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Quantitative
Global

Equity Risk Premia Investing

A New Methodology for Monitoring Style Performance

- **The Rise of Smart Beta** — There has been a surge of interest in Risk premia or smart beta investing since the global financial crisis as both active and passive management alike struggled with exposure to tail risks and hidden factors.
- **Defining Citi Pure Equity Risk Premia Indices** — This research outlines a pure equity risk premia portfolio construction technique which reduces tail risk and offers investors passive exposure to known style anomalies.
- **Pure Risk Premia Characteristics** — This new approach to style investing significantly reduces tail risk and drawdowns, leading to enhanced risk adjusted returns over more traditional quantile portfolio approaches.
- **Pure Risk Premia in Action** — Applying Risk Premia to style timing is operationally more efficient through style indices than stocks and can enhance portfolio performance. Furthermore, enhanced index mandates can use the dollar neutral indices to gain style exposure whilst maintaining low tracking errors.
- **Implementation** — Risk premia investing is still an attractive proposition even after considering transaction, shorting and liquidity costs.
- **Styles on Bloomberg** — All of our quantile and pure style factors are available on Bloomberg. Figure 1 outlines our Bloomberg style index ticker construction.

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Figure 1. Bloomberg Tickers for Citi Style Indices

CGRQ — Citi Research Quant Baskets

For Example: European Pure Value
CGRQPEUV Index

Product Type	
Q	Quantile Style
P	Pure Style

Region Type	
EU	Europe
AS	Asia ex Japan
JP	Japan
US	US
DW	Developed World
EM	Emerging Markets
AC	All Countries
AU	Australia

Style Type	
S	Size
V	Value
R	Low Risk
M	Price Momentum
E	Estimates Momentum
Q	Quality
G	Growth

Source: Citi Research

Contents

Introduction

'Pure' style indices have widespread application within the overall investment process

We introduce a new product suite of pure risk premia indices for a range of MSCI-based universes. Since each index is constructed to have a unit exposure to any one index and a zero exposure to all other indices, these indices provide "pure" style exposures. This characteristic, combined with their potential investability, facilitates widespread applications within the overall investment process in areas such as Portfolio Construction, Risk Management & Asset Allocation.

The Rise of Risk Premia Investing

Drawdowns and volatility through the global financial crisis caused investors to question classical portfolio construction…

Through the global financial crisis many investors have experienced both significant losses and surprisingly volatile portfolio returns. This has motivated the investment community to search for alternatives and enhancements to current portfolio construction methodologies. There has been a subsequent surge in literature attempting to build portfolios which are more robust to extreme market correlations. Institutional investors and asset allocators have since started to reconsider their asset choices and scrutinize tail risk; something that used to be regarded as too rare to be considered seriously.

…and led to a surge in research and literature on 'real' alpha separation and a focus on extreme market correlations…

Ang, Goetzmann and Schaefer (2009) wrote what is arguably the landmark paper reviving portfolio construction related research. In the paper the authors evaluated the active management of the Norwegian Government Pension fund. The key findings from this research were that idiosyncratic active management played a very small role in overall fund performance, especially at the height of global financial crisis, and that a significant proportion of performance was explained by its exposure to systematic risk premia rather than 'real' alphas. They initiated the debate on risk premia versus traditional asset allocation investing through their recommendation that this systematic risk premia exposure is taken as part of the benchmark and not considered true alpha.

…with academics arguing more robust diversification is achievable across multi-asset risk premia than across traditional asset allocation

Further academic research has examined multi-asset risk premia investing. Briand, Nielsen and Stefek (2009) and Chua, Kritzman and Page (2010) find correlations between multi asset risk premia significantly lower than correlations across asset classes. They therefore argue that more robust diversification, over time varying market regimes, can be obtained through diversifying across multi-asset risk premia rather than simply gaining diversification through asset classes. While recent research from Idzorek and Kowara (2013) has questioned the strength of previous findings they find multi asset risk premia to be no worse than asset class diversification. This note focuses on equity risk premia construction which can be used either on its own as an equity investment strategy, or as part of a broader multi-asset framework.

We have examined risk premia investing in two of our previous research papers[1] [2] focusing on the topical low volatility risk premia. Our research showed that the inclusion of such portfolios in the asset mix would have reduced some significant losses investors experienced at the height of the global financial crisis. Furthermore, we showed the changing landscape in the quant community where the low absolute volatility idea was utilized to create more maximum Sharpe ratio type of funds in response to demand from consultants and asset owners. We have also utilised the

[1] Low-Risk Equity Portfolios, More than Just Minimum Variance, November 2010, Citi Research

[2] Low-Risk Portfolio Strategies, Sharpe Ratio Maximization and Multi-Asset Applications, March 2012, Citi Research

approach to purify analyst forecasts of style bias, enhancing the alpha from analyst recommendations[3].

We define a suite of equity risk premia and provide a robust critique, highlighting practical applications and potential ramifications

In this report we broaden previous research to examine a suite of pure risk premia indices[4]. We firstly define the equity risk premia we are attempting to capture and then outline the calculation methodology. The third section examines risk premia correlation, risk and return characteristics with section four highlighting some key applications. Sections five and six examine practical application and potential ramifications to active investing respectively, with further reading and index performance highlighted in the appendix.

[3] Searching for Alpha: Purifying Analyst Recommendations, March 2013, Citi Research

[4] Introducing Citi QuantiFI Indices for Australian Equities, January 2010, Citi Research

What is Equity Risk Premia Investing?

Equity risk premia can be sourced from different dimensions. The traditional way of looking at risk premia in equities is to follow the capital asset pricing model (CAPM) and measure the amount of return generated through exposure to equity markets in excess of the risk-free rate. However, it is common for investors to decompose this risk (either deliberately or heuristically) into more specific tranches such as the risk derived from regions, sectors or specific stocks.

Traditional active investment management: monitors the risks derived from active stock selection

Traditional active investment management selects stocks to invest into and then monitors the risks derived from these stocks. As part of this process investors monitor the amount of risk coming from market exposure as well as the different market dimensions (region, sector, etc.). In contrast, Risk premia investing selects the desired level of risk derived from different market dimensions and then selects stocks in order to hold a portfolio with those risk exposures.

The standard approach to gaining risk premia exposure is through ranking stocks based on quantifiable characteristics and then buying equal amounts of the top quintile whilst shorting the bottom. This roughly equates to zero market exposure whilst gaining premia specific exposure. While the standard quantile based approach is appealing due to its simplicity there are a number of limitations including:

Risk premia investing: creates a portfolio/index of stocks to satisfy the desired level of risk exposure derived from different market dimensions …

- Information in the middle quantiles or centre of the distribution is completely ignored;
- Information embedded within the relative ranking of stocks in the top and bottom quantiles is ignored in the average process;
- Style exposure may be “infected” with significant exposure to other risk premia.

…indices are constructed to provide exposure to a single risk premia with zero exposure to other premia

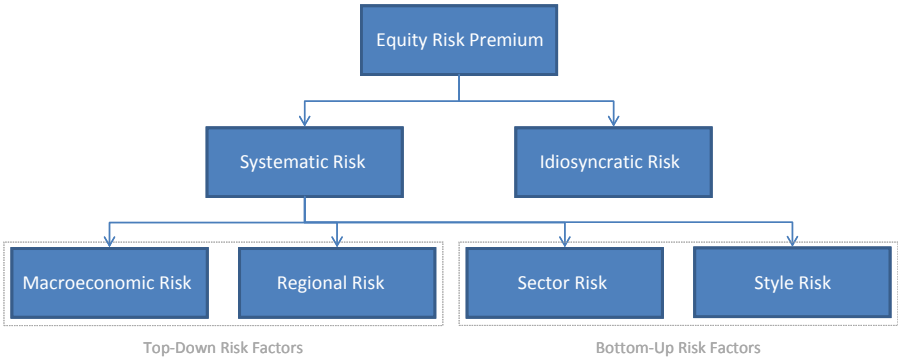
An alternative way of gaining premia specific exposure is to build pure risk premia indices. Pure risk premia indices are constructed such that they provide exposure to one particular risk premia and zero exposure to other premia. The significant benefit to this is that taking a view on one particular sector, style or macro attribute does not lead to additional unintended views which can significantly increase risk. The downside to using pure risk premia indices is that the construction methodology is a little more complex. Despite this more involved construction methodology, pure risk premia indices provide a complimentary perspective to quantile style performance, addressing some of their limitations and providing additional insights.

The Risk Premia Approach

Our proprietary RAM model splits the market into distinct dimensions…

Using Citi's proprietary risk attribution model (RAM) risk can be decomposed into four distinct dimensions; macroeconomic, regional, sector and style as depicted in Figure 2. Each dimension aims to explain a specific component of systematic risk which investment managers can allocate exposure to.

Figure 2. Decomposition of equity returns

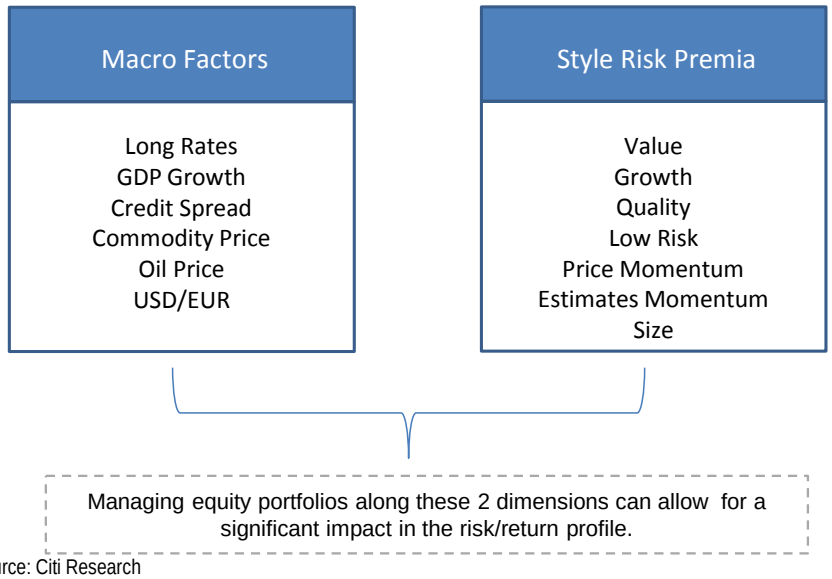


Source: Citi Research

…so that individual risk premia and be independently harvested

Figure 3 outlines the macro and style risk premia which we are harvesting. Whilst macro and style risk premia are always going to be subjective and open to debate, these indices represent premiums commonly documented in literature and which are perceived to describe the return/risk well within the equity class[5]. Furthermore, these risk premia are also globally consistent with the style definitions used in our more traditional quantile based approach allowing robust comparison across regions, countries and methodologies.

Figure 3. Macro and style definitions



Source: Citi Research

[5] Style factors are commonly referred to as risk premia or market anomalies whereas macro factors are not generally considered market anomalies but more the drivers of the overall market. Here we use risk premia to denote styles and risk factor to denote drivers.

Style Indices

We define our equity risk premia from well-established styles within academic literature

Our equity style classifications, along with the accompanying factors which we associate to the risk premia, can be seen in Figure 4. Equity style classifications contain an element of subjectivity and we by no means claim that these are the only available styles. Here we have focused on well-established styles within the academic literature which have been published on for a significant period of time. Equity style risk premia can be broadly divided into three categories by the inherent turnover of the styles, namely, low turnover, medium turnover and high turnover styles. Below we outline the risk premia the indices capture as well as some key associated literature to the style.

Figure 4. Factors within each Risk Premia

Style Index	Descriptors	
Size	Market Capitalisation (log)	
Value	Earnings Yield (12 month forward)	Earnings Yield (12 month historical)
	Cash Flow To Price	Dividend Yield
	Book to Price Ratio	Sales to Price Ratio
	EBITDA / EV	Sales / EV
Growth	Earnings Growth (12 month forward)	S&P Growth-Value Score
	One Year Sales Growth	Long Term Earnings Growth
	One Year EPS Growth	One Year DPS Growth
Low Risk	Debt to Equity (Inverted)	Earnings Stability
	Beta against MSCI AC World (Low-High)	Beta against MSCI Country Index (Low-High)
Quality	Earnings Certainty	Return on Equity
	Net Profit Margin on Sales	Margin Growth
	Earnings Quality (Accruals) (Inverted)	Balance Sheet Quality (NOA) (Inverted)
Price Momentum	3 Month Volatility Adjusted Price Trend	12 Month Volatility Adjusted Price Trend
	First 11 Month Volatility Adjusted Price Trend	
Estimates	1 Month Change in Earnings Forecast	Earnings Revision
	Sales Revisions	Cash Revisions

Source: Citi Research

Low Turnover Styles

- **Quality**: the quality premium is a measure of the excess return of high quality stocks relative to low quality stocks. Earnings quality is perhaps the most examined aspect of firm quality, typically measured through accruals (see Sloan 1996, Xie 2001). Other measures of quality include profit margin, profit margin growth, ROE, balance sheet quality and EPS certainty. Many of these variables constitute elements of Piotroski (2001) aggregate score which determines the financial strength of a company.

- **Low Risk**: the low risk premium is a measure of the excess return of low risk stocks relative to high risk stocks. This premium was first documented by Black, Jensen, and Scholes (1972) with a focus on market beta. Some other recent studies focus on total volatility (e.g. Baker, Bradley, and Wurgler (2011)), while others on residual volatility (e.g. Ang et. al. (2006)). In addition to the beta measures, which are purely price-driven, we measure firm's balance sheet risk through the inclusion of earnings stability and leverage.

- **Size**: the size premium is a measure of the excess return of small cap stocks relative to large cap stocks. Studies like Banz (1981) and Reinganum (1981) have shown how a firm's size is related to the cross-section of equity returns. Fama and French (1993, 1996) have also demonstrated that the size premium (along with the value premium) can adequately explain a number of return anomalies, together with value related metrics.

Medium Turnover Styles

- **Value**: the value premium is a measure of the excess return of value stocks, which are stocks with relatively low valuation, over stocks with high valuation. Several valuation ratios have been proposed in the academic literature that include (but are not limited to) book-to-price (Chan, Hamao, and Lakonishok, 1991), earnings-to-price (Basu, 1977), cashflow-to-price (Fama, 1990), dividend-to-price (Ball, 1978). Fama and French (1993, 1996) have also shown that the value premium (along with the size premium) can adequately explain a number of return anomalies.

- **Growth:** the growth premium is a measure of the excess return of stocks with positive/stronger growth in their earnings or sales, over stocks with negative/weaker in the respective domains. Earnings and earnings growth have long been viewed both theoretically and empirically as fundamental determinants of stock returns (see, e.g. Easton and Harris 1991, Ali and Zarowin, 1992, Easton et al., 1992; Ohlson and Juettner-Nauroth, 2005).

High Turnover Styles

- **Estimates Momentum**: the estimates momentum premium is a measure of the excess return of stocks with upward revisions in their EPS, sales and cashflow forecasts over stocks with downward revisions. Niederhoffer and Regan (1972) conclude that '…stock prices are strongly dependent on earnings changes, both absolute and relative to analysts' estimates. Several works thereafter have focused on the changes of other measures of profitability such as sales and cashflow.

- **Price Momentum**: this premium is a measure of the return spread between stocks with relatively high recent returns and stocks with lower return trends. This premium was first documented in Jegadeesh (1990) and was further studied in Chan, Jegadeesh and Lakonishok (1996) amongst many others that followed.

These styles are not exhaustive but representative of more stable premia suitable for strategic allocation

We reiterate that the risk premia chosen above are not the only risk premia one can consider when it comes to harvesting risk premiums in equity markets. Furthermore, there are alternative factors which can be used to capture risk premia defined above. However, we do believe that they represent a set of factors which are deemed to capture long-term risk premia in the market and therefore exhibit more stable profiles – suitable for strategic allocation - rather than other recent shorter-term factors such as liquidity which might be more appropriate for tactical allocation.

Macro Indices

Macro Factor Premia aim to characterize broader macroeconomic conditions…

Macro factors are outlined in Figure 5. These individual indices have been selected in order to characterize the broad macroeconomic conditions and are the same as the macro factors used in Citi's proprietary risk attribution model (RAM). Citi clients have had access to RAM for over 10 years for portfolio risk attribution. The latest version can be downloaded from Citi Velocity.

…and are used in our proprietary risk models…

…and facilitate hedging and speculation on related macro views

Unlike the style risk premia which are associated to specific mispricing, it is not always clear whether an investment manager would chose to be long or short a macro index at a particular point in time. However, these indices enable both hedging and speculation on key elements of the broad economy and remove the necessity to have interlinked macro views.

Figure 5. Macro factor sensitivity calculation[6]

Macro Factor	Calculation
Long Rates	% change in Euro 10Y rates
Economic Growth	% change in consensus GDP growth forecasts
Commodity Inflation	% change in GSCI non-energy commodity index
Credit Spread	% change in Citigroup HY index less 10-Yr Sov Bonds
Oil Price	% change in Brent Crude Oil price
Currency	% change in USD/EUR exchange rate

Stock Return and Factor History

Regression

Stock Sensitivity to Factors

$$R_s = \alpha_s + \sum_{k=1}^{6} \beta_k^s F_k^s + \varepsilon_k^s$$

Sensitivity to each factor are determined by a robust regression using 10 years of monthly returns.

Empirical analysis suggests that sensitivities to the core macro factors are quite resilient over time. The objective here is to capture the structural sensitivities of every stock from a given universe.

Source: Citi Research

Macro exposures are calculated, in Europe for example, through a regression using 10 years of monthly data. Returns of each stock are time series regressed against macro factors in order to estimate the sensitivities of each stock to macro factors. The macro sensitivities for each stock form the basis of stock weights within macro factor indices.

[6] GRAM-X: Global Risk Attribution Models eXtended Platform, September 2013, Citi Research

Risk Premia Construction Methodology

Perspective 1

Risk Premia Exposures

Factors from previous Citi Quantitative research and academia…

The first step in the index construction process involves the identification of the most important systematic drivers of risk and return across global markets over the long term. Using results from the extensive style performance research published by the Citi Global Quantitative Research team together, with stylized facts documented within academic literature, we arrive at our style risk premia as defined in the 'Style Indices' section of the report. We then utilize arbitrage pricing theory (APT) which prices assets as a linear function of factors.

…winsorised and equally weighted to form style composite factors and associated risk premia

For each risk premia, we calculate exposure through selecting a list of factors that best represent that specific attribute. For example we use a range of defensive and cyclical price based ratios to describe the Value attribute. After identifying factors to use for each style risk premia the data is winzorised, normalized and then equally weighted in order to form the style composite factor. This approach is consistent with the style loadings that we use for quantile based style indicies.

Macro factors are simply a stocks exposure/beta to the underlying macro series

For macro factors the descriptive factor is the macro series itself. The exposure of a stock to the macro series is calculated through a time series regression comprised of a stocks monthly return in excess of the market against the macro series.

$$R^i = \alpha_i + \sum_{k=1}^{6} \beta_k^i M^k + \varepsilon^i$$

Where:

R = Returns for stock i;
M = Macro index value for the 6 indices;
β = 1 to k factor sensitivities (for each macro factor);
i = 1 to n stocks (separate regression for each);
k = 1 to 6 macro indices;
β = 1 to k factors (for each of style, country and sector).

This regression captures each stocks sensitivity to each of our macro factor which are then used in the next phase of index construction.

Building Pure Style Factors

'Pure' styles consider relationships with other factors…

While the above process determines the factor exposure of a stock to macro and style risk premia it does not consider the relationship between different factors. The next process orthogonalises risk premia so that we create pure exposures. One of the main questions of any orthogonalisation procedure is what exposures should one remove and how far should one go – that is, should you try and orthogonalise for every exposure that you can think of? In our case we neutralise other style, country and Industry effects within each style, and other macro and country effects within each macro factor[7].

…and are orthogonal to macro, style, country and industry effects

Stripping out the influence of macro to style exposure was one consideration however we settled on our current methodology such that we aren't removing every form of return variability from our indices. One could argue that the macro environment plays an important part in the performance of style performance and therefore the decision on the relative weighting of style exposure within an investment strategy. Furthermore, there is a clear distinction between macro factors and style risk premia in that macro sensitivities are market observed variables whereas style risk premia are mispriced anomalies which are thought to generate risk adjusted returns in excess of the market. It is therefore intuitive to keep them separate.

Macro sensitivities are market observed variables…

To calculate pure risk premia, cross sectional regressions are run for each time period regressing stock returns against country and sector dummies as well as either macro or style sensitivities.

…where style premia are mispriced anomalies…

$$R_t^i = \alpha_i + \sum_{k=1}^{6} P_k^i \beta_{t-1}^k + \sum_{k=1}^{k} P_k^i C_{t-1}^k + \varepsilon_t^i$$ -Macro Factor Regression

..and are separated in our process

$$R_t^i = \alpha_i + \sum_{k=1}^{7} P_k^i S_{t-1}^k + \sum_{k=1}^{10} P_k^i IG_{t-1}^k + \sum_{k=1}^{k} P_k^i C_{t-1}^k + \varepsilon_t^i$$ - Equity Style Regression

Where:

R = returns for stock i ;
S = style premia loadings (7) for stock i ;
β = macro factor sensitivities (6) for stock i;
IG = dummy loadings for GICS sector membership (10) for stock i ;
C = dummy loadings for country membership (the number varies depending on underlying index) for i ;
i = 1 to n stocks;
t = 1 to T time periods;
f = 1 to k factors (for each of style, country and sector).

[7] Sectors are not included in Macro regressions to ensure all macroeconomic interactions are included. For example, including an energy dummy when constructing the oil price factor is likely to diminish the usefulness of the overall index.

Given our systematic loadings at time t-1and current stock prices at t, we are solving for the stock-level pure returns for each systematic factor grouping which is represented by $P^{i}_{(\beta+s+ig+c)}$ in the above equation. This can be seen more clearly through matrix notation where F is matrix of all the systematic factor loadings (macro, style, sector and country) and as stated, we are solving for P.

$$R_t = P_t^{'} F_{t-1}$$

The standard OLS solution for P is:

$$P_t = \left(F_{t-1}^{'} F_{t-1}\right)^{-1} F_{t-1}^{'} R_t$$

Where:
P_t = a row vector (1,*m*) of pure style portfolio returns from time *t-1* to time *t* ;
R_t = a column vector (*n*,1) of stock returns from time *t-1* to *t* ;
F_{t-1} = matrix (*n,m*) of style or macro factor loading formed at time *t-1*.

From the above derivation $\left(F_{t-1}^{'} F_{t-1}\right)^{-1} F_{t-1}^{'}$ represents pure factor weights for each stock.

Perspective 2: Construction of Indices

An alternative explanation is to split the construction process into two non-contemporaneous parts: the construction of the style portfolio exposures; and then the construction of the style return indices.

Part 1: Building of Style Portfolio Exposures

Construct style portfolios that have a unit exposure of 1 to themselves with zero exposure to all other styles

Style portfolio exposures are function of the style loadings and their corresponding betas. In matrix notation (simplified version):

$$Y = B^{'} F$$

Where (the equation above is contemporaneous, hence ignoring the time subscript):

Y = matrix (*n,m*) factor portfolio exposures;
B = matrix (*n,m*) of style portfolio weights;
F = matrix (*n,m*) stock exposures to style/country/sectors;
n = number of stocks;
m = number of styles, country and sectors.

Given our desire for a set of linearly independent style portfolios, Y can take the form of an identity matrix, F is our style factor loadings so we are therefore solving for B .

$$B = \left(F^{'} F\right)^{-1} F^{'} Y$$

The result of B is a set of stock level weights for each style that multiplied with the style factor loadings, produces orthogonal style exposures[8]. Or in other words, each style portfolio has a unit exposure to itself and zero exposure to all other styles.

[8] We also constrain the weighted sum of the sectors to be zero.

Part 2: Construction of Style Return Indices

Calculate style returns using the resultant long/short weights from the above 'pure' style portfolios

As part of the construction of the style portfolio exposures, at a point in time, we are left with a set of style portfolios and their corresponding long-short stock weights. Bringing this part of the style index construction to return space (i.e. the B matrix), we assume that cross-sectional stock returns over any period can be expressed with the following equation:

$$P_t = R_t^{'} B_{t-1}$$

Where:

P = a row vector (1,m) of pure style portfolio returns from time t-1 to time t

R = a column vector (n,1) of stock returns from time t-1 to t

B = matrix (n,m) of style portfolio weights formed at time t-1

Given we know R and we have calculated B, the product of the these two matrices is P, the return of each pure systematic factor (in total, *m*) at time *t*.

Index Characteristics

In this section we analyse key characteristics of the pure and quintile risk factor indices using the indices built on the MSCI Europe stock universe for illustrative examples.

Factor Relations

Unlike quintiled style equity risk premia, pure style risk premia have zero correlation to each other

By construction each pure style index is meant to have a unit beta to itself and a beta of zero to all other styles at the time of the monthly rebalance. This is in contrast to the quintile approach which creates style portfolios with significant residual exposure to other styles.

Ex-post pure risk premia correlations are not precisely zero…

In order to examine the ex-post relation between styles, Figure 6 shows full sample correlations for both the pure (lower triangle) and quintile (upper triangle) index construction methodologies. While pure risk premia correlations are not precisely zero, they are broadly distributed around zero and are, as expected, significantly lower (in absolute terms) than the quintile construction methodology.

…but are significantly lower than the quintiled construction methodology…

Figure 6. Risk Premia correlations January 2001-September 2013

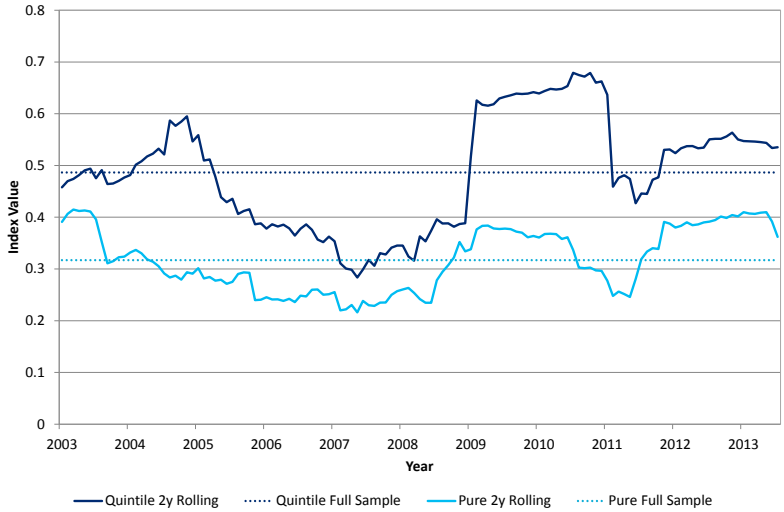
Lower Diagonal **Pure** index correlartions	Upper Diagonal **Quintile** portfolio correlations						
	Value	Growth	Low Risk	Size	Quality	Price Momentum	Emo
Value		-76.6%	-50.0%	-66.6%	-52.8%	-58.0%	-49.9%
Growth	24.3%		59.6%	60.9%	53.9%	57.2%	51.1%
Low Risk	-21.7%	-53.2%		57.9%	78.3%	78.7%	73.4%
Size	-6.5%	-27.9%	35.1%		60.8%	60.4%	58.9%
Quality	-15.6%	-8.9%	42.2%	25.6%		69.7%	62.5%
Price Momentum	-12.8%	-17.7%	54.9%	35.1%	36.3%		86.0%
Emo	9.2%	-11.1%	31.4%	20.2%	13.7%	27.7%	

Source: Citi Research

…enabling more predicable correlations, tighter risk controls and better execution of style views

While Figure 6 examines correlations across the whole time period Figure 7, on the following page, uses 24 month absolute pairwise correlations of both the pure and quintile sets of indices. Quintile absolute pairwise correlations are consistently higher than the pure indices and are over 75% more volatile with a standard deviation of 11% v 6% respectively. Both Figure 6 and Figure 7 highlight the lower, more predictable correlation structure between the pure indices enabling tighter risk management controls and better execution of style views.

Figure 7. 2y Rolling Risk Premia absolute pairwise correlations



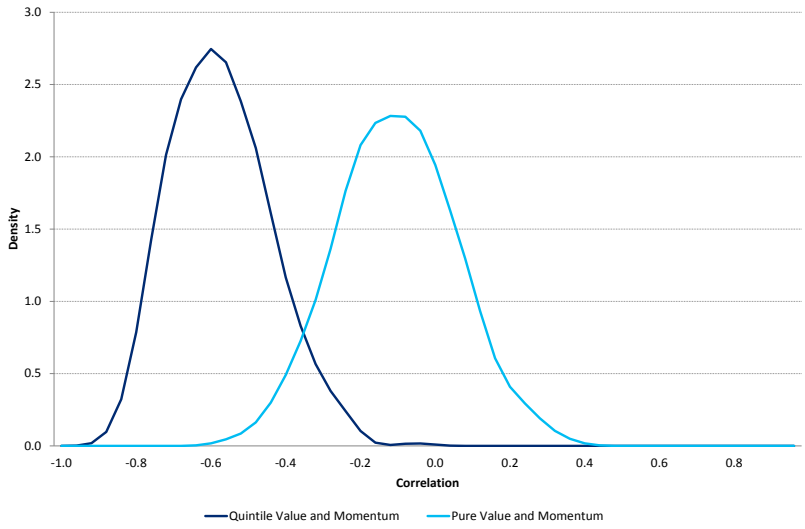
Source: Citi Research

'Pure' Value/Momentum correlation is centred around zero…

…whilst quintiled Value/Momentum correlation has a strong negative bias

This can also be observed when examining the distribution of correlation between two styles. Figure 8 uses 1000 resamples of subsets of data in order to infer correlation distribution of both the pure and quintile equity risk premia. Here we can see the pure index correlation is broadly centred around zero whereas quintile value momentum correlation has a structural negative correlation. Performing a Kolmogorov-Smirnov goodness of fit test between these two distributions generates a p-value of 0.039 rejecting the null hypothesis at 5% significance suggesting these distributions are statistically different

Figure 8. Value and Momentum Correlation Distribution



Source: Citi Research

Quintiles styles have a surprisingly high level of market exposure despite being constructed to be market neutral

An alternative approach to examining the extent to which risk factors are orthogonal is through calculating the time series regression coefficient between styles. These are displayed in Figure 9 and again highlight the lower interdependence of pure versus quintile styles. It is particularly interesting to examine the exposure of the various styles to the market. Despite being long short and so allegedly market neutral, quintile styles have a surprising amount of market exposure.

Figure 9. Risk Premia time series exposure of styles January 2001-September 2013

Quintile Portfolios

Risk Factor (y) \ Regressor Factor (x)	Market	Value	Growth	Low Risk	Size	Quality	Price Momentum	Emo
Value	0.38	1.00	-1.10	-0.37	-0.97	-0.80	-0.48	-0.65
Growth	-0.24	-0.54	1.00	0.31	0.62	0.57	0.33	0.46
Low Risk	-0.76	-0.68	1.16	1.00	1.14	1.60	0.88	1.30
Size	-0.23	-0.46	0.60	0.29	1.00	0.63	0.34	0.53
Quality	-0.31	-0.35	0.51	0.38	0.59	1.00	0.38	0.54
Price Momentum	-0.53	-0.70	0.99	0.70	1.07	1.27	1.00	1.36
Estimates Momentum	-0.28	-0.38	0.56	0.41	0.66	0.72	0.54	1.00

Pure Portfolios

Risk Factor (y) \ Regressor Factor (x)	Market	Value	Growth	Low Risk	Size	Quality	Price Momentum	Emo
Value	0.08	1.00	-0.15	-0.06	-0.16	-0.11	-0.07	-0.09
Growth	0.09	0.27	1.00	-0.09	-0.08	-0.16	-0.08	-0.11
Low Risk	-0.20	-0.34	0.23	1.00	0.26	0.38	0.22	0.32
Size	-0.05	-0.07	0.06	0.06	1.00	0.13	0.08	0.12
Quality	-0.07	-0.13	0.13	0.08	0.14	1.00	0.08	0.09
Price Momentum	-0.15	-0.21	0.29	0.21	0.30	0.35	1.00	0.42
Estimates Momentum	-0.02	0.07	0.07	0.06	0.09	0.13	0.07	1.00

Source: Citi Research

Macro Characteristics of Style Indices

Our styles are not orthogonalised to macro factors since style rotation models are likely to utilise macro…

Given that our styles have not been orthoganalised against macro factors it is interesting to examine the extent to which styles are driven by macro variability. The extent it is desirable for style factor returns to be related to macro factors is debatable. On one hand, large significant links between style and macro factors carries risk as taking a view on a style has potentially hidden embedded macro views. However, on the other hand, it is common for style rotation models to utilise macroeconomic information when selecting future style exposures. If styles are not linked to macro factors then this reduces these style timing models to little more than noise.

…doing so may reduce style timing models to little more than noise

It is desirable for styles to have macro sensitivities…

The net result, in our opinion, is that it is desirable to have style risk premia with sensitivity to macroeconomic factor exposures, as long as these exposures are not so large that they introduce significant exogenous volatility.

…provided they do not introduce significant volatility

In order to examine the extent to which our pure equity risk premia indices are affected by macroeconomic variables, the below utilises Citi's proprietary risk attribution model (RAM) to stress test style performance in relation to macroeconomic moves. RAM is a macroeconomic time series based model that can be used to predict portfolio volatility and to run volatility decompositions and scenario analyses.

Through running a macro sensitivity analysis on each style portfolio, as shown in Figure 10, the macro sensitivities for each style can be determined. Each row shows the likely return to the index for a one standard deviation move in the respective RAM factor, assuming a static long run factor covariance. This analysis provides a rudimentary scenario analysis of the performance impact for a large change in any of the RAM or specifically macro factors.

Pure equity risk premia have macroeconomic exposures

For example, if interest rates were to increase by one standard deviation, 18.8%, Low risk is forecast to outperform by 2% and growth to underperform by 1.17%. This is also intuitive from a theoretical perspective as increasing rates reduces the present value of future earnings; broadly a negative for stocks.

Figure 10. Pure Style Risk Premia macro factor stress testing

	Factor Volatility	Value	Size	Low Risk	Quality	Price Momentum	Growth	Estimates Momentum
Euro Long Rate	18.84%	0.32%	-0.62%	2.02%	0.91%	-0.17%	-1.17%	0.22%
Cdty Price Inflation	17.09%	0.48%	1.90%	8.18%	3.47%	0.99%	0.36%	1.07%
European Growth	72.41%	0.73%	0.70%	5.12%	0.93%	-1.69%	-0.15%	-0.54%
Oil Price [USD]	32.15%	0.70%	0.57%	6.57%	3.34%	1.69%	-0.97%	0.68%
FX rate	10.89%	0.08%	1.34%	9.36%	2.87%	-1.03%	1.66%	0.47%
Credit Spread	32.50%	-1.08%	-1.30%	-9.61%	-1.96%	2.71%	0.16%	0.79%
Market	9.56%	0.32%	-0.19%	7.05%	1.16%	-2.98%	0.39%	-0.67%

Source: Citi Research

Factor Performance Analysis

Previous analysis has examined the relationship between equity risk premia, finding pure risk premia are significantly less correlated and have a simpler, less time dependent risk structure, relative to their quintile counterparts. This section examines how these properties translate into attractive time series factor returns.

Figure 11 shows style and macro factor performance for both pure and quintile construction methodologies. Across all styles, the pure style indices have lower volatility when compared to the quintile indices with relatively similar returns. They are therefore marginally more attractive on an information ratio basis.

Pure equity risk premia have lower volatility with similar returns to their quintile counterparts…

More interestingly, the pure risk premia indices are arguably more symmetric than their quintile counterparts having skewness values closer to zero and only two indices with negative skew. This highlights a key benefit of using the pure indices and orthogonalising each risk factor to all others, consequently reducing negative skew and tail risk for style factors.

…resulting in more attractive Information Ratios

Inference from the macro factors is more difficult as there is not always an obvious direction (e.g. long rates or short rates) to take. Returns and hit rates are therefore approximately zero and 50% respectively.

One significant exception to this is the pure economic growth composite which has large annualised historical returns of 10% with a very significant 61% volatility and exceptionally fat tails with a maximum drawdown of 92%. The large drawdown and volatility of an economic growth risk factor is not entirely unexpected. In the 2008 global financial crisis stocks heavily levered to economic prosperity were hit very hard as brand name investment banks closed their doors and economic confidence deteriorated. Similarly, in the more prosperous 2000's, stocks levered to strong economic growth were exceptionally profitable leading to large, risk driven, gains. *Performance statistics for other regions are available via Bloomberg*.

Macro premia offer little alpha as there is not always an obvious direction…

…the exception being economic growth, although volatility renders economic growth premia un-investable from a risk adjusted perspective

Figure 11. Risk Premia performance MSCI Europe January 2001-September 2013

		Annualised Return	Annualised Volatility	Information Ratio	Hit Rate	Skewness	Kurtosis	Max Drawdown
Pure Style Risk Factor Perf	Value	3.72%	4.45%	0.84	63.39%	0.42	2.48	-16.53%
	Growth	-0.65%	4.29%	-0.15	51.79%	0.81	10.70	-30.45%
	Low Risk	0.28%	5.98%	0.05	50.00%	0.48	3.20	-22.63%
	Size	-0.14%	4.75%	-0.03	45.98%	-0.49	2.94	-26.02%
	Quality	5.16%	3.28%	1.57	68.30%	0.46	0.98	-4.37%
	Price Mon	1.85%	7.24%	0.26	54.02%	-0.62	4.19	-15.13%
	Emo	2.70%	3.64%	0.74	62.95%	0.03	4.09	-9.14%
Quintile Style Risk Factor Perf	Value	4.64%	15.45%	0.30	57.14%	0.56	3.37	-52.21%
	Growth	0.52%	10.63%	0.05	52.68%	-0.71	3.33	-52.42%
	Low Risk	5.57%	17.88%	0.31	58.93%	-0.77	3.76	-50.87%
	Size	0.74%	11.07%	0.07	50.00%	-0.52	2.40	-60.47%
	Quality	7.32%	9.15%	0.80	60.27%	-0.75	4.47	-31.33%
	Price Mon	5.25%	18.10%	0.29	58.04%	-0.90	2.09	-45.64%
	Emo	6.27%	10.61%	0.59	63.84%	-1.30	4.68	-28.46%
Pure Macro Risk Factor Perf	Credit Spr	-1.32%	25.05%	-0.05	52.63%	-0.25	1.25	-67.63%
	Growth	10.40%	61.12%	0.17	46.05%	2.26	11.27	-92.08%
	Commodit	-0.74%	8.06%	-0.09	50.00%	-0.29	2.61	-33.51%
	Oil Price	4.19%	18.59%	0.23	49.34%	0.85	5.60	-45.78%
	Rates	-2.20%	8.85%	-0.25	53.29%	-0.52	0.59	-46.25%
	Currency	1.72%	9.39%	0.18	50.00%	0.49	1.60	-19.30%
Quintile Macro Risk Factor Perf	Credit Spr	0.26%	17.08%	0.02	51.33%	-0.31	1.18	-39.67%
	Growth	0.59%	15.33%	0.04	49.33%	1.28	5.24	-42.75%
	Commodi	2.02%	9.02%	0.22	52.67%	-0.36	1.20	-19.27%
	Oil Price	0.04%	7.90%	0.00	50.00%	-0.05	0.42	-22.91%
	Rates	3.15%	8.43%	0.37	56.00%	0.22	0.62	-12.07%
	Currency	-0.62%	11.81%	-0.05	50.00%	-0.13	2.22	-42.36%

Source: Citi Research

Index Applications

Style Timing

One clear application of pure style indices is the relatively easy implementation of a style timing model. Holding a small number of indices rather than hundreds of equities is a significant operational benefit and significantly streamlines execution of style based trade ideas.

Replacing a stock level alpha model with pure equity risk premia has clear benefits…

As an illustrative example, Figure 12 and Figure 13 show backtest performance from a simple, equally weighted Value, Quality, Price Momentum (PM), Estimates Momentum (EM) strategy executed both at the stock and pure index level. For the stock model, each stocks Value, Quality, PM and EM scores are equally weighted every month leading to a monthly composite score for each stock. The strategy then buys the highest scoring stocks and shorts the lowest for the following month.

In contrast, the index model is simply returns from a portfolio holding four pure style indices, Value, Quality, PM and EM rebalanced every month end. Figure 12 displays summary stats of both strategies. The stock based strategy has higher risk and return characteristics and exhibits significantly more tail risk with negatively skewed fat tails.

…with the 'pure' style approach consistently outperforming

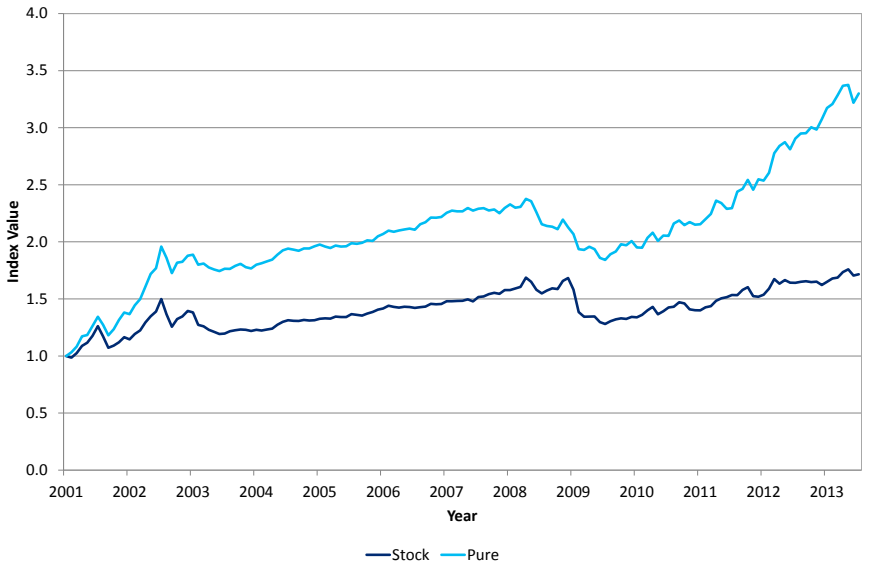
Figure 13 plots time series performance with both strategies levered, ex-ante, to 10% risk facilitating comparison. Here we can see the index strategy has consistently outperformed the stock strategy over the backtest period.

Figure 12. Backtest summary statistics

	Stock Model	Index Model
Return	8.75%	3.35%
Risk	17.21%	2.58%
IR	0.51	1.30
Max	13.62%	2.80%
Min	-19.77%	-1.89%
Skew	-1.07	0.05
Kurtosis	3.29	1.63
Hit Rate	62.00%	69.20%
Max Drawdown	-40.39%	-6.34%

Source: Citi Research

Figure 13. Backtest performance (levered to 10% volatility) January 2001 to September 2013



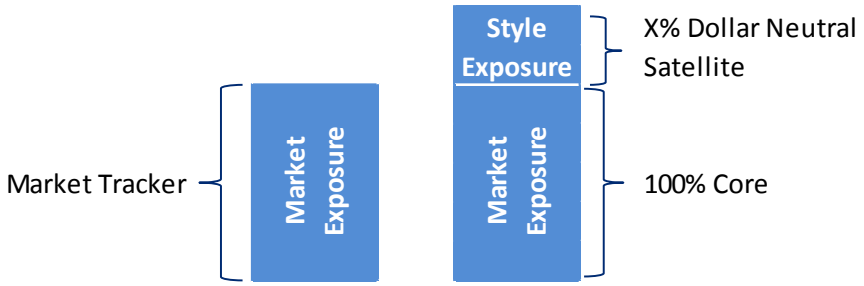
Source: Citi Research

Core Satellite Enhanced Indices

Index returns can be enhanced by overlaying exposure to pure style risk premia

Due to the dollar neutral nature of the pure style indices they can be used to gain exposure to a style risk premia relatively cheaply. Enhanced mandates can hold the market portfolio and then select a particular style tilt through obtaining exposure to a pure factor index.

Figure 14. Core Satellite Construction



Source: Citi Research

This generates robust outperformance without significantly increasing risk

As an illustrative example, Figure 15 examines the performance of the MSCI Europe relative to an enhanced MSCI Europe with 25% Quality exposure. The 125% gross investment exposure is possible due to the dollar neutrality of the pure factor indices.

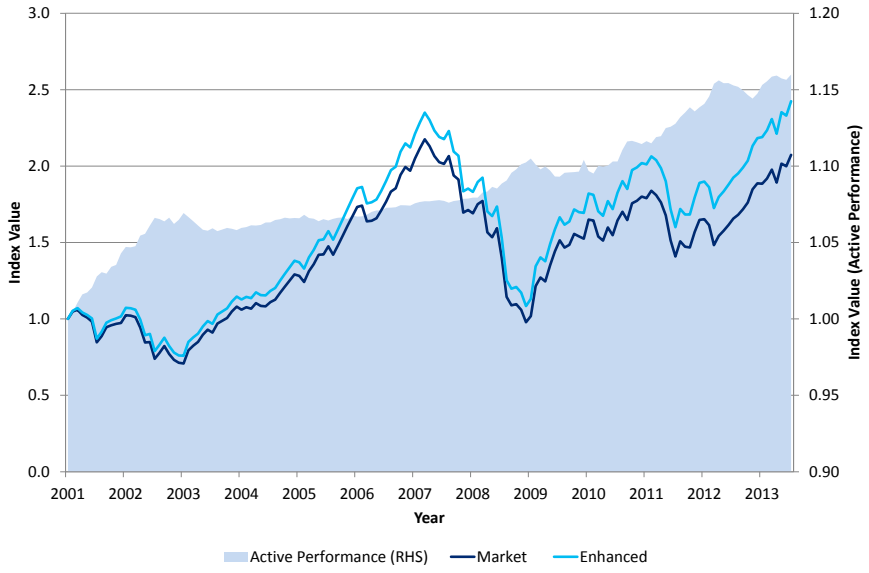
The enhanced strategy has a 0.25% tracking error to the market and earns over 1% in additional performance per year with a 0.4% reduction in risk. The hit rate of the enhanced strategy has improved with the enhanced portfolio outperforming the market 67% of the time.

Figure 15. Backtest Summary Statistics

	Market	Enhanced	Active
Return	7.39%	8.58%	1.19%
Risk	17.42%	17.05%	0.84%
IR	0.42	0.50	1.42
Max	19.30%	18.95%	0.73%
Min	-18.19%	-18.01%	-0.66%
Skew	-0.64	-0.68	0.39
Kurtosis	2.36	2.44	0.59
Hit Rate	60.00%	60.67%	66.67%
Max DD	-55.01%	-53.88%	-1.11%

Source: Citi Research

Figure 16. Backtest performance (levered to 10% volatility) January 2001 to September 2013, EU Market + Quality



Source: Citi Research

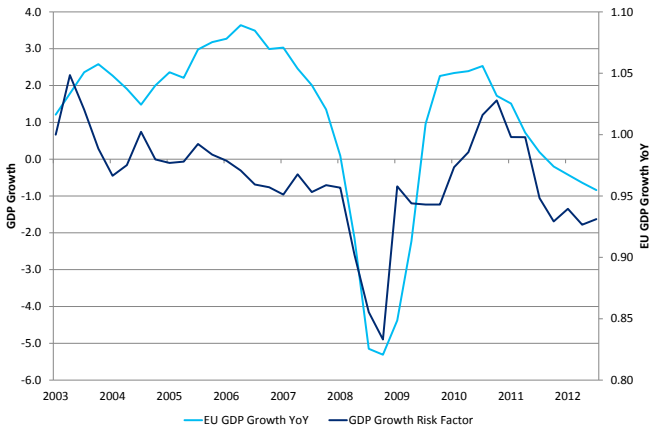
Economic Exposure

Pure macro factor indices…

…high correlation with the underlying enable macro views to be taken via synthetic equity portfolios

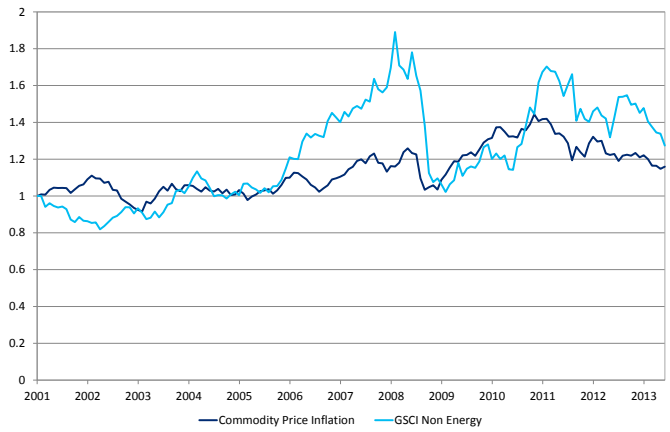
A clear application of the pure macro factor indices is to use equities to gain exposure to economic indices. Figure 17 and Figure 18 plot the pure macro factor indices for Economic Growth and Commodity Price Inflation against GDP growth and GSCI Non energy indices respectively. These highlight the relatively similar performance of the pure macro indices to the underlying economic series suggesting the pure macro factor indices are an efficient way to take macro views through equities.

Figure 17. Economic Growth Factor v European GDP Growth



Source: Citi Research,

Figure 18. Commodity Price Inflation Factor v GSCI Non Energy



Source: Citi Research

Portfolio Exposure Tilts

Pure style indices…

Pure style indices can also be used in conjunction with stocks for speculating and hedging risk. It is possible to alter a portfolio's macro or style tilts without changing the underlying idiosyncratic risk of the equities held. For example, an overweight banks sector tilt might also lead to a portfolio with a Value tilt. This Value tilt can be hedged away such that the portfolio is only exposed to macro and idiosyncratic bank specific drivers and not to other style biases.

…can also be used to hedge unwanted style exposures without unnecessary portfolio turnover

Another useful application of pure indices is in performance attribution and manager selection. Pure indices theoretically provide a higher alpha benchmark to active managers and also reduce style standard errors around exposure estimates due to the low dependent variable correlations. This increases the accuracy of performance attribution by cleansing performance drivers and increasing the ability to determine true alpha generating managers.

Implementation

There are a number of implementation challenges such as liquidity, transaction and stock borrow constraints

So far this research has analytically derived pure factor portfolio weights. There are however, a number of challenges in implementation which need to be addressed in order to make the indices investible. The most obvious is in liquidity constraints. Given the weights of pure indices are not related to a stocks market capitalization, theoretical weights might entail holding over 100% of the free float. One solution to this problem is to remove stocks with an average daily volume less than some given threshold from the universe related to the size of assets under management. An alternative is to impose single stock limits as a linear constraint.

Another consideration is the inability to short stocks. The above methodology results in stock weights which can be either positive of negative and which sum to zero leading to dollar neutral index weights and approximately zero exposure to the market. This is attractive as it is largely self-funding in the sense that short positions pay for the long exposure. However, shorting stocks can be expensive and is not always possible due to exchange restrictions and borrow availability.

While removing unavailable or expensive short stocks from the investible universe is one possible solution, it is not viable when a whole tranche of the market is on short restrictions, such as European bank stocks in 2011. In this case a viable alternative would be to re-base weights relative to a market and construct indices with a market beta of 1. Market beta can then be managed separately through futures hedging.

Here we incorporate a set of realistic constraints to highlight the cost of implementation

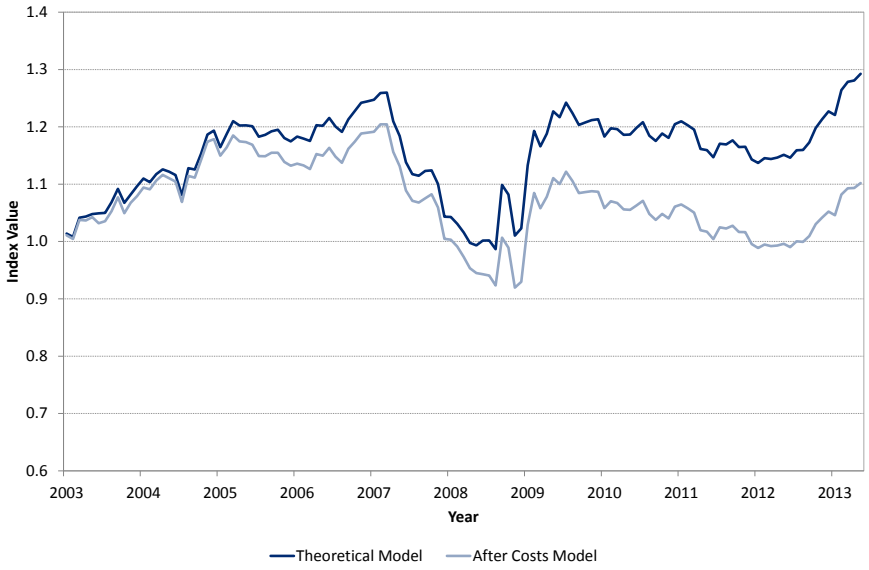
In order to highlight the costs associated to implementation, Figure 19 examines the performance of MSCI US Value pure risk premia with a significant number of implementation restrictions imposed. Stocks with a 1 month average daily volume below 15 million euros and a 10 day average daily trading VWAP volume less than 25 million euros are removed. In addition, 30 basis point transaction costs are implemented along with a cost to borrow of 50 basis points per annum. We would have liked to impose the additional constraint of removing stocks with a cost to borrow of greater than 1%, however, we did not have access to this data going back through time.

Figure 19. Backtest summary statistics

	Pre Costs	Post Costs
Return	2.75%	1.20%
Risk	7.63%	7.44%
IR	0.36	0.16
Max	11.35%	10.68%
Min	-6.62%	-7.03%
Skew	-0.41	-0.80
Kurtosis	8.87	6.84
Hit Rate	56.00%	52.40%
Tracking Error		1.57%

Source: Citi Research

Figure 20. Backtest performance January 2003 to September 2013, US Pure Value



Source: Citi Research

Here we can see the persistent drag on performance through time due to trading constraints and transaction costs leading to a tracking error of 1.5%. In implementation, we found trading costs to be a much more significant contributor to tracking error than liquidity problems, which are equally likely to contribute to performance as well detract from it.

Higher turnover risk premia styles, such as price momentum, generate higher tracking error of around 5%. Even in the depths of the financial crisis, there were rarely more than ten stocks removed per month due to liquidity concerns. Implementing short constraints will increase this number as discussed above with potential beta hedging possibilities available to mitigate the problem.

Implications for Active Investing

Easier access to 'Alpha'….

The advent of risk premia based investing has several ramifications for the quant community and more generally for active management. Before risk premia based investing it was relatively difficult to get exposure to a certain investment style or documented market anomaly. Investors were restricted to investing in actively managed funds with investment processes resulting in a particular style exposure. However, with the evolution of style based products (e.g. ETFs), even retail investors have access to the style anomalies they wish to be exposed to. Furthermore, the fees investors are willing to pay for such exposure has significantly decreased.

…has led to lower fees

While this renders traditional active management more difficult, as a significant swathe of alpha has now been reclassified as beta, it does offer opportunities particularly for quantitative or systematic investors. The factor exposure decision, which was once a consequence of stock selection, is now an active decision for investment managers to take. While style exposure is now readily available, it is not always apparent which exposure to take. The drivers behind style performance have been an active area of research since the mid-1990s for active quantitative investors with the topic likely to increase in relevance going forward.

Un-commoditised alpha should still be rewarded and is easier to identify

Another interesting implication is in the search for true alpha generators. Pure risk factor indices enable more accurate performance attribution which reduces the error in estimating alpha[9] thus benefiting active managers with true / un-commoditised alpha. Furthermore, as passive money flows into "naïve" style exposures their performance is likely to be arbitraged away again, increasing the gap between new / alternative sources of alpha and historic, now commoditised, factor anomalies. While identifying true alpha can be challenging, the benefits from "having it" are likely to increase going forward.

We expect pure syle risk premia to become cheaper, follow the main equity index ETF market in lower fees

This crowded trade problem is likely to be compounded by a small number of asset managers competing for the majority of risk premia mandates. Given the homogeneity of the product there are significant benefits to scale, meaning a small number of large providers are likely to be able to offer the product at lower fees than the rest. This has already started in the main equity index ETF and all things being equal, we do not see why it will not extend to risk premia products. This even opens up the possibility for large asset owners to bring fund management in house with execution being considerably easier than it has been in the past. Purchasing large quantities of a small number of risk premia assets is significantly easier to manage than trading in thousands of stocks.

This could be challenging for active management…

…but opportunities should still present themselves through top down risk premia selection

Risk premia investing opens up basic and known 'alpha' strategies to a wider audience at a cheaper price, and so can be seen to be making capital markets more efficient. While this brings challenges to active management significant opportunities still exist in the form of top down risk premia selection and through the likely enhanced profitability of non-commoditised alpha sources relative to their commoditised counterparts.

[9] In a statistical sense, having a more accurate factor model reduces estimation error around parameter estimates

Appendix

Appendix: Highlighted Literature and Further Reading

Figure 21. Summary of Literature

Paper Title	Authors	Factors Used	Construction Methodology	Asset Class
Risk Factors as Building Blocks for Portfolio diversification	Callan Investments Institute (2012)	Various	Proposing mapping factors onto the investable instruments	Cross
Applications of Systematic Indexes in the Investment Process – a new era in index-based asset management	D. Melas and X. Kang (2010)	Volatility, momentum, size, non-linear size, value, growth, leverage, liquidity + countries and industries	Minimum variance, risk-weighted, equal-weighted, pure factors derived weights, Sharpe Ratio weighting and fundamental weighting	Equities
Advancing Strategic Asset allocation in a Multi-Factor World	F. Asl and E. Etula (2012)	Equity, term, funding, liquidity, FX and EM	Advocate robust optimisation over risk parity as the latter ignores expected returns which results in higher allocation in bonds and other low-volatility asset classes. Investors then need to use leverage to increase the risk to the desired level	Cross
Portfolio of Risk Premia: A New Approach to Diversification	J Bender, R Briand, F Nielsen and D Stefek (2010)	Broad equity markets, size, value, momentum and merger arbitrage premiums	Break risk premia into "asset class risk premium", "style risk premium" and "strategy risk premium". Construction of the risk premia indices is done by using existing benchmarks	Cross
Strategic Allocation to Premiums in the Equity Market	D Blitz, Robeco (2011)	Size, value, momentum and low volatility	Discuss passive "smart beta" vs active quantitative funds as ways of obtaining exposure	Equities
A Factor Approach to Asset Allocation – Exposure to global market factors	R. Clarke, H. Silva and R. Murdock (2005)	In equities, they used IBES NTM EY and lagged price momentum (first 11 months)	Propose to gain exposure to factor premia through derivatives	Cross
Smart Beta 2.0	N. Amenc, F. Goltz and L. Martellini (2013)	Utilised readily available equity indices + custom version through EDHEC	Discuss diversity weights, fundamental weights, 1/n, diversified MinV, diversified risk parity, max decorrelation, global MinV, maximum diversification, ERC and maximum Sharpe ratio	Equities
The Death of Diversification Has Been Greatly Exaggerated	A. Ilmanen and J. Kizer (2012)	Value and momentum, together with market premium	Utilise risk parity to combine factor portfolios. Use 36-month rolling annualised volatility to determine the riskiness of the factors when combining. Suggest to combine factor investing with traditional asset allocation to smooth out transition	Cross
Risk Factors as Building Blocks for Portfolio Diversification: The Chemistry of Asset Allocation	E. Podkaminer, CFA (2013)	Developed economic growth, value, size and EM	Through readily available indices	Cross
Factor Indexing	B. Feldman and G. Parker (2012)	Growth, value, momentum, volatility, beta	Gain exposure through Russell-Axioma factor indices	Equities
Efficient Replication of Factor Returns: Theory and Applications	D. Melas, R. Suryanarayanan, and S. Cavaglia (2010)	Value, momentum, size and volatility	5 implementation methodologies: pure factor replication and total risk optimisation with various constraints. Advocate that factor-replicating portfolio with turnover and number of assets constraints can track the underlying factors reasonably well	Equities
Harvesting Risk Premia with Strategy Indices – From Today's Alpha to Tomorrow's Beta	D. Melas, R. Briand and R. Urwin (2011)	Value and volatility	Review risk-based strategies: equal weights, diversity weights, risk weights, minimum variance and low vol. Examine return-based methods: value weighting, earnings yield weighting, risk-adjusted value, classic value, country value (GDP-weighted index) and pure value	Equities
The Myth of Diversification: Risk Factors versus Asset Classes	S. Page and M. A Taborsky (2011)	Value/growth, beta, momentum, size, volatility, liquidity	Recommend a regime-specific approach driven by macroeconomics to portfolio construction and risk management	Cross
Risk Parity Portfolios with Risk Factors	T. Roncalli and G. Weisang (2012)	PCA factors	Show asset-weighted allocation has much higher concentration than ERC weighted approach but ERC approach has larger range than factor equally-weighted construct	Cross
Incorporating Risk Premia Mandates in a Strategic Allocation – A Client Case Study: Wyoming Retirement System	R. Aylur Subramanian (2011)	Value, size and volatility	Value weighted and risk weighted to capture value and low vol risk premiums	Equities
Factor-based Asset Allocation sv Asset-class-based Asset Allocation	T. Idzorek and M. Kowara (2013)	Market, value and size	Use standard indices to proxy risk premiums. Argue neither asset-based nor factor-based approaches are inherently superior. Not convinced that institutional investors would fully embrace the idea of factor investing due to leverage and macro consistency	Equities
Active Management of the Nowegian Government Pension Fund - Global	A. Ang, W. Goetzmann and S. Schaefer (2009)	Value, momentum, size and volatility	Recommend direct factor investing. Factor allocation is determined by (1) risk-return analysis (2) how much factor exposure to bear	Cross
Risk-factor Diversification and Portfolio Selection	S. Pappas, R. Bianchi, M. Drew and R. Gupta (2012)	Market, value and size	Equal-weighted, minimum variance and mean-variance with expected returns derived from a 60-month rolling window. Also risk parity construct with target volatility of 15%. Found longer history suggests no conclusive evidence that factor investing outperforms asset classes	Cross
The Tortoise and the Hare: Risk Premium vs Alternative Asset Portfolios	R. Bird, H. Liem and S. Thorp (2013)	Market, value, size and momentum	Equal-weighting, mean-variance and mean-CVaR optimisations. Found equal-weighting provides more robust risk-adjusted returns	Cross

Source: Citi Research

Appendix: Index Performance

Europe

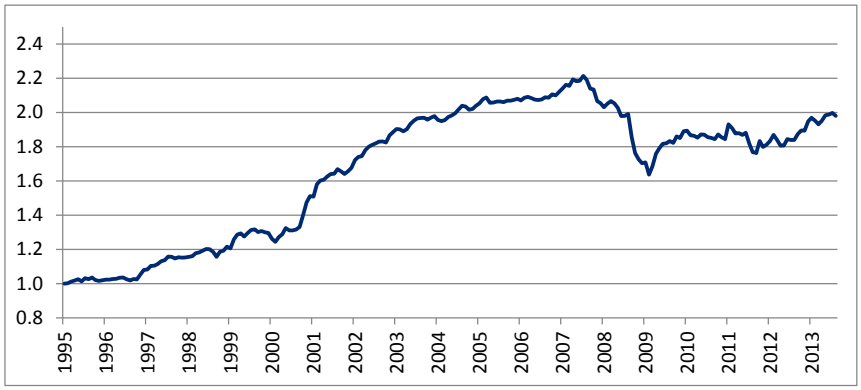
Figure 22. Value pure factor summary statistics

	Pure
Return	3.93%
Risk	5.29%
Information Ratio	0.743
Max Monthly Return	5.50%
Min Monthly Return	-6.90%
Hit Rate	63.39%
Skewness	-0.206
Kurtosis	3.659
Drawdown	-26.02%

Source: Citi Research

Figure 23. Value Pure factor return time series January 1995-September 2013

CGRQPEUV INDEX



Source: Citi Research

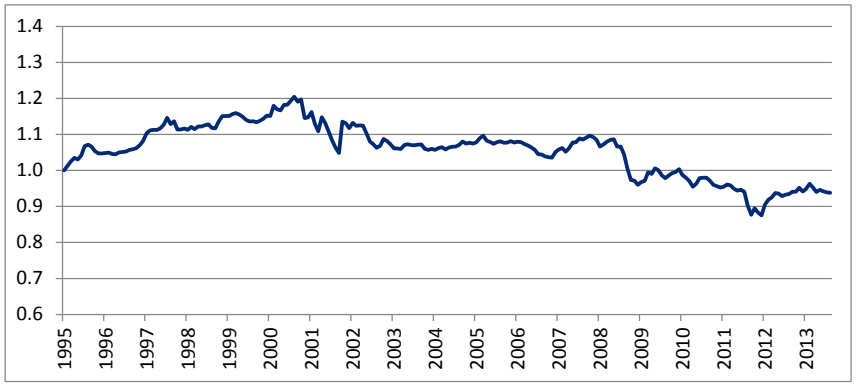
Figure 24. Growth pure factor summary statistics

	Pure
Return	-0.27%
Risk	4.32%
Information Ratio	-0.063
Max Monthly Return	8.32%
Min Monthly Return	-4.34%
Hit Rate	51.79%
Skewness	0.930
Kurtosis	9.690
Drawdown	-27.35%

Source: Citi Research

Figure 25. Growth Pure factor return time series January 1995-September 2013

CGRQPEUG INDEX



Source: Citi Research

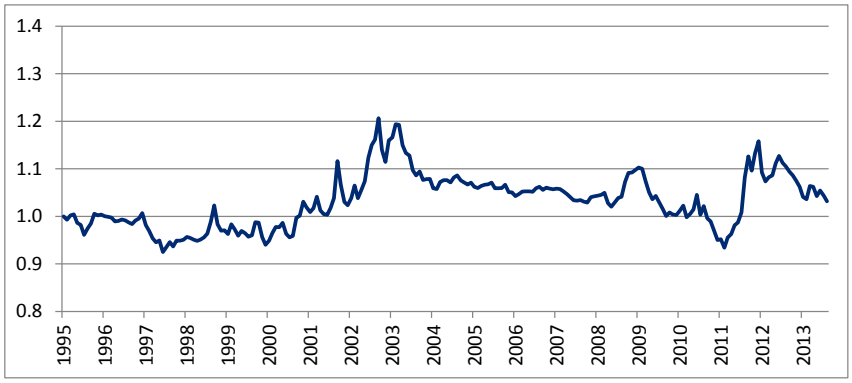
Figure 26. Low Risk pure factor summary statistics

	Pure
Return	0.35%
Risk	6.11%
Information Ratio	0.057
Max Monthly Return	7.51%
Min Monthly Return	-5.71%
Hit Rate	50.00%
Skewness	0.436
Kurtosis	2.859
Drawdown	-22.56%

Source: Citi Research

Figure 27. Low Risk Pure factor return time series January 1995-September 2013

CGRQPEUR INDEX



Source: Citi Research

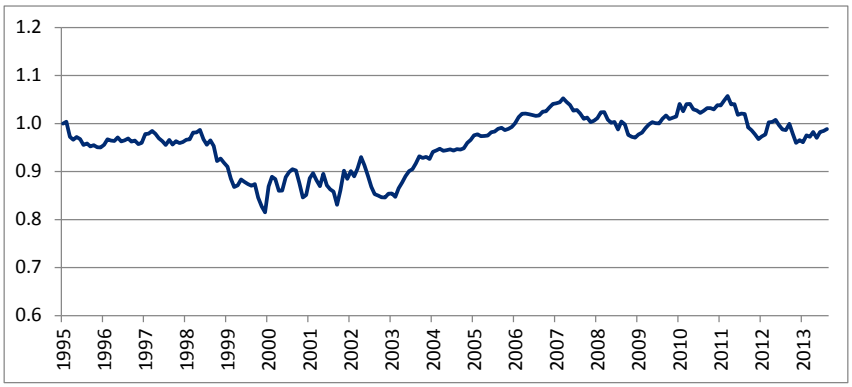
Figure 28. Size pure factor summary statistics

	Pure
Return	0.03%
Risk	4.69%
Information Ratio	0.007
Max Monthly Return	6.60%
Min Monthly Return	-3.49%
Hit Rate	54.46%
Skewness	0.518
Kurtosis	3.168
Drawdown	-18.80%

Source: Citi Research

Figure 29. Size Pure factor return time series January 1995-September 2013

CGRQPEUS INDEX



Source: Citi Research

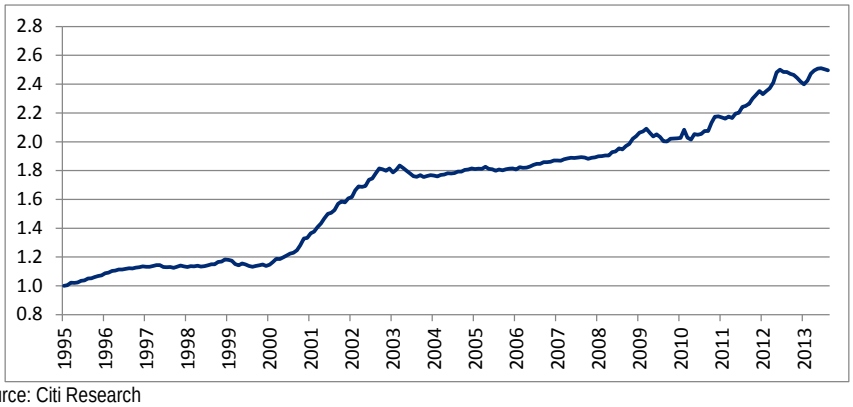
Figure 30. Quality pure factor summary statistics

	Pure
Return	5.14%
Risk	3.27%
Information Ratio	1.573
Max Monthly Return	3.67%
Min Monthly Return	-2.64%
Hit Rate	68.30%
Skewness	0.465
Kurtosis	1.014
Drawdown	-4.37%

Source: Citi Research

Figure 31. Quality Pure factor return time series January 1995-September 2013

CGRQPEUQ INDEX



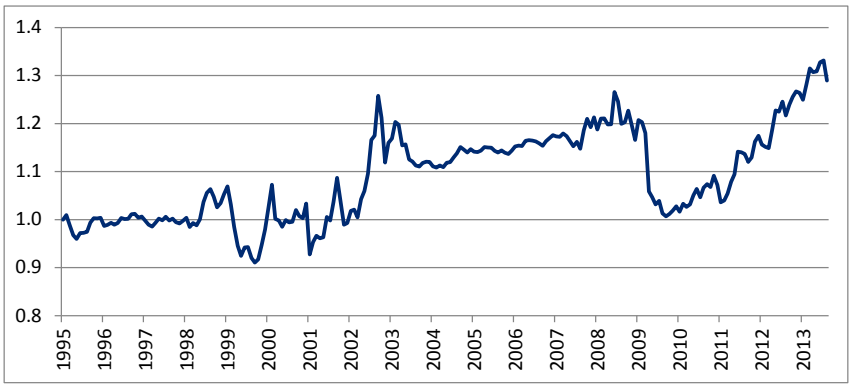
Source: Citi Research

Figure 32. Price Momentum pure factor summary statistics

	Pure
Return	1.67%
Risk	7.70%
Information Ratio	0.217
Max Monthly Return	7.04%
Min Monthly Return	-10.33%
Hit Rate	54.02%
Skewness	-0.879
Kurtosis	4.786
Drawdown	-20.45%

Source: Citi Research

Figure 33. Price Momentum Pure factor return time series January 1995-September 2013, CGRQPEUM INDEX



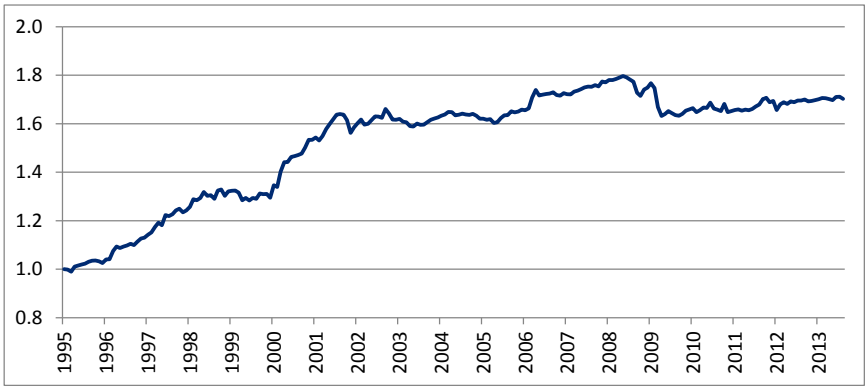
Source: Citi Research

Figure 34. Estimates pure factor summary statistics

	Pure
Return	2.99%
Risk	3.79%
Information Ratio	0.787
Max Monthly Return	4.69%
Min Monthly Return	-4.48%
Hit Rate	62.95%
Skewness	0.121
Kurtosis	3.430
Drawdown	-9.14%

Source: Citi Research

Figure 35. Estimates Momentum Pure factor return time series January 1995-September 2013, CGRQPEUE INDEX



Source: Citi Research

US

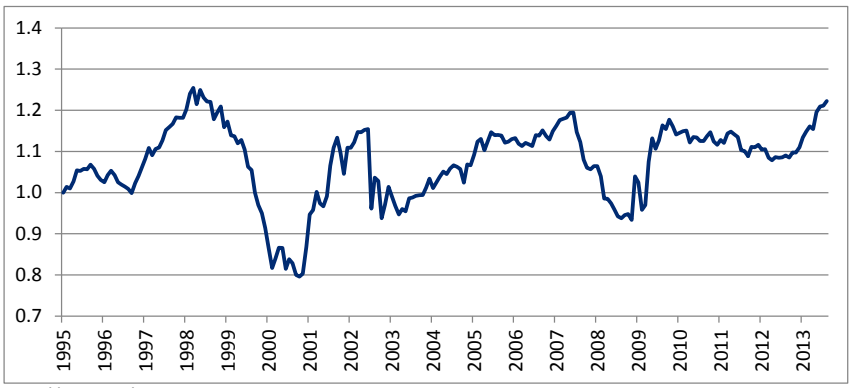
Figure 36. Value pure factor summary statistics

	Pure
Return	1.47%
Risk	9.75%
Information Ratio	0.151
Max Monthly Return	11.37%
Min Monthly Return	-16.75%
Hit Rate	51.79%
Skewness	-0.352
Kurtosis	7.847
Drawdown	-36.52%

Source: Citi Research

Figure 37. Value Pure factor return time series January 1995-September 2013

CGRQPUSV INDEX



Source: Citi Research

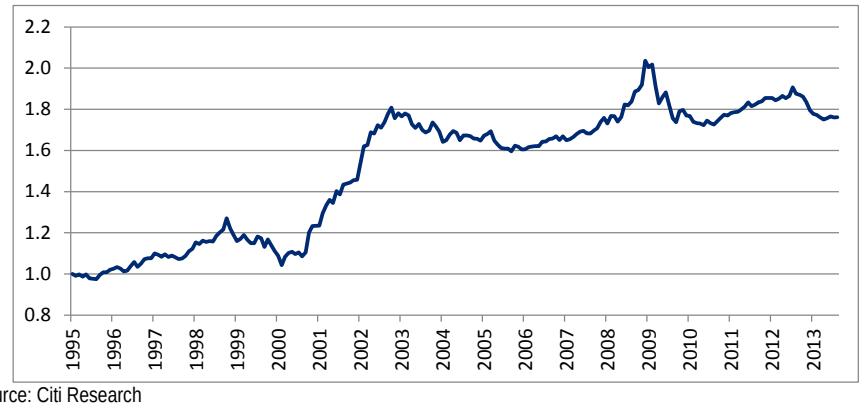
Figure 38. Growth pure factor summary statistics

	Pure
Return	3.32%
Risk	6.28%
Information Ratio	0.529
Max Monthly Return	8.67%
Min Monthly Return	-5.21%
Hit Rate	58.48%
Skewness	0.557
Kurtosis	2.665
Drawdown	-17.95%

Source: Citi Research

Figure 39. Growth Pure factor return time series January 1995-September 2013

CGRQPUSG INDEX



Source: Citi Research

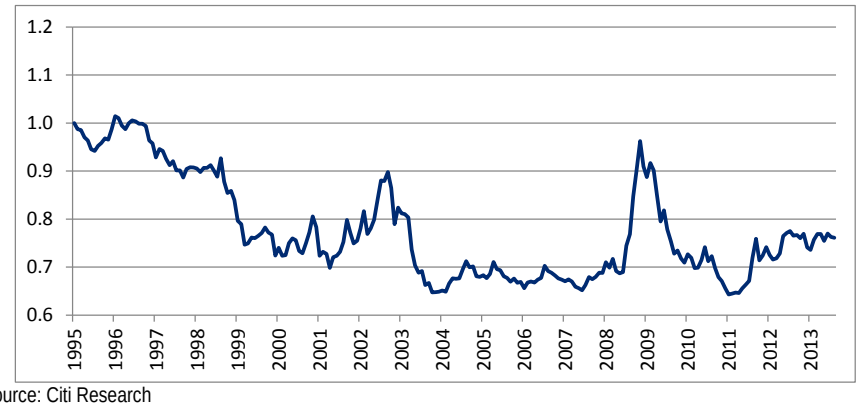
Figure 40. Low Risk pure factor summary statistics

	Pure
Return	-1.13%
Risk	9.54%
Information Ratio	-0.118
Max Monthly Return	10.21%
Min Monthly Return	-8.68%
Hit Rate	46.43%
Skewness	0.085
Kurtosis	1.466
Drawdown	-36.62%

Source: Citi Research

Figure 41. Low Risk Pure factor return time series January 1995-September 2013

CGRQPUSR INDEX



Source: Citi Research

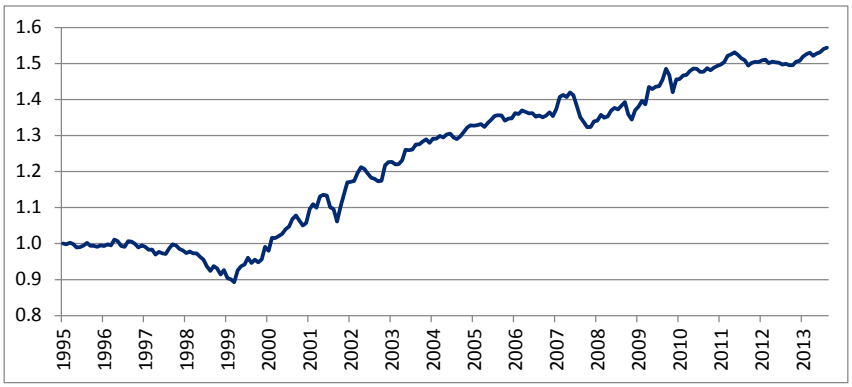
Figure 42. Size pure factor summary statistics

	Pure
Return	2.45%
Risk	4.04%
Information Ratio	0.606
Max Monthly Return	3.76%
Min Monthly Return	-3.21%
Hit Rate	57.59%
Skewness	0.535
Kurtosis	1.901
Drawdown	-11.68%

Source: Citi Research

Figure 43. Size Pure factor return time series January 1995-September 2013

CGRQPUSS INDEX



Source: Citi Research

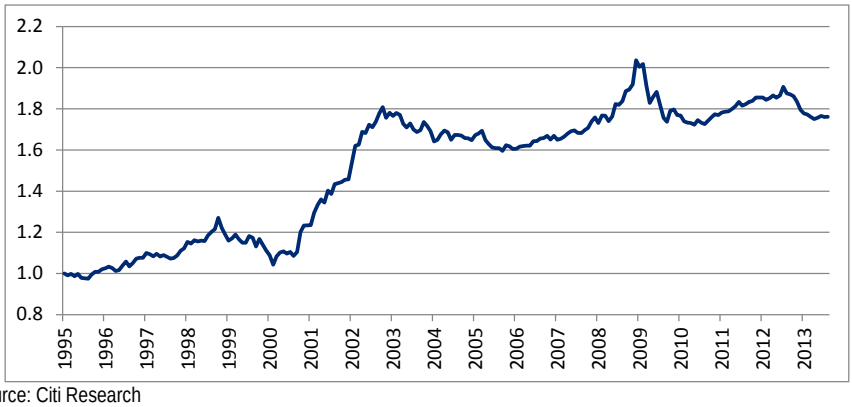
Figure 44. Quality pure factor summary statistics

	Pure
Return	3.32%
Risk	6.28%
Information Ratio	0.529
Max Monthly Return	8.67%
Min Monthly Return	-5.21%
Hit Rate	58.48%
Skewness	0.557
Kurtosis	2.665
Drawdown	-17.95%

Source: Citi Research

Figure 45. Quality Pure factor return time series January 1995-September 2013

CGRQPUSQ INDEX



Source: Citi Research

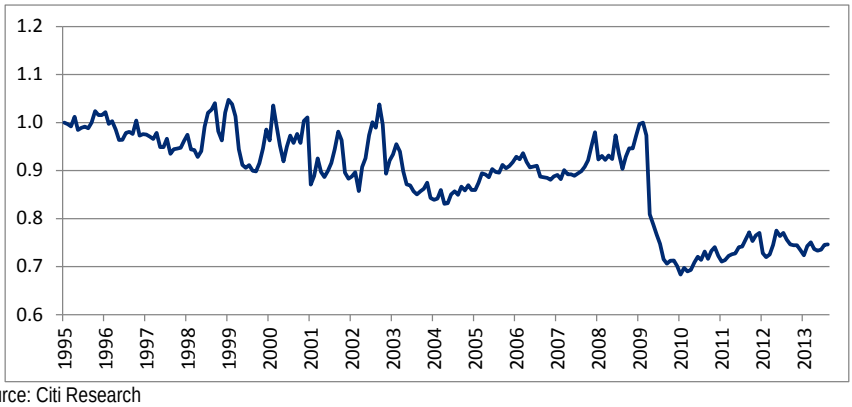
Figure 46. Price Momentum pure factor summary statistics

	Pure
Return	-1.03%
Risk	9.79%
Information Ratio	-0.105
Max Monthly Return	7.54%
Min Monthly Return	-16.85%
Hit Rate	53.57%
Skewness	-1.604
Kurtosis	7.739
Drawdown	-34.72%

Source: Citi Research

Figure 47. Price Momentum Pure factor return time series January 1995-September 2013

CGRQPUSM INDEX



Source: Citi Research

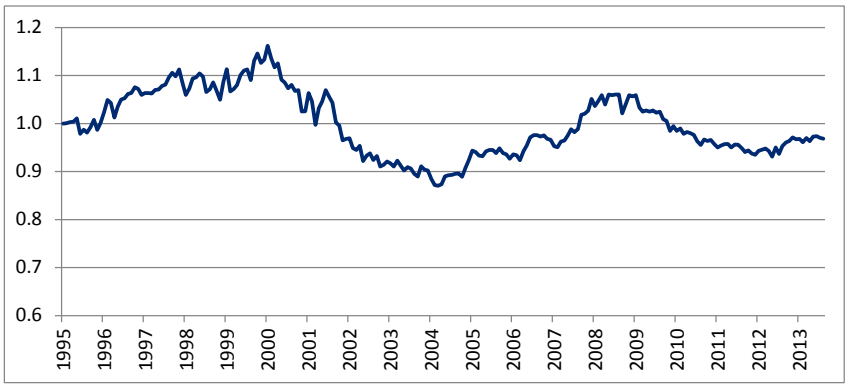
Figure 48. Estimates pure factor summary statistics

	Pure
Return	-0.01%
Risk	5.01%
Information Ratio	-0.002
Max Monthly Return	3.67%
Min Monthly Return	-4.71%
Hit Rate	54.02%
Skewness	-0.378
Kurtosis	0.825
Drawdown	-25.08%

Source: Citi Research

Figure 49. Estimates Momentum Pure factor return time series January 1995-September 2013

CGRQPUSE INDEX



Source: Citi Research

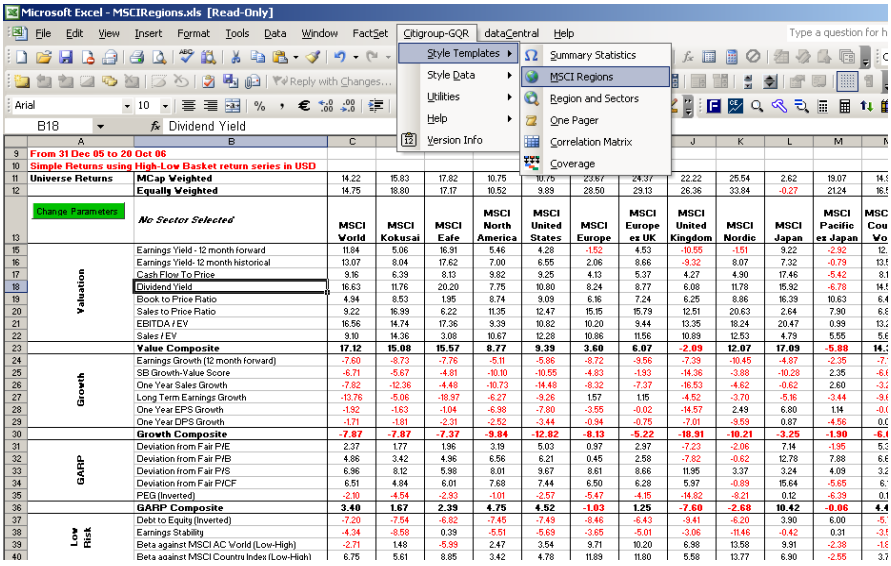
Appendix: Citi Style Addin Software

In response to client needs, we have developed an interactive style backtesting product. The software comes in the form of an excel add-in that clients can easily install on their desktop. The tool offers:

- Access to over 10,000 univariate backtests covering 50 factors and 16 broad investing universes.
- Flexibility in deciding which time period to use to calculate style returns (earliest start date is January 1995).
- Returns are total return based and are available in various currencies.
- Ability to look at the analysis in a number of methods — Simple Returns, Annualised Returns, Information Ratios, Hit Rates and Factor Correlations.
- Individual factor in depth analysis.
- Downloadable factor return series in a user-defined manner.
- Analysis down to sector level.

Please contact the European Quantitative Research team (gqrlondon@citi.com) if you wish to receive this tool.

Figure 50. Citi Quant Style Add-in



Source: Citi Research

Citi Quantitative Teams

Figure 51. Citi Quantitative Teams

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	12 Month Rating			*Relative Rating*		
Data current as of 30 Sep 2013	Buy	Hold	Sell	Buy	Hold	Sell
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% of companies in each rating category that are investment banking clients	31%	28%	27%			
Citi Research Quantitative Decision Tree Model Coverage	0%	0%	100%			
% of companies in each rating category that are investment banking clients	0%	0%	100%			
Citi Research Asia Quantitative Radar Screen Model Coverage	20%	60%	20%			
% of companies in each rating category that are investment banking clients	30%	27%	28%			
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