Global Multi Factor Equity

Key methodologies and approaches

January 2017
For professional clients only
Executive summary

Multi factor equity investing is a leading edge proposition aimed at delivering consistent risk adjusted returns through exposure to academically proven factor premia. Multi factor equity strategies may be able to provide investors with customised factor solutions, acknowledging their differing risk and portfolio construction requirements.

A portfolio which takes advantage of factor premia has been shown to offer opportunity to outperform the market-capitalization index over the medium to long term. However, by maximising exposure to a desired factor and minimising incidental factors, this return can be far better targeted towards the intended drivers of risk and return.

The five key factors, which are often employed within an effective multi factor equity portfolio are: value, quality, momentum, volatility and size. An optimal portfolio can be customised for investors by having a high or medium or possibly low exposure to each of these factors.

However, there are a number of elements which need to be addressed in order to ensure these exposures are correctly correlated through asset selection. These include:

- Factor methodology and the advantageous use of factor composites and sub components,
- An effective weighting system which identifies and provides greater weight to principle components,
- Ensuring data is statistically independent, to avoid correlation contamination, and,
- Avoiding high stock specific risk, by using alternative methods to weight stock selection.

This paper addresses these elements and offers further input into the computation of factors and the need for robust and efficient methodologies.
Factor composites vs simple factors

A key issue identified in multi-factor equity revolves around factor composites and the factor sub-component weighting methodology. This issue arises as there is no mathematical definition for each factor. The models discussed below comprise the value, quality and size composites, which are comprised of a number of sub-components.

Momentum is better defined but is still ambiguous, such as choosing relevant look back periods. Throughout this paper, we use an industry momentum signal covering multiple look back periods.

Finally, in the case of beta there is a strict academic definition and therefore no need for multiple components. Nevertheless it is imperative that the beta calculation is robust.

The use of factor composites (with sub-components) has significant advantages over using a single measure for a factor.

These include:

- **Robustness in the calculation of factor exposures**

  Data coverage for the universe can be limited for single measures. Most valuation measures contain accounting data or sell-side forecasts, and coverage is typically less than 100% of the universe. The combined signal will cover every company which has a data point for at least one of the sub-factors.

- **Increased explanatory power**

  Combined signals exhibit more consistent performance during different market regimes than a simple signal. As an example the risk-adjusted valuation component is likely to perform well during periods of high investor risk aversion, but less well during bull markets. A forward looking valuation measure is likely to perform well during periods where sell-side analysts have a clear view of company prospects; however during times of rapid economic change, sell-side earnings forecasts may not be adjusted rapidly enough to reflect the new economic reality. A composite will try to capture these different economic exposures.
What should we consider when replicating previous results?

Before combining single factor sub-components into a composite factor, they need to be transformed into equivalent scales – below we will use a normal distribution with mean 0 and standard deviation 1 (simple z-score). The two options below can be considered when combining these sub-components:

- Equal weighting, or
- Using PCA to identify the most important sub-components and weight them accordingly

The PCA approach assigns the normalised weights of the first principal component to the sub-components. In this paper we argue that PCA weighting scheme makes maximal use of the information in each sub-component.

The sub-component with the most information relative to the other sub-factors will receive the highest weighting. Exhibit 1, demonstrates six value sub-components and provides a consensus, an intrinsic measure of value. The process will result in something close to equal weighting if the sub-components are correlated. However if two sub-components become less correlated, higher loading should be applied to the sub-component closer to the overall style characteristic (i.e. more correlated with the first principal component). It follows that the weighting scheme achieved using PCA should be broadly stable given the chosen sub-components that contribute different information to the composite signal. The graph below shows the PCA weightings applied to the value sub-factors.

The usefulness of the PCA can be illustrated with a stylised example, in exhibit 2, by constructing a value signal from Sales to EV, EBITDA to EV and artificially constructed random noisy data. The latter should act as a “false signal” or miscalculated item.

In comparing equal weighting and the PCA approach, the former will of course assign 33% to each of the components regardless of the current efficacy of each sub-component. The resulting composite factor is then heavily diluted/distorted.

The PCA weighting method detects the information embedded in the Sales to EV and EBITDA to EV but intelligently assigns a significantly lower weight to the random noise in the composite.

Exhibit 1: Sub-component weighting - Value factor example

Exhibit 2: PCA weights in presence of noisy data

Sources: Thompson Reuters, IBES, Worldscope and MSCI. Calculations by HSBC Global Asset Management as of 31/08/2016
Combining factors: Benefits of orthogonalisation

Prior to the combination of composite factors, the factors must be orthogonalised. This is essential as this process places each of the composites on an equal footing before proceeding. Exhibit 3, highlights the cross correlations between the five orthogonalised factors, the correlation between each individual factor and the combined score. This combined score is calculated by the equal weighted sum of the composites’ z-scores.

The Exhibit 3, shows that the five orthogonalised factors have zero correlation among themselves, as expected by construction. Since there is minimal interference between the factors’ exposures and because they have been combined with equal weights, their individual correlations with the final combined score are similar.

These results show a clear benefit to the orthogonalisation process: it ensures each factor contributes broadly equally to the overall combined score. This provides confidence that the factor weighting scheme will “transmit” each single factor to the overall score effectively.

To demonstrate the significance of orthogonalisation, consider that the outcome had the five composites not been defined orthogonal. Exhibit 4 below, illustrates equal correlations as in Exhibit 3 however using unorthogonalised factors.

Following this approach, the cross correlation terms are not equal to zero. They are predominantly positive with the exception of value which has negative correlation with every other factor. The full implications of these cross correlations are reflected in the correlations with the combined score. Positive correlations with other factors may act to boost the extent to which quality, industry momentum, low beta and size exposures are “transmitted”.

However, the starkest observation is the weak representation of value exposure in the combined score. Negative value components within the other four factors act to erode value’s influence. The outcome is that the final score’s correlation with value is no longer significant, 0.05, ten times smaller than the other factors. In order to boost value exposure within the portfolio, further transformations would be required at the portfolio construction stage, rendering the process far less transparent.

Exhibit 3: Cross correlations – orthogonalised factors

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Quality</th>
<th>Grp Mom</th>
<th>Low beta</th>
<th>Size</th>
<th>Correlation with equal weighted combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.47</td>
</tr>
<tr>
<td>Quality</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Industry Momentum</td>
<td>0.00</td>
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<td>1.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.45</td>
</tr>
<tr>
<td>Low beta</td>
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<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.00</td>
<td>0.43</td>
</tr>
<tr>
<td>Size</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Sources: Thompson Reuters, IBES, Worldscope and MSCI. Calculations by HSBC Global Asset Management as of 31/08/2016

Exhibit 4: Cross correlations – unorthogonalised factors

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Quality</th>
<th>Grp Mom</th>
<th>Low beta</th>
<th>Size</th>
<th>Correlation with equal weighted combination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>1.00</td>
<td>-0.17</td>
<td>-0.06</td>
<td>-0.34</td>
<td>-0.33</td>
<td>0.05</td>
</tr>
<tr>
<td>Quality</td>
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<td>1.00</td>
<td>-0.08</td>
<td>0.16</td>
<td>0.18</td>
<td>0.53</td>
</tr>
<tr>
<td>Industry Momentum</td>
<td>-0.06</td>
<td>-0.08</td>
<td>1.00</td>
<td>0.15</td>
<td>0.11</td>
<td>0.53</td>
</tr>
<tr>
<td>Low beta</td>
<td>-0.34</td>
<td>0.16</td>
<td>0.15</td>
<td>1.00</td>
<td>0.08</td>
<td>0.51</td>
</tr>
<tr>
<td>Size</td>
<td>-0.33</td>
<td>0.18</td>
<td>0.11</td>
<td>0.08</td>
<td>1.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>

Sources: Thompson Reuters, IBES, Worldscope and MSCI. Calculations by HSBC Global Asset Management as of 31/08/2016
The stock weighting scheme used is paramount to multi-factor equity portfolios. Two alternative approaches are:

- Multiplying factor scores by market cap weights, or
- Approximating equal overweight's to high ranked stocks and equal underweights to low ranked stocks (subject to risk controls and the long-only constraint).

The former approach can result in pronounced stock specific risk, reducing some large benchmark positions close to zero, whilst the weights of high scoring stocks can be magnified significantly.

Considering the following example, a long only factor tilting methodology that multiplies factor scores requires $z$-scores to be mapped to a positive score for all values of $z$. The form of the mapping function has repercussions for the level of stock specific risk in the final weighting scheme.

Two commonly used mapping functions are:

$$M_1(z) = \begin{cases} 1 + z, & z > 0 \\ (1 - z)^{-1}, & z < 0 \end{cases}$$

where the output is a function that tends to zero in the limit $z \to -\infty$ and rises to infinity as $z$ does, and

$$C(z) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-x^2/2} \, dx$$

where the cumulative normal transformation provides a score between 0 and 1 for each stock.

Under $M(z)$, factor scores increase linearly with positive factor exposure and stocks with the greatest $z$-scores are allocated larger factor scores. Trimming of extreme $z$-score positions is essential under the $M(z)$ weighting scheme, otherwise positive exposure outliers will dominate index returns. The score can produce highly concentrated positions in high exposure stocks, leading to significant idiosyncratic risk in the portfolio. $C(z)$ mapping is less sensitive to increases in $z$-score at high positive values than it is to $z$-scores near zero and therefore the largest positions are slightly less prevalent than for $M(z)$, but still significant.

In a multi-factor context the extreme polarisation illustrated above will be partially reduced by the central limit theorem. Nevertheless, the top multi-factor tilt holdings can still be significant relative to the benchmark. This may introduce significant amounts of idiosyncratic risk and builds upon the explanation why tracking errors for this weighting scheme can be elevated.
Exhibit 6, considers a simple four-factor tilted portfolio (value, profitability, momentum and low volatility as defined by a standard risk model) using a Global Developed underlying universe.

In Exhibit 6, multi-factor tilting methodology roughly doubles the size of the largest positions relative to the benchmark. The effect is slightly worse under the M(z) mapping scheme given its treatment of high scoring stocks.

Whilst concentrated positions in the likes of Apple may seem appealing given the company’s historic performance, it is always worth considering the potential pitfalls of high stock-specific risk. A recent, highly publicised example of these dangers was the 2015 Volkswagen emissions scandal. The market reacted by wiping 36% off the stock price over the subsequent two days.

Using the European universe as an example, prior to the scandal Volkswagen scored highly on value (C(z)>0.95) and had an average score for the other three factors (C(z)<0.5) relative to the rest of Developed Europe.

There are further fundamental cases against the inclusion of concentrated single stock positions in factor portfolios. Amenc, Ducoulombier et Al (2016) argue that such an approach fails to appreciate the nature of the link between returns and factor scores. A concentrated position assumes a strict relationship between stock returns and factor exposures. Academic literature has largely focused on identifying the existence of statistically significant premia over the long term with monotonically increasing returns over a broad cross-section of factor exposures. This is more in line with a diversified investment approach which assumes a broad portfolio of many different high factor exposure stocks, obtaining higher long term expected return than a broad portfolio of different low factor exposure stocks. The diversified approach expects the relationship to hold in aggregate but allows for some inconsistencies on a stock by stock basis. By contrast, concentrated positions run the risk of failing to realise the potential factor return whilst exposing the investor to destructive stock specific events akin to the Volkswagen case above.

Exhibit 6: Four-factor tilted portfolio example

<table>
<thead>
<tr>
<th>C(z) Factor Tilt</th>
<th>M(Z) Factor Tilt</th>
<th>Global Cap-weighted Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verizon Communications Inc.</td>
<td>3.21%</td>
<td>Apple Inc.</td>
</tr>
<tr>
<td>Apple Inc.</td>
<td>3.02%</td>
<td>Verizon Communications Inc.</td>
</tr>
<tr>
<td>AT&amp;T Inc.</td>
<td>1.95%</td>
<td>Johnson &amp; Johnson</td>
</tr>
<tr>
<td>Johnson &amp; Johnson</td>
<td>1.55%</td>
<td>AT&amp;T Inc.</td>
</tr>
<tr>
<td>JPMorgan Chase &amp; Co.</td>
<td>1.30%</td>
<td>Home Depot, Inc.</td>
</tr>
<tr>
<td>Intel Corporation</td>
<td>1.28%</td>
<td>International Business Machines Co.</td>
</tr>
<tr>
<td>International Business Machines Co.</td>
<td>1.20%</td>
<td>Philip Morris International Inc.</td>
</tr>
<tr>
<td>Comcast Corporation Class A</td>
<td>1.01%</td>
<td>Coca-Cola Company</td>
</tr>
<tr>
<td>Exxon Mobil Corporation</td>
<td>0.98%</td>
<td>British American Tobacco P.L.C</td>
</tr>
<tr>
<td>Microsoft Corporation</td>
<td>0.94%</td>
<td>Gilead Sciences, Inc.</td>
</tr>
</tbody>
</table>

Sources: Thompson Reuters, IBES, Worldscope and MSCI. Calculations by HSBC Global Asset Management as of 31/08/2016
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