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Cross Asset Class Momentum

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Momentum in equities is widely discussed

The momentum anomaly within equities is one of the most widely discussed and hotly debated investment styles. In this research, we analyze whether momentum manifests in other asset classes.

Does momentum exist in other asset classes?

We test the momentum anomaly in seven different asset classes including traditional asset classes like commodities and treasuries as well as more exotic asset classes like hedge fund strategies and equity indices.

Momentum spans asset classes

We find that momentum permeates across several asset classes and that momentum within other asset classes has a low correlation to momentum in equities. Momentum portfolios from certain asset classes also have smaller drawdowns and are less volatile than equity momentum portfolios.

Combining cross asset momentum portfolios

We show how to combine pure momentum portfolios from various asset classes using simple as well as more sophisticated portfolio allocation techniques such as risk parity. We show that cross asset momentum portfolios significantly outperform traditional momentum strategies in equities. Lastly, we show how to boost performance further by using a simple regime switching model and volatility neutralization on cross asset momentum portfolios.

Source: gettyimages.com

Table Of Contents

A letter to our readers

Asset allocation techniques are evolving. Analytical progress and more importantly our understanding of volatility, correlations, and macroeconomic effects has slowly revolutionized the way we think about risk management. This evolution in asset allocation was partially motivated by the consequences of the financial crisis and the ongoing "risk-on" and "risk-off" market environment thereafter.

Conventional asset allocation is represented by the classic 60/40 policy between equity and fixed income allocation. This proved somewhat problematic during severe market downturns and frequent regime shifting episodes. Investment managers then shifted towards more non-traditional asset classes such as hedge funds, real-estate, and private equity etc. Again, this proved to be inadequate during severe market downturns as correlations among all asset classes rose sharply.

Our European Quantitative Strategy team recently published a research report presenting a new paradigm for asset allocation.[1] The paper describes an asset allocation framework that breeds diversification across various risk premia or factors across multiple asset classes. So rather than diversify risk across multiple asset classes as conventional wisdom would advocate, why not diversify across various risk factors within multiple asset class. In this research, we perform a thorough and detailed examination of one of these factors: Momentum.

Equity momentum is one of the most widely discussed and hotly debated factors by academics and practitioners. However, in this piece we study the persistence of the momentum anomaly across seven different asset classes (e.g. commodities, treasuries, currencies etc.) including non-traditional and more exotic asset classes such as hedge fund, sector, and equity indices. Studying momentum across several asset classes can uncover the commonalities within pure momentum strategies.[2]

We show that momentum portfolios across several asset classes is far superior to the traditional 12-1 month momentum in equities based on both risk adjusted performance and left tail risk perspective. Further, we compare the various portfolio allocation techniques to determine the most optimal way to combine various momentum portfolios derived from multiple asset classes. We explore some simple portfolio allocation methods as well as more sophisticated methods such as risk parity based portfolio allocation. Being selective when choosing your portfolio allocation method can definitely improve performance. Finally, we show how to boost performance even further by utilizing the principals of regime switching and volatility neutralization on cross asset momentum portfolios.

For more information on how to implement cross asset class ideas, please contact our Quantitative Investment Solutions (QIS) team – Miguel Alvarez in the US or Spyros Mesomeris in Europe or email DBEQS.Global@db.com. We hope you enjoy the rest of the report.

Regards,

Yin, Rocky, Miguel, Javed, John, and Sheng
Deutsche Bank North American Quantitative Strategy

[1] See Mesomeris et al. [2012].

[2] For more information, see Asness, Moskowitz, and Pedersen [2009], Antonacci [2012], Blitz and Vliet [2008], Kim [2012], and Moskowtiz, Ooi, and Pedersen [2011]

Momentum in Equities Revisited

Introduction

In 1993, Jegadeesh a Titman published a seminal paper suggesting that strategies which buy stocks that have performed well in the past and sells stocks that have performed poorly generate significant positive returns over the next three to twelve months. Ever since, the momentum anomaly has been discussed and debated ad infinitum within academia and by practitioners.

Almost twenty years later, Jegadeesh and Titman still contend that the momentum anomaly persists, in that stocks that perform the best over the past three- to twelve-months tend to continue to perform well over the subsequent three to twelve months (see Jegadeesh and Titman [2011]). There has also been a multitude of academic publications attempting to explain the underlying reasons for the momentum anomaly. These explanations typically fall into three buckets:

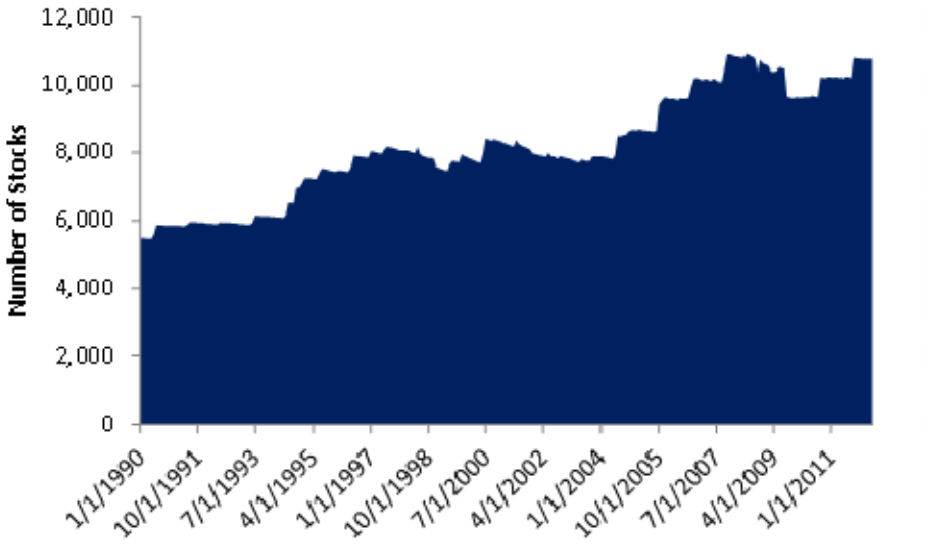
- **Behavioral or informational biases**: Investors typically under-react to news or published information regarding a company. The time needed by investors to comprehend and interpret the information may lead to an upward/downward trend in prices.
- **Risk factors**: There is some academic evidence showing that the momentum anomaly is linked to smaller firms, concentrated in more volatile firms, and linked to firms with poor credit ratings and high bankruptcy risk.
- **Limits to Arbitrage**: There is some academic evidence showing that the momentum anomaly is linked to transaction costs, limits to arbitrage, as well as liquidity factors.

The reasons underlying the momentum anomaly are still hotly debated within academia. For our purpose, we seek to revisit the momentum anomaly not only within equities world but also across multiple asset classes as explored by Asness, Moskowitz, and Pedersen [2009].

Setting up the analysis

To get started, we initially revisit the momentum effect within global equities. Our global universe consists of 24 developed and 21 emerging markets. Our global universe constituents are sourced from BMI indices for non-US markets and the Russell 3000 for the US market (Figure 1).

Figure 1:Global universe coverage



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Most momentum studies use a 12 month formation window. However, in this research we analyze various other formation windows including: twelve, nine, six, three, and one month periods. We form the portfolios at the end of each month and rebalance the portfolio monthly. Our long/short portfolios are constructed by taking the top and bottom deciles of equities based on the momentum factor. Note that when constructing our momentum factors, we skip the most recent month during the formation period for equities. This is done in order to distinguish the underlying momentum anomaly from shorter-term reversal effects which may be due to microstructure issues.[3] Note that the one-month contrarian/reversal effect typically exists for equities and tends not be persistent in other asset classes such as treasuries and currencies.[4]

How we measure and compare performance

In our study, we will use three main performance measures to gauge the efficacy of the momentum anomaly across the various asset classes:[5]

1. **Rank information coefficient**: Regular readers of our publication will recall that this is measure of how well the momentum score can predict one month ahead returns. The rank information coefficient or Rank IC is simply calculated by computing the correlation of the momentum score with next month's returns for each stock within our universe. Note that this metric will primarily be used to asses performance of equity momentum.

2. **Long/short portfolio performance**: This is simply the performance of a portfolio formed by taking the top and bottom quantiles of assets ranked by our momentum score at each month end. The performance of this portfolio which equally weights all stocks is tracked on a monthly basis.

[3] See Asness et al. [2009] for more information.
[4] See Asness et al. [2009] for more information.
[5] See Luo et al. [2010] for more details on quantitative performance measures.

3. **Annualized Sharpe ratio**: This of course gauges the performance on a risk adjusted basis. We simply compute the Sharpe ratio of the equally weighted portfolios formed by taking the top and bottom quantiles of assets ranked by our momentum score at each month end. The Sharpe ratio is calculated over the entire backtesting period.

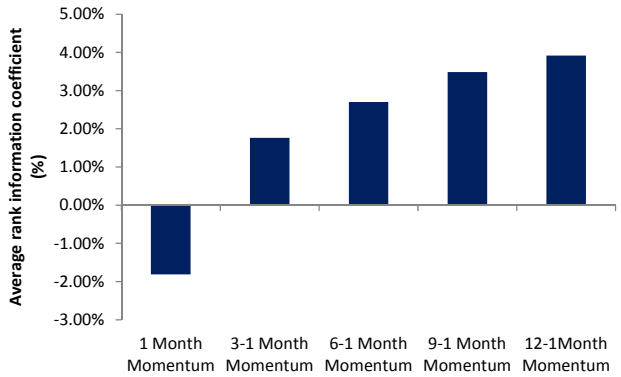
Momentum performance is strong

Here we present the backtesting results of the momentum factor within our global equities universe. Note that to mitigate any country and currencies effects; we have adjusted the returns to be country neutral and to be denominated in USD[6]. Figure 2 shows the Rank IC for various momentum factors backtested over our global equities universe. The results show that 12-1 month momentum has the strongest forecasting ability in predicting next month's returns.

Figure 3 shows the average long/short decile performance of the various momentum factors. Again the 12-1 momentum factor showed the most promising results. Figure 4 shows the Sharpe ratio for the various momentum portfolios. Not surprisingly, 12-1 momentum shows the best Sharpe ratio amongst all the other momentum portfolios.

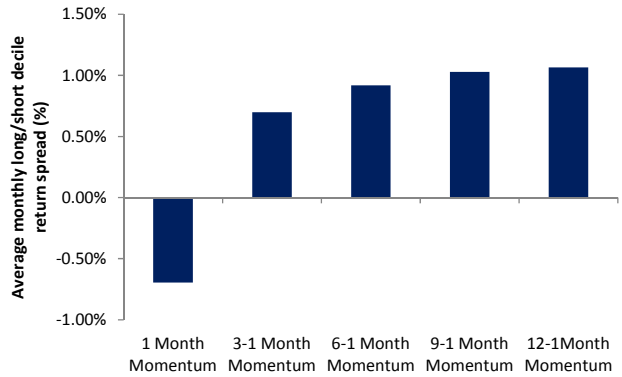
Lastly, Figure 5 shows the two way portfolio turnover for our various momentum portfolios. Harnessing the 12-1 month momentum anomaly within our global equities universe seems promising since it showed the best performing results with the lowest portfolio turnover.

Figure 2: Average rank IC for global portfolio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

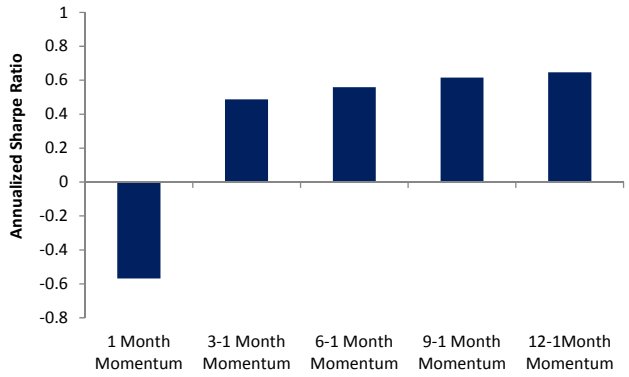
Figure 3: Long/short average monthly decile return



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

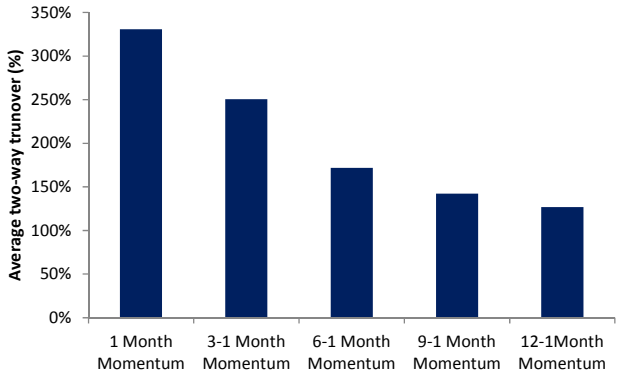
[6] We convert all returns to USD and subtract country returns from stock returns to take into account any country and currency effects.

Figure 4: Annualized Sharpe ratio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 5: Two-way portfolio turnover



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum has its peculiarities

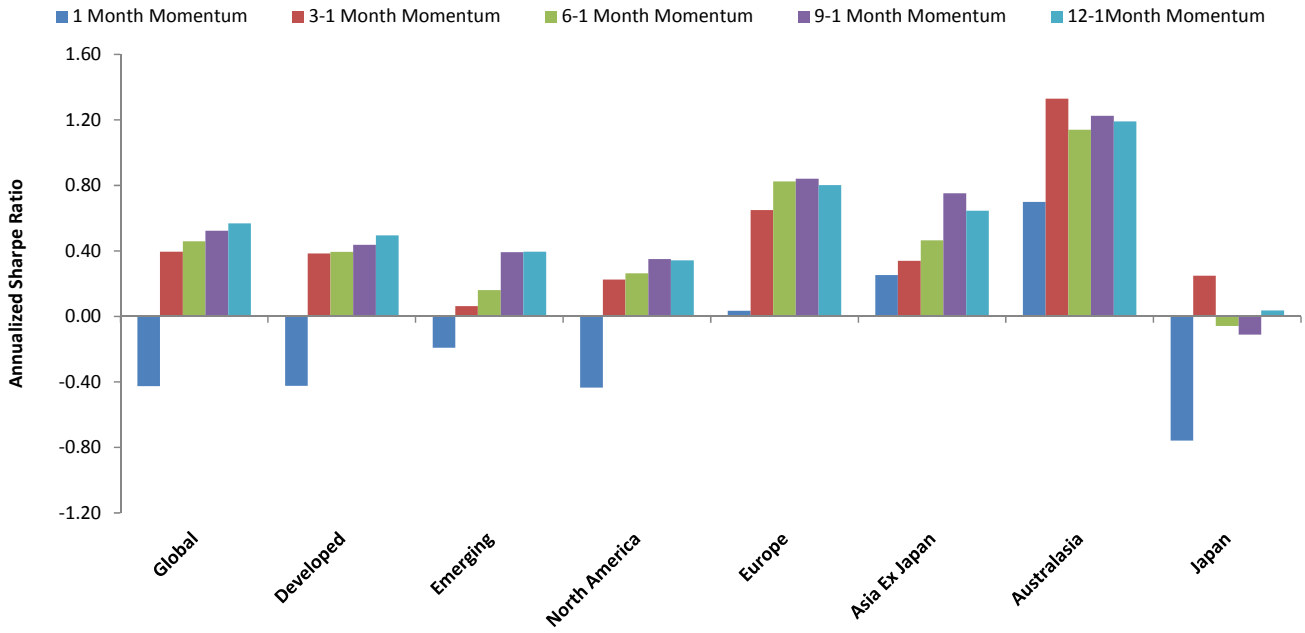
Before proceeding further, we feel it's prudent to briefly point out some of artefacts inherent in momentum equity strategies. Although, the allocation framework we present in this report is fairly comprehensive, it is not necessarily all encompassing. Like any quant framework, it is critical for managers to be cognisant of any peculiarities (favourable and unfavourable) with their strategies.

Regional effects

As Figure 6 shows, there are significant regional effects for the momentum portfolios within equities. Most notably, we find that momentum is a dominating strategy within the Australasia market. Some momentum portfolios within Australasia have a Sharpe ratio of over 1.3. One month momentum, which is typically a reversal strategy in most markets, is a trending strategy in Australasia. As such, quant managers should be cautious when going against momentum within Australasia. Additionally, momentum works well in Europe as well as in Asia (ex-Japan) to some extent.

Interestingly, momentum does not work well in Emerging markets or Japan. In fact, among all the markets we tested, momentum performs the worst in Emerging markets and Japan. The finding that momentum works poorly in Emerging markets is somewhat surprising as we would expect that such anomalies would be more persistent in less tapped regions like emerging markets. However, this may be due to regulatory restrictions which impede or even restrict shorting stocks in emerging markets.

Figure 6: Comparison of momentum annualized Sharpe ratio across regions

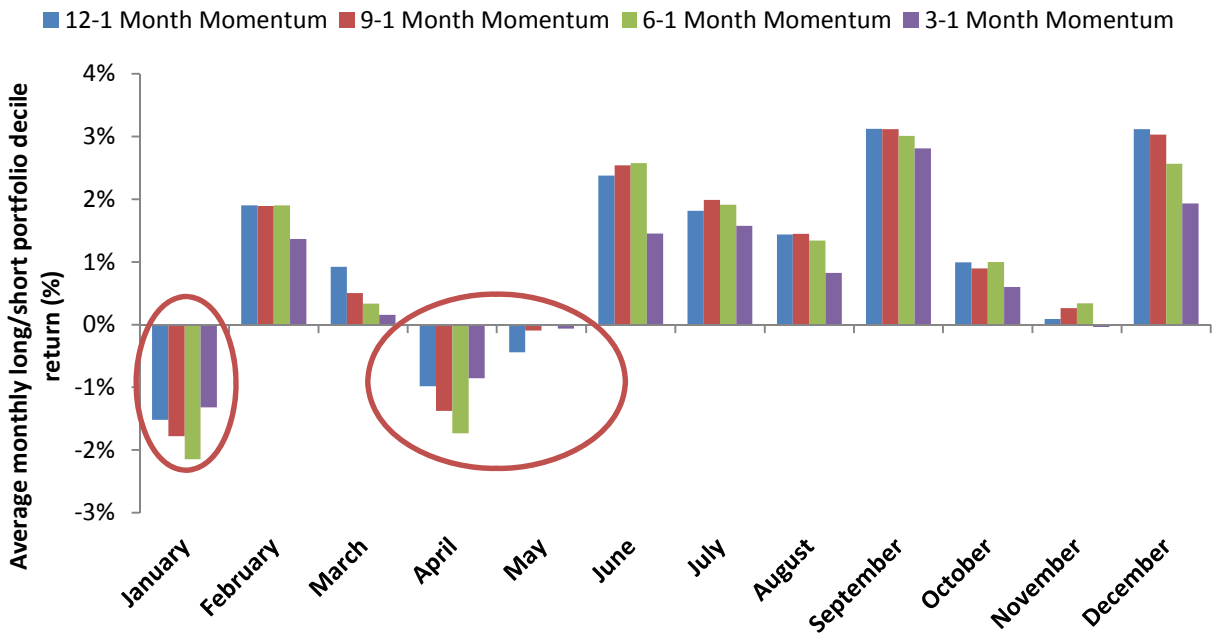


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

The January Effect

The January effect is a widely published market anomaly in which standard quant factors (i.e. such as value, momentum, and growth) perform poorly during the month of January. There has been a multitude of reasons attempting to explain this market anomaly including capital loss claims for tax purposes. However, for our purposes, we investigate the presence of any seasonal effects within equity momentum portfolios. Figure 7 shows the average long/short returns for various momentum portfolios for each month of the year. Interestingly, we clearly observe the sharp presence of the January effect. January is by far the worst performing month for momentum equity strategies. In addition, we notice similar performance degradation during the month of April and May. We touch upon this next.

Figure 7: Seasonal long/short portfolio decile returns for various momentum horizon periods

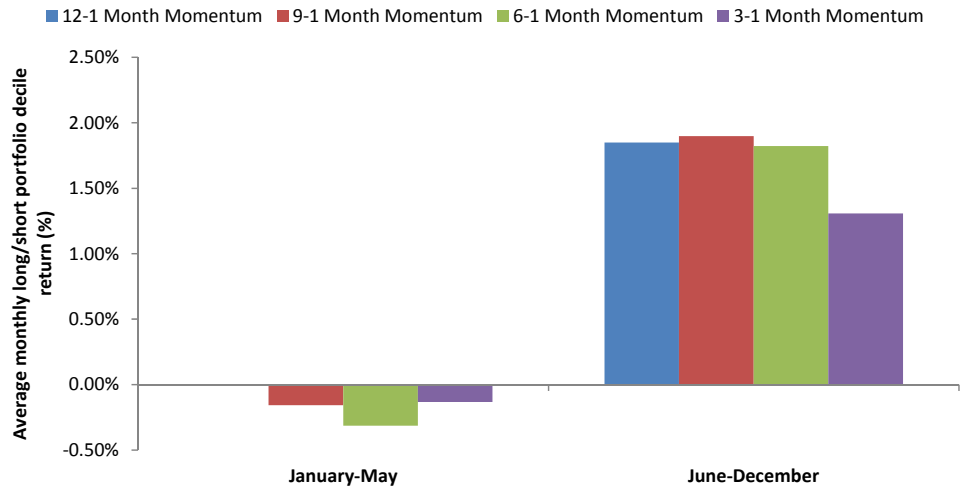


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Sell in May and go away

"Sell in May and go away" is an old British stock market adage that states that stock performance is significantly stronger during the period from November to April. As such, the adage suggests holding stocks during November to April and holding cash from May to October. For this reason, this is sometimes referred to as the Halloween indicator. This "supposed" market anomaly specifically refers to stock timing in general and not for a particular type of alpha strategy. In the quant domain, our findings suggest a slight tweak to this old claim. How about "Sell in December and go away". Figure 8 shows the performance results for various momentum portfolios during the period January to May and June to December. We clearly see a performance tilt to the latter part of the year. As quants, our primary purpose is not to come up with fanciful names for various market axioms, but we feel it's worthwhile to point out the various effects that need to be taken into account when constructing equity momentum portfolios.

Figure 8: Seasonality during the year

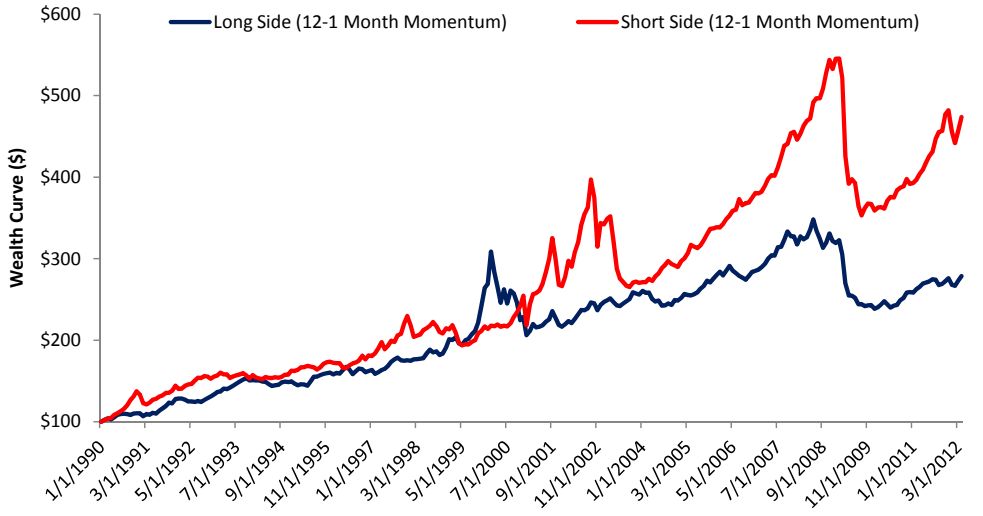


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

The long and short of momentum

Another interesting area of analysis is to look at the return makeup of momentum strategies. Is the return being dominated by the long side, short side, or is it fairly balanced. Figure 9 shows the wealth curve of the top decile of momentum (i.e. the long side) compared to the bottom decile of momentum (i.e. the sort side). To make the comparison easier to see we inverted (i.e. negated) the short side returns. Figure 9 shows that the momentum strategy for equities tends to be dominated by the short side. This finding is not too surprising. The cost of shorting stocks may deter investors away from shorting poor momentum stocks. Moreover, many institutional investors are unable to short stocks due to portfolio mandates. As such, the momentum anomaly will likely be more persistent on the short side (even if the cost of shorting stocks is not prohibitive). Another interesting finding is that the drawdown that is typically inherent in momentum based portfolios occurs both on the long and short side. We explore this drawdown in more detail next.

Figure 9: Long versus short performance of 12-1 month momentum

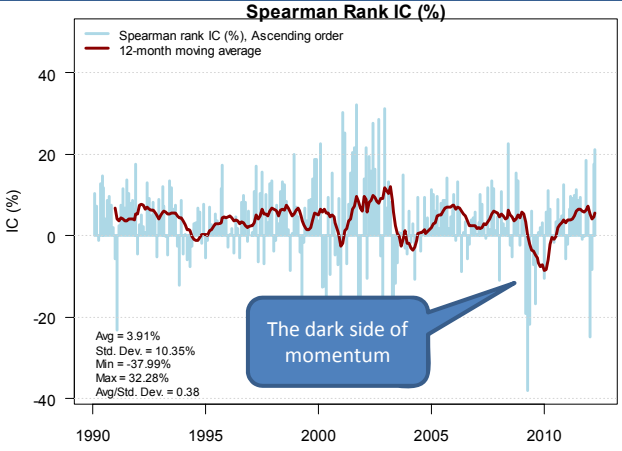


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum's dark side – How can we address this?

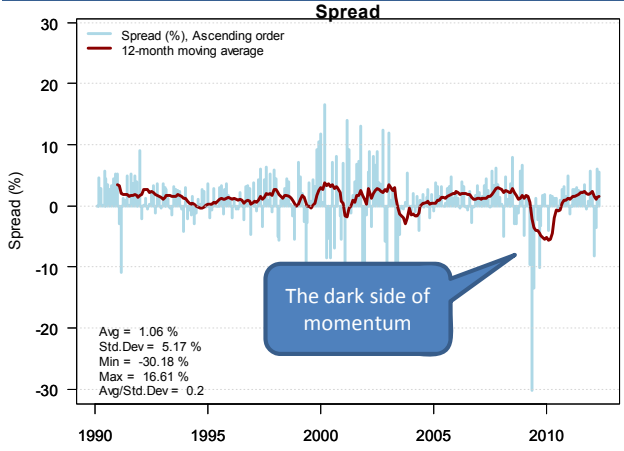
At first glance, momentum appears to be an attractive anomaly; however, as with most quant factors, there is no free lunch. Figure 10 and Figure 11 show the rank IC and long/short decile portfolio return performance for the 12-1 month momentum factor on a time series basis. We see that the factor has performed reasonably well over the entire period except during certain market episodes. We see that 12-1 month momentum performed poorly subsequent to the dot-com crash and the financial crisis. The long/short portfolio decile return fell to negative 30% during one month in 2009.[7] This we would claim is the dark side of momentum.

Figure 10: Time series rank information coefficient for 12-1 month momentum



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 11: Time series long/short average monthly decile return for 12-1 month momentum



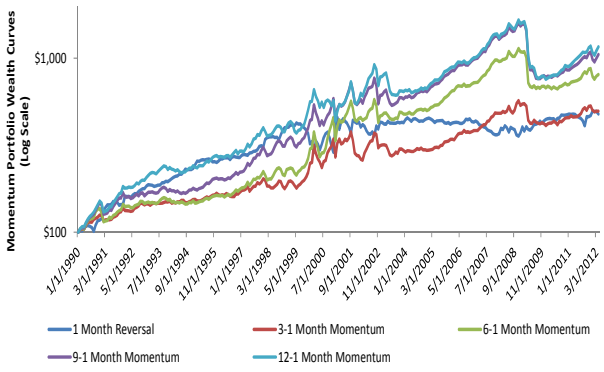
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum's impressive gains come at the price (or should we say expense) of significant left tail risk. In fact, 12-1 month momentum for our US stock universe has a kurtosis of 12.1 (i.e. high excess kurtosis) and a skewness of -1.5 (i.e. left or negative skewness). More importantly the drawdown inherent within momentum portfolios is substantial. Figure 12 shows the wealth curves of our various momentum portfolios. We can clearly see the major kink in the portfolio returns during the financial crisis period and to some extent during the dot-com bubble. As shown in Figure 12, this is consistent with most of our equity momentum portfolios.

More specifically, Figure 13 shows the maximum drawdown for various momentum equity portfolios within our global universe. The 12-1 month momentum long/short portfolio has a max drawdown of over 50%. Undoubtedly, this is a major issue for investment managers running momentum strategies.

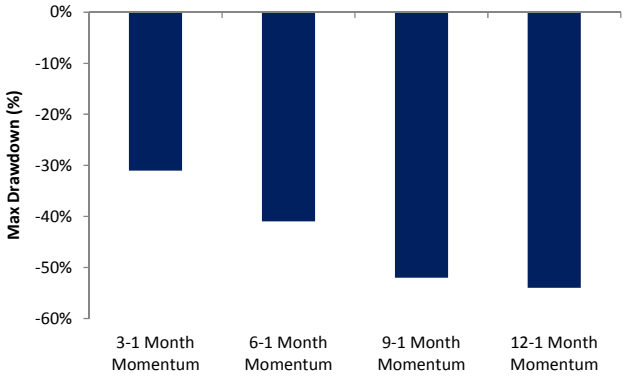
[7] See Alvarez et al. [2011a] for insight on how to mitigate large drawdown's in momentum based strategies.

Figure 12: Wealth curve for equity momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 13: Max drawdown for equity momentum portfolios

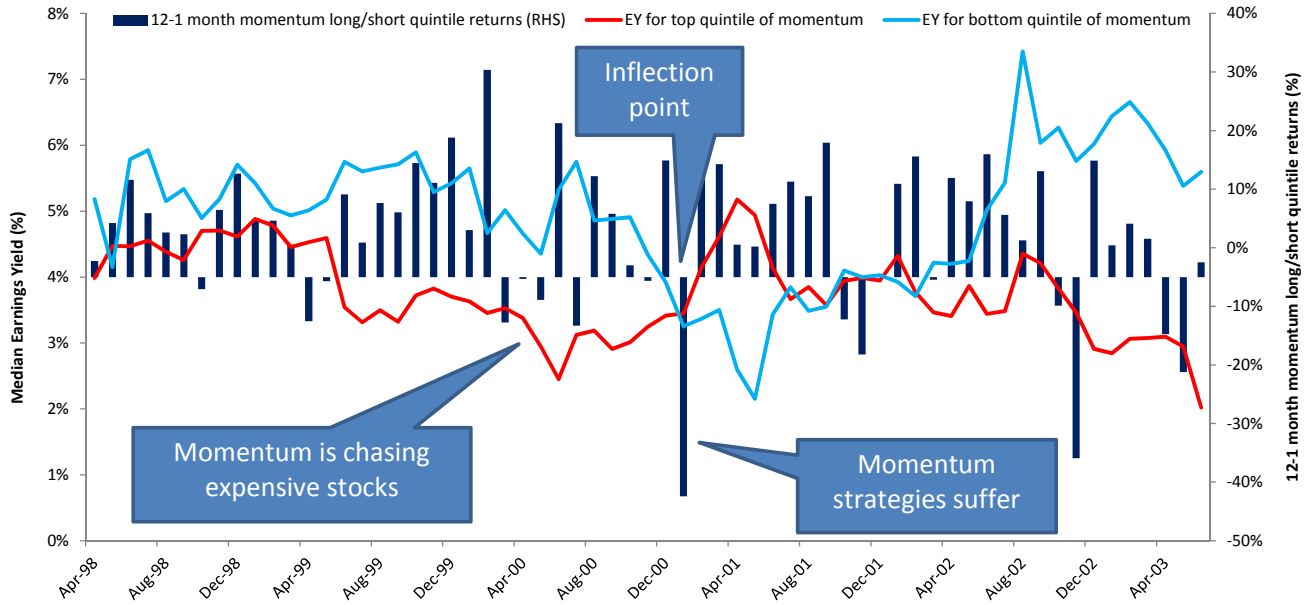


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

As shown in the above figures, there are specific periods in which momentum strategies suffer sharply. These periods tend to be when investors are constantly shifting between risk seeking and risk aversion strategies. These episodes are problematic for momentum strategies. As investors risk appetite suddenly changes, stocks that have performed well (i.e. stocks that have gained momentum) suddenly perform poorly.

The classic example is the value trap during the dot-com bubble. During this time, investors were chasing technology stocks (i.e. technology stocks were gaining momentum). Momentum strategies were positioned to long technology stocks which were undoubtedly expensive. Figure 14 shows that leading up to and during the technology bubble, long momentum strategies contained expensive stocks (as measured by trailing earnings yield).

Figure 14: The value trap and momentum



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

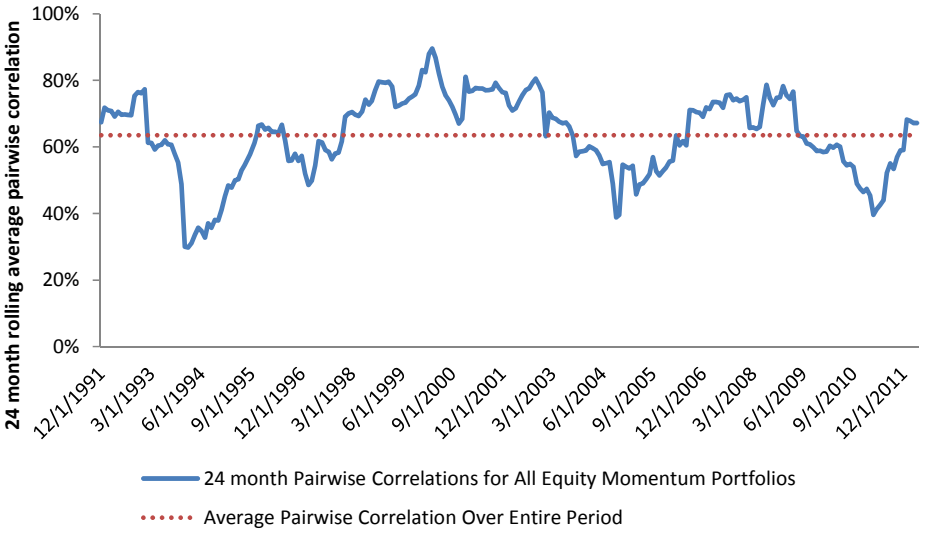
All of a sudden, when the dot-com bubble popped, investors shunned technology companies which led to a sharp and dramatic selloff. As such, momentum based strategies suffered sharply during this transition point. This is because the strategy that worked well in the past (i.e. buying technology companies) did not work well post the dot.com crash. Investors flocked to higher quality companies that (unlike most startup technology companies) had a stable stream of earnings. As such these safe haven (predominantly inexpensive) companies began gaining momentum. At this stage, we merely point out this adverse artifact of momentum. However, later in this report we show this artifact can be addressed.

The bright side – Momentum across asset classes

Thus far we have seen the many drawbacks (or shall we say drawdown's) inherent in equity momentum strategies. In summary, the most pressing issue is that equity momentum strategies suffer large drawdown's during constantly changing market regimes. So what is the way forward for investment managers who run momentum based strategies?

One possible solution would be to diversify across the various period momentum portfolios within equities. However, diversifying amongst the various momentum portfolios within equities is challenging (i.e. it may not remedy the kinks). This is because the momentum portfolios are highly correlated within equities.[8] Figure 15 shows the 24 month rolling pairwise correlations for all equity momentum portfolios (including 1 month reversal, 3-1 month, 6-1 month, 9-1 month, and 12-1 month). The overall correlation is above 60% and the correlation increases dramatically during the dot-com bubble and financial crisis.

Figure 15: 24 month pairwise correlations for equity momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

On the other hand, why not implement momentum strategies in other asset classes (including non-traditional asset classes) in search of exposure to pure momentum. But this is not an easy task. Does momentum exist in other asset classes? And if so, does

[8] However, in Alvarez et al. [2011a] we show how investors can switch between various horizons momentum portfolios. The proposed switching framework empirically outperforms the traditional standalone 12-1 month momentum strategy.

momentum perform well in these asset classes on a risk adjusted basis? How correlated are momentum strategies in other asset classes with equity momentum? Can momentum portfolios derived from other asset classes be combined with equity momentum to reduce drawdown's and improve risk adjusted performance? How should we combine multiple momentum portfolios across other asset classes? What is the best portfolio allocation method? It is these essential questions that we aim to answer in this research. Enjoy the remainder of the report.

Momentum in Equity Indices

Introduction

There is little research investigating the momentum anomaly across less traditional asset classes such as country, sector, and hedge fund indices. The analysis of the momentum across equity indices or even ETFs has garnished very little attention. Here we expand our scope of study to span other, less conventional yet more contemporary investment vehicles. In this section, we explore the momentum anomaly across equity indices. We seek to determine whether equity indices show the persistence of momentum and to what extent. Further, we want to determine how correlated index and equity based momentum are. Can equity index momentum potentially be a strong addition and diversifier to equity momentum strategies?

Setting up the analysis

First, we determine whether momentum persists among equity indices. Our equity index universe consists of 24 developed and 21 emerging market indices. Our index universe constituents are sourced from MSCI indices for both US and non-US markets (Figure 16). Note that our country indices are USD denominated total return indices.

Figure 16: MSCI country indices universe

Country	Category	Country	Category
MSCI Canada	Developed	MSCI Brazil	Emerging
MSCI USA	Developed	MSCI Chile	Emerging
MSCI Austria	Developed	MSCI Colombia	Emerging
MSCI Belgium	Developed	MSCI Mexico	Emerging
MSCI Denmark	Developed	MSCI Peru	Emerging
MSCI Finland	Developed	MSCI Czech Republic	Emerging
MSCI France	Developed	MSCI Egypt	Emerging
MSCI Germany	Developed	MSCI Hungary	Emerging
MSCI Greece	Developed	MSCI Morocco	Emerging
MSCI Ireland	Developed	MSCI Poland	Emerging
MSCI Israel	Developed	MSCI Russia	Emerging
MSCI Italy	Developed	MSCI South Africa	Emerging
MSCI Netherlands	Developed	MSCI Turkey	Emerging
MSCI Norway	Developed	MSCI China	Emerging
MSCI Portugal	Developed	MSCI India	Emerging
MSCI Spain	Developed	MSCI Indonesia	Emerging
MSCI Sweden	Developed	MSCI Korea	Emerging
MSCI Switzerland	Developed	MSCI Malaysia	Emerging
MSCI UK	Developed	MSCI Philippines	Emerging
MSCI Australia	Developed	MSCI Taiwan	Emerging
MSCI Hong Kong	Developed	MSCI Thailand	Emerging
MSCI Japan	Developed		
MSCI New Zealand	Developed		
MSCI Singapore	Developed		

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Our sector indices (Figure 17) are made up of the ten MSCI GICS sectors and our sourced conveniently from the MSCI World sector indices Note that our sector indices are USD denominated price return indices.

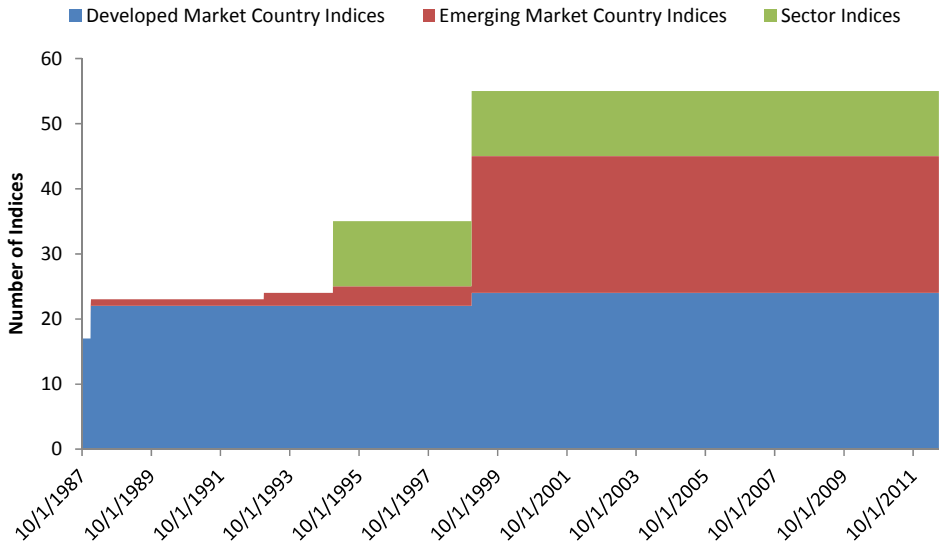
Figure 17: MSCI sector indices universe

Sector Index	GICS Sector Code
MSCI World Energy	10
MSCI World Materials	15
MSCI World Industrials	20
MSCI World Consumer Discretionary	25
MSCI World Consumer Staples	30
MSCI World Health Care	35
MSCI World Financials	40
MSCI World Information Technology	45
MSCI World Telecommunication Services	50
MSCI World Utilities	55

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 18 shows the time series coverage of our index universe delineated between emerging markets, developed markets, and sector indices. We see that the historical coverage is reasonable. When constructing our momentum factors for indices, we did not skip the most recent month during the formation period. This is because we did not find that the one-month reversal effect exists for indices although rampant within individual stock universes (as shown in the previous section).

Figure 18:Coverage of equity indices



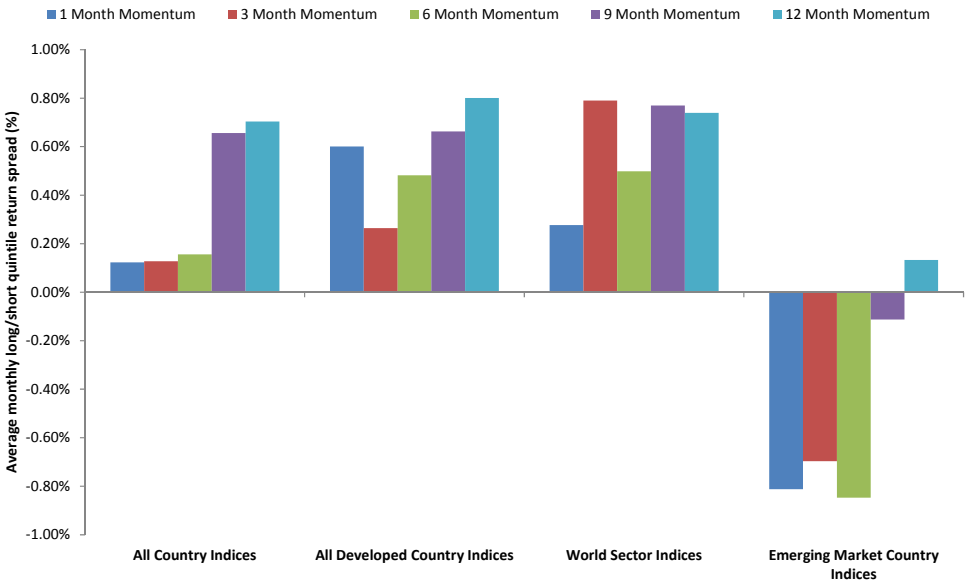
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Similar to the analysis we did for equities, for these indices we analyze various formation windows including: twelve, nine, six, three, and one month periods. Our momentum scores are constructed by taking the returns of the index levels over the various formation periods. We form the portfolios at the end of each month and rebalance the portfolio monthly. Our long/short portfolios are constructed by taking the top and bottom quintile indices based on the momentum factor.

Momentum persists within equity and sector indices

Figure 19 shows the average long/short quintile performance of the various momentum factors across the various equity indices. From a long/short quintile performance perspective, the results are surprisingly strong. Certain momentum based portfolios have an average long/short monthly quintile return of approximately 0.8%. This result outperforms most US quant factors. We also note that most long-term horizon momentum portfolios outperform short-term horizon portfolios. This is a appealing because it means that we can gain incremental alpha without incurring excessive turnover.

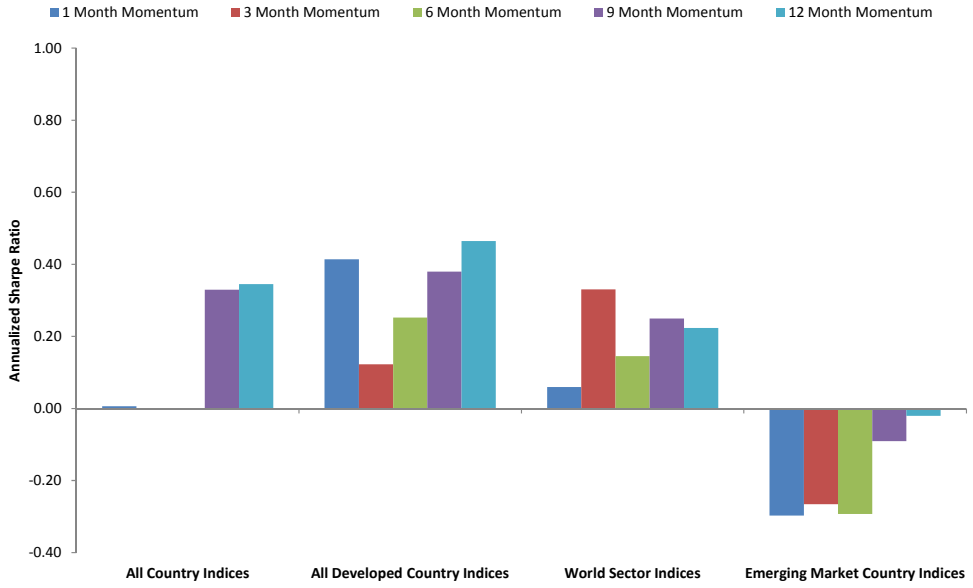
Figure 19:Long/short quintile performance of equity index momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 20 shows the Sharpe ratio for the various momentum portfolios. From a risk adjusted basis, we see that momentum across equity and sector indices shows modest results. Longer-term momentum within developed market indices shows the most promising results. Surprisingly, emerging market indices show more reversal than momentum patterns. We discuss this in more detail next.

Figure 20:Sharpe ratio of equity indices

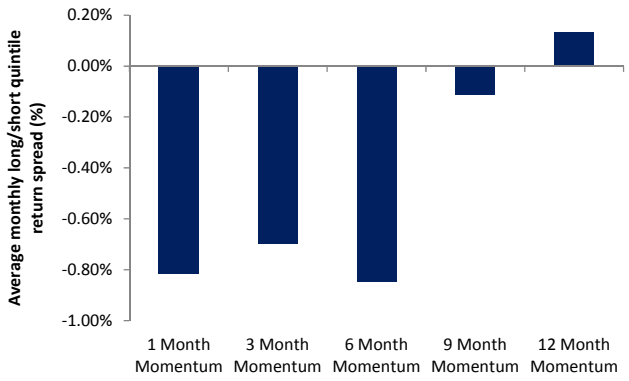


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Emerging market country indices show reversal effects

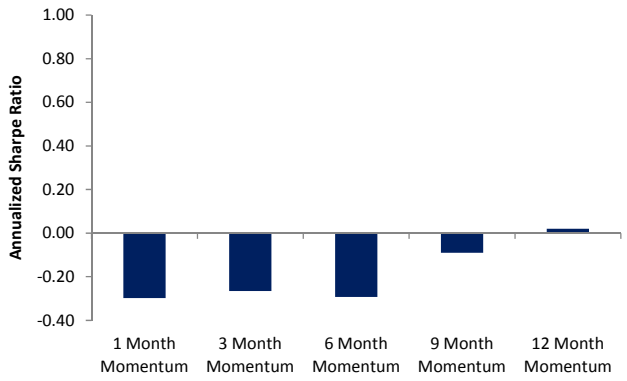
Figure 21 and Figure 22 show the long/short quintile monthly return and annualized Sharpe ratio for various horizon momentum portfolios within emerging market indices. To immunize against asynchronous trading due to regional time differences, we capture index returns one day prior to the month end. Nevertheless, we clearly see a strong reversal effect for emerging market indices. This seems to be consistent with the fact that the momentum effect is weak for emerging market stocks.

Figure 21: Long/short average monthly quintile return



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 22: Annualized Sharpe ratio



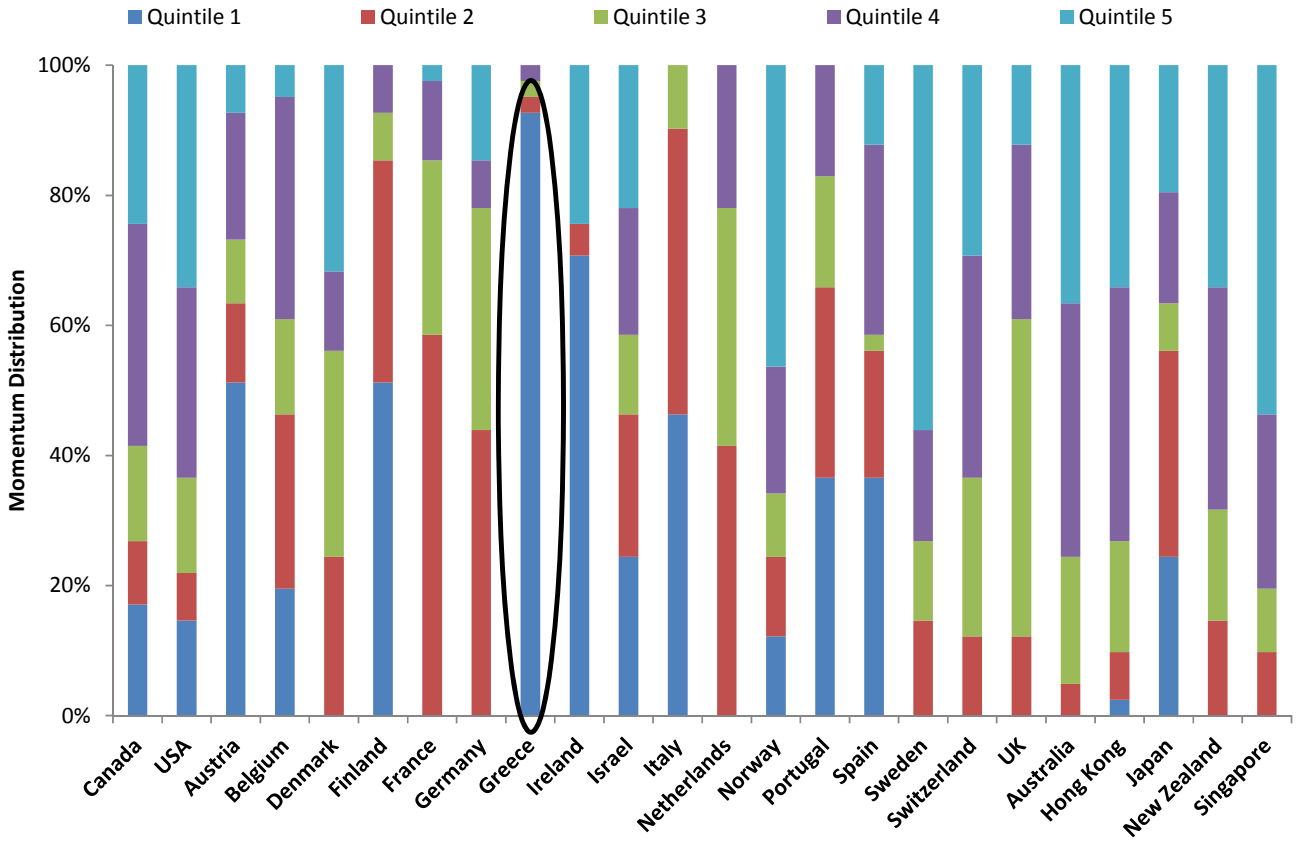
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum indices are tied to economic conditions

As an aside, here we show how the analysis of country momentum index portfolios is reflective of prevailing economic conditions. Figure 23 shows the distribution of each 12 month momentum quintile portfolio for all of the developed market indices. Essentially, this chart shows which country indices exhibit the most and least amount of 12 month momentum. In this chart, we show the momentum quintile distribution

from 2009 onwards. This time frame represents the onset of the European crisis. We can clearly see from Figure 23 that the Greece country index (not surprisingly) shows the most negative 12 month momentum from 2009 onwards.[9] This is apparent because during this time, Greece is situated almost entirely in quintile one, the most negative momentum bucket.

Figure 23: 12 month momentum quintile distribution across developed country indices from 2009 onwards

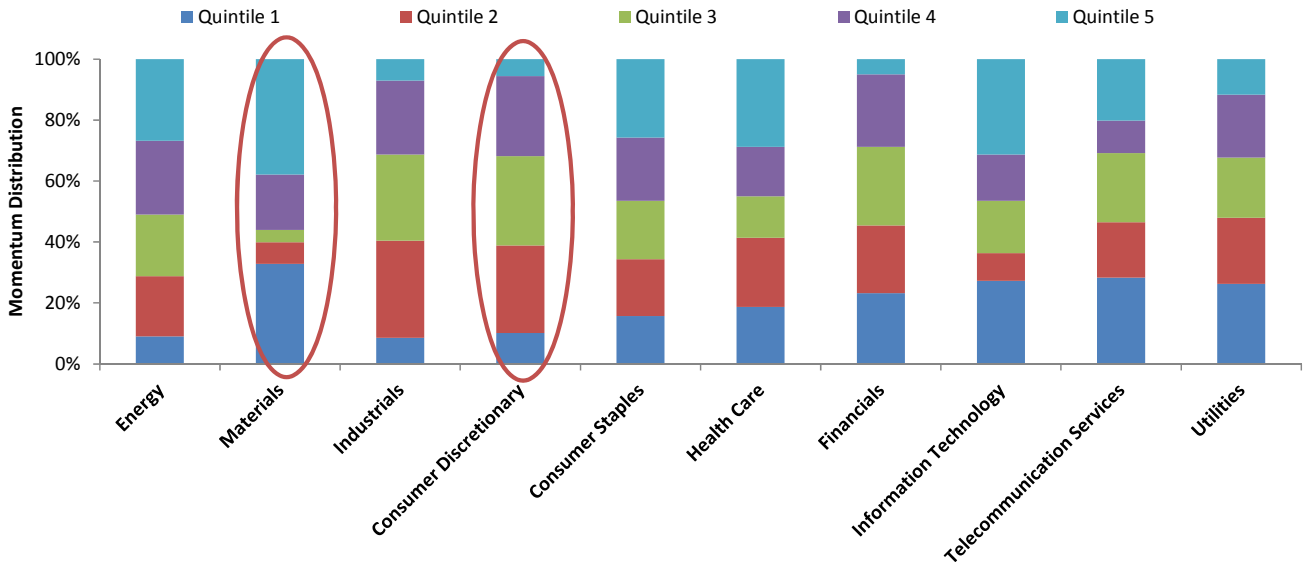


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

The same analysis framework can also be applied to sector indices. Figure 24 shows the distribution of each 12 month momentum quintile portfolio for all of the sector indices within our universe. In this chart, we show the momentum quintile distribution from 1994 onwards, our entire historical dataset for sector indices. The distribution results are quite interesting. For more speculative sectors such as Materials, we see the quintile distribution highly skewed to the tail ends (i.e. quintile one and five). However, for more stable and less speculative sectors (i.e. Industrials and Consumer Discretionary), we see the quintile distribution more evenly distributed or condensed to the inner quintiles (i.e. quintile two, three, and four).

[9] In our analysis, quantile 1 always represents the lowest factor value. Since our factor is momentum or past returns, quantile 1 in this case represents the worst momentum.

Figure 24: Momentum quintile distribution across sector indices



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Country and sector rotation are beyond the scope of this report[10]. However, the above analysis does provide some impetus (albeit subtly) for further research with respect to investigating whether index momentum can be used for country and sector rotation and timing.[11]

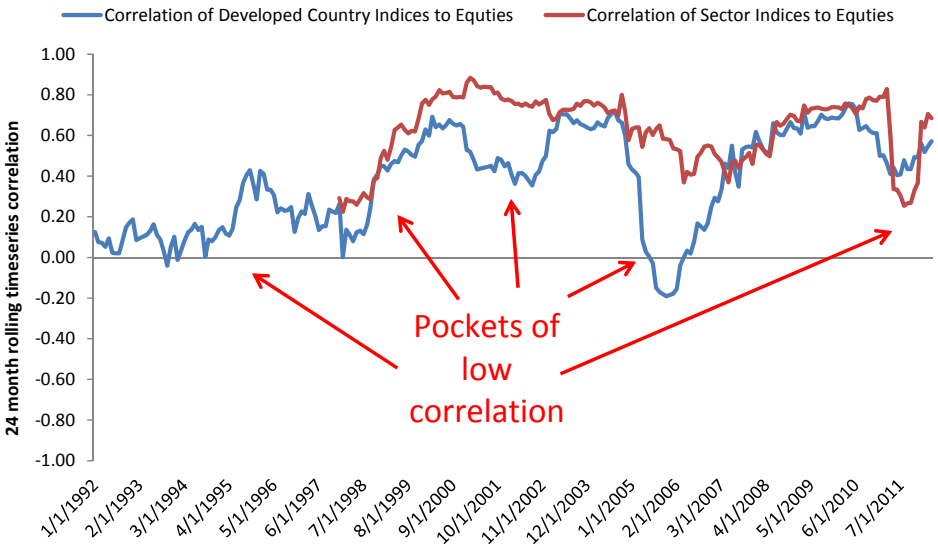
Combining country and sector momentum with equity momentum

Thus far the performance of country and sector index momentum seems to be fairly good. We what really care about are whether these momentum strategies can add diversification benefit to a standalone equity momentum strategy. Our results seem to suggest so. Figure 25 shows the rolling 24 month time series correlation between our standalone equity momentum portfolio and our country and sector index momentum portfolio. We use the 12 month momentum portfolios in this analysis. Figure 25 shows that there are some definitive pockets of low correlation (and even negative correlation) between standalone equity momentum and country and index momentum. This is promising as it suggests that country and sector index momentum portfolios may be a good diversifying ingredient to add to standalone equity momentum portfolios. Next we look another (more exotic) potential index momentum strategy, momentum in hedge fund strategies.

[10] However we do explore three sets of country rotation signals in Luo et al. [2012]

[11] For more information on sector rotation based on predictive information embedded in macroeconomic, news sentiment, and earnings momentum signals see Salvini et al. [2011]

Figure 25: 24 month time series correlation between equities and equity indices for 12-1 month momentum



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum in Hedge Fund Strategies

Introduction

Momentum within hedge fund indices undoubtedly seem like an interesting arena to explore. This is an area that has thus far captured little attention. Are hedge fund strategies persistent? How strong or weak are momentum effects in hedge fund indices? And can hedge fund index momentum portfolios be combined with standalone equity momentum. Read on for answers to these questions.

Setting up the analysis

The first step is to look at the presence or absence of momentum within hedge fund indices. The Hedge Fund Research Inc (HFR) indices are designed to track the overall hedge fund universe. Their construction methodology aggregates the performance of over 2,200 different hedge funds into discrete strategic indices (e.g. Event Driven: Merger Arbitrage Index). HFRI indices (a subset of the overall HFR indices) are monthly rebalanced indices that are typically used by hedge fund managers as a benchmarking index. The historical dataset is fairly expansive and commences from 1990 onwards at a monthly frequency. Note that the HFRI indices are not investable indices; however, we will address this in a moment.

HFRI monthly indices are equally weighted indices. This means that HFR equally weights the underlying fund managers' investment performance when constructing the overall HFRI index. HFR requires that all the underlying hedge funds must have at least $50M under management or have been actively traded for at least 12 months. Also note that all performance is reported net of fees and typically in USD. Figure 26 shows the universe of HFRI indices included in our study. The universe is fairly expansive and includes a broad and comprehensive range of strategies.

Figure 26: HFRI indices

Description	Ticker	Type	Region	Currency
Equity Market Neutral Index	HFRIEMNI	Equity Hedge	Global	USD
Quantitative Directional	HFRIENHI	Equity Hedge	Global	USD
Sector - Energy/Basic Materials Index	HFRISEN	Equity Hedge	Global	USD
Sector - Technology/Healthcare Index	HFRISTI	Equity Hedge	Global	USD
Short Bias Index	HFRISHSE	Equity Hedge	Global	USD
Distressed/Restructuring Index	HFRIDSI	Event-Driven	Global	USD
Merger Arbitrage Index	HFRIMAI	Event-Driven	Global	USD
Private Issue/Regulation D Index	HFRIREGD	Event-Driven	Global	USD
Conservative Index	HFRIFOFC	Fund of Funds	Global	USD
Diversified Index	HFRIFOFD	Fund of Funds	Global	USD
Market Defensive Index	HFRIFOFM	Fund of Funds	Global	USD
Strategic Index	HFRIFOFS	Fund of Funds	Global	USD
Systematic Diversified Index	HFRIMTI	Macro	Global	USD
Fixed Income-Asset Backed	HFRIFIMB	Relative Value	Global	USD
Fixed Income-Convertible Arbitrage Index	HFRICAI	Relative Value	Global	USD
Fixed Income-Corporate Index	HFRIFIHY	Relative Value	Global	USD
Multi-Strategy Index	HFRIFI	Relative Value	Global	USD
Yield Alternatives Index	HFRISRE	Relative Value	Global	USD
Latin America Index	HFRIEMLA	Various	Americas	USD
Asia ex-Japan Index	HFRIEMA	Various	Asia	USD
Russia/Eastern Europe Index	HFRICIS	Various	Europe	USD
Global Index	HFRIEMG	Various	Global	USD

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Alternatively, the HFRX indices (another subset of the overall HFR indices) are designed to mirror the hedge fund universe but with only a handful of underlying funds. HFRX Indices utilize sophisticated quantitative screening and clustering techniques when deciding which underlying funds should be added to the overall indices. HFR states that this "ensures that each index is a pure representation of its corresponding investment focus". This methodology does not necessarily equally weight the underlying funds' performance. In fact, the weight of the underlying fund is determined by a proprietary optimization process.

HFRX indices are rebalanced on a quarterly basis. Historical coverage for these indices commences from 1998. HFR requires that all the underlying hedge funds must have at least $50M under management and have been actively traded for at least 24 months. Also note that all performance is reported net of fees and typically in USD. Figure 27 shows the universe of HFRX indices included in our study. The universe is more comprehensive than its HFRI counterpart, however, the historical coverage is less expansive. Note that the HFRX indices are not investable either.

Figure 27: HFRX indices

Description	Ticker	Type	Region	Currency
MLP Index	HFRXMLP	Concept	Americas	USD
Alternative Energy Index	HFRXALTE	Concept	Global	USD
Diversity Index	HFRXDVRS	Concept	Global	USD
Fixed Income - Credit Index	HFRXFIC	Concept	Global	USD
Energy/Basic Materials Index	HFRXEBM	Equity Hedge	Global	USD
Equity Market Neutral Index	HFRXEMN	Equity Hedge	Global	USD
Fundamental Growth Index	HFRXEHG	Equity Hedge	Global	USD
Fundamental Value Index	HFRXEHV	Equity Hedge	Global	USD
Multi-Strategy Index	HFRXEHMS	Equity Hedge	Global	USD
Quantitative Directional Index	HFRXQD	Equity Hedge	Global	USD
Short Bias Index	HFRXSB	Equity Hedge	Global	USD
Technology/Healthcare Index	HFRXTH	Equity Hedge	Global	USD
Activist Index	HFRXACT	Event-Driven	Global	USD
Credit Arbitrage Index	HFRXCRED	Event-Driven	Global	USD
Distressed Restructuring Index	HFRXDS	Event-Driven	Global	USD
Merger Arbitrage Index	HFRXMA	Event-Driven	Global	USD
Multi-Strategy Index	HFRXEDMS	Event-Driven	Global	USD
rivate Issue/Regulation D Index	HFRXREGD	Event-Driven	Global	USD
Special Situations Index	HFRXSS	Event-Driven	Global	USD
Active Trading Index	HFRXTRAD	Macro	Global	USD
Commodity Index	HFRXCOM	Macro	Global	USD
Commodity-Agriculture Index	HFRXAGRI	Macro	Global	USD
Commodity-Energy Index	HFRXENEG	Macro	Global	USD
Commodity-Metals Index	HFRXMETL	Macro	Global	USD
Currency Index	HFRXCUR	Macro	Global	USD
Discretionary Thematic Index	HFRXDT	Macro	Global	USD
Multi-Strategy Index	HFRXMMS	Macro	Global	USD
Systematic Diversified CTA Index	HFRXSDV	Macro	Global	USD
Latin America Index	HFRXLA	Regional	Americas	USD
North America Index	HFRXNA	Regional	Americas	USD
HFRX Asia Equally Weighted Index	HFRXAEW	Regional	Asia	USD
HFRX Asia ex-Japan Index	HFRXAXJ	Regional	Asia	USD
HFRX Asia with Japan Index	HFRXAWJ	Regional	Asia	USD

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 27: HFRX indices (Continued)

Description	Ticker	Type	Region	Currency
Japan Index	HFRXAJP	Regional	Asia	USD
Brazil Index	HFRXBRZL	Regional	Emerging Markets	USD
BRIC Index	HFRXBRIC	Regional	Emerging Markets	USD
China Index	HFRXCHN	Regional	Emerging Markets	USD
India Index	HFRXIND	Regional	Emerging Markets	USD
Korea Index	HFRXKOR	Regional	Emerging Markets	USD
MENA Index	HFRXMENA	Regional	Emerging Markets	USD
Multi-Emerging Markets Index	HFRXMEM	Regional	Emerging Markets	USD
Russia Index	HFRXRUS	Regional	Emerging Markets	USD
Northern Europe Index	HFRXNE	Regional	Europe	USD
Russia/Eastern Europe Index	HFRXEE	Regional	Europe	USD
Western/Pan Europe Index	HFRXWE	Regional	Europe	USD
Multi-Region Index	HFRXMREG	Regional	Other	USD
Relative Value Arbitrage Index	HFRXRVA	Relative Value	Global	USD
Energy Infrastructure Index	HFRXEINF	Relative Value	Global	USD
Fixed Income-Asset Backed	HFRXFAB	Relative Value	Global	USD
Fixed Income-Convertible Arbitrage Index	HFRXCA	Relative Value	Global	USD
Fixed Income-Corporate Index	HFRXFCO	Relative Value	Global	USD
Fixed Income-Sovereign Index	HFRXFSV	Relative Value	Global	USD
Multi-Strategy Index	HFRXRVMS	Relative Value	Global	USD
Real Estate Index	HFRXREAL	Relative Value	Global	USD
Volatility Index	HFRXVOL	Relative Value	Global	USD
Yield Alternative Index	HFRXYA	Relative Value	Global	USD

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Lastly, a subset of the HFRX indices are in fact investable (Figure 28). These indices are currently open to investment and have capital allocated to them.

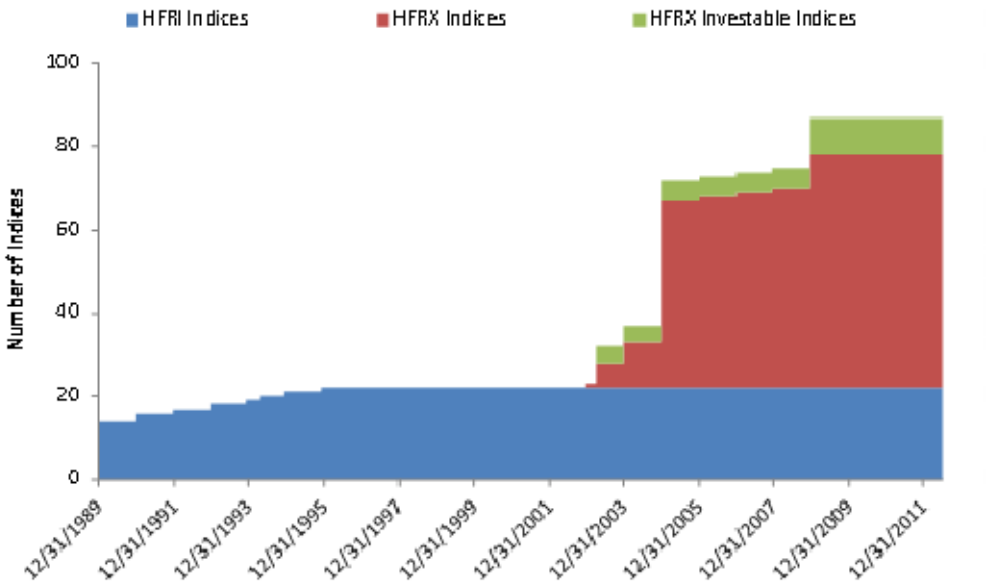
Figure 28:HFRX investable indices

Description	Ticker	Type	Region	Currency
Equity Market Neutral Index	HFRXEMN	Equity Hedge	Global	USD
Fundamental Growth Index	HFRXEHG	Equity Hedge	Global	USD
Fundamental Value Index	HFRXEHV	Equity Hedge	Global	USD
Distressed Restructuring Index	HFRXDS	Event-Driven	Global	USD
Merger Arbitrage Index	HFRXMA	Event-Driven	Global	USD
Discretionary Thematic Index	HFRXDT	Macro	Global	USD
Systematic Diversified CTA Index	HFRXSDV	Macro	Global	USD
FI-Convertible Arbitrage Index	HFRXCA	Relative Value	Global	USD
Multi-Strategy Index	HFRXRVMS	Relative Value	Global	USD

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 29 shows the historical coverage of the HFRI, HFRX, and HFRX investable indices within our study. HFRI indices have more history but lack the breadth of its HFRX counterpart. Nevertheless, the historical coverage and breadth is suffice for our momentum study.

Figure 29:Coverage of hedge fund indices



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

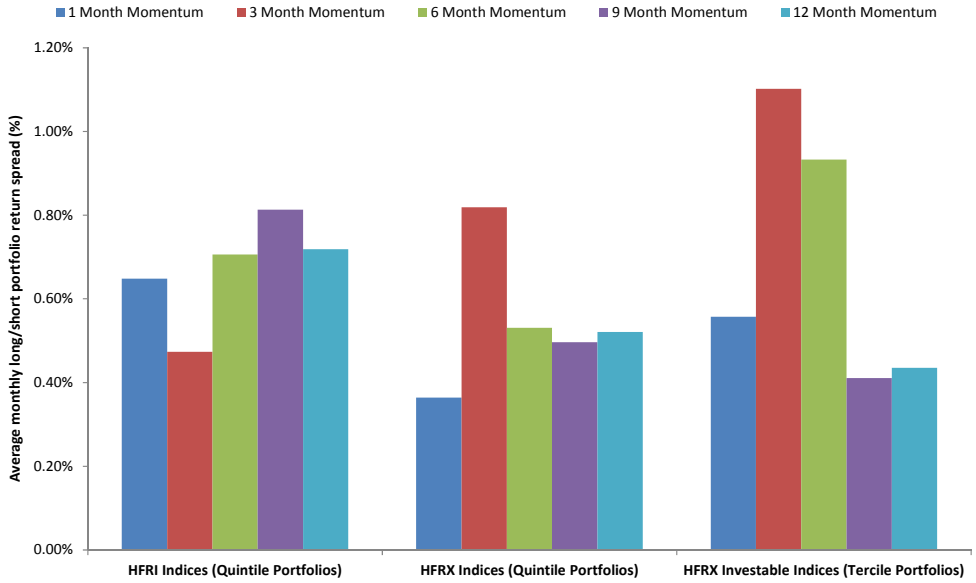
Similar to the analysis we did for equities, for hedge fund indices we analyze various formation windows including: twelve, nine, six, three, and one month periods. Our momentum scores are constructed by taking the returns of the index levels over the various formation periods. We form the portfolios at the end of each month and rebalance the portfolio monthly. Our long/short portfolios are constructed by taking the top and bottom quintile hedge fund indices based on the momentum factor.

When constructing our momentum factors for hedge fund indices, we did not skip the most recent month during the formation period. This is because we do not find that the one-month contrarian/reversal effect exists for hedge indices. In fact, we observe quite the opposite effect for momentum within hedge fund indices.

Hedge fund indices show a strong presence of momentum

Figure 30 shows the average long/short portfolio performance of the various momentum factors across the HFR indices. From a long/short quintile performance perspective, the results are very promising. Some momentum portfolios have an average long/short monthly portfolio return of close to or greater than 1%. Surprisingly, we find that the investable indices (HFRX investable indices) perform fairly strongly. Interestingly, unlike the country equity indices described in the previous section, for hedge fund indices, shorter-term strategies generally perform better than longer-term momentum strategies.

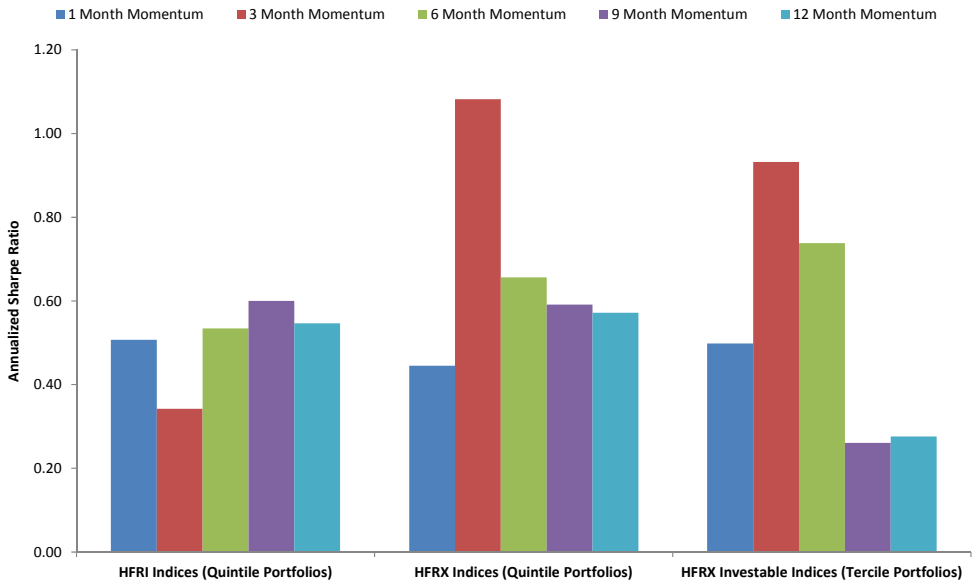
Figure 30:Long/short performance of hedge fund indices momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

From a risk adjusted perspective, we find the performance equally strong. Figure 31 shows the Sharpe ratio for the various momentum portfolios. We find that some momentum based portfolios have a Sharpe ratio of close to or greater than one. Again, even after taking into account the volatility or risk of each momentum portfolio, we still find that for hedge fund indices, shorter-term strategies generally perform better than longer-term momentum strategies.

Figure 31:Sharpe ratio of hedge fund indices momentum portfolios

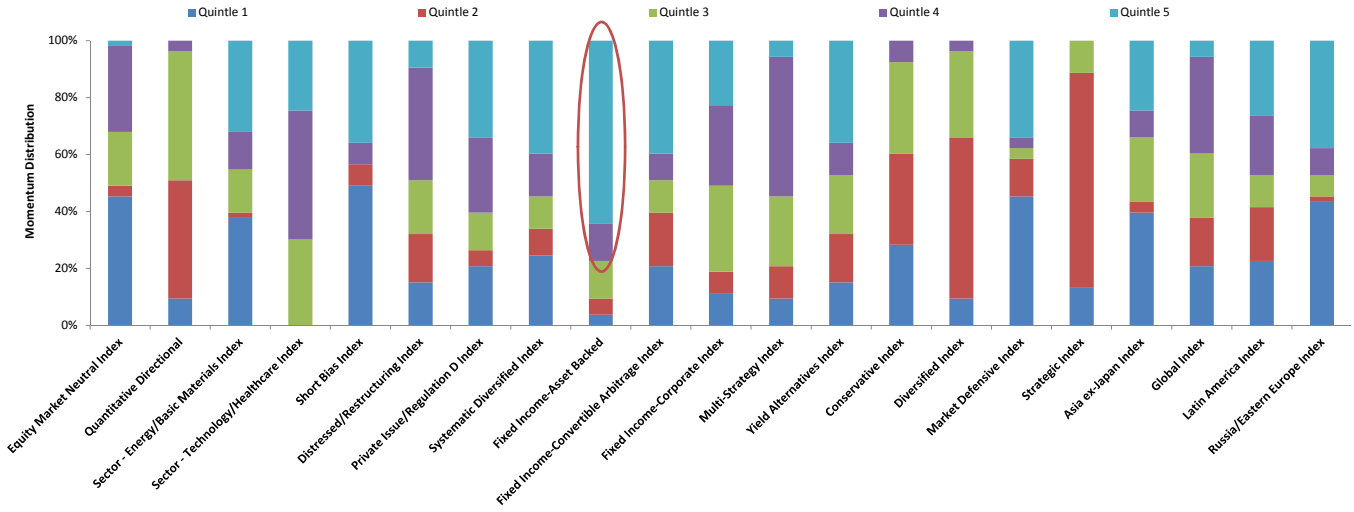


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Which hedge fund strategies are gaining momentum?

As an aside, here we show which hedge fund strategies are exhibiting momentum. Figure 32 shows the distribution of each 12 month momentum quintile portfolio for all of the HFRI indices. Essentially, this chart shows which hedge fund strategies show the most and least amount of 12 month momentum. In this chart, we show the momentum quintile distribution from 2008 onwards. This time frame was dominated by the financial crisis. We can clearly see from the figure that fixed income asset backed strategies garnished the most amount of momentum as the market recovered from the financial crisis. This is apparent because during this time, fixed income asset backed strategies were situated mostly in quintile five, the most positive momentum bucket. This is just an interesting aside for our readers that momentum strategies can reveal the current economic market conditions.

Figure 32: 12 month momentum quintile distribution across HFRI indices from 2008 onwards

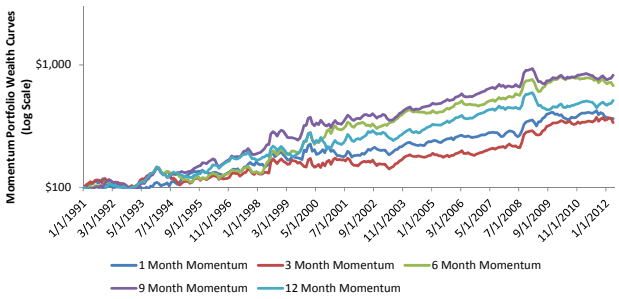


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Moulding hedge fund and equity momentum

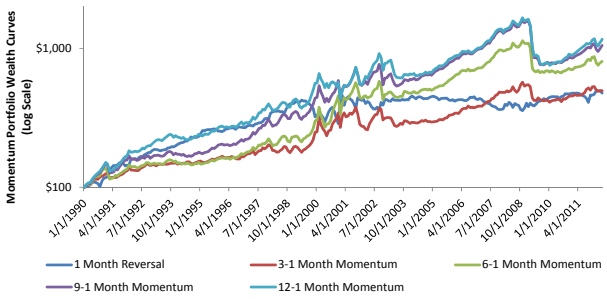
Figure 33 shows the wealth curves of our various HFRI momentum portfolios. Interestingly, the 9 month momentum strategy has the highest cumulative return. Both the equity and hedge fund momentum portfolios seem to have similar trends. We can see the presence of a kink in the equities momentum portfolio returns during the financial crisis period and to some extent during the dot-com bubble. However, for hedge fund indices, this kink is not as pronounced as it was for equity momentum portfolios (Figure 34). On the surface, this is a good finding. Not only is the performance of momentum within hedge fund indices strong, but also, hedge fund momentum has smaller drawdowns and recovered quicker. The volatility of the hedge fund momentum portfolios also appears to be less than the equity momentum portfolios.

Figure 33: Wealth curve HFRI momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

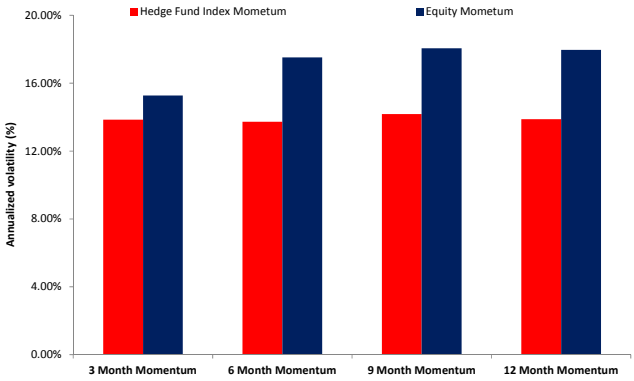
Figure 34: Wealth curve equity momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

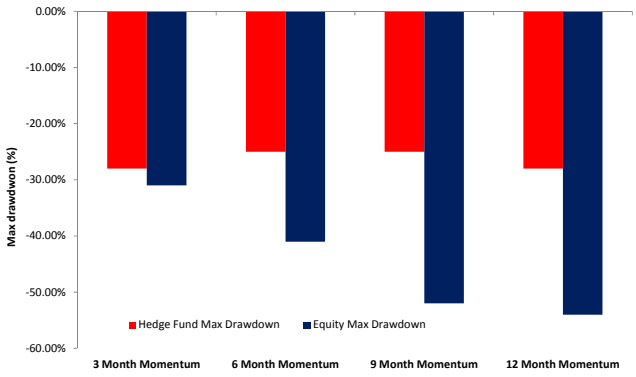
We can better see this if we compare the annualized volatility of the equity and hedge fund momentum portfolios. Figure 35 compares the annualized volatility of the HFRI momentum portfolios with the equity momentum portfolios. For every momentum period portfolio, the hedge fund portfolios showed lower annualized volatility. Further, the hedge fund momentum portfolios also showed smaller drawdown's (Figure 36). The above analysis indicates strong support for diversifying traditional equity momentum with hedge fund momentum portfolios.

Figure 35: Annualized volatility of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 36: Max drawdown of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum in Currencies

Introduction

As discussed in Menkhoff, Sarno, Schmeling and Schrimpf [2011], compared to equity markets, foreign exchange markets tend to offer greater liquidity, lower transaction costs, and fewer regulatory restrictions. Moreover, foreign exchange markets are generally not hindered by short squeezes that could potentially be rampant among certain equity securities especially during highly volatile market episodes. Furthermore, investors can naturally short currencies in foreign exchange markets by simply selecting the counterpart currency. As such, investors are not hampered by the procedural regulations and limitations inherent when shorting equities. Clearly, foreign exchange markets may be a viable arena for quants to explore.

Surprisingly, there is not much academic research examining cross-section momentum effects in currencies. Research and studies within the foreign exchange markets have predominantly been focussed on momentum effects within a time series of certain currencies. Most research studies have fused technical trading and momentum strategies within the context of a currency time series. However, Menkhoff, Sarno, Schmeling and Schrimpf [2011] found large and significant excess returns to currency momentum strategies of up to 10% per annum. They find many instances of significant momentum returns for strategies with longer holding periods. Even when taking risk into account on the basis of Sharpe Ratios, momentum strategies with currencies seem highly attractive.

Menkhoff et al. show that FX momentum returns are not driven by policy measures including monetary regimes, currency intervention or the implementation of capital account controls. Menkhoff et al. contend that systematic risk factors cannot explain currency momentum returns. Adhering to their viewpoint, Burnside, Eichenbaum, Kleshchelski, and Rebelo [2006] show that the payoff from implementable currency speculation strategies are uncorrelated with standard risk factors.

Understandably, for all the aforementioned reasons, exploring momentum effects within the currency marketplace is a worthwhile endeavour. In the following sections, we will walk our readers through the analysis of our currency based momentum portfolios. First we test the presence of momentum within currency markets and then we determine whether it's worthwhile to comingle currency and equity momentum.

Setting up the analysis

As in Menkhoff et al. we focus on forming currency portfolios cross-sectionally rather than in a time-series fashion. We form our currency portfolios based on currencies that have exhibited strong/weak returns over the formation period. Essentially, we take long positions in currencies that have posted strong historical returns within the formation period. Conversely, we take short positions in currencies that have posted weak historical returns within the formation period. Similar to the analysis we did for equities, for currencies we analyze various formation windows including: twelve, nine, six, three, and one month periods.

We followed a similar methodology as outlined in Menkhoff et al. Our universe of study includes approximately 48 different currencies including developed and emerging markets (Figure 37). Our analysis period commences from the end of January 1976 onwards. We obtain spot exchange rates for our sample currencies from Bloomberg. We take the perspective of US investors and therefore all currency spot rates are against USD. This means that we only take one side of a currency pair. Our momentum scores are constructed by taking the difference in the log of spot exchange rates over the various formation periods.

We form the currency portfolios at the end of each month and rebalance the portfolio monthly. Lastly, it's worthwhile to point out that our sample of currencies varies overtime in terms of breath and coverage. Certain currencies enter and exit our universe due to a multitude of reasons (for example the creation of the Euro). Figure 37 below is a chart summarizing our currency universe.

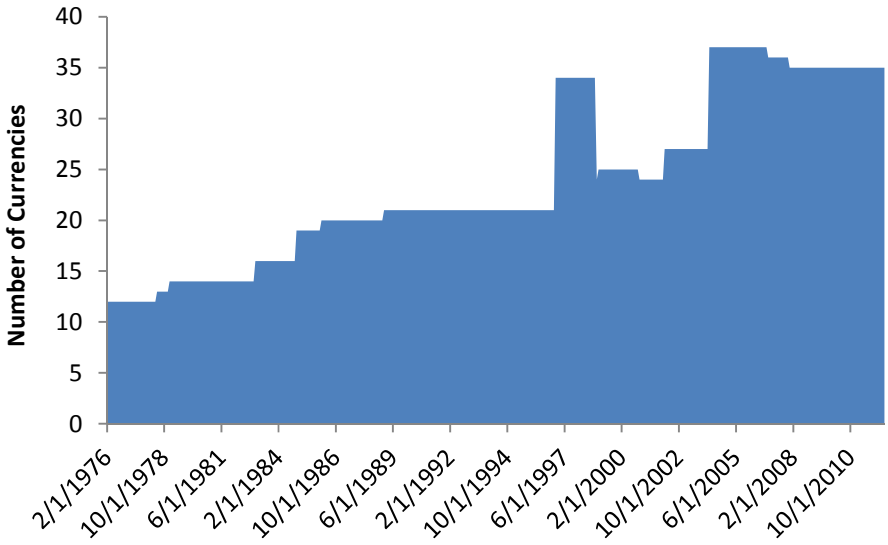
Figure 37: Currency universe

Country	Start Date	End Date	Currency Code	Currency Name	Average Monthly Spot Rate per $USD	Average Monthly Spot Rate Volatility
Australia	Dec-1984	Apr-2012	AUD	Australian Dollar	1.38	0.23
Austria	Jan-1976	Dec-1998	ATS	Austrian Schilling	14.01	3.07
Belgium	Jan-1976	Dec-1998	BEF	Belgium Francs	37.96	8.47
Brazil	Mar-2004	Apr-2012	BRL	Brazilian Real	2.06	0.40
Bulgaria	Mar-2004	Apr-2012	BGL	Lev	1.47	0.11
Canada	Jan-1976	Apr-2012	CAD	Canadian Dollar	1.25	0.16
Croatia	Mar-2004	Apr-2012	HRK	Croatian Kuna	5.52	0.42
Cyprus	Mar-2004	Dec-2007	CYP	Cyprus Pound	0.45	0.02
Czech Republic	Jan-1997	Apr-2012	CZK	Czech Koruna	26.58	7.43
Denmark	Jan-1976	Apr-2012	DKK	Danish Krone	6.70	1.38
Egypt	Mar-2004	Apr-2012	EGP	Egyptian Pound	5.75	0.23
Euro	Jan-1999	Apr-2012	EUR	Euro	0.85	0.15
Finland	Jan-1997	Dec-1998	FIM	Markka	5.28	0.20
France	Jan-1976	Dec-1998	FRF	French Franc	5.85	1.26
Germany	Jan-1976	Dec-1998	DEM	Deutsche Mark	1.98	0.44
Greece	Jan-1997	Dec-2000	GRD	Drachma	311.50	36.89
Hong Kong	Jan-1983	Apr-2012	HKD	Hong Kong Dollar	7.76	0.13
Hungary	Jan-1997	Apr-2012	HUF	Forint	218.14	35.38
Iceland	Mar-2004	Apr-2012	ISK	Iceland Krona	91.53	27.43
India	Jan-1997	Apr-2012	INR	Indian Rupee	44.73	3.53
Indonesia	Jan-1997	Apr-2012	IDR	Rupiah	8,852.80	1,894.95
Ireland	Jan-1979	Dec-1998	IEP	Irish Pound (Punt)	0.68	0.12
Israel	Mar-2004	Apr-2012	ILS	New Israeli Sheqel	4.02	0.40
Italy	Feb-1986	Dec-1998	ITL	Lira	1,453.71	194.79
Japan	Jun-1978	Apr-2012	JPY	Yen	142.12	51.24
Kuwait	Jan-1997	Apr-2012	KWD	Kuwaiti Dinar	0.29	0.01
Malaysia	Jan-1997	Apr-2012	MYR	Malaysian Ringgit	3.56	0.35
Mexico	Jan-1997	Apr-2012	MXN	Mexican Peso	10.72	1.56
Netherlands	Jan-1976	Dec-1998	NLG	Netherlands Guilder	2.20	0.48
New Zealand	Dec-1984	Apr-2012	NZD	New Zealand Dollar	1.69	0.30
Norway	Jan-1976	Apr-2012	NOK	Norwegian Krone	6.65	1.07
Philippines	Jan-1997	Apr-2012	PHP	Philippine Peso	46.62	6.97
Poland	Feb-2002	Apr-2012	PLN	Zloty	3.21	0.52
Portugal	Jan-1989	Dec-1998	PTE	Portugese Escudo	156.75	15.56
Russia	Mar-2004	Apr-2012	RUB	Russian Ruble	28.34	2.54
South Africa	Jan-1983	Apr-2012	ZAR	Rand	5.02	2.56
South Korea	Feb-2002	Apr-2012	KRW	Won	1,110.88	126.03
Saudi Arabia	Jan-1997	Apr-2012	SAR	Saudi Riyal	3.75	0.00
Singapore	Dec-1984	Apr-2012	SGD	Singapore Dollar	1.68	0.25
Slovakia	Feb-2002	Apr-2012	SKK	Slovak Koruna	28.22	7.34
Slovenia	Mar-2004	Dec-2006	SIT	Tolar	191.70	7.23
Spain	Jan-1976	Dec-1998	ESP	Spanish Peseta	115.32	30.08
Sweden	Jan-1976	Apr-2012	SEK	Swedish Krona	6.91	1.51
Switzerland	Jan-1976	Apr-2012	CHF	Swiss Franc	1.56	0.42
Taiwan	Jan-1997	Apr-2012	TWD	New Taiwan Dollar	32.25	1.82
Thailand	Jan-1997	Apr-2012	THB	Baht	37.36	5.02
United Kingdom	Jan-1976	Apr-2012	GBP	Pound Sterling	0.60	0.08
Ukraine	Mar-2004	Apr-2012	UAH	Hryvnia	6.33	1.46

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

The historical coverage and breadth of our currency universe is reasonable. Our currency data dates back to 1976. The breadth of our currency universe grows from approximately 10 to just under 40 global currencies (Figure 38).

Figure 38:Coverage of currencies



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Understandably, certain currencies are too volatile and illiquid (to some extent) for many investors. As such, we have also conducted our momentum study on a subset of our overall currency universe. This subset (listed in Figure 39) represents the major world currencies (i.e. G10 currencies).

Figure 39: G10 currency universe

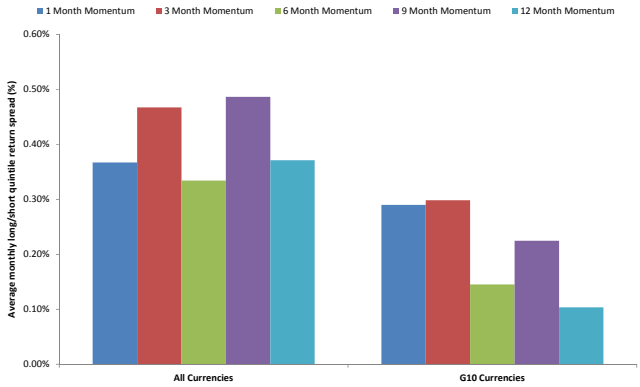
Country	Start Date	End Date	Currency Code	Currency Name	Average Monthly Spot Rate per $USD	Average Monthly Spot Rate Volatility
Australia	Jan-1976	Apr-2012	AUD	Australian Dollar	1.27	0.28
Canada	Jan-1976	Apr-2012	CAD	Canadian Dollar	1.25	0.16
Euro	Jan-1999	Apr-2012	EUR	Euro	0.85	0.15
Hong Kong	Jan-1976	Apr-2012	HKD	Hong Kong Dollar	7.25	1.06
Japan	Jan-1976	Apr-2012	JPY	Yen	150.54	59.65
New Zealand	Jan-1976	Apr-2012	NZD	New Zealand Dollar	1.57	0.36
Norway	Jan-1976	Apr-2012	NOK	Norwegian Krone	6.66	1.06
Sweden	Jan-1976	Apr-2012	SEK	Swedish Krona	6.92	1.50
Switzerland	Jan-1976	Apr-2012	CHF	Swiss Franc	1.56	0.42
United Kingdom	Jan-1976	Apr-2012	GBP	Pound Sterling	0.60	0.08

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Currencies exhibit modest levels of momentum

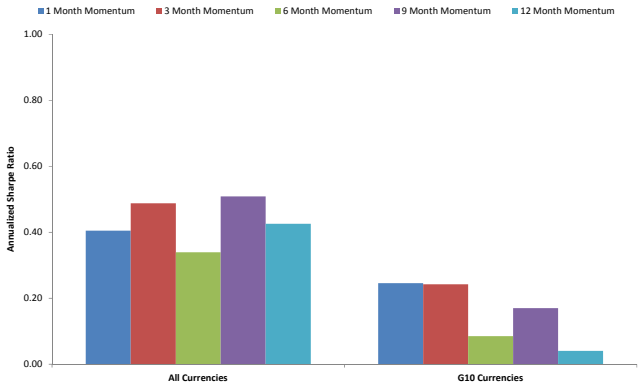
Overall the performance of momentum strategies within currencies is somewhat modest. Figure 40 and Figure 41 show the average long/short quintile performance and annualized Sharpe ratio of our momentum based currency portfolios respectively. The results indicate that most shorter-term strategies outperform longer-term momentum strategies within currencies. And, as expected, momentum portfolios within the more covered and traded G10 currency universe underperform a more expansive currency universe. More volatile, less traded, and illiquid currencies may be frowned upon by investment managers. This may explain why the momentum anomaly performs better in a more expansive currency universe that includes such currencies.

Figure 40: Long/short average monthly quintile return



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 41: Annualized Sharpe ratio

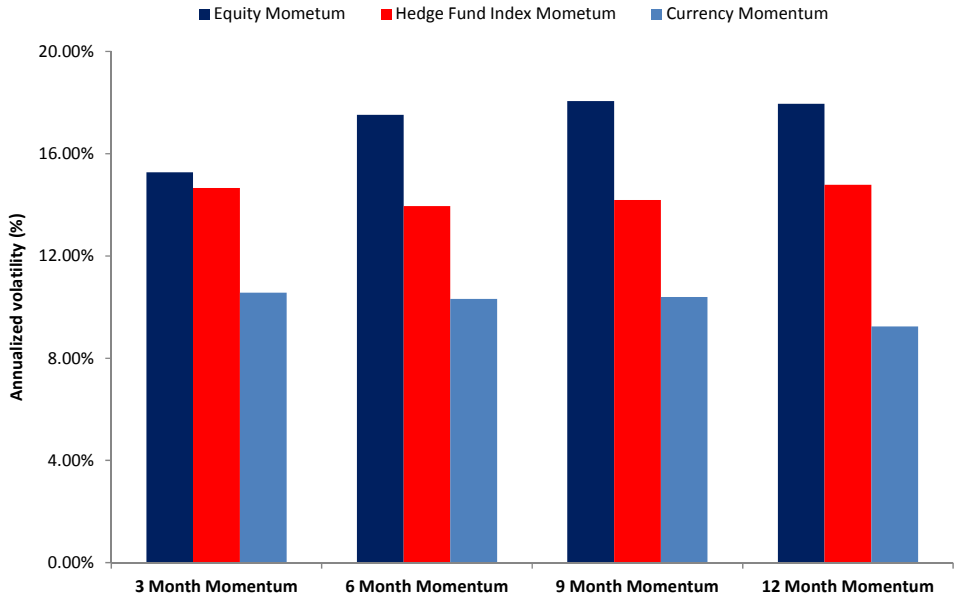


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

What we like about currency momentum

Although our findings for the persistence of currency momentum are not spectacular when compared to other asset classes (i.e. such as hedge fund indices), currencies do have some interesting traits. Figure 42 shows the annualized volatilities of various momentum portfolios for various different asset classes. For every momentum period portfolio, the currency portfolios showed lower annualized volatility. In fact, equity momentum shows the highest annualized volatility.

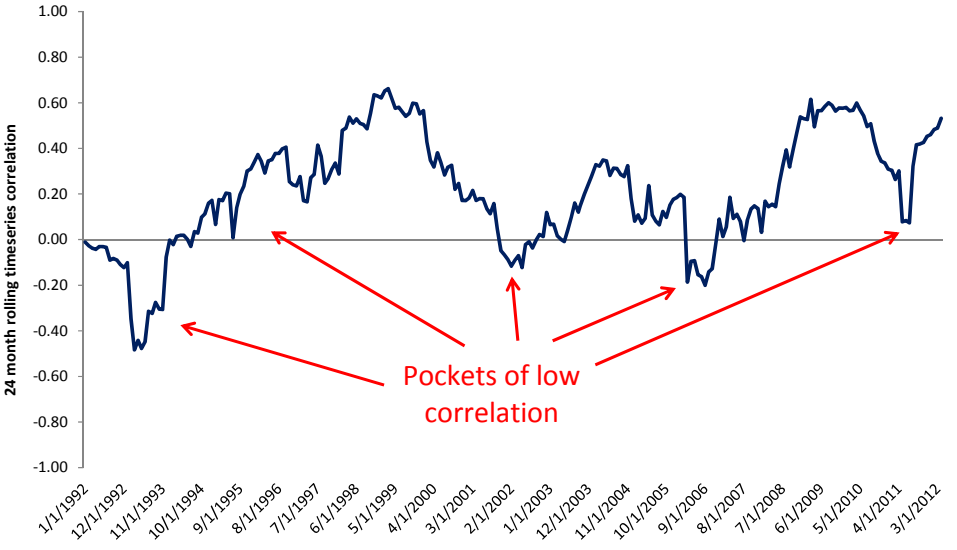
Figure 42: Annualized volatility of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Additionally, we find that currency momentum is weakly correlated with standalone equity momentum. Figure 43 shows the rolling 24 month time series correlation between our standalone equity momentum portfolio and our currency momentum portfolio. We use the 12 month momentum portfolios in this analysis. Figure 43 shows that there are some definitive pockets of low correlation (and even negative correlation) between standalone equity momentum and currency momentum. This is attractive as it suggests that currency momentum portfolios may be a good diversifier to standalone equity momentum portfolios. Next we look at commodities in search of momentum effects.

Figure 43: 24 month time series correlation between equities and currencies



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum in Commodities

Introduction

There are a multitude of reasons to explore momentum effects with commodities futures. Commodity futures contracts are highly liquid with low transaction costs. Miffre and Rallis [2006] contend that commodity futures contracts are not subject to the short-selling restrictions that are often imposed in equity markets. They further point out that commodities markets are sharply siloed to approximately thirty commodity futures instruments only (as opposed to hundreds or thousands of stocks). It is therefore unlikely that the abnormal returns we identify will be eroded by the costs of implementing the momentum strategy or will be a compensation for a lack of liquidity as discussed in Lesmond et al. [2004].

Bolstering their views, there has been ample academic evidence showing strong momentum persistence within commodity futures markets. Miffre and Rallis [2006] showed that tactically allocating wealth towards the best performing commodities and away from the worst performing generates an average return of 9.4% a year. Gorton, Hayashi, and Rouwenhorst [2008] showed that high momentum commodities have outperformed a portfolio of low momentum commodity futures by 13.4% per annum (t = 4.9), earning positive excess returns in 58% of the months.

Academic and practitioners alike have cited several reasons for the existence and persistence of the momentum within the commodities market. Gorton, Hayashi, and Rouwenhorts [2008] argue that momentum anomaly persists in the commodities market due to:

- **Inventory levels**: Positive demand shocks (and negative supply shocks) lead to a drop in inventories, and result in an increase in spot prices, signalling the scarcity of the commodities in the spot market. Futures prices will also increase, but not by as much as spot prices. First, futures prices reflect expectations about future spot prices, and embed expectations that inventories will be restored over time and spot prices will return to "normal" levels.
- **Risk premium:** When inventories are low, the risk of stock-out increases, which raises the conditional variance (volatility) of the future spot price. Because commodity futures are used to insure future price risk, there is an increase in the futures risk premium.
- **Momentum in futures excess returns**: Inventories can only be restored through new production, a process which can take a considerable amount of time depending on the commodity. Therefore deviations of inventories from normal levels are expected to be persistent, as are the probability of stock-outs and associated changes in the conditional volatility of spot prices. Because past unexpected increases in spot and futures prices are signals of past shocks to inventories, they are expected to be correlated with expected futures risk premiums. This will induce a form of "momentum" in futures excess returns: the initial unexpected spot price spike due to a negative shock to inventories will be followed by a temporary period of high expected futures returns for that commodity.

Understandably, for all the aforementioned reasons, exploring momentum effects within the commodity futures marketplace is worthwhile. In the following sections, we will walk our readers through the construction of our commodity based momentum portfolios.

Setting up the analysis

Our universe of study includes approximately 24 different commodities future indices (Figure 44). Our data is obtained from Bloomberg but sourced from the DB Liquidity Commodities indices Optimum Yield family. Our analysis period commences from the end of January 1990 onwards. We take the perspective of US investors and therefore all commodity indices are based in USD.

As an aside, we briefly elaborate on how the DB Liquidity Commodities indices Optimum Yield family are constructed. Conventional commodity based indices roll over futures contracts within the constraints of a predefined schedule (i.e. typically monthly) and a predefined contract (i.e. the one month forward contract). However, DB Liquid Commodities Indices Optimum Yield (DBLCI-OY) offers a different approach to rolling over futures contracts. (DBLCI-OY) utilize a rules-based approach when it rolls from one futures contract to another for each commodity in the index. This rule stipulate that each new commodity futures contract will be the one with the maximum "implied roll yield" based on the closing price for each eligible contract. Effectively, this enhanced rollover process is systematically optimizing the return generated by rolling a short-term contract into a longer-term contract and vice-versa.

Figure 44: DB commodity future indices (Optimum yield family)

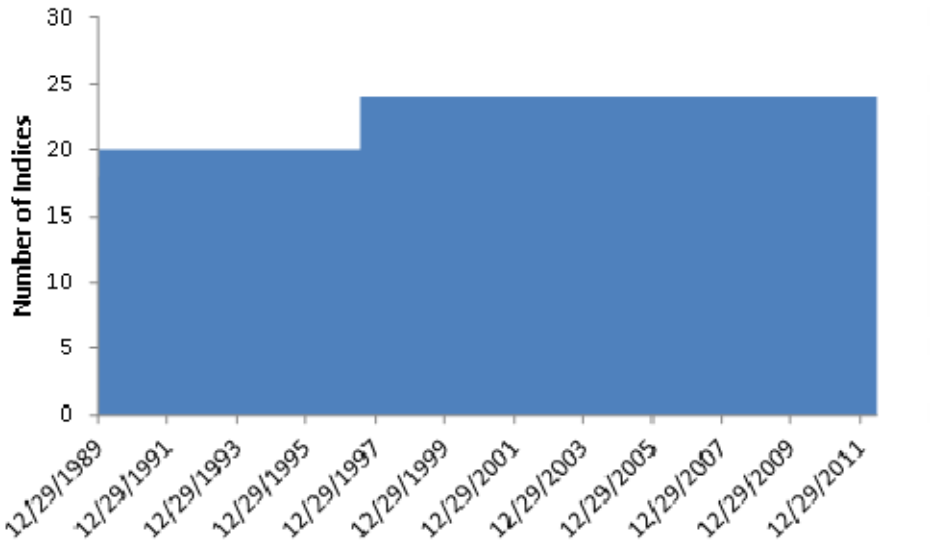
Commodity Group	Name	Bloomberg Ticker
Energy	Light Crude	DBLCOCLT
Energy	Heating Oil	DBLCOHOT
Energy	Rbob Gas	DBLCYTRB
Energy	Natural Gas	DBLCYTCO
Energy	Brent Crude Oil	DBLCYTCO
Energy	Gasoline	DBLCYTGO
Precious Metal	Gold	DBLCOGCT
Precious Metal	Silver	DBLCYTSI
Industrial Metal	Aluminum	DBLCOALT
Industrial Metal	Zinc	DBLCYTZN
Industrial Metal	Copper	DBLCYTCU
Industrial Metal	Nickel	DBLCYTNI
Industrial Metal	Lead	DBLCYTPB
Agriculture	Corn	DBLCOCNT
Agriculture	Wheat	DBLCOWTT
Agriculture	Soybeans	DBLCYTSS
Agriculture	Sugar	DBLCYTSB
Agriculture	Coffee	DBLCYTKC
Agriculture	Cotton	DBLCYTCT
Agriculture	Cocoa	DBLCYTCC
Agriculture	Kansas Wheat	DBLCYTKW
Livestock	Live Cattle	DBLCYTLC
Livestock	Lean Hogs	DBLCYTLH
Livestock	Feeder Cattle	DBLCYTFC

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

We form our commodity portfolios based on commodities that have exhibited strong/weak returns over the formation period. Essentially, we take long positions in commodities that have posted strong historical returns within the formation period. Conversely, we take short positions in commodities that have posted weak historical returns within the formation period. Similar to the analysis we did for equities and currencies, for commodities we analyze various formation windows including: twelve, nine, six, three, and one month periods. Our momentum scores are constructed by taking the returns of the index levels over the various formation periods. We form the commodity portfolios at the end of each month and rebalance the portfolio monthly. Our long/short portfolios are constructed by taking the top and bottom quintile commodities based on the momentum factor.

Note that when constructing our momentum scores for equities, we skipped the most recent month during the formation period due to short-term reversal effects. However, we have found that no such short-term reversal effects exist for commodities. Therefore, we do not skip the most recent month when constructing our momentum scores for our commodities portfolio. In fact, performance results improve when including the most recent period. To get started, Figure 45 below shows the time series coverage of our commodities universe. Our commodities universe is reasonable and includes approximately 25 different commodity indices.

Figure 45:Coverage of commodity indices

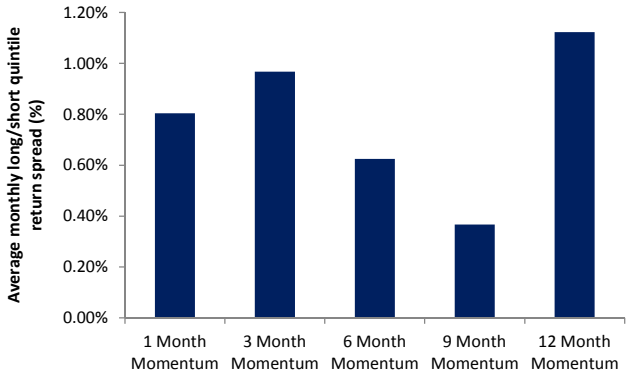


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Commodity results are strong

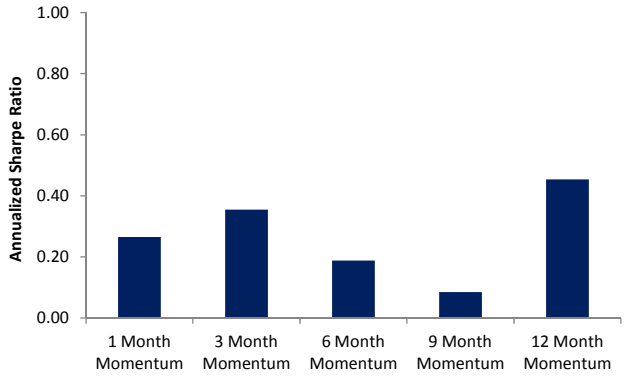
Figure 46 shows the average long/short quintile performance of the various momentum factors across our commodities universe. From a long/short quintile performance perspective, the results are strong. The twelve month momentum portfolio has an average long/short monthly portfolio return of 1.1%. Similarly, from a risk adjusted perspective (Figure 47), the 12 month momentum commodity portfolio performs the best.

Figure 46: Long/short average monthly quintile return



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

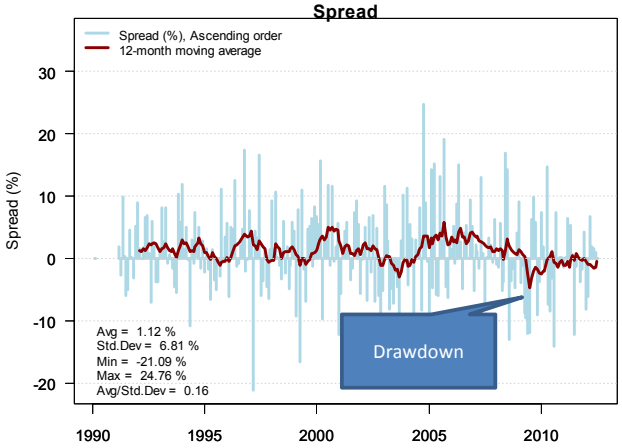
Figure 47: Annualized Sharpe ratio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

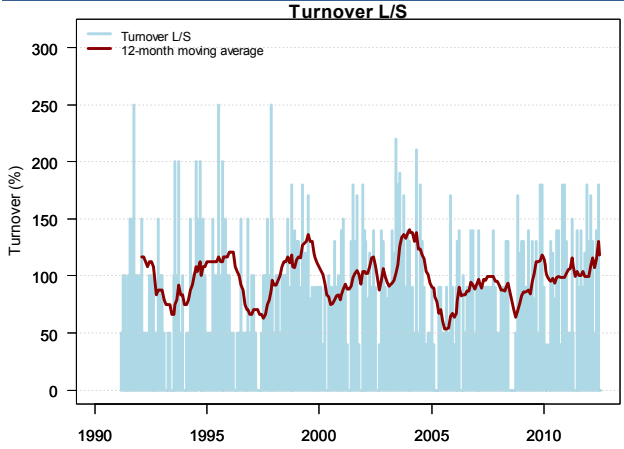
Figure 48 shows the long/short quintile portfolio performance for 12 month momentum from a time-series perspective. Historically, the 12 month momentum portfolio has performed reasonably well. However, we must point out the drawdown in the momentum strategy during the financial crisis. This is of course yet another example of the downside of momentum. As investors risk appetite suddenly changes, assets that have performed well suddenly perform poorly. This drawdown within commodities momentum is less pronounced than equity momentum. Figure 49 shows the time-series two way turnover of our 12 month momentum portfolio within our commodities universe. The turnover is relatively stable and comparable with our equity momentum portfolios.

Figure 48: Long/short average monthly quintile return for 12 month momentum of commodity indices



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 49: 2 way turnover of 12 month momentum of commodity indices

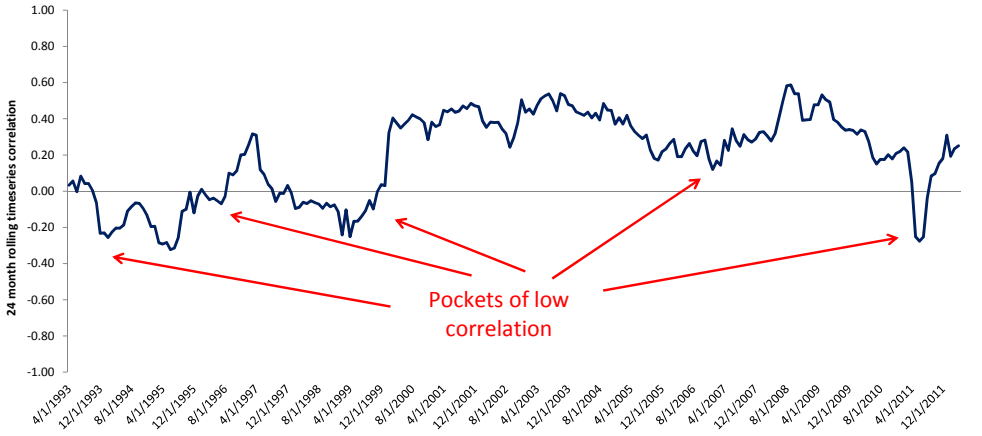


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Commodities and equity momentum are loosely correlated

To end off this section, we want to briefly illustrate the correlation between commodity and equity momentum portfolios. In summary, we find that commodity momentum is has a low correlation with standalone equity momentum. Figure 50 shows the rolling 24 month time series correlation between our standalone equity momentum portfolio and our commodity momentum portfolio. We use the 12 month momentum portfolios in this analysis. The figure shows that there are some definitive pockets of low correlation (and even negative correlation) between standalone equity momentum and commodity momentum. The overall correlation is approximately 20%. Next we look at our final asset class portfolio, treasury momentum.

Figure 50: 24 month time series correlation between equities and commodities



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum in Rates

Introduction

The historical persistence of the momentum anomaly within equity markets often challenges the efficient market hypothesis. A natural question to ask is if there is any spillage in the momentum anomaly into the fixed income world. Academic evidence exploring the momentum anomaly within fixed income markets has been mixed.

Josotva, Nikolova, Philipov and Stahel [2010] showed that a bond momentum strategy is profitable (using three to twelve month formation periods) from over the 1991-2008 period. However, they find that the bond momentum is unprofitable from 1973 to 1990. More notably, they find that bond momentum profitability is highly concentrated within non-investment grade bonds, an asset class that may be overlooked by traditional investors. Momentum profits become insignificant at the 10% confidence level when bonds rated B- or worse are removed as shown in Josotva et al.

Gebhardt, Hvidkjaer, and Swaminathan [2002] found no evidence of long term momentum among investment grade bonds. In fact, they find significant reversal effects. Winners over the past three to 12 months underperform bonds that were losers over the same period by about 1% over the subsequent twelve months.

Setting up the analysis

Our universe of study includes approximately 25 different government/country bond indices. (Figure 51). Our data is obtained from Bloomberg/EFFA government bond indices. These are total return indices with maturities ranging from 7 to 10 years. We take the perspective of a US investor and thus all total return indices are denominated in USD. Our analysis period commences from the end of January 1992 onwards.

Figure 51: Treasury universe

Currency	Country	Bloomberg Ticker
CAD	Canada	CAG4TR Index
USD	USA	USG4TR Index
EUR	Austria	ATG4TR Index
EUR	Belgium	BEG4TR Index
DKK	Denmark	DEG4TR Index
EUR	Finland	FIG4TR Index
EUR	France	FRG4TR Index
EUR	Germany	DEG4TR Index
EUR	Greece	GRG4TR Index
EUR	Ireland	IEG4TR Index
EUR	Italy	ITG4TR Index
EUR	Netherlands	NEG4TR Index
NOK	Norway	NOG4TR Index
EUR	Portugal	PTG4TR Index
EUR	Spain	SPG4TR Index
SEK	Sweden	SWG4TR Index
CHF	Switzerland	SZG4TR Index
GBP	United Kingdom	UKG4TR Index
AUD	Australia	AUG4TR Index
JPY	Japan	JNG4TR Index
NZD	New Zealand	NZG4TR Index
CZK	Czech Republic	CHG4TR Index
HUF	Hungary	HNG4TR Index
PLN	Poland	PDG4TR Index
ZAR	South Africa	SYG4TR Index

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

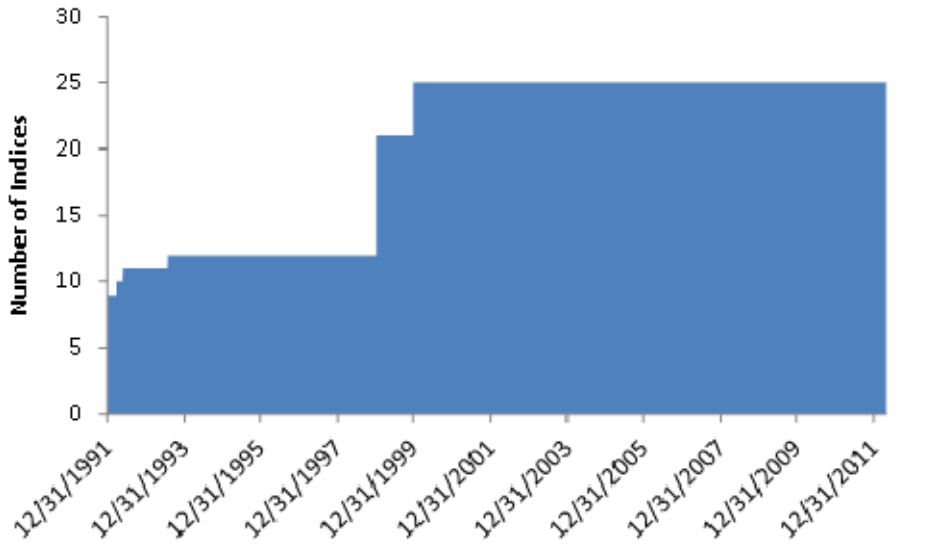
We form our portfolios based on treasuries that have exhibited strong/weak returns over the formation period. Essentially, we take long positions in treasuries that have posted strong historical returns within the formation period. Conversely, we take short positions in treasuries that have posted weak historical returns within the formation period. Similar to our previous analysis, we analyze various formation windows including: twelve, nine, six, three, and one month periods.

Our momentum scores are constructed by taking the returns of the index levels over the various formation periods. We form the treasury portfolios at the end of each month and rebalance the portfolio monthly. Our long/short portfolios are constructed by taking the top and bottom quintile treasuries based on the momentum factor.

Note that the academic evidence that we reviewed on bond momentum shows evidence of reversal effects. As such, when analyzing bond momentum in our study, we felt that it was necessary to analyze the momentum anomaly with and without skipping the most recent month. However, in the analysis to follow, we show the results of treasury momentum without skipping the most recent month. Empirically constructing the momentum factor without skipping the most recent month, showed better results.

As always, to get things started, Figure 52 shows the coverage of our treasury universe. The historical coverage and breadth of our treasury universe is reasonable.

Figure 52:Coverage of treasury indices

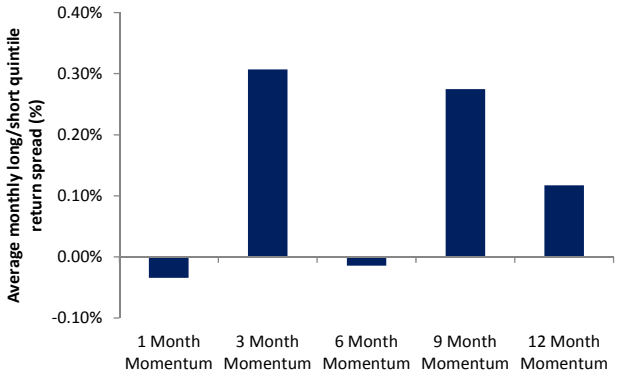


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Treasury exhibit modest levels of momentum

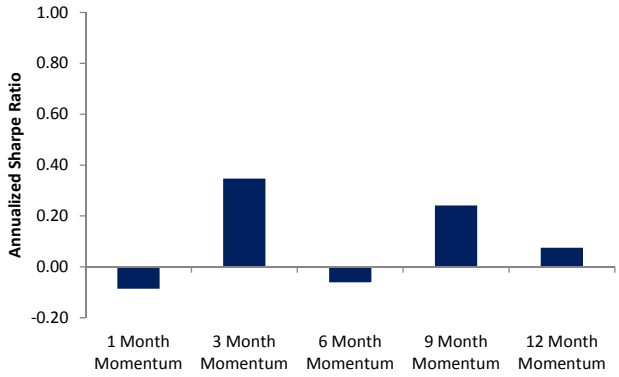
Overall the performance results of momentum strategies within treasuries are somewhat modest. Figure 53 and Figure 54 show the average long/short quintile performance and annualized Sharpe ratio of our momentum based treasury portfolios respectively. The results indicate that some treasury momentum portfolios exhibit reversal tendencies. This finding is consistent with the academic studies cited before.

Figure 53: Long/short average monthly quintile return



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

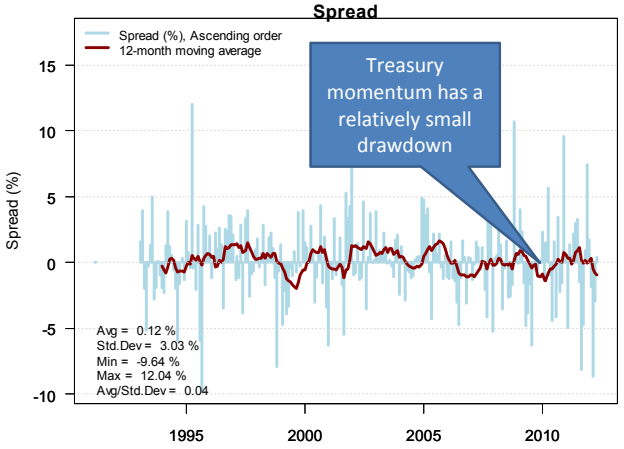
Figure 54: Annualized Sharpe ratio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

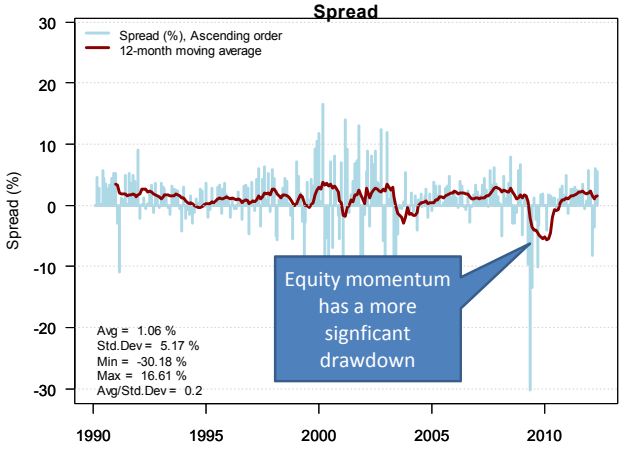
Next we look at the results from a time series perspective. Figure 55 shows the long/short quintile portfolio performance for 12 month treasury momentum. The results are not spectacular. However, it's critical we point out that our treasury momentum portfolio did not suffer as severe a drawdown during the financial crisis as our equity portfolio (Figure 56). This is an important finding because it bolsters our viewpoint that diversifying momentum strategies across asset classes (e.g. treasuries) may be a viable approach to reducing overall portfolio drawdown and potentially volatility.

Figure 55: Long/short average monthly quintile return for 12 month momentum of treasury indices



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 56: Long/short average monthly decile return for 12-1 month momentum for global equties

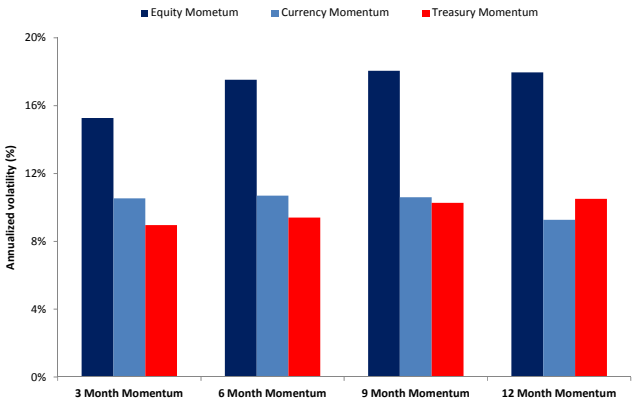


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Treasuring fixed income momentum portfolios

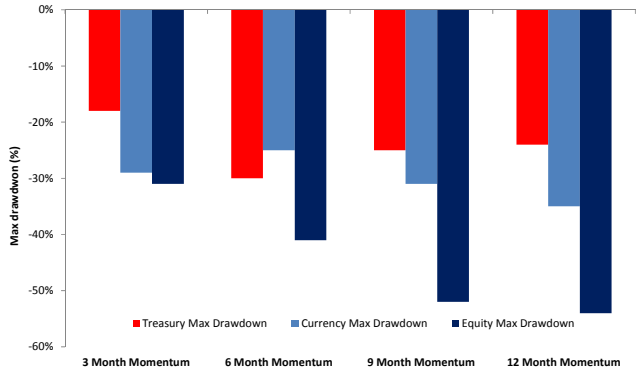
Figure 57 compares the annualized volatility of the treasury and currency momentum portfolios with the equity momentum portfolios. For every momentum period portfolio, the treasury and currency portfolios showed lower annualized volatility. In fact, the treasury and currency momentum portfolios show lower volatility than any other asset class momentum portfolio we investigated. Further, the treasury momentum portfolios also showed smaller drawdown's (Figure 58).

Figure 57: Annualized volatility of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

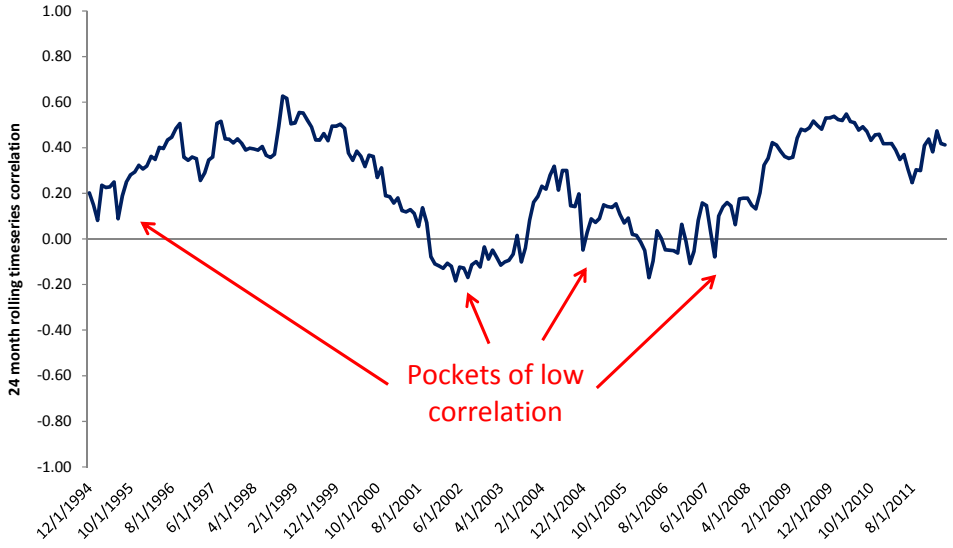
Figure 58: Max drawdown of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

We further find that treasury momentum portfolios are weakly correlated with equity momentum portfolios. Figure 59 shows the rolling 24 month time series correlation between our standalone equity momentum portfolio and our treasury momentum portfolio. We again use the 12 month momentum portfolios in this analysis. The figure shows that there are some definitive pockets of low correlation (and even negative correlation) between standalone equity momentum and treasury momentum. The above analysis indicates strong support for diversifying traditional equity momentum with treasury momentum portfolios. Now let's look further into combing all the asset class momentum portfolios we have studied thus far.

Figure 59: 24 month time series correlation between equities and treasuries



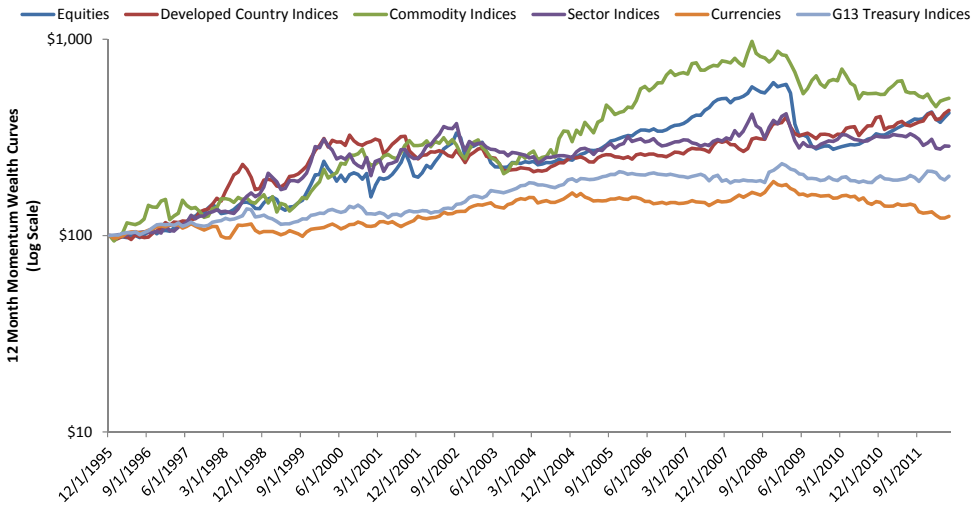
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Simple Portfolio Allocation

Setting up the analysis

Thus far we have analyzed the persistence of momentum across various asset classes including: stocks, country and sector equity indices, hedge fund indices, currencies, commodities and treasuries. Figure 60 shows the wealth curves for the 12 month momentum portfolios for various asset classes.

Figure 60:Wealth curve for all asset classes (12 month momentum portfolios)



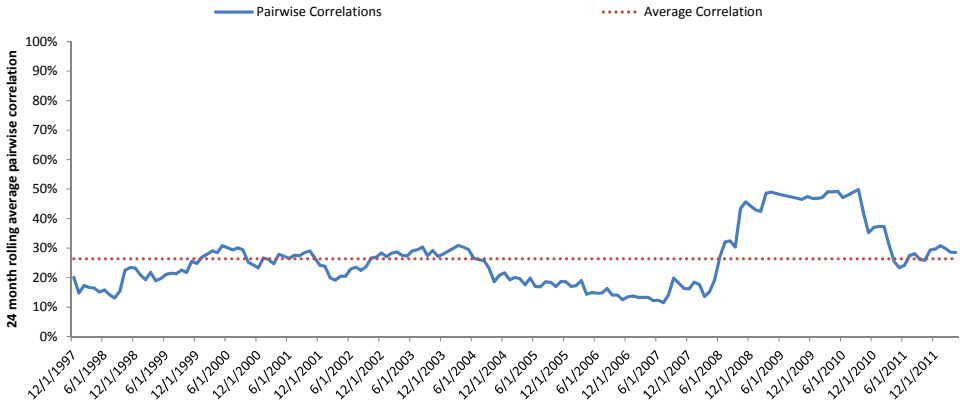
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

In this section, we build upon the preceding analysis to determine how we can combine the various momentum portfolios together. The simplest way is to equally weight all the momentum portfolios across the various asset classes. While this is a naïve approach, experience tells us that simplicity is often better. In this section, we seek an optimal allocation method to combine our cross asset momentum portfolios which can outperform the equally weighted allocation. For this exercise, we limit our universe to twelve portfolios: the 3 and 12 month momentum portfolios from the following six asset classes:

- Equities
- Developed Country Indices
- Sector Indices
- Currencies
- Commodities
- G13 Treasuries (Universe is limited to the top 13 developed countries)

We have excluded hedge fund momentum because the universe of investable indices is limited. Figure 61 shows the 24 month rolling average pairwise correlation of the twelve cross asset momentum portfolios. Overall the correlations are fairly low, which is promising for diversification purposes.

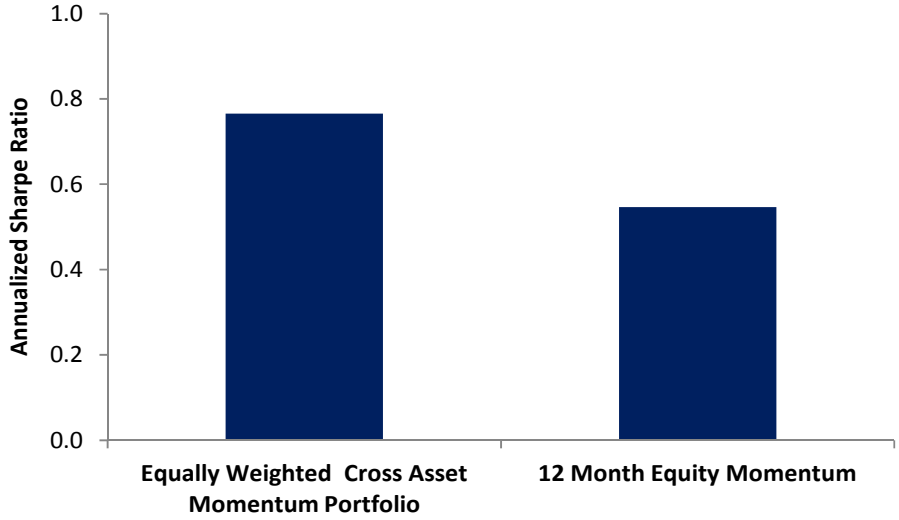
Figure 61:Pairwise correlations across all twelve momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Our equally weighed allocation outperforms the simple equities momentum portfolio. Figure 62 compares the Sharpe ratio of our equally weighted cross asset momentum portfolio and a simple 12-1 month equity momentum portfolio from 1996 onwards. The improved Sharpe ratio reaffirms our hypothesis that combining momentum portfolios from various asset classes outperforms equities momentum on a risk adjusted basis.

Figure 62: Sharpe ratio comparison of momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

In the upcoming sections, we look at various portfolio allocation methods from simple to more sophisticated schemes to determine whether we can outperform the equally weighted cross asset momentum portfolio.

Inverse volatility weighted

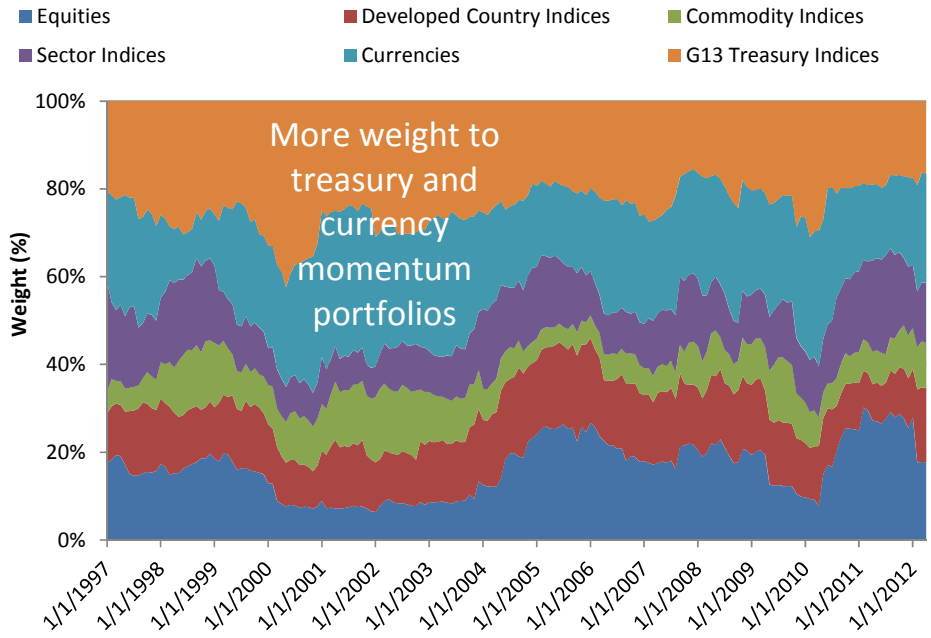
The first allocation technique we explore is Inverse Volatility (IV), a naïve risk parity based allocation technique. The lure of the IV allocation is its simplicity. In this scheme, portfolios are weighted inversely to their volatility. As such, more volatile portfolios (such as equities momentum and commodities momentum) are relatively down weighted and less volatile portfolios (such as treasuries momentum and currencies momentum) are relatively up weighted. Mathematically, this can be expressed as follows:

$$w_i = \frac{1/\sigma_i}{\sum_n 1/\sigma_i}$$

Computational IV is easy to implement. However, the ease of implementation naturally comes at a cost. The main drawback of IV is that it does not take into account the correlation between portfolios. Similar to other naïve allocation techniques, IV does not take into account correlation. The issue lies in that a portfolio may be unnecessarily penalized (i.e. down weighted) simply because it's relatively more volatile. For example, a more volatile portfolio which is negatively correlated to the other portfolios would be down weighted removing some diversification benefit.

Recall that in this research, we are not allocating among various asset classes. Instead, we are allocating momentum portfolios across various asset classes. To get a better picture of this, we employ the IV allocation scheme on our cross asset momentum portfolio described previously. Recall that this portfolio is formed by combining 12 different portfolios (including 6 different asset classes for both 3 and 12 month momentum). Figure 63 shows the time series weight of each momentum portfolio using IV. Here, we utilize a 12 month look back window to compute the volatility of each asset class. As we alluded to above, overall IV allocates more weight to less volatile momentum portfolios like treasuries and currencies. Conversely, it allocates less weight to more volatile momentum portfolios like equities momentum and commodities momentum. Understandably, this allocation becomes more pronounced during more volatile market episodes such as the dotcom bubble and the financial crisis.

Figure 63:Momentum portfolio weights using IV with a 12 month look back window



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

We also explore the IV allocation using various look back windows when calculating the volatility of each momentum portfolio. This is to see if a shorter look back window performs betters since it is arguably more reactive and adaptive to changing market conditions. However, we must analyze the tradeoff between a more reactive versus nosier estimates. Figure 64 shows some rudimentary statistics of IV based allocation

utilizing various look back windows. We compare the results with the equally weighted cross asset momentum portfolio. Interestingly, from a risk adjusted perspective (i.e. Sharpe ratio) we do not see much difference between IV allocation schemes using various look back windows. In fact, from a risk adjusted perspective, the equally weighted momentum portfolio actually performs in line with the IV allocation.

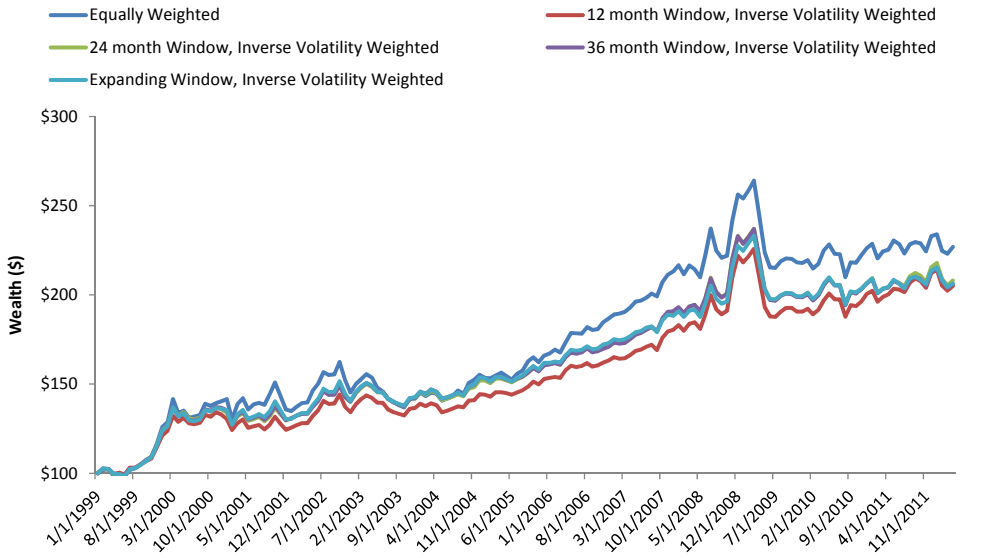
Figure 64: Inverse volatility allocation statistics

Weighting Scheme	Annualized Return	Monthly Avg Return	Sharpe Ratio	Annualized Volatility	Skew	Kurtosis
Equally Weighted	6.98%	0.56%	0.68	10.30%	-0.14	4.32
12 month Window Inverse Volatility Weighted	5.98%	0.49%	0.72	8.36%	-0.02	5.07
24 month Window Inverse Volatility Weighted	6.12%	0.50%	0.71	8.57%	0.06	5.07
36 month Window Inverse Volatility Weighted	6.03%	0.49%	0.70	8.67%	0.08	5.07
Expanding Window Inverse Volatility Weighted	6.05%	0.49%	0.70	8.69%	0.19	4.7

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Last, we compare the wealth curve of the various IV weighted cross asset momentum portfolios as well as the equally weighted momentum portfolio (Figure 65). The most noteworthy aspect of this figure is the clearly apparent kink or drawdown exhibited in all the momentum portfolios. Essentially, this illustrates that IV based allocation does not remedy the sharp drawdown inherent in cross asset momentum based portfolios. Maybe other allocation techniques (described next) can address this issue better.

Figure 65:Wealth curve for inverse volatility weighted momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Momentum weighted

The next naive allocation technique we explore is a return or momentum weighted allocation. This technique allocates more weight to outperforming portfolios and less to underperforming portfolios. The intuition underlying this allocation method is that there is persistence in the performance of portfolios. It is a linear allocation scheme and its best illustrated through simple example.

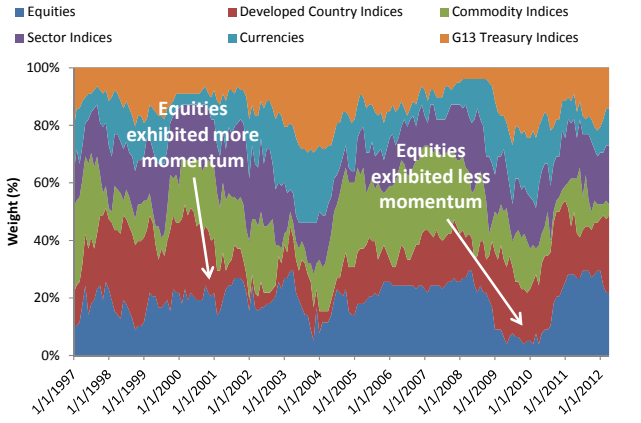
Assume that we have 3 portfolios: asset A, B, and C with historical 1 month returns of 5%, 3%, and 8% respectively. We rank the portfolio based on their returns. Portfolio A will be given a rank of 2, portfolio B a rank of 1 and portfolio C a rank of 3. Portfolio C has the best relative return and will be allocated the most weight. Conversely, portfolio B has the worst relative return and will be allocated the least weight. The weight of portfolio C (for example) will be its rank divided by the sum of all the ranks (i.e. 3/[1+2+3] or 3/7). Similarly, portfolio B's weight will 1/7 (i.e. 1/[1+2+3]) . Formulaically this can be expressed as follows:

$$w_i = \frac{rank(r_i)}{\sum_n rank(r_i)}$$

Recall again that in this research, we are not allocating amongst asset classes; rather we are allocating to momentum strategies across various asset classes. The pitfall of momentum or return based allocation is that it does not take into account the correlation between each portfolio. Essentially it bets on the persistence of returns of each portfolio.

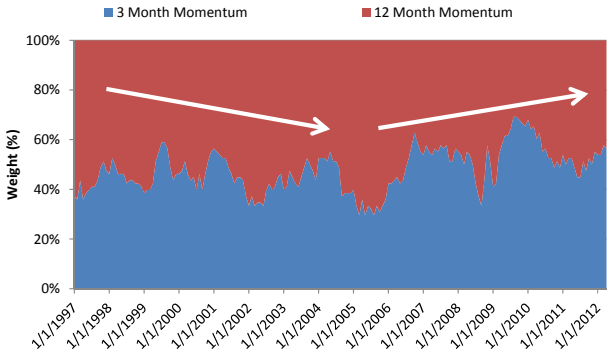
To get a better picture of momentum based allocation, we employ this strategy on our cross asset momentum portfolio. Figure 66 shows the time series weight of each portfolio. We use a one month look back window. During the financial crisis as equity momentum portfolios lacked persistence, they were severely penalized by the momentum based allocation technique. This is a stark contrast to the weight of equity momentum portfolios during the dotcom bubble. During this time, equity momentum portfolios exhibited the strongest levels of return persistence and as such were heavily weighted in the overall portfolio.

Figure 66: Momentum portfolio weights using momentum weighted allocation



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 67: Momentum period weight within the overall portfolio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 67 shows the time series weight allocated to the various momentum portfolios. The allocation has a moderate tilt towards short term momentum strategies during the latter part of the time series. This is likely due to increased market volatility and macroeconomic uncertainty during this period. Typically during periods of sustained macroeconomic uncertainty, we have found that strategies based on long term persistence do not outperform.

We also explore the momentum allocation using various look back windows when calculating the historical performance. Figure 68 shows some rudimentary statistics of momentum based allocation utilizing various look back windows. We again compare the results with the equally weighted momentum portfolio. From a risk adjusted perspective (i.e. Sharpe ratio), surprisingly none of the portfolios outperform the equally weighted portfolio. In fact, the equally weighted portfolio is the least volatile among all momentum allocation based portfolios.

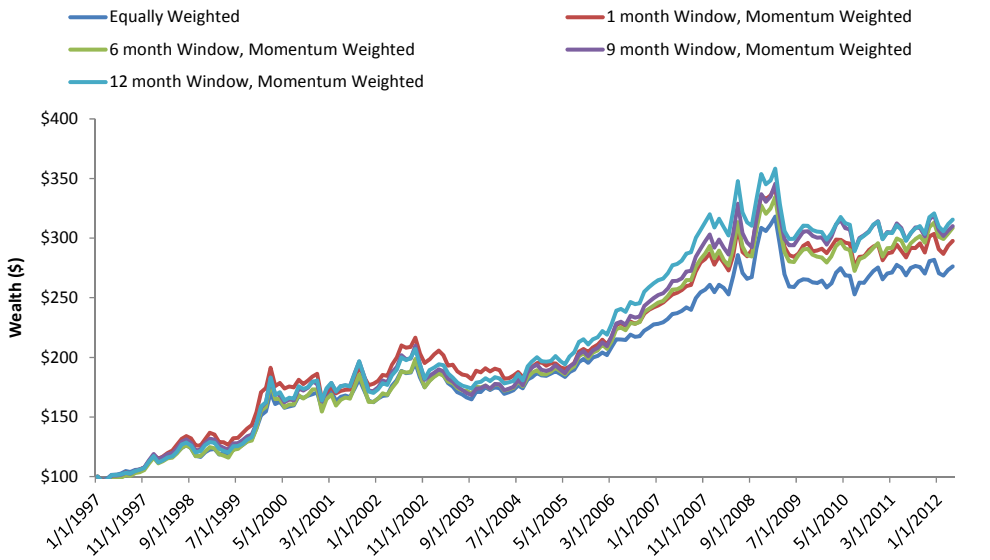
Figure 68: Comparison of equally versus momentum rank weighted portfolios

Weighting Scheme	Annualized Return	Monthly Avg Return	Sharpe Ratio	Annualized Volatility	Skew	Kurtosis
Equally Weighted	7.52%	0.61%	0.75	10.02%	-0.19	4.35
1 month Window Momentum Weighted	8.11%	0.65%	0.75	10.79%	-0.28	4.93
6 month Window Momentum Weighted	8.43%	0.68%	0.74	11.41%	-0.15	4.61
9 month Window Momentum Weighted	8.49%	0.68%	0.74	11.46%	-0.09	4.05
12 month Window Momentum Weighted	8.62%	0.69%	0.75	11.57%	-0.13	4.29

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

We compare the wealth curve of the various momentum weighted portfolios as well as the equally weighted portfolio (Figure 69). Unfortunately, momentum based asset allocation does not alleviate the drawdown exhibited during the financial crisis.

Figure 69:Wealth curve for momentum rank volatility weighted portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Sharpe weighted

To conclude our analysis of simple asset allocation techniques, we look at one more weighting scheme: Sharpe weighted portfolio allocation. This is very similar to the momentum based allocation described previously. This technique allocates more weight to portfolios that have been performing well on a risk adjusted basis. Formulaically this can be expressed as follows:

$$w_i = \frac{rank(sharpe_i)}{\sum_n rank(sharpe_i)}$$

We also explore the Sharpe allocation utilizing various look back windows when calculating the historical risk adjusted performance. Figure 70 show some rudimentary statistics of Sharpe based allocation utilizing various look back windows. The Sharpe allocation method does show some promise. From a risk adjusted perspective the Sharpe allocation outperforms the equally weighted portfolio by approximately 12%.

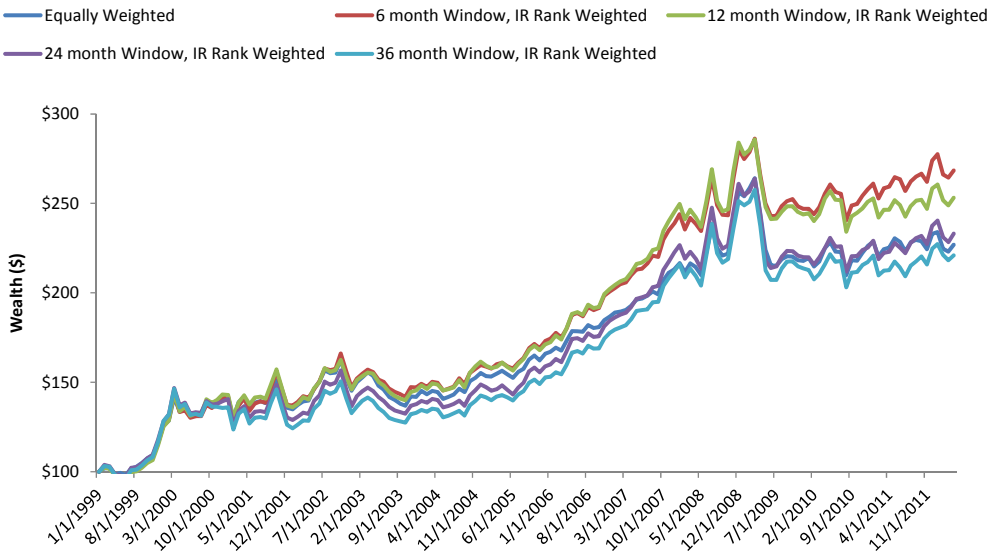
Figure 70: Comparison of equally versus Sharpe weighted momentum portfolios

Weighting Scheme	Annualized Return	Monthly Avg Return	Sharpe Ratio	Annualized Volatility	Skew	Kurtosis
Equally Weighted	6.98%	0.56%	0.68	10.30%	-0.14	4.32
6 month Window IR Weighted	8.47%	0.68%	0.76	11.10%	-0.18	4.46
12 month Window IR Weighted	7.98%	0.64%	0.71	11.18%	-0.05	4.19
24 month Window IRWeighted	7.38%	0.60%	0.63	11.69%	-0.3	4.44
36 month Window IR Weighted	6.91%	0.56%	0.58	11.83%	-0.21	4.41

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

However, when we compare the wealth curves of the various Sharpe weighted portfolios as well as the equally weighted portfolio (Figure 71) the results are not as promising. The Sharpe based allocation does not alleviate the drawdown exhibited during the risk rally of Spring 2009. We discuss portfolio drawdown in more detail in the coming sections. It seems that none of our simple portfolio allocation techniques have addressed this sharp drawdown. Could this just be a property of momentum based portfolios? Do all momentum based portfolios face such an issue? Or can this be addressed through the use of some more sophisticated allocation techniques? It is these very questions we seek to answer in the coming sections where we explore more sophisticated portfolio allocation schemes.

Figure 71:Wealth curve for Sharpe weighted momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Sophisticated Portfolio Allocation

Setting up the analysis

In this section, we study more sophisticated portfolio allocation techniques. We analyze four widely discussed allocation methods: equal risk contribution, minimum variance, maximum diversification and the traditional mean variance allocation. Again the goal is to determine the most optimal way to combine all the cross asset momentum portfolios. Can any of the techniques describe below outperform the equally weighted cross asset momentum portfolio?

Note that these portfolio construction techniques require us to estimate the covariance matrix. We use two different approaches for this estimation:

1. A 24 month moving window of portfolios returns, equally weighted. We denote this technique with a "_M".

2. An exponentially weighted moving average (EWMA) using a 24 month half life window. This means that the entire history of portfolio returns is used to calculate the volatility but it allocates half of the weight to the most recent 24 months. We denote this technique with a "_E".

Note also that we do not constrain our portfolio weights except for the fact that we ensure they are non-negative. This ensures that you cannot take a negative exposure to a long/short momentum portfolio. We also apply no leverage so all weights sum to 100%.

Equal risk contribution is fairly consistent throughout time

The first sophisticated portfolio construction technique we look at is equal risk contribution (ERC) or often called risk parity.[12] The allure of the risk parity allocation strategy is that it seeks to give equal risk budget to each asset in the portfolio. The purpose of balancing risk equally across the assets in the portfolio is consistent with a "no-alpha" strategy in that it gives each asset "equal opportunity" to contribute to the portfolio's overall performance.

ERC takes into account the correlation between the associated momentum portfolios. And it can be implemented via an optimization problem based on the following equation:

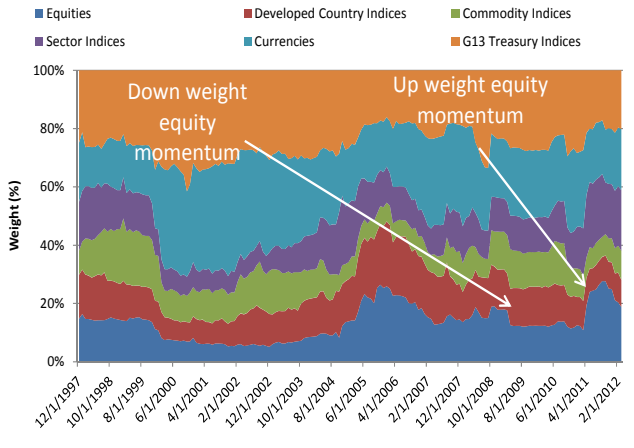
$$w_i = \arg\min_w \sum_{i=1}^{n}\sum_{j=1}^{n}[w_i \operatorname{cov}(r_i, r_p) - w_j \operatorname{cov}(r_j, r_p)]^2$$

where r_i and r_j are the returns of the each underlying momentum portfolio and r_p is the overall portfolio return.

[12] For a detailed explanation on Risk Parity based allocation, please see Alvarez et al. [2011c]

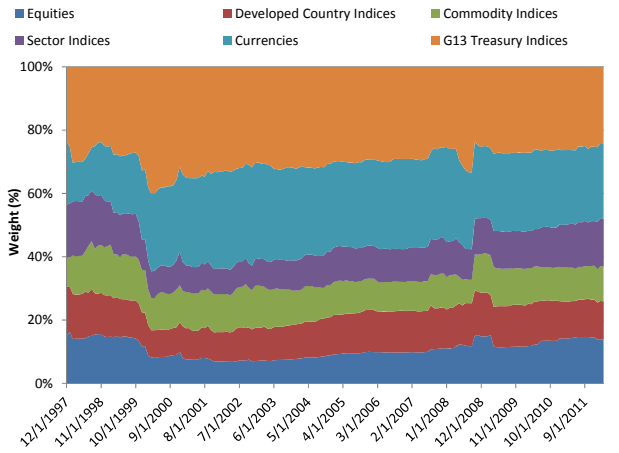
To see ERC in action, we employ it on our momentum portfolios. Figure 72 and Figure 73 show the time series weight of each portfolio using the two estimation techniques described earlier. Most notably, the weights derived from ERC appear fairly consistent over time and somewhat resemble an equally weighted portfolio. Although, we do notice a down weight of equity momentum during and post the dotcom bubble and financial crisis as equity momentum became more volatile. This is followed by an up weight in equity momentum during the risk seeking episode in 2010 and 2011.

Figure 72: ERC _M time series portfolio weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 73: ERC _E time series portfolio weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Minimum variance is especially punitive

The next portfolio allocation method we look at is the widely discussed Minimum Variance (MVP) method.[13] The MVP method aims to weight portfolios such that the overall portfolio risk is minimized without taking any particular view on expected portfolios returns. This can be implemented via an optimization problem based on the following equation:

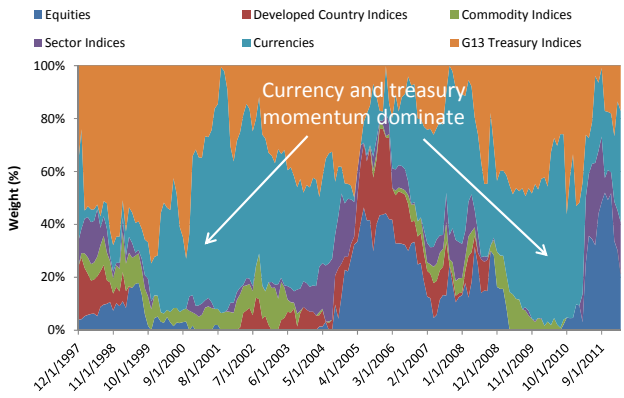
$$\arg\min_w \frac{1}{2} w' \Sigma w$$

The above equation is subject to the constraint that all the weights in the portfolios are non-negative and sum to 100%.

Figure 74 and Figure 75 show the time series weight of each class using the two estimation techniques described earlier. As expected, MVP gears towards lower volatility portfolios while taking into account the correlation between the portfolios. The figures below show that MVP portfolio is dominated by treasury and currency momentum, the least volatile of all the momentum portfolios. In fact, during more volatile market episodes, MVP allocation completely rids the portfolio of any equity, country indices, and sector indices momentum.

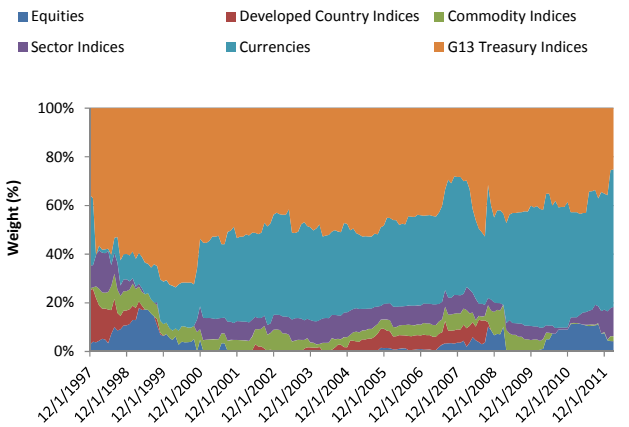
[13] For a more detailed analysis of Minimum Variance portfolios, please see Alvarez et al. [2011b]

Figure 74: MVP _M time series portfolio weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 75: MVP _E time series portfolio weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Maximum Diversification reaps the benefits of multi-asset class diversification

Next we look at Maximum Diversification (MD).[14] This allocation strategy attempts to create portfolios that are more diversified by maximizing the distance between the weighted average volatility of each underlying portfolio and the overall portfolio volatility. This can be shown in the following equation:

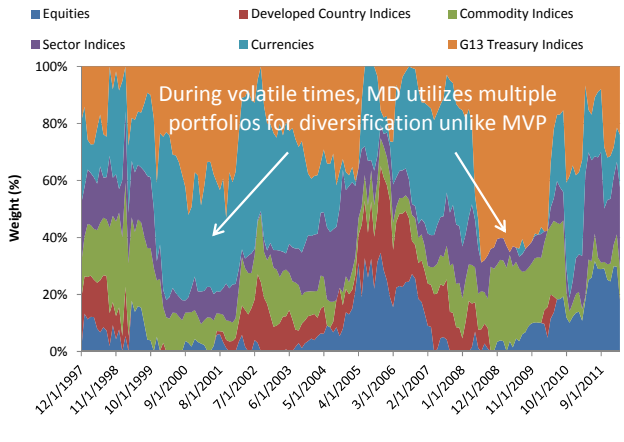
$$\arg\max_{w} \frac{\sum_{n} w_i \sigma_i}{w' \sum w}$$

The equation above warrants some further explanation. The numerator is simply the weighted sum of the underlying portfolio volatilities. The denominator is the total portfolio volatility which takes into account the correlation between the underlying portfolios. The difference between the two is essentially the correlation component within the denominator. To maximize the overall ratio, the denominator containing the correlations must be minimized. This allocation strategy attempts to select portfolio weights that minimize the correlation between the underlying portfolios and hence "maximize diversification" as the name suggests.

Figure 76 and Figure 77 show the time series weight of each underlying portfolio using the two estimation techniques described earlier. MD is not as punitive to the more volatile momentum portfolio relative to the MVP allocation. Although equity momentum has been penalized during periods of increased volatility, other momentum portfolios offer diversification benefits when compared to MVP.

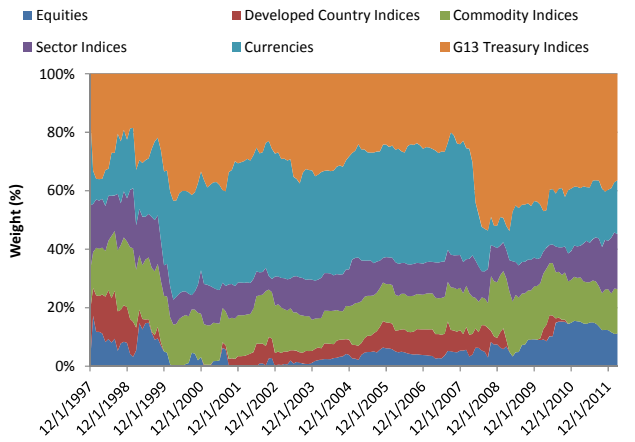
[14] For more information on Maximum Diversification, please see Alverez et al. [2011c]

Figure 76: MD _M time series asset class weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 77: MD _E time series asset class weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Mean Variance Optimization sits somewhere in between

Lastly, we explore the Mean Variance (MV) asset allocation technique.[15] MV simply attempts to weight the underlying portfolios to gain the maximum expected return for minimum risk. This can be implemented via an optimization problem based on the following equation:

$$\arg\max_w w'\hat{r} - \lambda(w'\sum w)$$

where, $\hat{r}$ is the vector of expected returns (aka alphas) of the momentum portfolios and $\sum$ is their covariance matrix. In the subsequent analysis, the expected returns $\hat{r}$, are estimated using each portfolio's average return[16]. While the historical average is a naïve estimator of alpha, it has a momentum quality in that, all else equal, the portfolios with better historical performance will be overweighed in the final allocation. More sophisticated expected return models are nonetheless warranted to implement this technique more successfully, but this falls outside the scope of this report[17].

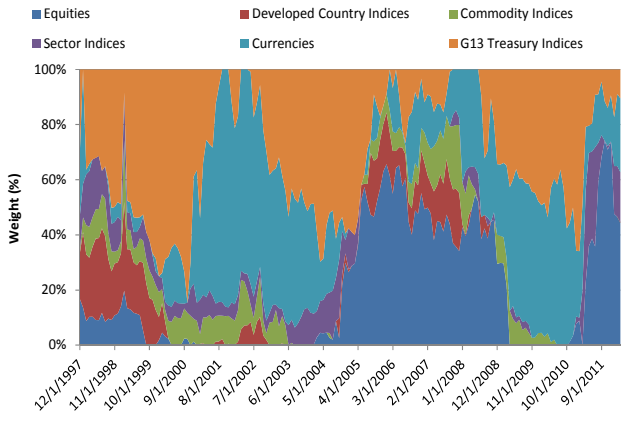
The above equation is subject to the constraint that all underlying portfolio weights are non-negative and sum to 100%. Note that the alphas for the mean variance optimized portfolios are simply the historical returns of the two estimation techniques described earlier. The results of the mean variance weighting scheme sits somewhere in between maximum diversification and minimum variance (see Figure 78 and Figure 79).

[15] For more information on Mean Variance optimization, please see Luo et al. [2010].

[16] To keep consistency with the covariance matrix estimation, we used the same estimation technique (moving window and EWMA) to compute the average return.

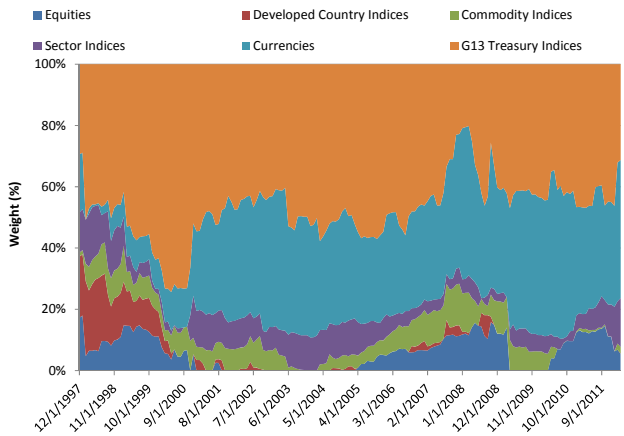
[17] For more sophisticated return modeling techniques, see Luo *et al* [2012] "From Macro to Micro" or Luo *et al* [2010] "Style Rotation Model".

Figure 78: MV _M time series asset class weights



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 79: MV _E time series asset class weights



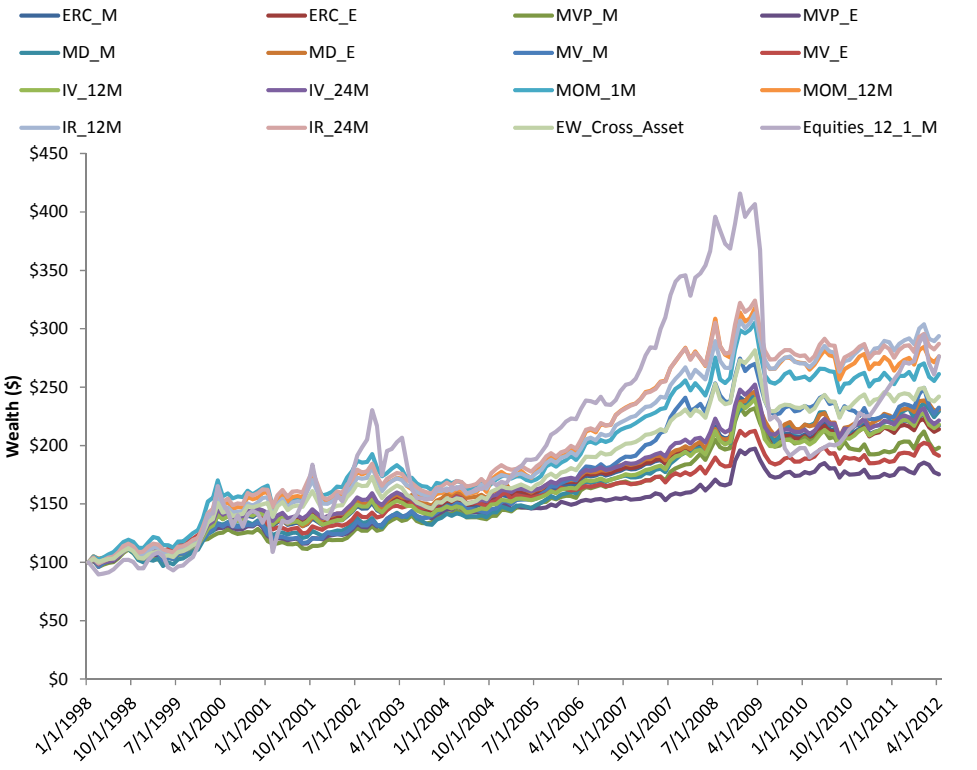
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

What is the Optimal Allocation Method?

Simple versus sophisticated versus equally weighted allocation

In the prior sections we explored the various portfolio allocation methods and their implications on the portfolio weights. Naturally, the next step is to compare the performance of the various portfolio allocation methods. What investment managers' care most about is risk adjusted performance. To get started, Figure 80 compares the wealth curve of the various allocation methods including: simple allocation, sophisticated allocation, equally weighted cross-asset momentum portfolio (EW_Cross_Asset) and the 12-1 month equities momentum portfolio (Equities_12_1_M). Although the results of the various allocation schemes vary to some extent, we do want to point out that similarity of drawdowns during the financial crisis. It seems that all of the portfolio allocation methods suffered this large drawdown. Could this drawdown be a common drawback in all momentum based portfolios? We will dig deeper into the performance attribution of each portfolio allocation method next.

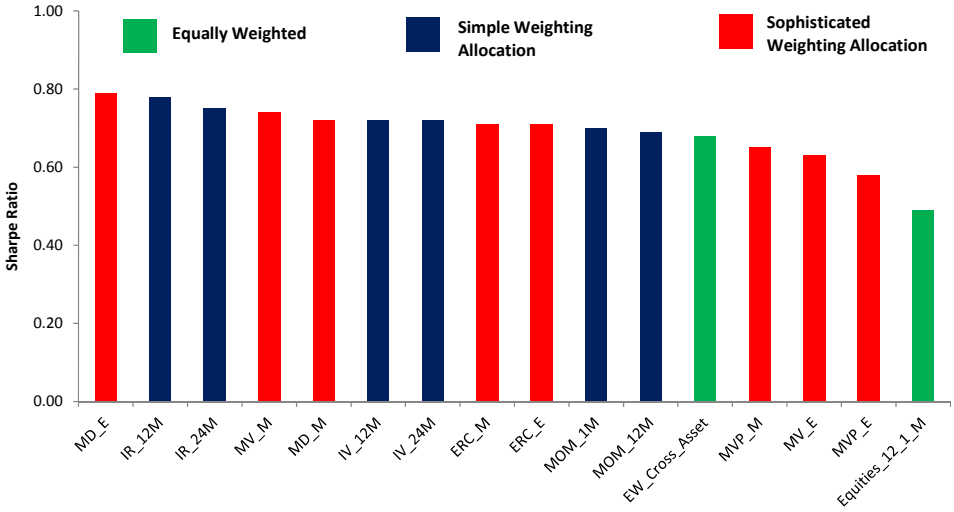
Figure 80: Wealth curve for various portfolio allocation methods



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 81 compares the Sharpe ratio for all the portfolio allocation methods implemented thus far. In this figure, we have also distinguished between the simple, sophisticated, and equally weighted allocation methods. The results are promising and at the same time, very interesting. We note that Maximum Diversification (MD), a more sophisticated allocation technique, was the best performer with a Sharpe ratio of approximately 0.8.[18] However, the simpler allocation methods were not for behind MD in terms of performance. Interestingly, the 12-1 month equities only momentum portfolio showed the worst performance as measured by the Sharpe ratio. The results of the equally weighted cross asset momentum portfolio were not as stellar as compared to other techniques. This does highlight the importance of portfolio construction.

Figure 81: Comparison of Sharpe ratio for all portfolio allocation methods

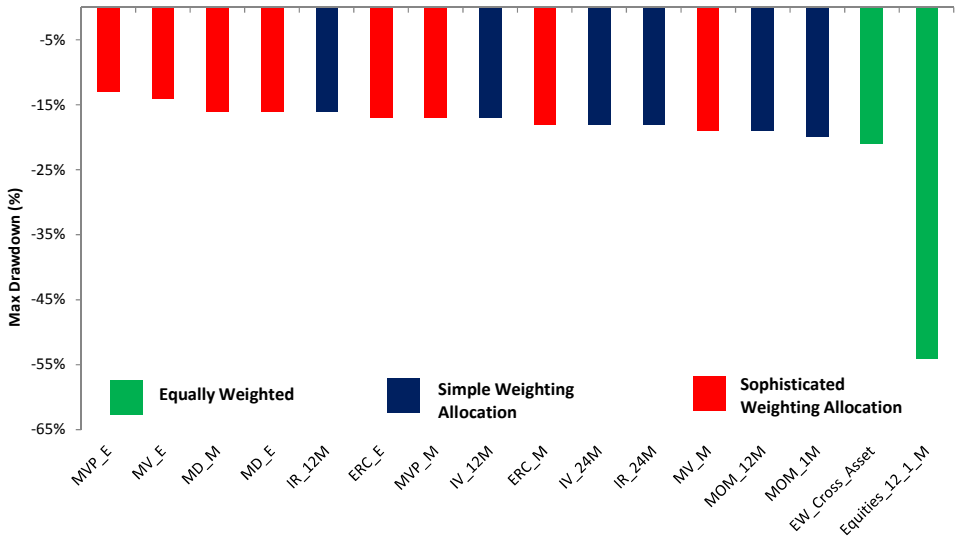


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

One persistent concern is the major drawdown present within all momentum portfolios. Figure 82 compares the maximum drawdown among all the portfolio allocation methods. Again, the 12-1 month equities only momentum portfolio had the worst drawdown. The equally weighted cross asset momentum portfolio had the second largest (worst) drawdown. As expected, the more sophisticated allocation methods showed better (less) drawdowns.

[18] We have also noted the outperformance of MD in a few other applications for example in cross-asset class risk premia allocation in Mesomeris et al. [2012] and country rotation in Luo et al. [2012].

Figure 82: Comparison of maximum drawdown for all portfolio allocation methods



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

To end this session, Figure 83 compares some simple portfolio metrics among all the allocation methods. Next we investigate whether we can enhance performance even further by conditioning on macroeconomic regimes.

Figure 83: Overall performance from 1998 onwards

Method	Type	Category	Annualized Return	Monthly Avg Return	Sharpe Ratio	Annualized Volatility	Skew	Kurtosis	Max Draw Down
MD_E	Maximum Diversification	Sophisticated	6.42%	0.52%	0.79	8.12%	0.18	4.62	-16.0%
IR_12M	Information Ratio	Simple	8.57%	0.69%	0.78	11.01%	-0.21	4.39	-16.0%
IR_24M	Information Ratio	Simple	8.40%	0.67%	0.75	11.15%	-0.1	4.06	-18.0%
MV_M	Mean Variance	Sophisticated	6.66%	0.54%	0.74	8.97%	-0.31	3.61	-19.0%
MD_M	Maximum Diversification	Sophisticated	6.50%	0.53%	0.72	9.01%	0	3.95	-16.0%
IV_12M	Inverse Volatility	Simple	6.03%	0.49%	0.72	8.42%	-0.1	4.84	-17.0%
IV_24M	Inverse Volatility	Simple	6.17%	0.50%	0.72	8.63%	-0.02	4.83	-18.0%
ERC_M	Equal Risk Contribution	Sophisticated	6.01%	0.49%	0.71	8.47%	0	4.8	-18.0%
ERC_E	Equal Risk Contribution	Sophisticated	5.87%	0.48%	0.71	8.31%	0.07	4.77	-17.0%
MOM_1M	Momentum	Simple	7.67%	0.62%	0.70	10.99%	-0.26	4.86	-20.0%
MOM_12M	Momentum	Simple	8.18%	0.66%	0.69	11.80%	-0.11	4.21	-19.0%
EW_Cross_Asset	Equal Weighted All	Simple	6.99%	0.56%	0.68	10.20%	-0.17	4.26	-21.0%
MVP_M	Minimum Variance	Sophisticated	5.36%	0.44%	0.65	8.19%	0.26	5.23	-17.0%
MV_E	Mean Variance	Sophisticated	5.00%	0.41%	0.63	7.90%	0.22	4.75	-14.0%
MVP_E	Minimum Variance	Sophisticated	4.34%	0.36%	0.58	7.45%	0.49	6.56	-13.0%
Equities_12_1_M	Equally Weighted Equities	Equal	10.29%	0.82%	0.49	21.05%	-1.43	8.3	-54.0%

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Regime shifting shows promise

Our European research team recently published an interesting white paper on a new asset allocation paradigm.[19] In this research, they show how to integrate market timing into the portfolio construction process via a sentiment based index. In this section, we perform a similar type of analysis. We want to determine whether conditioning momentum portfolios using a macro timing signal can enhance performance even further. However, what macro timing signal should we choose?

In our recent research, we have spent a lot of time studying an indicator called the Variance Risk Premium (VRP). Complete details can be found in Luo et al. [2012], but in a nutshell the VRP is the difference between options implied variance and realized variance, at the index level. For example, Figure 84 shows the US VRP, overlaid with S&P 500 performance. When VRP is high and positive, this tends to be a buying opportunity, and when it is large and negative that is a selling opportunity. The intuition is that VRP captures market overreaction to what the actual data is telling us. For example, when VRP is high, typically VIX (i.e. options implied risk) has shot up well beyond realized risk. This can indicate that investors are overly fearful, a scenario we can profit from because typically the price of risky assets in such an episode will be overly depressed. On the flip side, when VRP is low or negative, it tends to signal complacency – the realized risk is rising but for whatever reason the market is not pricing this in the options market. This is a selling opportunity.

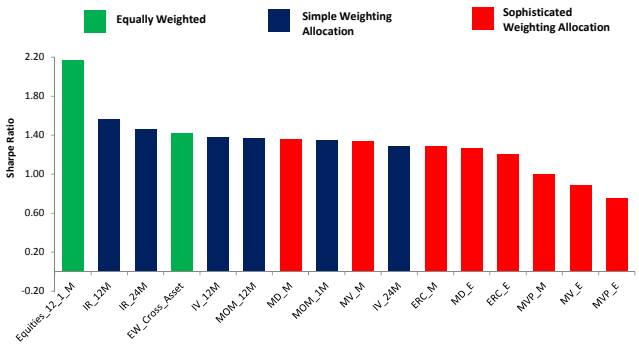
Figure 84: The US Variance Risk Premium (VRP)

Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

In this research, we condition based on the volatility of VRP. When the current volatility of VRP is above its historical volatility (based on expanding window) we classify this as an unstable market regime. Conversely, if VRP is below its historical volatility levels, then we classify this as a more stable market regime. Figure 85 and Figure 86 show the Sharpe ratio of our various momentum portfolios under the two market regimes described above.

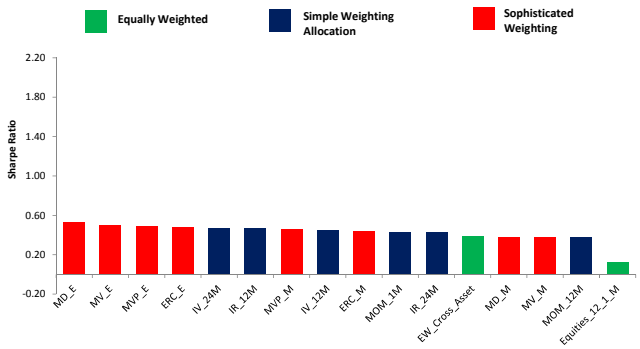
[19] See Mesomeris et al. [2012].

Figure 85: Sharpe ratio in a stable macro environment



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

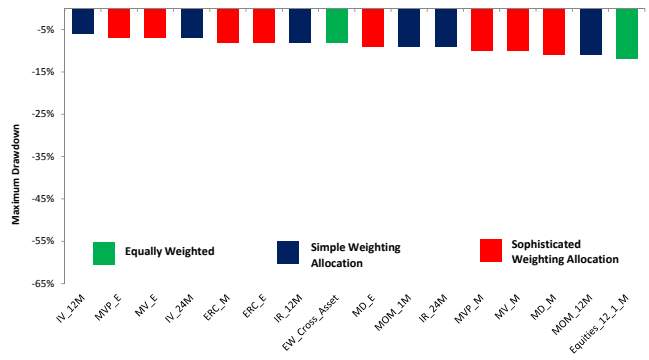
Figure 86: Sharpe ratio in a unstable macro environment



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

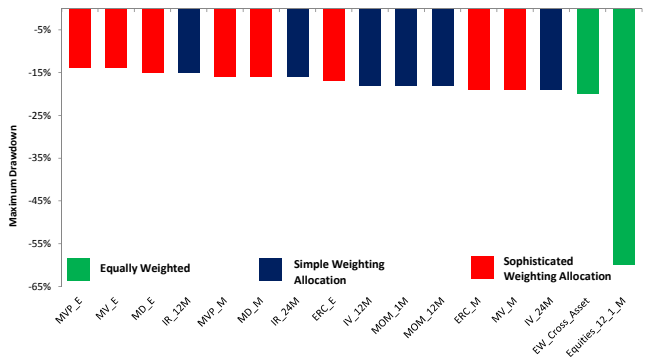
The above results are very interesting. In a stable macro regime (as defined earlier), the 12-1 month equities only portfolio performs the best. The simple allocation weighted portfolios perform strongly as well during this regime. However, in an unstable macro regime, the more sophisticated portfolio weighting methods perform relatively better. The 12-1 month equities only momentum portfolio and the equally weighted cross asset momentum portfolio underperform on a relative basis. We see a similar picture when we observe the max drawdown under the two market regimes.

Figure 87: Max DD in a stable macro environment



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 88: Max DD in a unstable macro environment



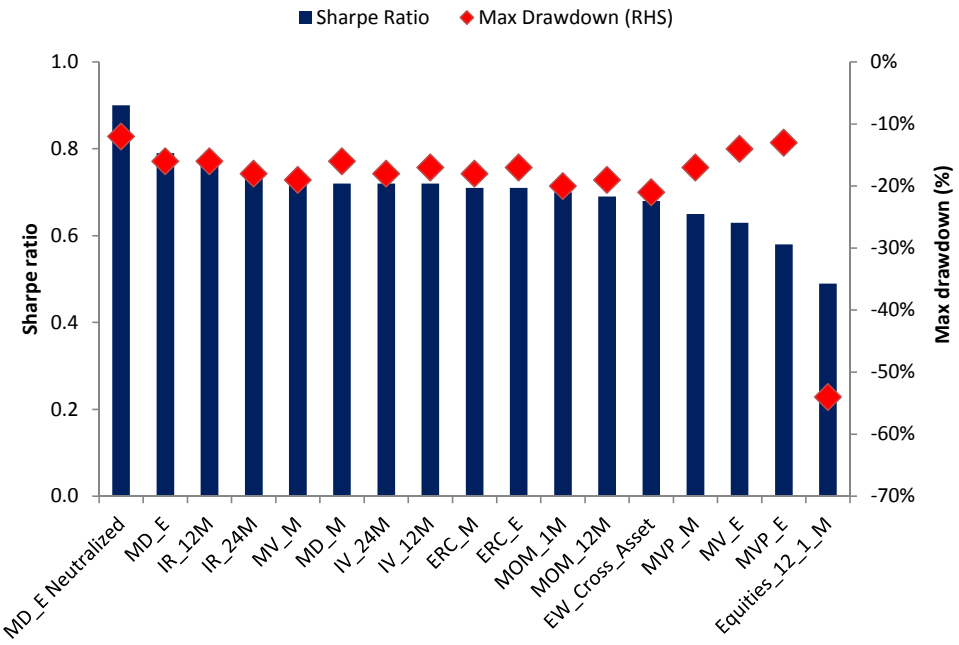
Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Figure 87 and Figure 88 show the max drawdown under the two regimes. Interestingly, irrespective of the macro regime, the 12-1 month equities only momentum portfolio shows the worst drawdown. However, during an unstable macro regime, the more sophisticated allocation methods tended to perform better on a relative basis. In summary, the above analysis suggests that conditioning momentum strategies on macro timing signals can enhance performance. Lastly, we explore one more technique to enhance performance even more: Portfolio Neutralization.

Neutralization works yet again

In a previous research paper, we showed how momentum portfolios can take on significant exposures to beta and volatility at various points in the economic cycle.[20] We suggested a simple technique for removing such unwanted exposures. Here we utilize the same algorithm to volatility neutralize our MD_E portfolio. Figure 89 compares the Sharpe ratio and max drawdown our neutralized MD_E portfolio with the various portfolio allocation methods we have studied thus far. Interestingly, our neutralized MD_E portfolio has the highest Sharpe ratio and the smallest max drawdown.

Figure 89: Portfolio performance including neutralized MD_E portfolio

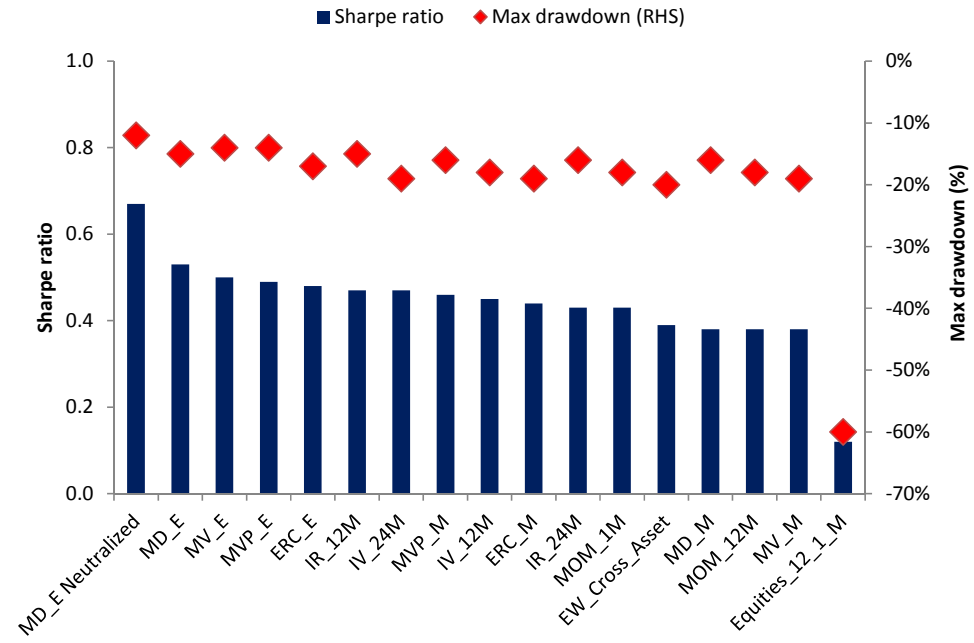


Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

We perform the same analysis as above but within an unstable macro regime (as defined earlier). The neutralized MD_E portfolio again shows the most promising results. Figure 90 compares the Sharpe ratio and max drawdown our neutralized MD_E portfolio with the various portfolio allocation methods under an unstable macro regime. Again, our neutralized MD_E portfolio has the highest Sharpe ratio and the smallest max drawdown.

[20] For more information on the neutralization methodology, see Alvarez et al. [2010].

Figure 90: Portfolio performance in an unstable regime



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Let's end with a smile

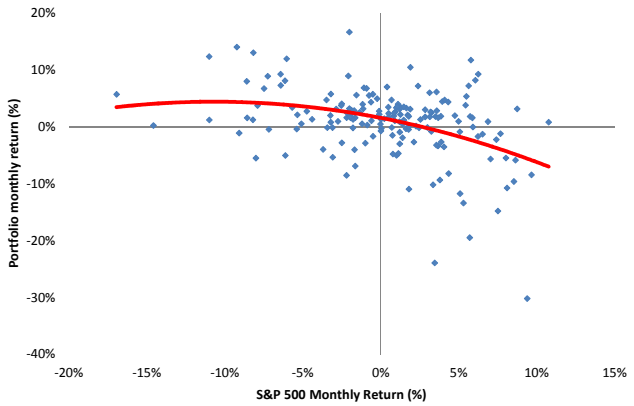
Momentum smirks, sneer, or smile?

Finally, we want to conclude our momentum research with a smile from our readers. A long observed and well researched pattern in finance is the volatility smile. This stems from the notion that at-the-money options have lower implied volatilities than in or out-of-the money options. As such, a smile like impression is created when option implied volatility is charted against option strike prices

Similarly, when assessing the various portfolio allocation techniques discussed in this research, we ideally would like a SMILE like impression, literally. Another simpler way to assess our allocation techniques (taking into account various market regimes at a high level) is to form a scatter plot of the portfolio returns against the market returns. We then attempt to fit a binomial function through the scatter data to best gauge the relationship between portfolio returns and market returns.

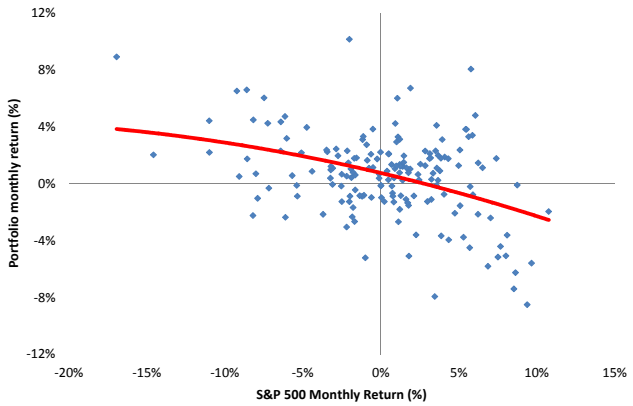
Ideally, a smile like impression would indicate that portfolio returns tend to perform well in good and bad markets. However, in reality, this is obviously not the case. We are sad to see the frown pattern of the 12-1 month equity momentum portfolio (Figure 91) as well as the equally weighted cross asset momentum portfolio (Figure 92). The presence of a SMILE impression is clearly not rendered.

Figure 91: 12-1 month momentum equities only momentum portfolio



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

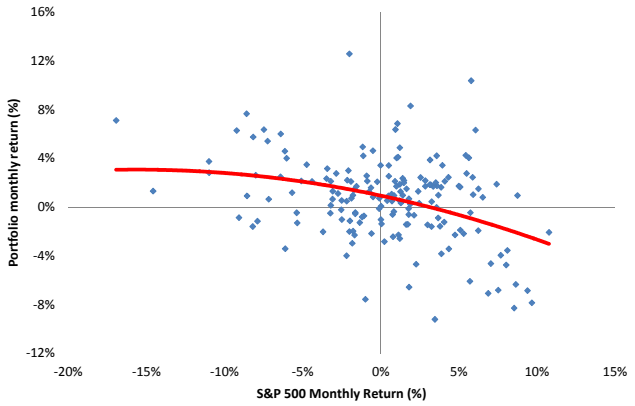
Figure 92: Equally weighted cross asset momentum portfolios



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

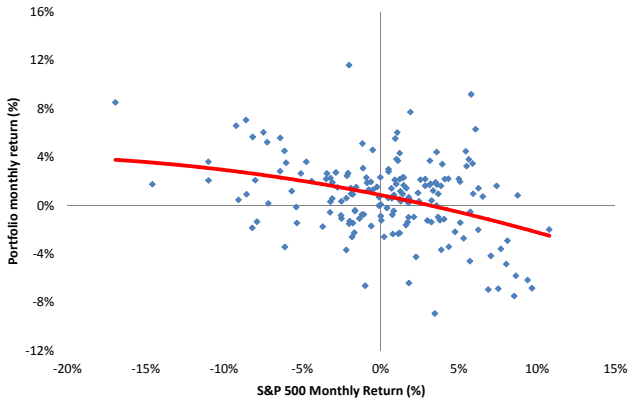
Could the simple portfolio allocation techniques show more promising results? Not really. Figure 93 and Figure 94 show the scatter plot for momentum and Sharpe ratio weighted portfolio allocation techniques. Again, the results are not too promising. The presence of a SMILE impression is not rendered using the simple portfolio allocation techniques.

Figure 93: MOM_24 scatter plot



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

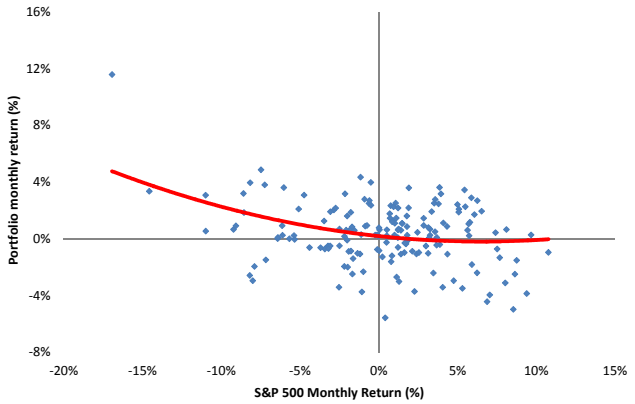
Figure 94: IR_24 scatter plot



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

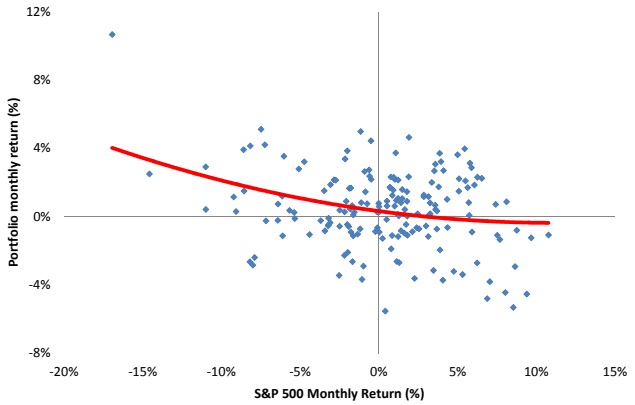
However, when utilizing the more sophisticated asset allocation techniques we do notice a half smile. Figure 95 and Figure 96 show the scatter plots of our more sophisticated asset allocation methods. The MVP and MV momentum portfolios appear to show more promising results with respect to this analysis.

Figure 95: MVP_E scatter plot



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

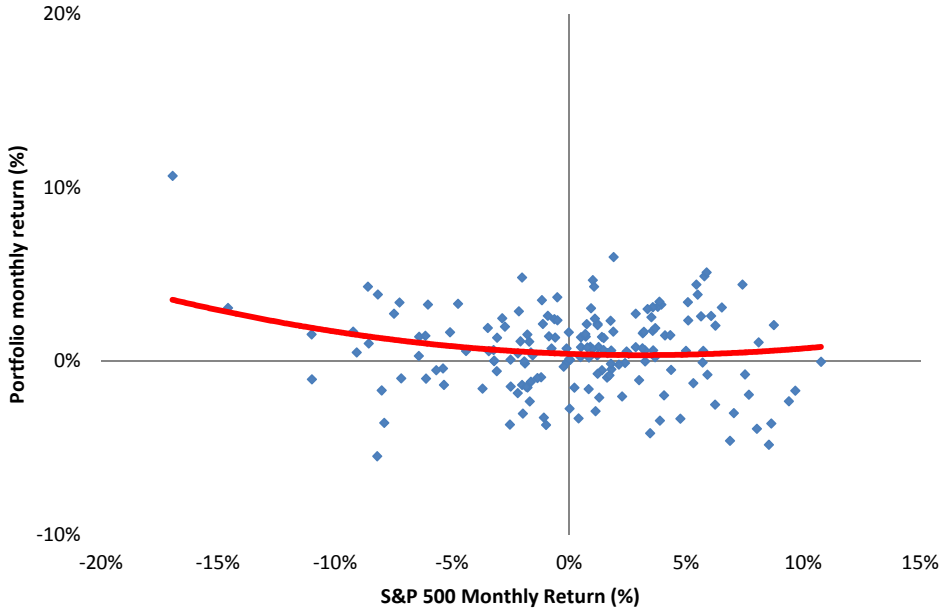
Figure 96: MV_E scatter plot



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

Lastly, we show the scatter plot of the neutralized MD_E portfolio. As shown in Figure 97, we can end our research discussion with a smile.

Figure 97: MD_E neutralized portfolio scatter plot



Source: Axioma, Bloomberg Finance LLP, Compustat, IBES, S&P, Thomson Reuters, MSCI, BMI, Deutsche Bank Quantitative Strategy

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Appendix 1

Important Disclosures

Additional information available upon request

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