21
12	1	12	**12.20%**	**13.61%**	**0.90**	**11.50%**	**3.49**	**0.22**
13	1	12	7.76%	13.35%	0.58	7.21%	2.23	0.22
14	1	12	8.62%	13.16%	0.66	7.98%	2.51	0.22
12	**1**	12	**12.20%**	**13.61%**	**0.90**	**11.50%**	**3.49**	**0.22**
12	**2**	12	9.60%	14.22%	0.67	8.82%	3.92	0.28
12	**3**	12	11.05%	11.24%	0.98	10.00%	5.68	0.31
12	**4**	12	7.76%	12.80%	0.61	7.02%	4.48	0.30
12	**5**	12	7.86%	12.68%	0.62	7.28%	5.08	0.27
12	1	**8**	12.83%	18.55%	0.69	12.38%	2.77	0.31
12	1	**9**	13.36%	17.00%	0.79	12.70%	3.11	0.29
12	1	**10**	14.15%	15.78%	0.90	13.38%	3.50	0.25
12	1	**11**	13.77%	14.60%	0.94	13.00%	3.66	0.22
12	1	**12**	**12.20%**	**13.61%**	**0.90**	**11.50%**	**3.49**	**0.22**

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

period, rebalancing period, and the number of assets. Obviously, the parameters should stay within a reasonable range that would be compatible with medium-term momentum.

The return statistics remain very positive even if we depart significantly from the optimal strategy. The alpha against the GSCI is statistically and economically significant in all reported cases and remains significant even outside the reported range.

It is not necessary to trade all commodities, as alpha remains strong when the strategy focuses on the extreme performers. Concentrating on a few ones will, however, increase volatility and trading.

Additional robustness analysis

This section considers other robustness tests besides changes in parameters. Once again, the analysis is based on the benchmark strategy only. The following variations and analysis are performed:

1. **Excluding** some of the commodities, the analysis shows that the results do not rely on any particular composition.
2. Using a **longer sample** to verify our results at the cost of restricting the number of commodities used.
3. Performing **sub-sample analysis** and relation to market conditions such as returns and volatility.
4. Using **other indices and futures** besides GSCI and also direct exposures to futures contracts.
5. Testing monthly rebalancing but with **partial rebalancing** that allows longer average holding periods.
6. Considering **time-varying risk** as volatility and the beta of the strategy may change over time.
7. Verifying that **correlation to CTA**'s is not high due to our focus on commodities.

Excluding commodities

A strategy is strong when it is not highly dependent on the data that we use. This analysis shows that none of the individual commodities are essential for the performance of this strategy. We compute the returns of the strategy when only a subset of the available commodities are included and consider all possible combinations.

Chart 11 shows the Sharpe ratio of all possible one-by-one exclusions plus the case without any exclusion, the regular strategy. Performance remains roughly the same. The general message is that momentum strategies are profitable independently of the underlying commodities that are used. Of course, the set of commodities should be large enough to guarantee that there is sufficient dispersion in returns. If there is no dispersion, there is one less reason for momentum.

Taking this analysis a few steps further, we analyzed how the strategy performs if additional commodities are dropped. Table 9 shows the performance of the strategy when particular sectors are excluded from the analysis. Even in the worst scenario, alphas remain economically and statistically significant (t-stats not reported). The energy sector has a large contribution to the profitability of the momentum strategies, but it is not essential.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

Jan Loeys (44-20) 7325-5473
jan.loeys@jpmorgan.com

Longer sample

The strategies also outperform with a longer sample, starting in 1971. Even though it is necessary to use fewer assets because of lack of index data earlier in the sample, performance remains very strong.

We tested three possible variations:

1. **neutral backfilling**: use neutral returns (zero in the case of excess returns) whenever a certain index is not available.
2. **GSCI backfilling**: use GSCI aggregate returns whenever a certain index is not available.
3. **"progressive" rule**: use an adjusted rule that is proportional to the number of commodities that are available at each point in time. A certain commodity is added whenever there is enough information for ranking.

Tables 10, 11 and 12 (next page) show the main statistics for all these variations and for different types of strategies, including robustness analysis. Performance earlier in the sample is roughly the same as in the recent past. The recommended rules based on earlier data are the same in most of the cases. This is evidence that the strategy is likely to remain profitable out of sample, since we can interpret the analysis using post-91 data as out-of-sample analysis.

Sub-sample analysis and relation to market conditions

Table 13 also shows the performance in subsamples for the post-91 period. Chart 12 shows the evolution of the geometric return until the end of the sample for two different strategies depending on different starting dates, confirming the stability

Table 9. Sharpe ratio when excluding sectors

	Geometric mean	Sharpe Ratio	Alpha (GSCI)
No exclusions	12.20%	0.90	11.50%
No precious metals	13.93%	0.96	13.12%
No livestock	14.78%	0.95	13.75%
No agricultural	9.30%	0.52	9.29%
No energy	7.03%	0.61	7.37%
No industrial metals	13.31%	0.82	12.70%

Source: JPMorgan. In all cases, strategy is long top half and short bottom half. Alpha is based on regression All alphas are statistically significant at 5%.

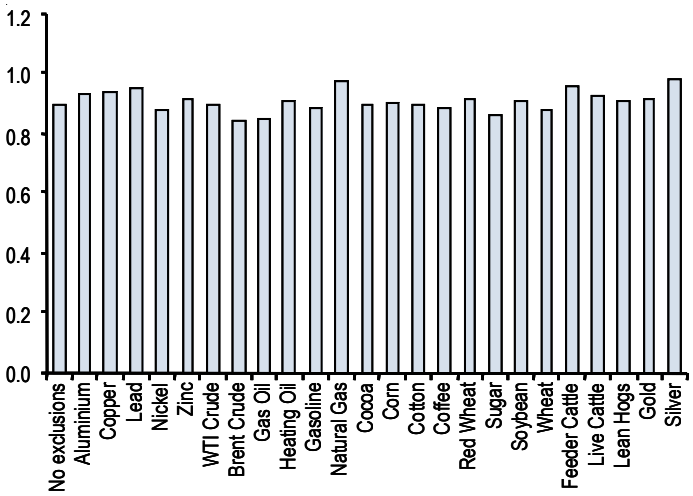
Tables 10, 11 and 12 (see page 14)

Table 13. Sub-sample analysis

	First Half	Second Half
Geometric mean	8.1%	16.5%
Standard deviation	9.2%	16.9%
Sharpe ratio	0.88	0.98
Correlation (GSCI)	-0.10	0.41
Beta (GSCI)	-0.07	0.31
Alpha (GSCI)	7.9%	12.7%
Alpha t-stat (GSCI)	2.41	2.30

Source: JPMorgan. Divides the sample 1991-2006 into two halves.

Chart 11. Sharpe ratio when excluding commodities one at a time



Source: JPMorgan. Strategy is long 11 and short 11 when one commodities is excluded.

Chart 12. Geometric mean for different starting dates

Source: JPMorgan.

Table 10. Robustness analysis for Relative momentum (long-short) since 1971 using neutral backfilling

Observation (Ranking)	Rebalancing	Assets	Average Excess Return	Standard Deviation	Sharpe Ratio	Alpha (GSCI)	t-stat	Beta (GSCI)
10	1	12	7.98%	11.75%	0.68	7.31%	3.82	0.15
11	1	12	9.62%	11.77%	0.82	8.64%	4.56	0.18
12	1	12	**10.13%**	**12.01%**	**0.84**	**9.01%**	**4.69**	**0.19**
13	1	12	7.89%	11.81%	0.67	6.92%	3.67	0.20
14	1	12	8.02%	11.79%	0.68	6.87%	3.70	0.22
12	**1**	12	**10.13%**	**12.01%**	**0.84**	**9.01%**	**4.69**	**0.19**
12	**2**	12	8.35%	11.99%	0.70	7.19%	3.80	0.22
12	**3**	12	9.02%	11.83%	0.76	7.66%	4.16	0.24
12	**4**	12	7.59%	12.02%	0.63	6.15%	3.35	0.26
12	**5**	12	7.22%	12.19%	0.59	5.80%	3.11	0.27
12	1	**8**	12.30%	16.95%	0.73	10.98%	4.08	0.29
12	1	**9**	11.93%	15.35%	0.78	10.60%	4.34	0.26
12	1	**10**	11.94%	14.09%	0.85	10.65%	4.73	0.23
12	1	**11**	11.19%	12.99%	0.86	10.01%	4.81	0.20
12	1	**12**	**10.13%**	**12.01%**	**0.84**	**9.01%**	**4.69**	**0.19**

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

Table 11. Robustness analysis for Relative momentum (long-short) since 1971 using GSCI backfilling

Observation (Ranking)	Rebalancing	Assets	Average Excess Return	Standard Deviation	Sharpe Ratio	Alpha (GSCI)	t-stat	Beta (GSCI)
10	1	12	5.78%	12.96%	0.45	5.29%	2.51	0.16
11	1	12	7.70%	13.24%	0.58	7.02%	3.27	0.18
12	1	12	**8.32%**	**13.53%**	**0.62**	**7.57%**	**3.45**	**0.19**
13	1	12	5.72%	13.05%	0.44	5.07%	2.40	0.19
14	1	12	4.95%	12.79%	0.39	4.22%	2.05	0.20
12	**1**	12	**8.32%**	**13.53%**	**0.62**	**7.57%**	**3.45**	**0.19**
12	**2**	12	6.43%	13.39%	0.48	5.68%	2.64	0.20
12	**3**	12	6.06%	12.56%	0.48	5.31%	2.63	0.19
12	**4**	12	5.40%	13.45%	0.40	4.45%	2.09	0.24
12	**5**	12	4.40%	12.94%	0.34	3.73%	1.79	0.20
12	1	**8**	9.79%	17.71%	0.55	9.11%	3.18	0.25
12	1	**9**	9.72%	16.31%	0.60	8.93%	3.39	0.23
12	1	**10**	9.75%	15.61%	0.62	8.95%	3.55	0.22
12	1	**11**	9.09%	14.46%	0.63	8.32%	3.55	0.20
12	1	**12**	**8.32%**	**13.53%**	**0.62**	**7.57%**	**3.45**	**0.19**

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

Table 12. Relative momentum (long-short) since 1971 using "progressive rule"

Observation (Ranking)	Rebalancing	Assets	Average Excess Return	Standard Deviation	Sharpe Ratio	Alpha (GSCI)	t-stat	Beta (GSCI)
12	1	12	12.89%	19.22%	0.67	12.68%	4.00	0.18

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

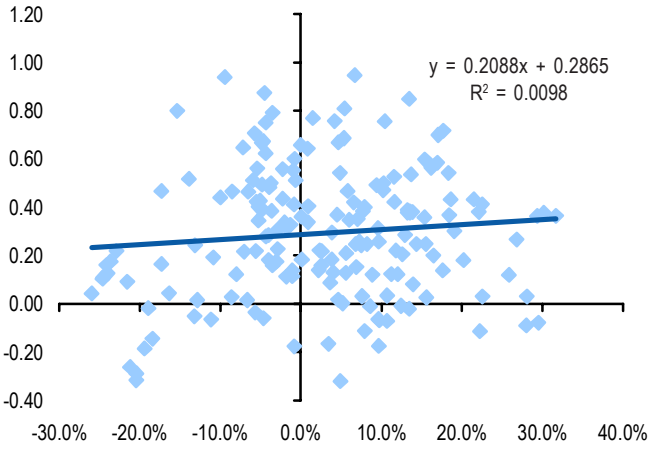
of the performance. The first strategy is the benchmark strategy and the second is an enhanced version that includes also aggregate and absolute momentum and introduces an exponentially-weighted consistency test.

An analysis based on one-year horizons shows additional confirmation of performance stability in sub-samples. The **strategy outperforms its appropriate benchmark almost always** and has a **good correlation with market conditions.** More specifically, we look at the relation between outperformance measured by information ratio[7] with respect to GSCI-EW and both the GSCI-EW return and its volatility for all one-year horizons.

The striking result is that **almost all information ratios are positive** as seen in Chart 13 for example. Hence, an investor following this strategy would outperform the benchmark in almost all one-year horizons. The strategy underperforms in only a few cases, but the magnitude of the information ratio is very small, implying the underperformance is not significant.

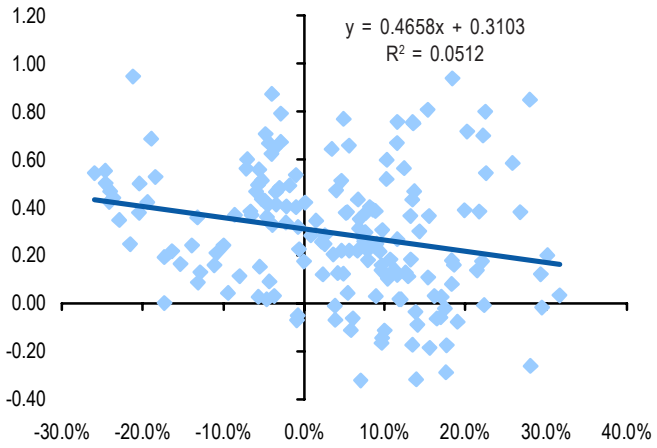
There is negligible correlation between the information ratio and past/contemporaneous market direction/volatility. Charts 13, 14, 15 and 16 show that past/contemporaneous aggregate commodity returns and past/contemporaneous volatility are not affecting the outperformance of the strategy. The mild relation is even positive for the strategy since information ratios are higher when contemporaneous market returns are lower.

Chart 13. 1-year IR over GSCI-EW vs. past 1-year GSCI-EW return



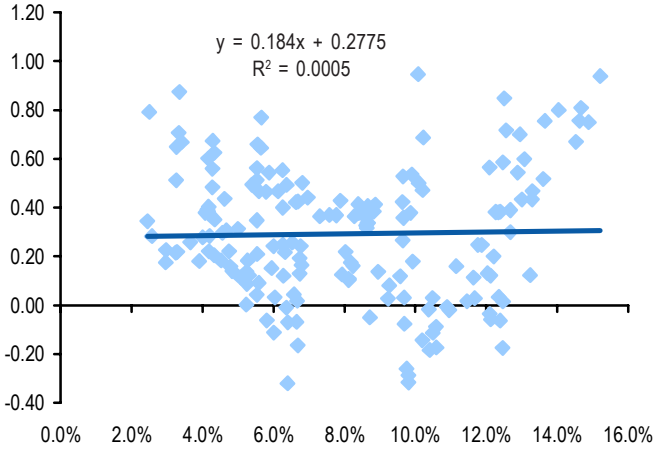
Source: JPMorgan.

Chart 14. 1-year IR over GSCI-EW vs. GSCI-EW return



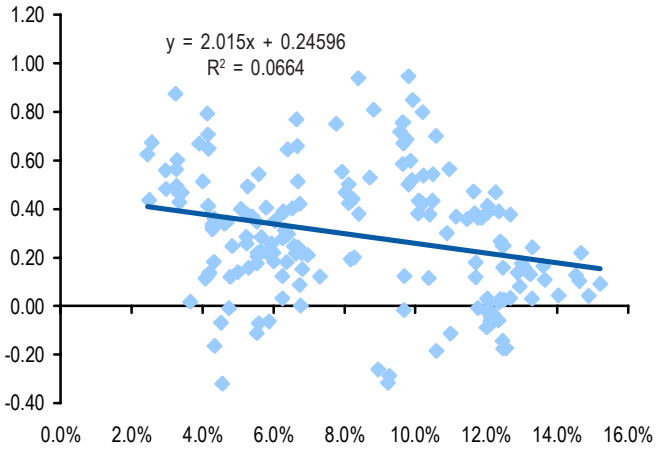
Source: JPMorgan.

Chart 15. 1-year IR over GSCI-EW vs. past 1-year GSCI-EW vol



Source: JPMorgan.

Chart 16. 1-year IR over GSCI-EW vs. GSCI-EW vol



Source: JPMorgan.

7 Our calculation of information ratio is based on regression analysis to account for the low but not negligible beta. It is the time-series average of the series (strategy return - beta x GSCI-EW return) divided by the standard deviation of the same series, where beta is a regression coefficient.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

JPMorgan

Table 14. Robustness analysis for Relative momentum (long-short) using Dow Jones/AIG

Observation (Ranking)	Rebalancing	Assets	Average Excess Return	Standard Deviation	Sharpe Ratio	Alpha (GSCI)	t-stat	Beta (GSCI)
10	1	10	6.04%	14.15%	0.43	5.13%	1.41	0.20
11	1	10	12.26%	14.46%	0.85	10.35%	2.79	0.25
12	1	10	**12.96%**	**14.56%**	**0.89**	**11.84%**	**3.12**	**0.16**
13	1	10	9.99%	14.46%	0.69	8.84%	2.35	0.19
14	1	10	7.74%	14.60%	0.53	6.62%	1.74	0.21
12	**1**	10	**12.96%**	**14.56%**	**0.89**	**11.84%**	**3.12**	**0.16**
12	**2**	10	11.90%	14.56%	0.82	10.79%	2.84	0.17
12	**3**	10	9.73%	14.18%	0.69	8.72%	2.37	0.18
12	**4**	10	9.74%	14.59%	0.67	8.86%	2.33	0.16
12	**5**	10	3.98%	16.18%	0.25	4.19%	0.99	0.11
12	1	**6**	13.60%	18.83%	0.72	10.68%	2.24	0.43
12	1	**7**	13.52%	17.08%	0.79	11.37%	2.59	0.31
12	1	**8**	12.73%	15.92%	0.80	10.86%	2.65	0.27
12	1	**9**	13.45%	15.22%	0.88	12.06%	3.05	0.20
12	1	**10**	**12.96%**	**14.56%**	**0.89**	**11.84%**	**3.12**	**0.16**

Source: JPMorgan. Alpha is the annualized intercept of a regression on GSCI excess returns.

Other indices

We also applied these rules to other indices to make sure results were not driven by GSCI-specific rolling and commodities selection. As an example, Table 14 shows that momentum strategies based on Dow Jones with very similar performance.

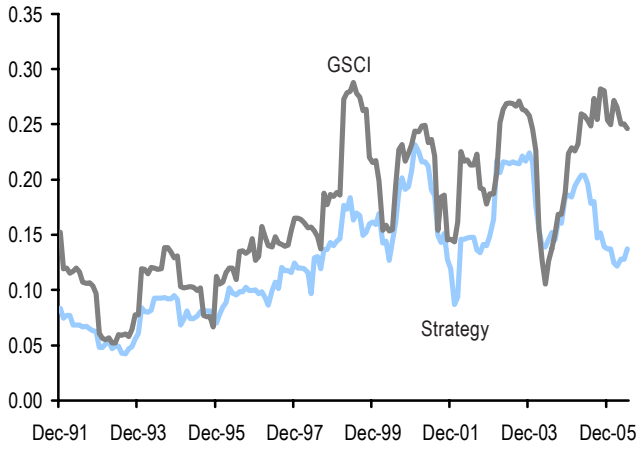
Partial rebalancing

The rebalancing scheme can be changed in many different ways. One possibility is to use partial rebalancing every month, which can be less costly and generate less drastic changes in the portfolio. In this variation, the rebalancing frequency remains monthly, but the holding period becomes longer. It is similar to divide the portfolio into many smaller portfolios that rebalance infrequently and at different dates. Results are not reported for brevity but the use of longer holding periods has negative effect on performance.

Time-varying Risk

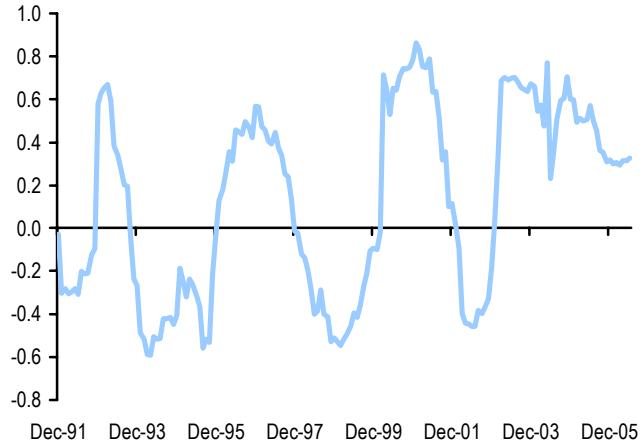
Another important issue is fluctuations in volatility. Expected volatility fluctuates over time as the strategy changes its allocations to commodities with different volatilities and correlation structures. The fluctuations in volatility can be economically significant depending on the rule we apply. An investor with target volatility exposures can address this by combining this strategy with an investment in the risk-free asset and dynamically change the allocation in order to maintain a constant volatility. Just as an example, Chart 17 shows a plot of the conditional volatility of the benchmark strategy since 1991.

Chart 17. 1-year Standard Deviation for Relative Momentum and GSCI



Source: JPMorgan.

Chart 18. 1-year Beta for Relative Momentum (long-short) with respect to GSCI



Source: JPMorgan.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

Jan Loeys (44-20) 7325-5473
jan.loeys@jpmorgan.com

Table 15. Relation to CTA's

	Benchmark Strategy	Barclays CTA Index
Geometric mean	12.2%	5.7%
Standard deviation	13.6%	8.7%
Sharpe ratio	0.90	0.65
Correlation (CTA)	0.19	

Source: JPMorgan.

These strategies will also have time-varying betas to the overall market, as seen in Chart 18. Depending on the rule, this variability can be higher or lower. Even a simple long-short relative momentum will have variability in betas with respect to GSCI because of the composition effects.

Relation to CTA performance

These momentum strategies have low correlation to the performance of CTA's. Table 15 shows the comparative performance of CTA's and the benchmark strategy. CTA's are positively correlated to medium-term momentum strategies, but the correlation is not close to one. CTA's are not only focused on medium-term trends and many of them also exploit shorter-term trends using other futures markets besides commodities. CTA's that focus only on commodities are not common.

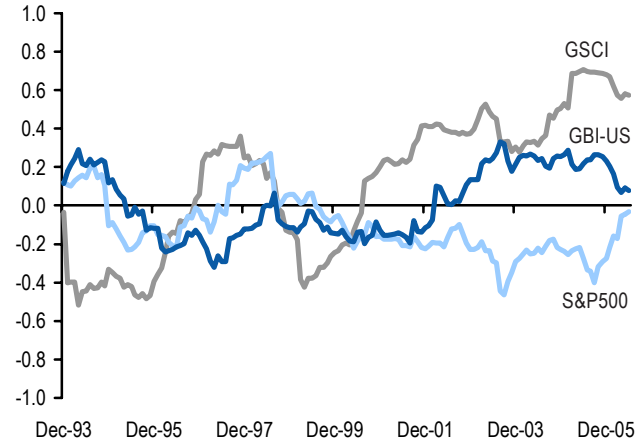
Portfolio analysis and other strategies

Correlation to other asset classes: still a good diversifier

One of the main reasons why investors consider commodities in their overall portfolio is the diversification benefit of adding a low-correlated asset. Similar diversification benefit remains when we use momentum-based investments in commodities. Chart 19 shows the rolling correlation between commodities momentum and JPMorgan US Government Bond Index (GBI-US), S&P500 and GSCI. Correlations can be even negative depending on the time period.

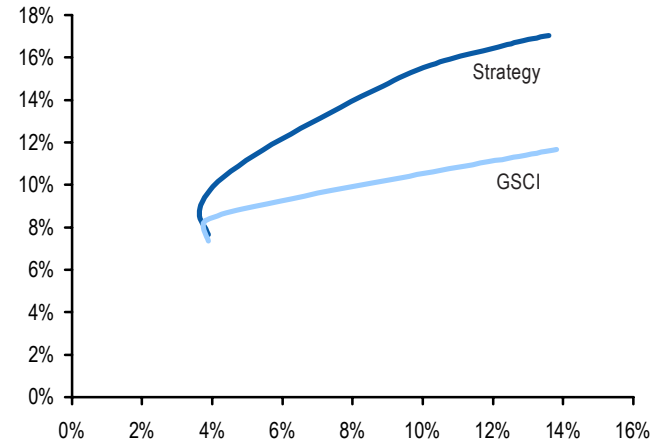
The correlation to GSCI will depend on the positioning we use (long-short or long-only). The long-only versions will have higher correlation to GSCI, while long-short strategies will tend to have near-zero correlation. Part of the fluctuation in correlation derives from composition issues. Aggregate momentum rules will also have more variable correlation to aggregate commodity indices.

Chart 19. Rolling 3-year Correlations with Stocks, Bonds and GSCI



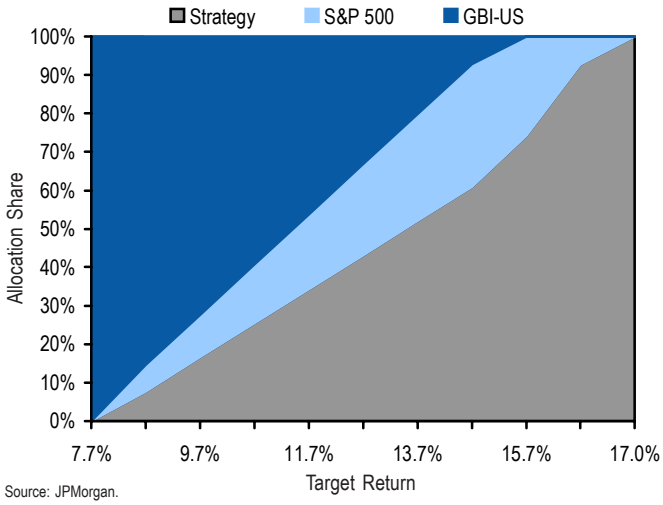
Source: JPMorgan.

Chart 20. Mean-Variance Frontier with Commodities Strategy or GSCI %, both axes



Source: JPMorgan.

Chart 21. Allocations into Bonds, Equities and Commodities Strategy



Source: JPMorgan.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

Efficient frontier

The implications for portfolio allocation are obvious as the correlation to standard asset classes remain low and returns are higher. Here we use the benchmark strategy. The efficient frontier expands when this strategy is added to portfolios of bonds (GBI-US) and equities (S&P 500) and a lot more than the case when GSCI is added, as Chart 20 shows. The Sharpe ratio of the optimal risky portfolio increases significantly and a significant fraction of the allocation would be invested in the commodities strategy (Chart 21).

Inflation-hedging ability

The momentum strategies will be less efficient in hedging against inflation than a more representative index like GSCI. (see *Hedging Inflation with Real Assets,* J. Normand, 2006). Moreover, the positioning (long-short or long-only) will severely affect the correlation with inflation. A long-only strategy will provide higher correlation to inflation than the long-short. Table 16 shows that correlation to inflation surprises remains high for a long-only relative/absolute and a enhanced momentum strategy (relative/absolute/aggregate with exponentially-weighted consistency check).

Relation to other strategies with commodities

Momentum is not the only empirical regularity that can be exploited in the commodity space. Therefore, it is important to understand the relation between momentum and other types of strategy, as they may take advantage of similar anomalies. In the case of some momentum strategies, most of the return may derive from the shape of the curve and not spot price momentum.

Many opportunities arise from the shape of the term structure of futures prices. One simple strategy is to go long commodities that are in backwardation and short the ones in contango. Another strategy is to exploit the relative backwardation/contango as you simply go long the "flatter" curves (negative or small positive slope) and short the "steeper" ones (large positive slope).

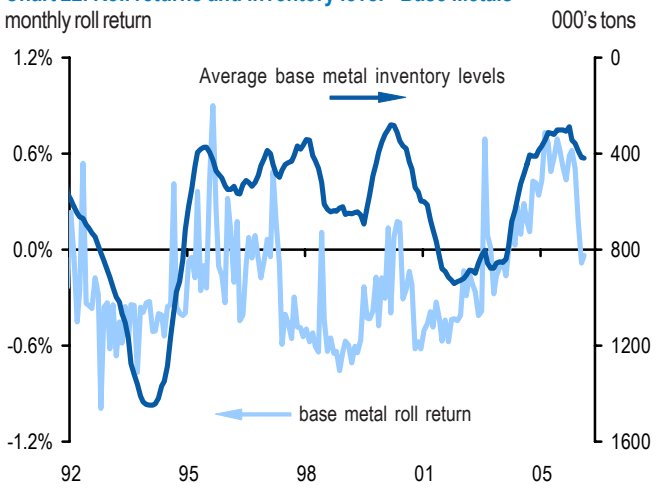
We find that momentum strategies are likely to select commodities that are in backwardation for long positions and the contangoed ones for shorts. The reason is that we sort commodities based on the past excess return and not spot returns. In the hypothetical case that spot prices remain constant, the rule will select commodities based on the average roll return over the past year. Consequently, part of the return comes from the persistency in the shape of the curve, as the slope of the curve tends to remain with the same sign for some time.

Table 16. Annual correlation with inflation surprises

	Inflation Surprises	GSCI
GSCI	0.83	
Long-only Rel/Abs	0.81	0.82
Long-short Rel/Abs	0.05	-0.09
Long-only Enhanced	0.75	0.81
Long-short Enhanced	0.14	-0.02
S&P 500	-0.45	-0.20
JPMorgan GBI	-0.37	-0.24

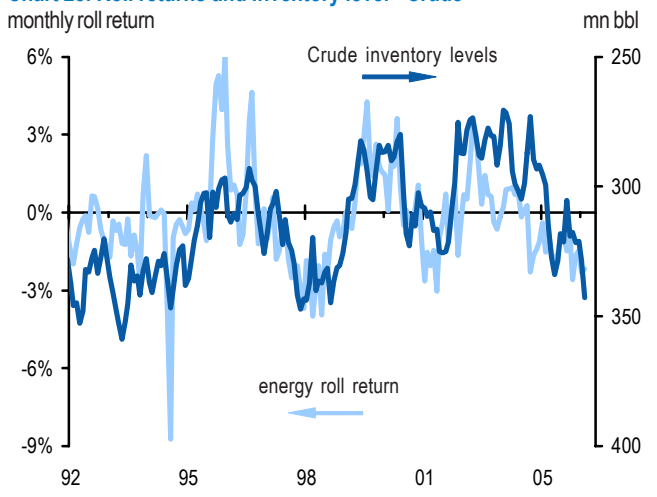
Source: JPMorgan.

Chart 22. Roll returns and inventory level - Base Metals



Source: JPMorgan.

Chart 23. Roll returns and inventory level - Crude



Source: JPMorgan.

This persistency in the shape of the curves arises from the persistency in economic conditions. Chart 22 and 23 shows the relation between roll yield and inventory levels for base metals and crude. Inventory levels are clearly correlated to roll yields.

We postpone a more detailed discussion of this topic to a future paper, since it requires a comprehensive analysis of roll-based strategies.

Conclusions and Caveats

This analysis shows that **it makes sense to use a momentum strategy in commodities**, as the empirical evidence shows that the strategy is robust. Nonetheless, a few caveats are also necessary.

Momentum may change or disappear as investors become aware of its existence. Even if it changes, the direction of a possible transformation is not clear. It can become shorter or longer. In the case of commodities, the risk of momentum disappearing is less of a concern because of the long data availability and the widespread use of momentum rules by active investors in the commodity space.

Another concern is the risk of being caught by turning points. It is true that sudden reversals will hurt the performance of any momentum strategy, but these reversals were not that frequent in our sample. Momentum strategies will benefit from the belly of the cycles.

Generally, a **decision to invest in commodities cannot be based solely on momentum arguments**. Other considerations are also important in most of the cases, but we find that momentum captures most of the simple benefits of active investing in commodities.

Another possible concern is the loss in performance due to replication costs. The **implementation costs reduce the alpha, but it remains significantly positive**. JPMorgan has created structured products that use the class of strategies proposed here as underlying risky asset. The family of underlying strategies is called Commodity IGAR. The different Commodity IGAR indices replicate long-only and long-short strategies using many of the different ideas and refinements discussed here. JPMorgan also considered additional and enhanced variations of this strategy with positive results. These products show that the idea adds alpha independently of implementation costs.

Appendix – Data

Most of the results here are based on the 24 GSCI individual commodity indices, even though the strategies are also successful with other indices and directly with futures contracts. The main reason for using indices is to avoid discussion about the "correct" roll strategy if the underlying futures contracts are used. Moreover, this approach will also allow us a fair comparison to the most commonly-used commodity index, GSCI. GSCI is also likely to select the most liquid commodities since this is one of the criteria for inclusion in the index. Therefore, this selection guarantees that we can actually implement this strategy.

All results are reported based on excess returns indices, since this facilitates the actual implementation of the strategy and allows more flexibility in the creation of payoffs. Both excess return and total return indices would imply the same allocation decisions, since the cash component or whatever the collateral is will be the same for all commodities.

The strategy is based on the commodity excess return sub-indices with available data in the beginning of 2006, as published by GSCI. Most of the results are based on data after 1991 for a fair comparison with GSCI, which was launched that year. But some results are also presented with the full GSCI sample since 1971. The backtesting with longer data is severely constrained by the availability of fewer sub-indices further in the past.

J.P. Morgan Securities Ltd.
Ruy Ribeiro (44-20) 7777-1390
ruy.m.ribeiro@jpmorgan.com

John Normand (44-20) 7325-5222
john.normand@jpmorgan.com

JPMorgan

Investment Strategies Series

This series aims to offer new approaches and methods on investing and trading profitably in financial markets.

1. *Rock-Bottom Spreads*, Peter Rappoport, Oct 2001
2. *Understanding and Trading Swap Spreads*, Laurent Fransolet, Marius Langeland, Pavan Wadhwa, Gagan Singh, Dec 2001
3. *New LCPI trading rules: Introducing FX CACI*, Larry Kantor, Mustafa Caglayan, Dec 2001
4. *FX Positioning with JPMorgan's Exchange Rate Model*, Drausio Giacomelli, Canlin Li, Jan 2002
5. *Profiting from Market Signals*, John Normand, Mar 2002
6. *A Framework for Long-term Currency Valuation,* Larry Kantor and Drausio Giacomelli, Apr 2002
7. *Using Equities to Trade FX: Introducing LCVI,* Larry Kantor and Mustafa Caglayan, Oct 2002
8. *Alternative LCVI Trading Strategies,* Mustafa Caglayan, Jan 2003
9. *Which Trade,* John Normand, Jan 2004
10. *JPMorgan's FX & Commodity Barometer*, John Normand, Mustafa Caglayan, Daniel Ko, Nikolaos Panigirtzoglou and Lei Shen, Sep 2004.
11. *A Fair Value Model for US Bonds, Credit and Equities*, Nikolaos Panigirtzoglou and Jan Loeys, Jan 2005.
12. *JPMorgan Emerging Market Carry-to-RiskModel*, Osman Wahid, February 2005
13. *Valuing cross-market yield spreads*, Nikolaos Panigirtzoglou, January 2006
14. *Exploiting cross-market momentum*, Ruy Ribeiro and Jan Loeys, February 2006
15. *A cross-market bond carry strategy*, Nikolaos Panigirtzoglou, March 2006
16. *Bonds, Bubbles and Black Holes*, George Cooper, March 2006
17. *JPMorgan FX Hedging Framework*, Rebecca Patterson and Nandita Singh, March 2006
18. *Index Linked Gilts Uncovered*, Jorge Garayo and Francis Diamond, March 2006
19. *Trading Credit Curves I*, Jonny Goulden, March 2006
20. *Trading Credit Curves II*, Jonny Goulden, March 2006
21. *Yield Rotator*, Nikolaos Panigirtzoglou, May 2006
22. *Relative Value on Curve vs Butterly Trades*, Stefano Di Domizio, June 2006
23. *Hedging Inflation with Real Assets,* John Normand, July 2006
24. *Trading Credit Volatility*, Saul Doctor and Alex Sbityokov, August 2006