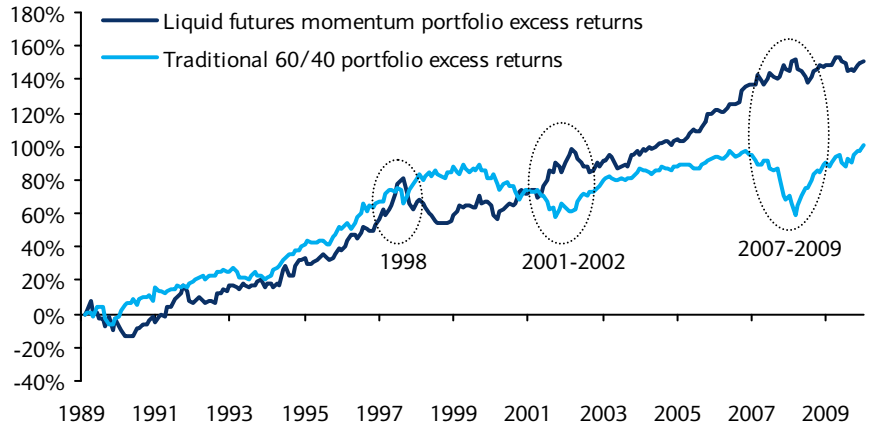
LIQUID MOMENTUM STRATEGIES

Diversification through risk premium rotation

Momentum trading is one of the classic investment strategies. The simplest form of the strategy – going long winners and short losers based on the past one year's return – was established more than 20 years ago and has broadly stood the test of time. Most analysis, however, has focused on the application to stocks. In this report, we explore momentum from a practical perspective in its simplest form across four liquid markets – commodity futures, equity index futures, currency forwards and US Treasury futures. In summary, we find that:

- Momentum strategies have a unique appeal for institutional investors, combining modest positive returns with strong diversifying properties for traditional mixed portfolios.
- They demonstrate remarkably consistent performance profiles across time periods and asset-classes. We show that momentum strategies share many properties of classic risk premia strategies, including modest positive long-run risk-adjusted performance, systematic negative skewness, and periods of substantial drawdowns.
- Momentum strategies in each asset class can be characterised as systematically rotating through risk factors. We show how a careful analysis of the beta of momentum strategies to the market exposes the diversification value and the key risk factor – that of sharp market reversals.
- Finally, we propose a liquid momentum portfolio, comprising the four asset class momentum strategies, and demonstrate its diversification value for traditional institutional portfolios. We also illustrate how an allocation to momentum can be considered an attractive complement to option-hedging programs.

Figure 1: Empirically, momentum diversifies during broad-market draw-downs



Note: Traditional portfolio is 60% S&P 500, 40% US Aggregate Bonds, excess returns over 1M USD Libor.
Source: Bloomberg, Barclays Capital

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Momentum: An overview

In essence, momentum strategies try to capture persistence in *relative* performance of different investments. Momentum is not trend-following: momentum is non-directional[1], it exploits relative performance differences that exist in rising, falling, and neutral markets. For momentum to work, all we need is that winners continue to outperform losers over our investment horizon, even if that means that winners are performing less poorly than losers.

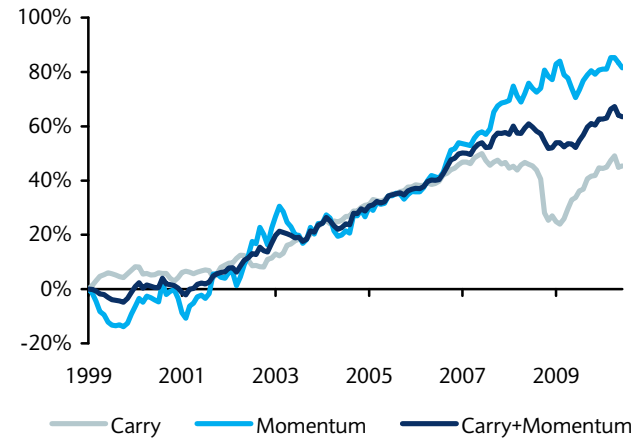
Momentum strategies have been analysed extensively by academics and practitioners. The first academic studies were completed in the early 1990s (see Jegadeesh and Titman (1993)). Pervasive momentum in equities has subsequently been documented out-of-sample across regions, and as far back as Victorian times (Chabot et al (2009)).

The majority of analysis has been centred on stocks, typically US stocks, and tends to ignore many tradability issues such as realistic transaction costs and short selling constraints. In this report, we take a practical focus relevant to managers of large institutional portfolios, by shifting the analysis to liquid futures markets across commodities, country equity indices, currencies, and fixed income. Momentum strategies in these liquid markets should be easier and more practical to implement. Further, we investigate in detail the risk profiles and interactions of these strategies, their diversifying properties, and, finally, their risks and benefits in traditional portfolios as potential alternatives to, or complements to, option-hedging programs.

Momentum: a diversifying systematic strategy

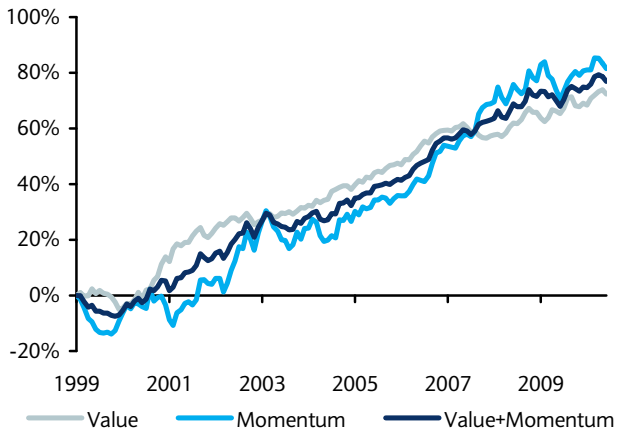
There is, and will continue to be, extensive debate on the existence, cause, interpretation, and justification of momentum effects. In particular, the subject of whether momentum can be considered a risk premium is particularly contested. We make the case that profitable momentum strategies in liquid futures markets might be considered compensation for profitable rotation through identifiable systematic risks, and document and discuss their diversifying properties versus traditional portfolios (Figure 1) and versus other classic risk premia (Figure 2 and Figure 3). Most classic risk premia strategies tend to be positively correlated with each other and with traditional markets, so this interpretation of momentum is especially appealing.

Figure 2: Momentum diversifies "carry" strategies



Source: Barclays Capital

Figure 3: Momentum diversifies "value" strategies



Source: Barclays Capital

[1] The simple definition of momentum is non-directional in the sense that an equal notional of long and short positions is always taken, in contrast to trend-following strategies which explicitly go long or short the market. In practice, however, we show that the momentum strategies can inadvertently take significant market beta exposure.

Outline of this report

This report is arranged into seven sections as follows:

1. **The puzzle of profitable momentum strategies**: A review, from a practical perspective, of the common explanations for momentum.
2. **Momentum in futures markets**: Extending the application of momentum strategies to liquid futures markets which are readily tradable.
3. **Characterising momentum as risk rotation:** Understanding momentum strategies as rotating through known risk factors.
4. **Understanding risk and diversification of momentum strategies:** A detailed analysis of the dynamics of the beta of momentum strategies to the market.
5. **Forming a portfolio of liquid momentum strategies:** Benefiting from the diversification across the momentum strategies, portfolios of momentum may be appealing.
6. **Comparing momentum with other risk premia:** Momentum consistently diversifies the returns of other classic risk premia such as carry, volatility and term premia.
7. **Allocating to momentum in traditional portfolios:** Final analysis indicating the potential value of momentum in institutional portfolios.

Importantly, there are also several aspects of momentum strategies that we specifically do not address in this report, notably, any attempt to find the "best-performing" momentum strategies by optimizing parameters such as look-back window, return calculations or instrument universe. Though interesting and potentially fruitful, optimization runs the risk of over-fitting to historical data and artificially boosting returns with look-back and selection bias. Momentum strategies are particularly susceptible to such biases as it is often hard to establish any particular parameterization from a fundamental or intuitive perspective. By sticking to a very basic form of the strategy, and applying this identically across asset classes and across time, we aim to provide benchmark results for the properties of momentum as an investment style.

The puzzle of profitable momentum strategies

The profitability of momentum strategies is puzzling to many investors. After all, basic finance theory states that past price performance does not provide information about future performance. Not surprisingly, attempts to explain the existence of consistently profitable momentum strategies abound in the academic and industry literature. Broadly speaking these fall in to one of two camps: momentum returns are driven by exposure to a unique source of systematic risk, or momentum captures one or more behavioural phenomena. We review some of the common arguments and provide a pragmatic view of our own.

Momentum as a unique risk premium

The long run profitability of momentum strategies in the equity markets is sometimes explained as compensation for exposure to a unique systematic risk factor. The argument for this is usually based on empirical analysis that shows through statistical testing that momentum is a unique factor explaining stock returns. The analysis of similarities between momentum strategies and some well known risk premia strategies is a theme throughout this paper. We will highlight the broad similarity of the properties of momentum and risk

premia strategies, and we identify "reversal risk" and "skewness risk" as key risk factors to which most momentum strategies are systematically exposed.

Momentum as a market inefficiency

A second common explanation for the profitability of momentum is some form of market inefficiency. Several behavioural explanations for momentum have been proposed based on different aspects of investor psychology.

The most cited of the behavioural explanations is the concept of *under-reaction* to news (see Hong and Stein (1999)). Different investors receive, interpret and process information over different horizons. The slow and partial reaction of these investors to new information leads to information about securities being priced into the markets only gradually over a period of time, generating trends in prices. A separate but related argument is based on what behavioural economists call the *disposition effect* (see Frazzini (2006)). The preference of investors to realize gains and avoid losses makes them prone to hold on to losing positions for too long in an attempt to break even, and to sell winning positions too early to lock in the upside. Again, this means that information is only partially and gradually incorporated into prices. One other aspect of investor psychology can lead to an amplification effect of trending behaviour. Investments that performed well in the recent past often seem more attractive than underperforming ones, leading to a *bandwagon effect* that leads investors to favour investments in past winners.

A pragmatic view: Momentum as a risk-factor rotation approach

Perhaps momentum just captures whatever works at a particular point in time? Going long winners and short losers could be interpreted as choosing assets that have maximum and minimum exposure to particular systematic sources of return and risk. It has been shown in stock-based momentum strategies that this is indeed the case – the systematic risk factors include industry concentrations as well as classic factors such as the small-cap and value premia (see for example Grundy and Martin (2001)). We demonstrate in this report that the characterisation of momentum in this way extends beyond stocks to other asset classes. The particular risk-factors involved naturally vary by asset class. This interpretation suggests that momentum strategies to some extent capture the dynamics of risk premia over the business cycle. Many risky assets' values, as well as currencies, are directly linked to the business cycle. Business cycles themselves can be characterized as very persistent, slow moving changing economic conditions, having long periods of growth followed by shorter, but still persistent, downturns. Long horizon momentum strategies may pick up on this persistence. For example, in the rates market, the smoothing effect of central bank monetary policy may lead to significant trends across the yield curve. In commodities markets, supply side capacity is often a slow-moving, trending variable – for example, in the construction of mines, drilling capacity, farming capacity and so on. Likewise, marginal commodity demand is thought to be from emerging market economies which show periods of persistence in growth followed by sharp reversals.

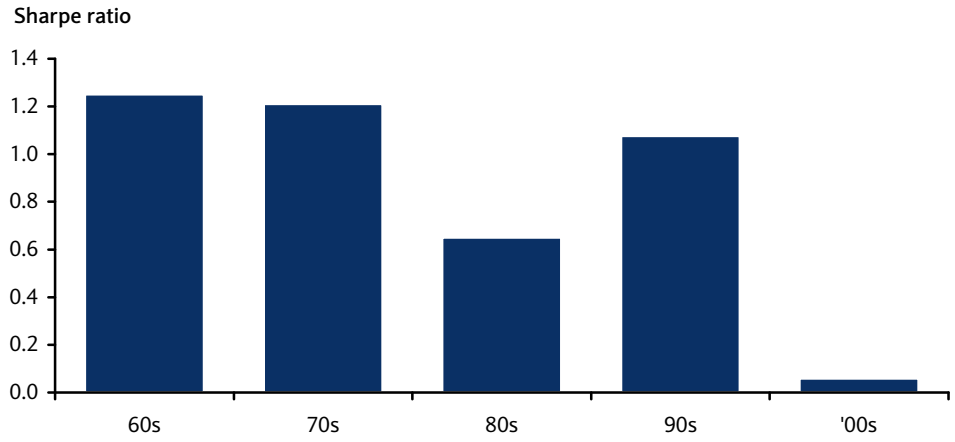
These different explanations can help build intuition for the behaviour of momentum strategies, and inspire potential avenues to improve upon the primitive versions.

Momentum in liquid futures markets

Classic momentum strategies are implemented on large baskets of stocks, selected from a broad universe such as the Russell 1000. Implementing these strategies, however, can be problematic. First, they require the ability to short stocks, which can be difficult or costly

(we will see later that the short component of the strategy contributes more than its fair share to the attractive overall properties). Second, they can be impractical from a trading perspective, due to high turnover and maintenance. Additionally, although the returns of stock-based momentum strategies have been attractive historically, performance over the last decade has been weaker (Figure 4). If we believe in the market-inefficiency explanation of momentum, this could be a sign of the strategy reaching capacity and inefficiencies being arbitraged away.

Figure 4: Diminishing returns in classic US stock momentum? Chart shows Sharpe ratio by decade of the standard momentum strategy



Note: Based on the daily history of 10 portfolios formed on 12-2 month momentum (excluding most recent month). This differs slightly from our simpler implementation used in this article.
Source: Kenneth R. French data library, Barclays Capital

In this section, we apply the standard momentum strategy beyond single-stock equities[2]. We selected four markets with liquid futures (or forwards) in which implementation of the strategy should be considerably more straightforward than for single-stock equities. We will apply the strategy to each in turn, and then consider portfolios of momentum strategies across these markets:

- **Equity index futures**: Selects from a basket of 12 major stock indices, one per country. The 12 futures are chosen as those that are liquidly traded and represent the major stock market indices in countries included in the 23 MSCI Developed Country Indices. Data starts from December 1988.
- **Commodity Futures**: Selects from Barclays Capital Single Commodity indices, which measure the return of rolling "front month" contracts of 23 major commodity futures. Data start from December 1999.
- **US Treasury Futures**: Selects from Barclays Capital 2y, 5y, 10y and Long-bond Treasury Futures Targeted Exposure Indices. These indices reflect the returns of rolling futures positions with notional exposures that are each rescaled on a monthly basis to target a 1 point index change per 1bp change in respective yield. We take a 0.20% return per index point exposure for this analysis[3]. The use of these targeted exposure indices has the

[2] Our initial analysis also included US investment grade credit default swaps (CDS). Early evidence of momentum effects in CDS was documented in Erlandsson and Rennison (2008). While results even for the basic momentum strategy were promising, implementation was viewed as challenging because of a lack of market transparency, and further analysis is left to future work.
[3] The 0.20% exposure is consistent with the exposures used in the 2y, 10y, and long bond (30y) iPath exchange-traded notes which reference these same indices.

effect of duration equalizing these four "assets", making a sensible performance comparison possible. Data start from August 1991[4].

- **G10 FX Forwards**: Selects from the nine currency pairs formed from the G10 currencies versus the dollar. Implemented on 1 month FX forwards, the most liquid market (there is no liquid exchange-traded futures market for FX). Data start from February 1991.

All historical performance results are, of course, indicative, and are shown without transaction costs, due to the challenge of accurate estimation historically. Part of the appeal of these four markets, however, is the low associated trading costs and ease of creating short or leverage positions. While trading costs in an actual implementation would not be negligible, our assessment in these four asset classes is that their inclusion would not substantially alter any of our conclusions. Note that, at the time of writing, the strategies as described herein are not formally published as Barclays Capital Indices (though many are based on underlying Barclays Capital Indices).

Strategy details

The simple momentum strategy starts with a pool of assets/instruments and ranks them based on the past one year total return performance[5] from top to bottom. The strategy then forms two portfolios: one of winners (in our case the top 30% of performers over the past year) and one of losers (the bottom 30% of performers over last year). The cut-off of 30% has not been chosen for any particular reason other than as a sensible division to give reasonable diversification among the portfolios. Where the number of instruments does not divide into tenths, we round down the bucket size. The portfolios are equally-weighted. The strategy goes long the "winners" portfolio, short the "losers" portfolio and holds these positions for one calendar month.

This formulation is based on the one proposed in Jegadeesh and Titman (1993). In that paper, they also explore other combinations of look-back window and holding periods. We selected the one year look-back window, prior to any testing, for two reasons. Firstly, the past one year's return is a natural window to choose if we aim to target lower frequency performance differences. Secondly, the relative stability of the volatility of the signal will reduce potential turnover.

The next sections report simple performance summaries for each of the four strategies over the available sample periods. Later sections then further analyse the diversification effects and risk factors in the strategies.

Momentum in commodity futures

We compare winners, losers and the momentum strategy separately

Figure 5 and Figure 6 report the results of the momentum strategy on the basket of 23 liquid commodity futures. Figure 5 shows summary statistics for the winners (going long the basket of recent winners every month), the losers (going long the recent losers every month) and the strategy (which goes long the winners and short the losers each month). The top section shows overall performance from January 2000 to December 2010. The bottom section shows corresponding results when the sample is restricted only to those months in which the traditional 60/40 portfolio experiences a loss of one standard deviation

[4] Returns from August 1991 to April 1999 are based on an approximate extended back-test. The indices have formal inception dates of April 29 1999.
[5] Many more recent papers use an alternative version of the strategy which excludes the most recent month's return from the calculation. Typically this has been justified empirically, but with weak intuitive backing. For this reason we stick to the original definition including the most recent month, hoping to avoid any bias from historical data.

or more. We include this second section in all tables to give a consistent assessment of the "diversifying" value of the momentum strategy in bad months for the traditional portfolio.

Figure 6 shows the cumulative (non-compounded[6]) excess returns of each of the winners, losers and strategy. Immediately clear is the biased sample period, which generally saw the commodity market make strong returns. This is evident from the fact that even the losers' portfolio has a cumulative return of close to 0% over these 11 years. The winners' portfolio, however, returned 150% over the same period, and, consequently, the strategy also had a cumulative return around this level. A possible question arises of why bother with the losers at all? The answer is that by going long and short equal notionals of futures, the momentum strategy should, to some extent, be robust to future down markets, as well as profitable in bull markets like we have seen. Concrete examples of this are seen below with the other momentum strategies.

Overall performance is moderately positive but with substantial drawdowns…

Over the full period, the Sharpe ratio of the strategy is modestly positive at 0.54, corresponding to an annual excess return of 14.2%. The strategy also experiences a significant drawdown of 45% steadily from 2008-10. This is, however, a more moderate drawdown than either the winners or losers separately.

…but the strategy continues to perform even in down markets in the traditional portfolio – a pattern that is repeated in the other tests below

Focusing instead on the months in which the 60/40 portfolio underperforms (in the second half of the table) reveals the diversification value of the momentum strategy. While the long-winners and long-losers portfolios are highly correlated with the 60/40 portfolio and experience dramatic underperformance, the long-short momentum strategy maintains respectable, albeit not spectacular, performance, roughly in line with the full sample returns and Sharpe ratio.

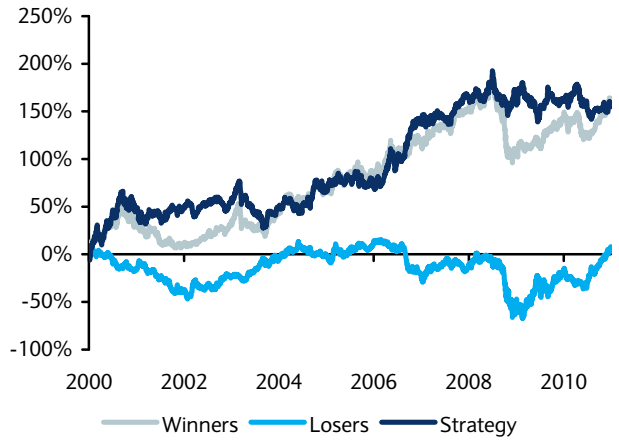
Figure 5: Performance data for commodity futures

Full sample until Dec 2010	Winners	Losers	**Strategy**
Start Date	Jan 2000	Jan 2000	**Jan 2000**
Annual Exc. Ret.	14.8%	0.7%	**14.2%**
Annual Volatility	25.0%	20.4%	**26.0%**
Sharpe Ratio	0.59	0.03	**0.54**
Max Drawdown	58.6%	60.4%	**45.1%**

60/40 Tail Performance*	Winners	Losers	**Strategy**
Annual Exc. Ret.	-22.7%	-34.5%	**11.9%**
Annual Volatility	30.3%	23.4%	**27.5%**
Sharpe Ratio	-0.75	-1.48	**0.43**

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Figure 6: Cumulative returns for commodity futures momentum



Source: Barclays Capital

[6] Throughout this paper we use cumulative non-compounded excess returns for the purposes of showing historical time-series of returns. This is to avoid obscuring dynamics in the early part of the sample periods, which may happen if using compounding on high return strategies.

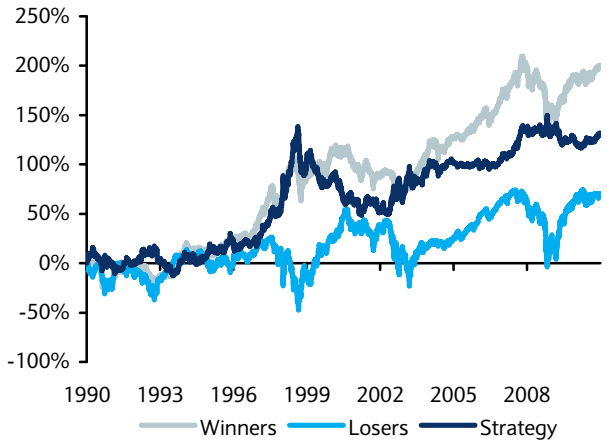
Figure 7: Performance data for equity index futures

Full sample until Dec 2010	Winners	Losers	Strategy
Start Date	Jan 1990	Jan 1990	**Jan 1990**
Annual Exc. Ret.	9.6%	3.3%	**6.3%**
Annual Volatility	18.0%	20.6%	**19.3%**
Sharpe Ratio	0.53	0.16	**0.32**
Max Drawdown	53.9%	58.1%	**62.8%**

60/40 Tail Performance*	Winners	Losers	Strategy
Annual Exc. Ret.	-79.2%	-101.7%	**22.5%**
Annual Volatility	29.7%	33.7%	**28.7%**
Sharpe Ratio	-2.66	-3.02	**0.78**

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Figure 8: Cumulative returns for equity index futures momentum



Source: Barclays Capital

Momentum in equity index futures

Weak overall performance for equity index futures is partly compensated by strong diversification

Figure 7 and Figure 8 show corresponding results for the momentum strategy applied to equity index futures. Overall performance in this case is weak, but still positive, with a Sharpe ratio of 0.32. The strategy drawdown is significant at 62.8% and slightly larger than the individual winners' and losers' portfolios. Inspection of the chart, however, shows that the drawdowns of the strategy are not in fact coincident with market drawdowns, especially in the credit crisis.

Again, the true value of the momentum strategy becomes apparent in its diversifying properties. In months when the 60/40 portfolio underperforms, the momentum strategy shows much more robust performance with a Sharpe ratio of 0.78, while the winners, and losers, portfolios during these months significantly underperform in line with the market.

Momentum in G10 FX Forwards

Moving to the G10 FX forwards strategy, Figure 9 and Figure 10, we find a very similar pattern to equity index futures with a weak overall Sharpe of 0.31 but with a jump to 0.83 during underperforming months on the 60/40 portfolio. The strategy drawdown is smaller, at 26.8%.

The FX strategy is subtly different in nature to the first two strategies in that there is no obvious market component to the returns. However, the strategy is set up as non-dollar G10 currencies versus the dollar, so a strong component in all returns is the strength of the dollar on an absolute basis. This explains why the winners' and losers' portfolios underperform along with the 60/40 portfolio as they reflect the flight-to-safety effect strengthening the dollar against all other currencies in these periods. The chart shows that the losers' portfolio drives most of the performance, positive and negative, through this sample.

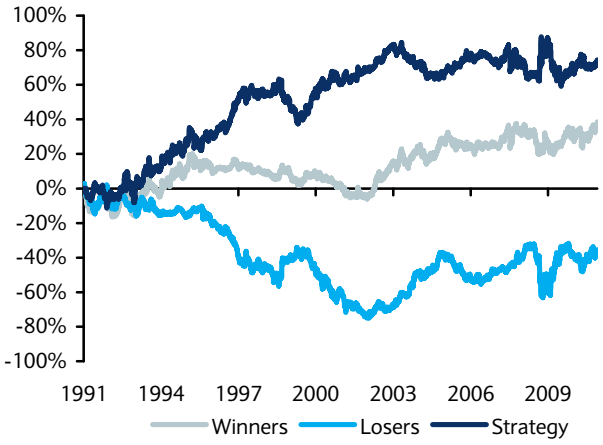
Figure 9: Performance data for G10 FX forwards

Full sample until Dec 2010	Winners	Losers	Strategy
Start Date	Feb 1991	Feb 1991	**Feb 1991**
Annual Exc. Ret.	2.0%	-1.8%	**3.7%**
Annual Volatility	10.0%	10.6%	**12.2%**
Sharpe Ratio	0.20	-0.17	**0.31**
Max Drawdown	24.5%	56.6%	**26.8%**

60/40 Tail Performance*	Winners	Losers	Strategy
Annual Exc. Ret.	-9.3%	-23.9%	**14.6%**
Annual Volatility	11.5%	14.7%	**17.7%**
Sharpe Ratio	-0.81	-1.63	**0.83**

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Figure 10: Cumulative returns for G10 FX forwards momentum



Source: Barclays Capital

Momentum in UST futures

The last set of results, for UST futures, is given in Figure 11 and Figure 12. Immediately noticeable from Figure 11 and Figure 12 is the fact that the strategy underperforms the winners' and losers' portfolios in terms of absolute returns in this period. This reflects the one-way market that rates have experienced over the past 20 years, during which time, it was hardly optimal to take a short position. Naturally, things may not continue in this pattern, and we would expect the momentum strategy to outperform both in a rising-rates environment.

Overall performance in the case of UST futures is nonetheless strong, with a Sharpe of 0.76 and a moderate draw-down of 33.7%. Once again, the diversifying effect of this strategy is striking – the Sharpe ratio of the strategy leaps to 2.56 during underperforming months of the 60/40 portfolio. The winners and losers separately also perform well in these periods, due to the flight-to-quality rates rallies.

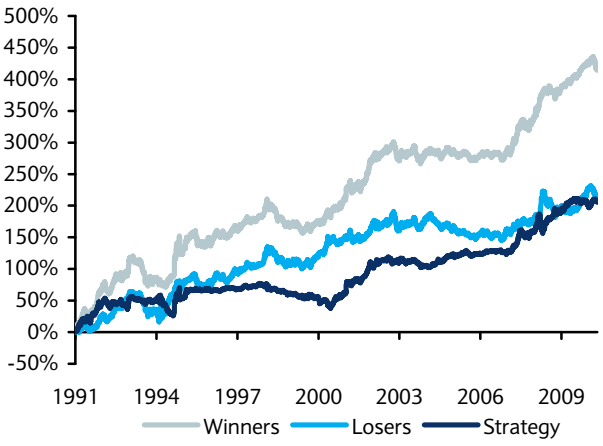
Figure 11: Performance data for G10 FX forwards

Full sample until Dec 2010	Winners	Losers	Strategy
Start Date	Sep 1991	Sep 1991	**Sep 1991**
Annual Exc. Ret.	21.6%	11.0%	**10.7%**
Annual Volatility	22.9%	20.3%	**14.0%**
Sharpe Ratio	0.95	0.54	**0.76**
Max Drawdown	43.7%	40.0%	**33.7%**

60/40 Tail Performance*	Winners	Losers	Strategy
Annual Exc. Ret.	62.0%	9.9%	**52.1%**
Annual Volatility	28.9%	22.7%	**20.4%**
Sharpe Ratio	2.15	0.43	**2.56**

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Figure 12: Cumulative returns for G10 FX forwards momentum



Source: Barclays Capital

Summary of individual strategy performance

Figure 13 summarises the historical performance of the four strategies. As observed individually above, a number of consistent patterns emerge:

- Weak to moderately positive overall risk-adjusted performance, Sharpe ratios between 0.3 and 0.8.
- Substantial drawdowns of 25-60%, but typically not coincident with broad market drawdowns.
- Moderate to strong risk-adjusted performance during months of underperformance in the traditional 60/40 portfolio with Sharpe ratios from 0.5 to above 1.

The next section digs into more detail on each of the four strategies to deepen the understanding of the sources of returns and risks.

Figure 13: Full period historical performance of momentum strategies

	Commodities	Equity Indices	G10 FX	UST Futures
Start Date	Jan 2000	Jan 1990	Feb 1991	Sep 1991
Annual Exc. Ret.	14.2%	6.3%	3.7%	10.7%
Annual Volatility	26.0%	19.3%	12.2%	14.0%
Sharpe Ratio	0.54	0.32	0.31	0.76
Max Drawdown	45.1%	62.8%	26.8%	33.7%
60/40 Tail Performance*				
Annual Exc. Ret.	11.9%	22.5%	14.6%	52.1%
Annual Volatility	27.5%	28.7%	17.7%	20.4%
Sharpe Ratio	0.43	0.78	0.83	2.56

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Characterising momentum strategies as risk rotation

The results so far do not provide insight into the actual long and short positions being taken by the momentum strategies. To gain more insight, we examine the extent to which momentum strategies can be characterised as "rotating through risk factors". In other words, to what extent do the winners' portfolios pick up on investment styles that are doing well, and the losers pick up on those that are out of favour.

This characterisation of momentum is important for two reasons. Firstly, it will help explain return and risk profiles. We show, at the simplest level, that one of the risk-factors is the market itself, and that many momentum strategies are rotating between high and low beta assets. This helps motivate the analysis we provide in the next section on the diversification and risks of these strategies. Secondly, this characterisation helps indicate potential future paths for improving the basic momentum strategies. Specifically, strategies could be constructed to be neutral to these factors, instead relying on idiosyncratic momentum only. This may lead to more stable performance (though, equally, we may find in some cases that returns are in fact driven by persistence in factor returns reducing the factor-neutral momentum strategy to noise).

Taking our lead from the extensive work done in the equity space, Grundy and Martin (2001) show that simple stock momentum strategies effectively take dynamic factor exposures to

classic equity risk factors such as the size effect (rotating between small-cap stocks and large-cap stocks) and value effect (rotating between value stocks and growth stocks).

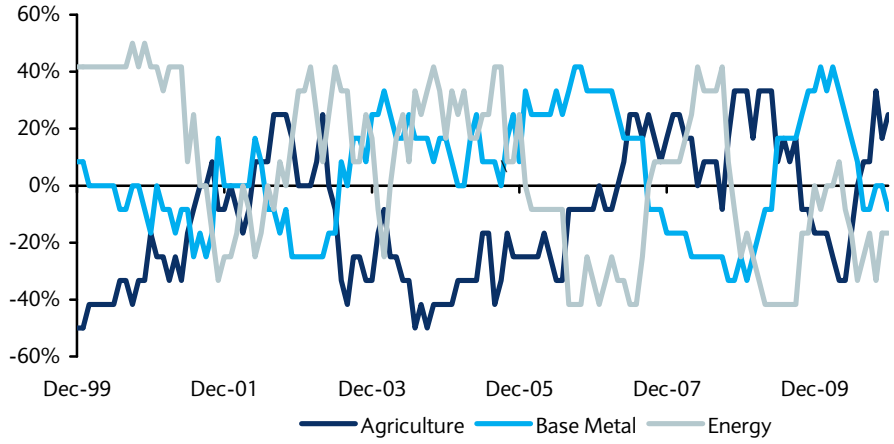
Another simple interpretation of stock momentum risk rotation is simply in the selection of high and low beta stocks. During a bull market, the strategy will naturally select the high beta stocks since they have been outperforming and will continue to do so while the bull market persists. In a bear market, the reverse will be true and the strategy is likely to short high beta stocks. These effects also help explain why the momentum strategy empirically underperforms during sharp reversals. For instance, on a sharp rally, the simple stock momentum strategy will be short the high beta stocks which are typically the ones to experience the strongest rebound. We explore this reversal effect precisely in the next section.

In this section, we look for various risk-factor rotation interpretations for the liquid futures momentum strategies. This turns out to be not as straightforward as for the equity case, but we nonetheless identify some simple such effects in each asset class.

Commodity sector rotation

Starting with commodities, Figure 14 shows the net positions taken by the basic momentum strategies grouped by broad sectors (we exclude precious metals from the chart as they contribute only a small percentage of total notional exposures – this results in the three lines not quite summing to zero in certain periods). Although no clear pattern is apparent, Figure 14 does show substantial and persistent long or short sector exposures through most of the sample, indicating a sector component driving the strategy. In particular, the strategy appears to be rotating between agriculture and base metal.

Figure 14: Commodity momentum implicitly making sector rotation bets – chart shows net percentage of monthly positions attributable to each of the four main commodity sectors



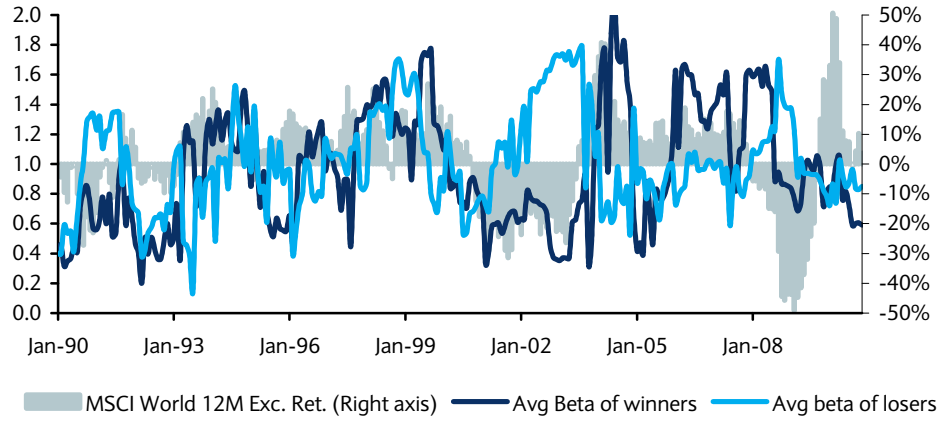
Source: Barclays Capital

Equity indices risk rotation

A risk factor rotation interpretation for the equity index futures strategy is tricky as the global equity market is, arguably, the only common driver of returns. For this reason, we look simply at the betas of the individual stock markets to the MSCI World index. Figure 15 shows the time series of average betas of the winners' and losers' portfolios separately. The MSCI World trailing one-year excess return is also shown on the right-hand axis for comparison. The chart shows some distinct periods where the winners and losers are high or low beta indices – notably between 1990 and 1992, and again between 2000 and 2008.

These correspond to clear bull and bear markets. Other periods, such as the 1994-2000 bull market, show little differentiation in beta exposures. This may indicate a period of unstable betas for country indices.

Figure 15: Equity index futures rotating between high and low beta indices (betas to MSCI World)

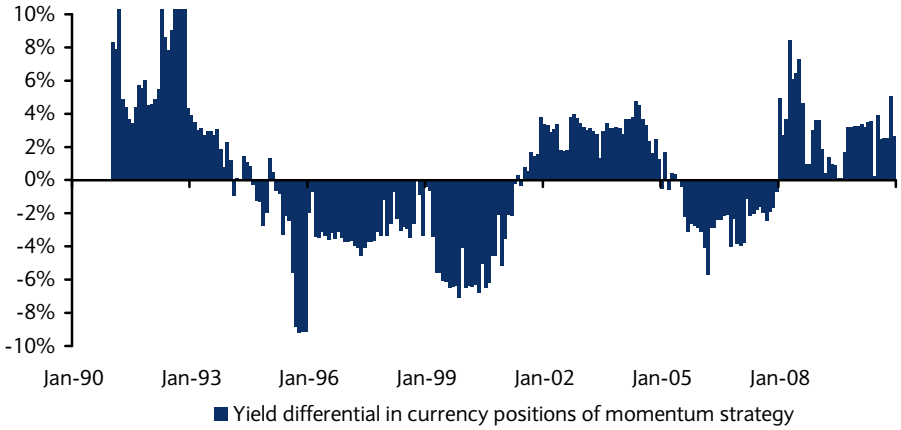


Source: Bloomberg, Barclays Capital

FX risk rotation

The G10 FX strategy, surprisingly, offers a neat interpretation in terms of risk-factor rotation. The risk factor we analyse is the FX carry risk premium – that is premium available for taking on higher yielding versus lower yielding currency crash risk (see *Update: The G10 FX Carry Premium: Refining and timing the crash risk premium*, November 24 2010) for a detailed analysis of FX carry). Figure 16 shows the net differential in yields of the winners' and losers' portfolios selected by the momentum strategy. We clearly see that the momentum strategy is itself taking rotating long and short positions on the FX carry strategy, based on its performance. Between 1990 and 1995 the momentum strategy is broadly long carry, then short through 1996 to 2001, for example.

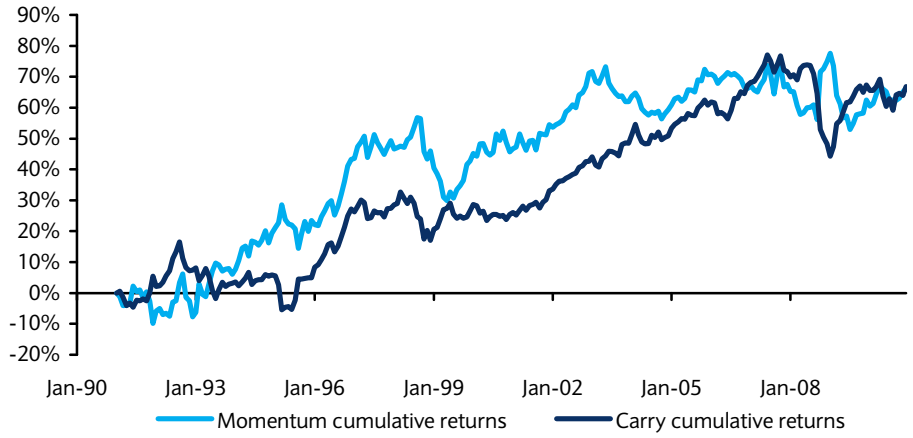
Figure 16: The FX momentum portfolios have distinct periods of positive and negative carry, indicating dynamic factor exposures to the FX carry factor



Source: Bloomberg, Barclays Capital

This observation immediately leads us to compare the two strategies' returns directly. Figure 17 shows the cumulative returns of the two strategies. Both strategies have similar overall performance, indicating that the momentum strategy is not wholly successful at timing FX carry. Consistent with the above, however, there are clear periods of positive and negative correlation. Most noticeable is the negative correlation during fall 2008 when the carry trade dramatically underperformed. The last section of this report shows that this diversifying effect of carry and momentum is not unique to the FX market.

Figure 17: The returns of the FX momentum and FX carry strategies show clear periods of positive and negative correlation



Source: Barclays Capital

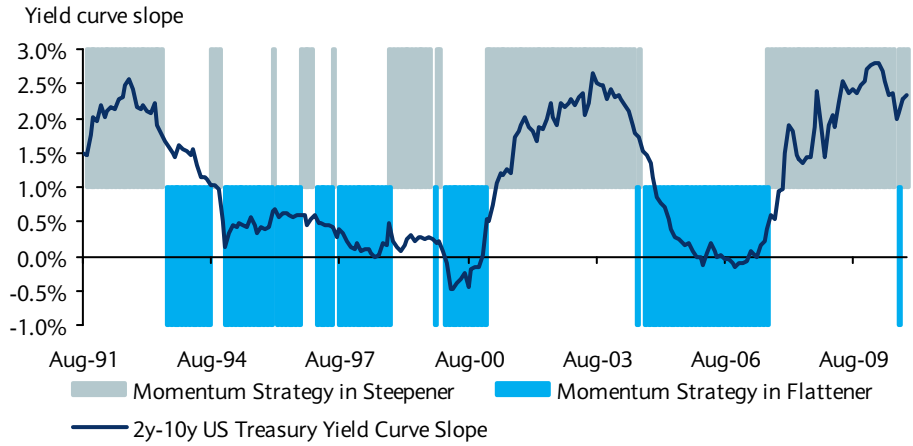
UST Futures – Curve position rotation

Lastly, the UST Futures strategy also has an elegant interpretation, this time in terms of rotating between steepeners or flatteners on the Treasury yield curve. Since the strategy is based only on the 2y, 5y, 10y and 30y points, and it goes long exactly one and short exactly one, every position taken is essentially a (duration-neutral[7]) curve position.

Figure 18 shows this clearly by demarcating the history of the 2y-10y yield curve slope (note that all slopes, 2-10, 5-10, 2-30 etc. are highly correlated) by periods in which the momentum strategy has implicitly positioned for a steepener or a flattener. The chart quickly reveals why the UST futures strategy has such strong returns, with remarkably accurate positioning through most of the sample. It also reveals the weakness in the strategy – that is, the lag in the strategy changing position during changes in curve direction episodes (see for example the one year turning time needed to move from a steepener to a flattener in 2003).

[7] By construction, see original strategy description earlier.

Figure 18: UST futures momentum – Timing steepeners and flatteners on the yield curve



Source: Bloomberg, Barclays Capital

Understanding risk and diversification of momentum strategies

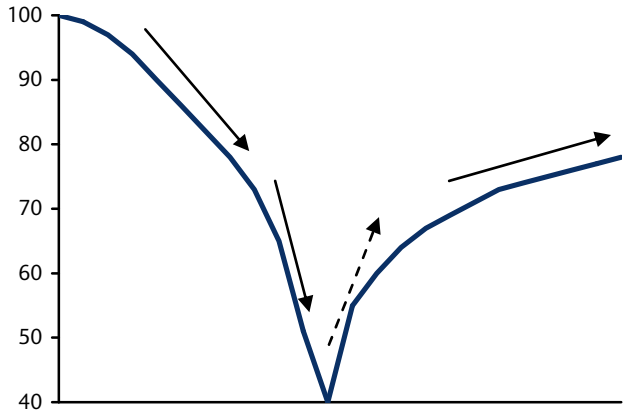
So far, we have seen that the liquid momentum strategies deliver weak to modest long-run performance, with stronger performance in market downturns, but also sizeable drawdowns. We have also seen how momentum strategies can be considered to be timing rotation between sectors or risk factors. In this section, we analyse the risks and diversification properties of momentum strategies, from an empirical and economic viewpoint.

Diversification and Reversals

Understanding the diversification properties of momentum strategies requires a careful beta analysis. Simple analysis of the betas of the strategies to traditional markets shows that they are unstable through time, and, therefore, hard to interpret on an unconditional basis. Further investigation reveals that the betas are dependent on whether the markets are outperforming or underperforming (see Daniel (2010)). Further, the beta empirically changes again during market reversals – short periods of rallies following long bear markets.

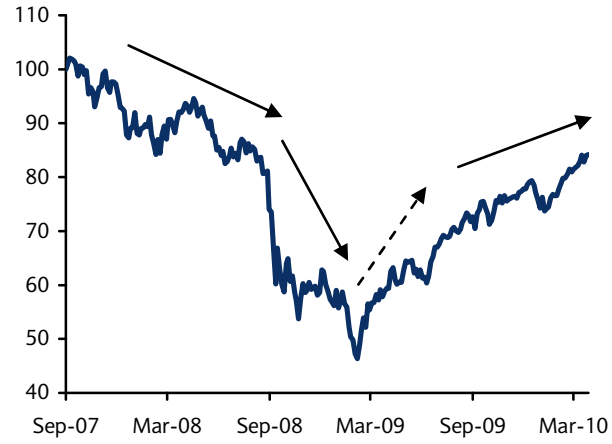
Momentum strategies are empirically exposed to sharp reversals in market trends. Even though we distinguish momentum from trend-following, we saw in the last section that many momentum implementations inadvertently take market exposure through the overweighting of high beta versus low beta assets, for example. Figure 19 and Figure 20 help to show this effect by considering a stylized downturn, as well as the recent credit crisis as an example, and the likely positions taken by momentum strategies.

Figure 19: Stylized market downturn – Solid arrows indicate paths for which momentum strategy can profitably identify high or low beta assets, dashed arrows indicate reversals



Source: Barclays Capital

Figure 20: The credit crisis of 2007-09 shows elements of the stylized downturn (S&P 500)



Source: Barclays Capital

Statistical evidence for diversification and reversals

We can formalise and quantify these concepts through simple statistical analysis of the returns. Here we again follow Daniel (2010) in setting up the following regression:

$$Momret_t = \alpha + \left(\beta_0 + \beta_1 \times I\left[Mktret_{t-1yr,t} < 0\right] + \beta_2 \times I\left[Mktret_{t-1yr,t} < 0, Mktret_{t-1mth,t} > 0\right]\right) \times Mktret_t + \varepsilon_t$$

$Momret_t$	α	β_0	β_1	β_2	ε_t
Strategy returns (weekly)	Constant	**Overall** market beta	Market beta when market return is negative over the past year (**down market**)	Market beta when market return is negative over the past year, but turned positive in the last month (**reversal**)	Error term

Note that the market return $Mktret_t$ multiplies all the betas inside the brackets. The $I[\bullet]$ operator is an indicator function that takes the value 1 when its argument is true and 0 otherwise.

This regression essentially decomposes the beta to the market into three components:

- β_0 – Ideally POSITIVE – Is the overall beta to the market, after taking into account the specific effects of the beta effects during bear markets and market reversals. Since the bear market periods are separately accounted for, ideally β_0 should be positive, so that the strategy does well when the market does well.
- β_1 – Ideally NEGATIVE – Is the beta to the market when the market return has been negative over the last year. A negative β_1, therefore, indicates that the strategy performs *positively* during these market downturns, and acts as a diversifier.
- β_2 – ideally POSITIVE – Is the beta to the market specifically during market rallies that immediately follow a down market. A positive β_2 would indicate that the strategy is

able to capture this sudden upswing profitably. As discussed, β_2 isolates one of the key risks for momentum strategies.

We use the respective asset class benchmarks as the market returns in each case. Specifically, we select the DJ UBS Commodity index, MSCI World equity index and Barclays Capital US Aggregate Bond Index for commodities, equity index futures and UST futures, respectively. We do not run the analysis for FX as there is no appropriate market benchmark to use here.

Figure 23 reports the value of the betas and the corresponding t-statistic (a t-statistic with a magnitude in excess of 1.96 indicates the value of the beta is significant at the 95% level). Some overall patterns emerge:

- The overall betas are slightly positive (zero for Equity Indices). This shows that, once you account for bear market effects, the momentum strategies are able to benefit broadly from periods of positive market returns, as hoped.
- Bear market betas are significantly negative. This confirms the general diversifying behaviour documented in the earlier results – i.e. that the momentum strategies generally outperform when their markets underperform,
- Reversal betas are also significantly negative, confirming that reversal is indeed a key risk factor for these strategies. They underperform when the markets rebound sharply.

Note that the t-statistics for the Equity Indices strategy are weaker overall – this maybe because the MSCI World as the market return is possibly not ideal as it is market-cap weighted and therefore dominated by the US market. Further investigation may lead to a more suitably defined benchmark return in this case. Nonetheless, the betas are consistent in pattern with the other asset classes.

Figure 21: Market beta regression results – Against respective benchmarks

	Commodities	Equity Indices	UST Futures
Benchmark	DJ UBS Exc. Ret.	MSCI World Exc. Ret.	Barclays Capital US Agg Exc. Ret.
Overall (β_0)	0.18	-0.01	0.09
t-statistic	5.24	-0.29	1.28
Bear market (β_1)	-0.26	-0.06	-0.42
t-statistic	-4.25	-1.71	-2.92
Reversal (β_2)	-0.15	-0.10	-0.16
t-statistic	-1.63	-1.86	-0.69

Source: Barclays Capital

As hoped, Figure 21 confirms and quantifies the diversifying effects of momentum (negative bear market betas), and their key risk factors (negative reversal betas), when compared against their own asset classes. We again use the regression introduced here when assessing the risks and diversification of a portfolio of momentum strategies in the last section of this report.

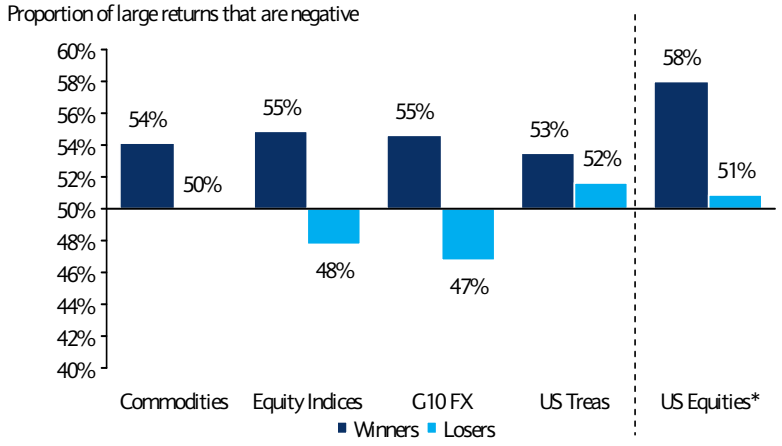
We next discuss the second systematic risk factor of momentum strategies: negative skewness of returns.

Systematic skewness of winners and losers

Another consistent property of momentum strategies is the negative skewness – that is, the tendency to experience large negative returns more frequently than large positive returns. This can be seen through the different patterns of returns of winners and losers. We find that recent winners tend subsequently to have a higher negative skewness than losers, even though they outperform losers on average. This is intuitive – in other words, assets that have recently outperformed have higher risk of significant snap-backs than they do of significant further positive jumps. The converse is also true of assets that have recently underperformed. This suggests that the returns of the momentum strategy may, in some respect, be a compensation for this skewness – or crash risk. One simplistic interpretation would be that jumping on the band-wagon may lead to incremental returns but at the cost of greater risk of a snap-back.

Figure 22 demonstrates the skewness empirically. Rather than report the statistical skewness itself, which can be hard to interpret, the chart shows the proportion of large daily returns that are negative for each of the winners' and losers' portfolios. A large daily return is defined as being more than two standard deviations above or below the mean. We clearly see that the winners' portfolios have a higher probability of experiencing large negative returns than the losers. For example, for equity indices, large returns in the winners' portfolio are negative 55% of the time, versus only 47% for the losers. As a cross-check, we include on the right the same analysis for the US stocks momentum strategy, finding consistent properties.

Figure 22: Although recent winners tend to outperform recent losers, on average, their subsequent returns are also more negatively skewed. This chart shows the proportion of large daily returns that are negative – Large is defined as more than two standard deviations above or below the mean



Note: * Based on the top 3 and bottom 3 of the 10 portfolios formed on momentum daily data, covering the period 1963-2010. Publicly available on the Kenneth R. French data library.
Source: Kenneth R. French data library, Barclays Capital

Forming a liquid momentum strategy portfolio

A natural next question is whether there is any diversification value across the momentum strategies themselves. Figure 23 shows the correlations between individual momentum strategies during periods of overlap. None of the correlations are especially high.

Figure 23: Correlation matrix, based on weekly returns

	Commodities	Equity Indices	G10 FX
Equity Indices	4.1%		
G10 FX	9.7%	7.9%	
UST Futures	3.1%	0.5%	-11.5%

Source: Barclays Capital

We construct a portfolio of momentum strategies simply by assigning equal weights across the four strategies, rebalanced monthly (see below for a comment on the use of equal-weighting). Figure 24 and Figure 25 show historical performance of the momentum portfolio. Overall, performance is strong with a Sharpe ratio of 0.75. Similar to the individual strategies, the performance jumps significantly during losing months in the 60/40 portfolio, to 1.88. The overall drawdown is lower than the individual strategies, indicating the value of diversifying across asset classes, at 27.5%.

In *Portfolios of Strategies: Does anything beat equal volatility weighting?,* 1 June 2010, we argued that the use of equal-volatility weights was a good universal approach to allocating between strategies. In this example, we chose to use equal-weights, rather than volatility weights. The reason for this comes back again to the unusual property of momentum strategies that they tend to perform at least as well during periods of high volatility. It does not make sense necessarily to reduce weight during these episodes, as would be the case with an equal-volatility weighting. The empirical performance of an equal-volatility weighted basket of the same strategies is indeed weaker in our testing. We plan further research on the suitability of volatility weighting for different styles of strategies.

Figure 26 reports results of the market beta regression analysis introduced in the previous sections. Betas are decomposed into overall, bear market and reversals, as defined earlier. In this analysis, the market portfolio is defined as the more generic 60/40 portfolio excess returns, rather than the asset class specific market returns used earlier..

Broadly, Figure 26 shows the same characteristics we expected in individual strategy analyses. Overall, beta is marginally positive, bear market beta marginally negative and reversal beta significantly negative. All results are based on weekly excess returns. The betas

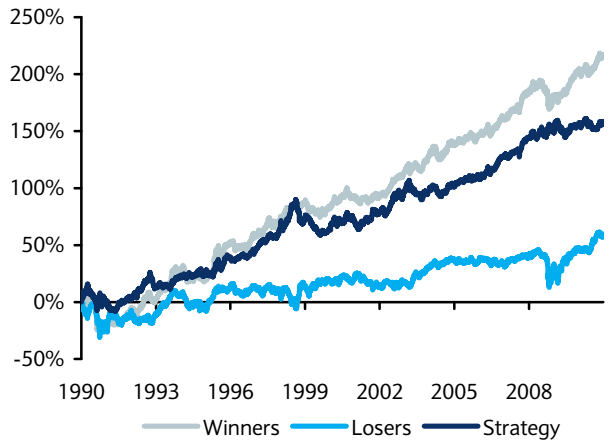
Figure 24: Performance data for Momentum Portfolio

Full sample until Dec 2010	Winners	Losers	Strategy
Start Date	Jan 1990	Jan 1990	**Jan 1990**
Annual Exc. Ret.	10.4%	2.9%	**7.5%**
Annual Volatility	10.9%	10.6%	**10.0%**
Sharpe Ratio	0.96	0.27	**0.75**
Max Drawdown	27.8%	28.7%	**27.5%**

60/40 Tail Performance*	Winners	Losers	Strategy
Annual Exc. Ret.	-20.2%	-44.8%	**24.6%**
Annual Volatility	15.5%	13.8%	**13.1%**
Sharpe Ratio	-1.30	-3.25	**1.88**

Note: *Performance restricted to months where 60/40 portfolio excess return is a loss of one standard deviation or more. Source: Barclays Capital

Figure 25: Cumulative Returns for Momentum Portfolio



Source: Barclays Capital

for the momentum portfolio are generally small and not highly significant. However, they do broadly follow the expected patterns described earlier. We find more significant results for the momentum portfolio in a different analysis later (Figure 33), which demonstrates the same pattern in more economic terms.

Figure 26: Market beta regression results – Against 60/40 portfolio excess returns

	Momentum Portfolio
Overall (β_0)	0.01
t-statistic	0.52
Bear market (β_1)	-0.03
t-statistic	-1.09
Reversal (β_2)	-0.20
t-statistic	-4.85

Source: Barclays Capital

Momentum as a diversification strategy

We have shown that momentum strategies have interesting, though not spectacular, performance profiles by themselves. As alluded to repeatedly, the real value of these strategies comes in their combination with other strategies and in portfolios. Allocations to momentum may improve overall Sharpe ratios, reduce drawdowns, and reduce correlation with broad markets. In this last section, we demonstrate these effects, by analysing momentum in the context of other classic risk premia strategies, as well as in traditional portfolios. For simplicity, all the results in this section are based on the liquid momentum portfolio as defined in the last section.

Diversification versus well-known risk premia strategies

Classic risk premia style strategies can be considered the simplest systematic investment strategies for adding returns over traditional portfolios, by seeking compensation for identifiable risk factors. The topic of risk premia studies has been examined extensively in academic literature, and in our own research (see for example *Risk, return and timing of alternative beta strategies*, 7 April 2010). A general feature of most risk premia strategies is a small to moderate positive correlation, with each other, and with broad markets, as well as substantial drawdowns which may coincide with broad market drawdowns. Our results so far suggest that momentum strategies may combine well with these classic risk premia, and deliver more stable returns. Asness, Moskowitz and Pedersen (2008) look specifically at the case of combining momentum with value strategies. Here, we give a brief assessment of combining momentum with four broad categories of classic risk premia:

- **Carry**: Carry strategies seek additional compensation by going long high-yielding and short low-yielding assets from a pool of similar assets/instruments.
- **Value:** Value strategies seek additional compensation by selecting undervalued assets and shorting overvalued assets in a long-term convergence trade.
- **Curve:** Curve, or term-premium, strategies seek additional compensation for taking longer maturity risk versus shorter maturity risk.

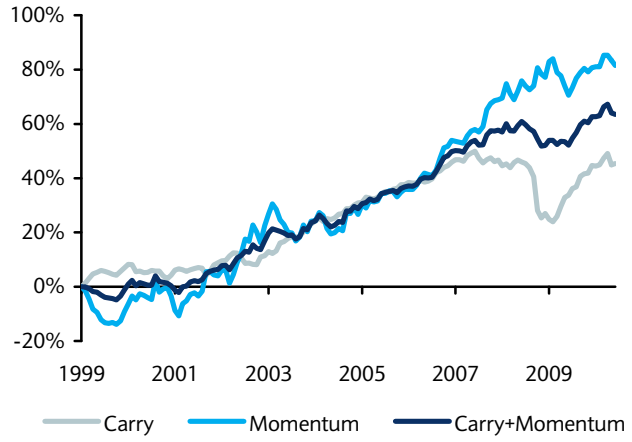
- **Volatility:** Volatility premium strategies seek to earn the premium available between implied volatility and realized volatility in options markets.

In each of the four cases, we have identified the simplest possible implementations of each strategy. We do this in each asset class where there is a natural interpretation of the risk premium definition. This generates three to five individual strategies per risk premium bucket, which we then equal-weight to form a risk premium strategy portfolio for each.

Figure 27 to Figure 30 show cumulative excess returns series based on the above method. The four charts show each of the four risk premia strategy portfolios against our liquid momentum portfolio, and a 50/50 equal-weighted split portfolio between the two. In all four cases, the pattern is striking. Overall, returns are broadly similar between momentum and the risk premia portfolios, but the negative correlation is clearly visible, especially during the credit crisis. The 50/50 combination portfolios in each case generate similar returns but with lower draw downs and lower volatility, and, hence, higher Sharpe ratios. The returns are shown pre-trading costs, as with the momentum strategies.

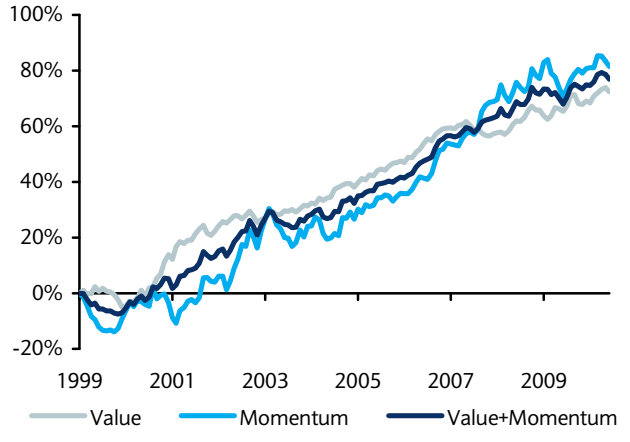
Although these results are promising, they remain indicative only at this stage. Research on the definition, properties and interactions of risk premia strategies is a core theme of Barclays Capital Systematic Strategies ongoing research series.

Figure 27: Carry and momentum



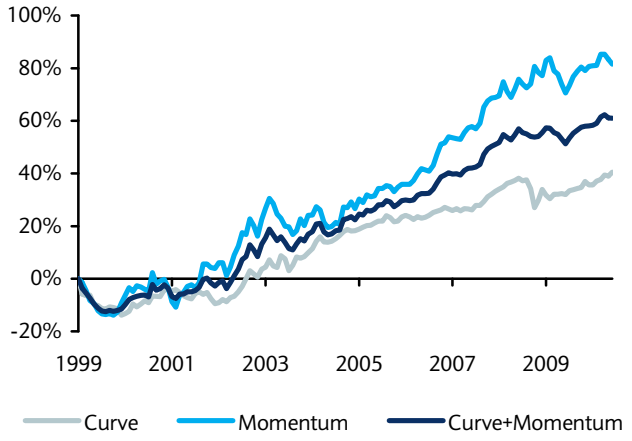
Source: Barclays Capital

Figure 28: Value and momentum



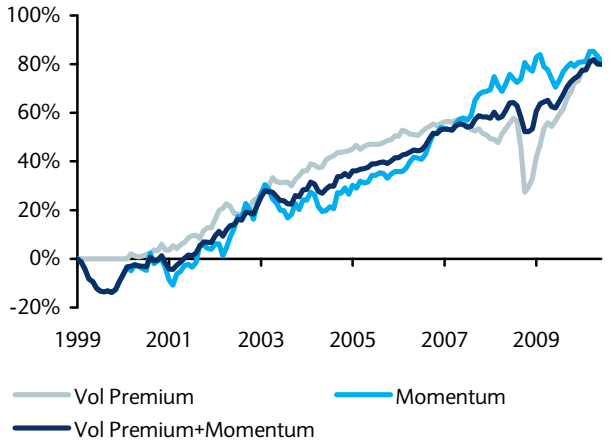
Source: Barclays Capital

Figure 29: Curve (or "Term premium") and momentum



Source: Barclays Capital

Figure 30: Volatility premium and momentum



Source: Barclays Capital

Diversification in traditional portfolios

Our final discussion topic is the role of momentum strategies in traditional portfolios as an alternative investment. Once again, the core properties of the momentum strategies make this potentially appealing:

- Long-run positive performance
- Negative beta to traditional portfolio during bear markets
- Non-coincident strategy drawdowns

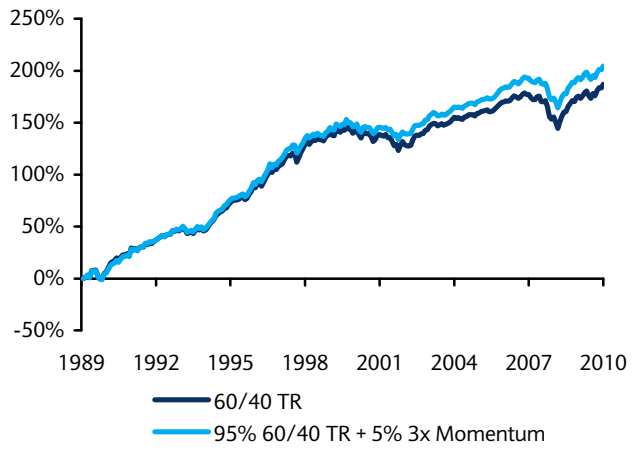
We use the standard 60% S&P 500, 40% US Aggregate bond portfolio as a base and consider an allocation to the liquid momentum portfolio defined in the last section. As an unfunded strategy, the questions of leverage and suitable allocation size arise. The answers to these questions are dependent on specific real-world portfolio constraints. As a simple example, we consider a 15% allocation to the momentum portfolio. We assume this is collateralised with 5% of the portfolio's cash, earning 1 month USD Libor.

Figure 31: Historical performance summary for the standard 60/40 portfolio, and the combined portfolio with momentum allocation

Full sample until Dec 2010	60/40 Portfolio	95% 60/40 TR + 5% 3x Momentum
Start Date	January 1990	January 1990
Annual Total Return	8.9%	9.8%
Annual Excess Return	4.8%	5.7%
Annual ER Volatility	9.3%	8.7%
Sharpe Ratio	0.52	0.65
Max Drawdown	30%	27%

Source: Barclays Capital

Figure 32: Cumulative total returns of the standard 60/40 portfolio, and the combined portfolio with momentum allocation



Source: Barclays Capital

Figure 31 and Figure 32 report the performance of the 60/40 portfolio with and without the momentum allocation. The momentum allocation significantly improves on all statistics, most notably an increase in Sharpe ratio from 0.52 to 0.65 and a decrease in drawdown from 30% to 27%. Although small differences in absolute terms, these improvements should be considered in the context of the relatively small allocation.

In the last section below, we further show that the liquid momentum portfolio can be considered an alternative to certain option strategies as portfolio overlays.

Momentum diversification as a complement to an option-hedging program

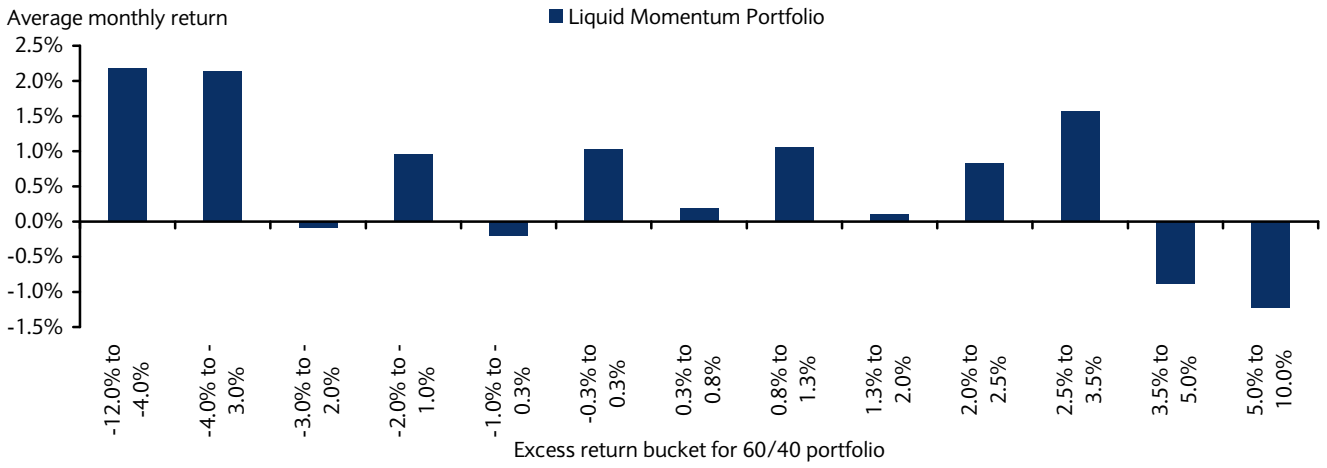
Allocating to a momentum strategy in a traditional portfolio could be considered as a complement to a typical option-hedging program. To illustrate this, we first motivate the idea with Figure 33, which is a return decomposition of the liquid momentum portfolio split by buckets of returns on the 60/40 portfolio. Specifically, we arrange historical monthly excess returns of the 60/40 portfolio in ascending order and form buckets such that there are roughly 20 observations per bucket. The horizontal axis labels identify these buckets in the chart. For each bucket, we then compute the average corresponding excess return in those months on the liquid momentum portfolio.

As an example, the liquid momentum portfolio earned, on average, just over 2.0% per month during sell-off months in which the 60/40 portfolio excess returns were between -12% and -4%. Conversely, the liquid momentum portfolio lost, on average, almost 1.5% per month during rallying months in which the 60/40 portfolio excess returns were between +1% and +5%. By construction of the chart, there were approximately 20 such months in each of these two buckets, as well as in each of the other buckets.

Three observations from Figure 33:

- The negative beta, already noted, to the 60/40 portfolio during sell-offs and during rallies (end zones of this chart), and the zero beta during normal market conditions (middle zone of chart).
- A small convexity in returns, giving an option-like payoff profile. This comes from the property of momentum strategies described earlier that winners' and losers' portfolios can often be considered to be taking positions on high beta versus low beta

Figure 33: Average monthly returns of the liquid momentum portfolio bucketed by returns on the 60/40 portfolio



Source: Barclays Capital

instruments. which becomes more pronounced during periods of large market moves, leading to outsized returns during these periods.

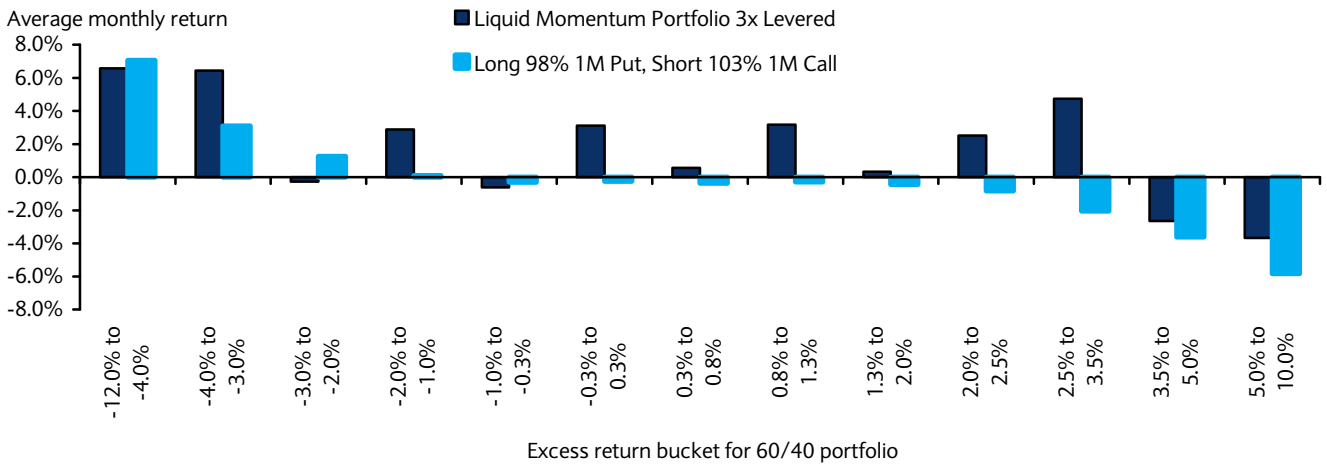
- The momentum portfolio risk profile is again made clear – sharp rallies (which typically only occur as bounce-backs after bear markets) lead to momentum losses.

The shape of the payoff diagram in Figure 33 shows some resemblance to an option-hedging program payoff. As a simple example, we show in Figure 34 that the momentum payoff is very close to a S&P 500 put-buying program, partially funded by selling out-of-the money calls (we discuss similar such programs in detail in the context of hedging FX carry strategies – see *Active Tail Risk Hedging: Improving the risk-return profile of the FX carry trade*, 31 January 2010). Figure 34 is identical in structure to Figure 33 – we add in each bucket, the average corresponding monthly return on a portfolio of a long S&P 500 1 month 98% strike put and a short S&P 500 1 month 103% strike call. This example option-program has the effect of flooring monthly losses at 2% while giving up any positive monthly returns beyond 3%. We contrast this with the 3x levered momentum returns used in Figure 32, as a reasonable comparison.

The two payoff profiles show clear similarity in the tails. The option strategy naturally shows greater convexity than the 3x levered momentum strategy, but magnitudes of returns in these ranges are similar. The momentum strategy, however, substantially outperforms the option strategy in the middle zone of returns, where the cost of the options makes this approach unattractive.

The momentum strategy appears, in this analysis, to be superior to the option strategy. However, a key difference between the two approaches is the guaranteed nature of the protection offered by the options, in contrast to the expected performance of the momentum strategy. Additionally, the option-program is simplistic in this example. Nonetheless these results certainly inspire further investigation and we believe that the momentum strategies could act as a complement to an active option-hedging program in improving institutional portfolio risk-return characteristics.

Figure 34: Average monthly returns of the liquid momentum portfolio 3x levered, compared with the S&P 500 option strategy, bucketed by returns on the 60/40 portfolio. Similar profiles in the tails – momentum outperforms in the middle.



Source: Barclays Capital

Concluding remarks and future directions

In conclusion, this report outlines several possibly underappreciated properties of momentum strategies that should be relevant to institutional portfolio managers seeking diversification. Our analysis has shown that momentum strategies, while simple in concept, require detailed investigation to understand the risks, returns and interactions with other investments.

In terms of future directions, there are many aspects that leave room for further investigation. These include expanding the number of markets for which momentum is applied, extending time series of historical returns and assessing optimal allocations to momentum in traditional portfolios. We intentionally did not approach the subject of enhancing the basic momentum strategy, but careful analysis here may be fruitful if it can be suitably justified.

As a final note, we plan further additions to our research series on risk premia strategies. The common theme is the analysis of the properties of these basic strategies, their interaction, and – eventually – the development of dynamic allocation mechanisms to form portfolios of risk premia.

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