Factor Purity
Get what you desire

HSBC Quantitative Research Team

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Executive summary

This note sets out the premise behind our views on smart beta investing and describes a method of identifying the ‘purest’ factor driven strategies. Smart beta strategies have become increasingly popular, with many providers offering a broad suite of such strategies. Most are based on well recognised risk premium factors such as value, small cap, momentum, low volatility and quality. However, many such approaches have unintended risks and additional exposure to untargeted factors because of their construction methodology. We investigate a method of determining the purity of a factor product and apply it to our smart beta investment solutions. By showing these strategies exhibit greater factor purity than those of other providers, we can conclude that they are relatively efficient: they have a larger portion of active risk attributed to the targeted factor.
Getting What You Desire

The appeal behind smart beta strategies is that they are systematic and transparent, rendering them easy to construct and rebalance. Smart beta is also a low cost way for an investor to obtain exposure to factors which they might be lacking within their portfolios. Many smart beta approaches tend to be constructed with an emphasis on simplicity, often using simple sorting and weighting techniques based on either a single factor (e.g. book-to-price) or a composite score (e.g. value). Some are constructed to maximise investability, combining factor tilts with market cap weighting. Unfortunately, even though this sort of construction technique tends to result in higher factor exposures, there are usually few restrictions on other style characteristics. This leads to unintended factor exposures and thus undesired risk.

Much of the debate on smart beta construction stems from unintended factor exposures. These are usually the result of conforming to the requirements of transparency, simplicity and investability. Strategies are constructed from stocks ranked by factor of interest (e.g. factor indexes sold by FTSE, MSCI and Russell). There is evidence that simple minimum variance optimisation, a common smart beta strategy, results in time-varying factor exposures. Goldberg et al.¹ suggest that it is important to be aware of these exposures and highlight the benefits of targeting pure exposures when building such strategies.

In what follows we discuss the significance of efficient risk allocation in factor strategy construction. In particular, we introduce the idea of the Factor Purity Ratio (FPR) to compare factor strategies, explaining how it should be interpreted and its relevant applications.

Building Factor Strategies

A plethora of factor construction methods have been proposed in the academic literature, some of which have been implemented by industry practitioners. In this expanding ecosystem of factor based products, there is a common misconception that factor investing is very simple, providing superior results to traditional funds (e.g. cap-weighted indices, active management, strategic asset allocation). ‘Raw’ strategies approach factor construction by overweighting stocks that exhibit a particular characteristic (e.g. Price-to-Book). To respond to the challenge of transforming academic risk factors into investable portfolios we focus on four key qualities: our products must be Precise, Unbiased, Robust and Efficient.

**Precise:** The factors we seek exposure to are precisely defined, guided by empirical research.

**Unbiased:** Our indices are constructed to remove hidden bias towards untargeted factors.

**Robust:** Strong technological infrastructure, proprietary risk models and the conceptual clarity of our mathematical formulation ensure robust implementation.

**Efficient:** Our indices deliver strong factor purity ratios, exhibiting a high proportion of targeted risk per unit of active risk.

We refer to this product range as our “pure” factor strategy.

Davis and Menchero (2010) – Risk Contribution is Exposure times Volatility times Correlation, MSCI Barra Research

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Understanding the FPR

The Factor Purity Ratio (FPR) is defined as the ratio of tracking error from the desired factor(s) to the total tracking error. This can be used to measure the efficiency of a strategy, i.e. the proportion of the total active risk budget appropriately allocated to the target factors.

Formally, it is constructed as follows:

\[ \text{FPR}_D = \frac{\sum \text{ARD}}{\text{TAR}} \]

\( \sum \text{ARD} \) is the sum of active risk contributions of the desired factors while TAR is the total active risk of the portfolio. Here we look at active risk contribution as opposed to absolute risk contribution as the purpose of smart beta is to add exposure beyond that of a specified benchmark. For example, the FPR of a single-factor value strategy is given by:

\[ \text{FPR}_{\text{value}} = \frac{\sum \text{AR}_{\text{value}}}{\text{TAR}} \]

Ex-ante active risk can be decomposed as follows:\(^2\):

\[ \text{TAR} = \text{Var}(R^A) = \sum_i \sigma^2_i \rho_{F_i, R^A} + \sum_k \sigma^2_k \rho_{u_k, R^A} \]

where \( \sigma_{F_i} \rho_{F_i, R^A} \) is otherwise equivalent to the marginal contribution to risk of the value factor.

The FPR ratio is therefore by construction an ex-ante ratio which decomposes the risk the portfolio expects to deliver into desirable and undesirable active risk.

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\(^2\) For more detail, see Davis and Menchero (2010) – Risk Contribution is Exposure times Volatility times Correlation, MSCI Barra Research

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**Figure 1: Decomposition of total active risk in a cross-sectional factor risk model**

Total Return/Risk

- Systematic Contributions
  - Style
  - Industry
  - Country
  - Currency

- Stock Specific Contributions

Source: HSBC Global Asset Management, for illustrative purposes only

The variables required can be estimated using a factor risk model which is broadly similar to commercially available factor models from Barra, Axioma and Bloomberg. It is cross-sectional and decomposes systematic market risk into broad style factors as well as industry, country and currency factors. The cross-sectional variance-covariance matrix is built using 10 years of weekly data and covariance shrinkage.

**Data Requirements**

First, we obtain the constituents and weights through time for HSBC’s Pure strategies and MSCI’s style indexes. We care about how these change over time as the calculated factor purity is time-varying. Next, we construct the factor risk model specific to the investment universe, in this case the MSCI World. We extract factor exposures and factor returns from the risk model, which we use to calculate marginal active contributions to risk. Finally, we calculate the factor purity ratio for each HSBC Pure strategy (value, momentum, small cap, low volatility and quality) and compare them to their closest competitors.

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Evaluating Factor Strategies

A strategy with high exposure to a particular factor will not necessarily have high factor purity. For example, a simple ranking of value stocks often has significant small-cap exposure. If we were to buy the top quintile of value names, we would anticipate a high exposure to both value and small cap factors. We would prefer a smart beta approach to have a large proportion of active risk driven by the targeted style factor and minimal active risk contributions from the other factors.

In the table below we show the FPR ratios for our Pure strategies, alongside their active exposures to the target factor.

<table>
<thead>
<tr>
<th>Factor</th>
<th>FPR (%)</th>
<th>Active Exposure (standard deviations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VALUE</td>
<td>69%</td>
<td>1.1</td>
</tr>
<tr>
<td>QUALITY</td>
<td>17%</td>
<td>0.8</td>
</tr>
<tr>
<td>MOMENTUM</td>
<td>74%</td>
<td>0.7</td>
</tr>
<tr>
<td>VOLATILITY</td>
<td>53%</td>
<td>0.6</td>
</tr>
<tr>
<td>SIZE</td>
<td>54%</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Source: HSBC Global Asset Management, Thompson Reuters, IBES, Worldscope and MSCI as of end of December 2016

It is clear that high factor exposure does not directly correlate with factor purity. For example, Pure Momentum has a low factor exposure of 0.7 but a high factor purity ratio of 74%. This is understandable as momentum is a more volatile factor with a higher active risk contribution. Looking at the desired factor’s exposures alone might be misleading. Factor exposures fail to take into account the risks from exposure to other potentially undesirable factors.

Concentrating on active risk contribution also connects back to the general debate on risk premia factors. There is a degree of risk in investing in factors and their returns are time-varying. Note that strategies with the same factor exposures may have different active risks based on the nature of the factor. A strategy that is pure has less contribution from undesired risks. The key point is that we are only taking a risk on the factors that we choose to invest in.

We will go on to compare these FPR ratios with those of key competitors and to show that our Pure strategies are indeed relatively ‘efficient’ from an FPR perspective. This is not surprising as HSBC’s portfolio construction process aims to minimise unwanted factor exposures as well as broad active risk due to its active weight constraints.

Figure 2 shows the decomposition of active risk for HSBC Pure Value as of December 2016. This is a common risk attribution output from portfolio attribution packages. As is evident from both the FPR ratio and the breakdown (Figures 2 & 3), the active risk contribution from value is significantly larger than most other active risk components. This is indeed what we expect to see from a pure strategy.

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When comparing this to the MSCI World Enhanced Value Index (MSCI’s high exposure version of a value index), we can see how different they are in terms of factor purity. The FPR of the MSCI World Enhanced Value Index is 35%, compared to HSBC’s figure of 69%. This implies that our Pure strategy takes on approximately twice as much value-related active risk as the MSCI World Enhanced Value Index per 1% of non-value active risk, yet both strategies exhibit the same level of active exposure to value (1.1).

Looking at the decomposition of style active risk for the MSCI index in Figure 4, we can see that even though the biggest component of active risk is indeed value, there are still significant active risk contributions from volatility and momentum. A significant portion of its total active risk also comes from contributions. A closer look at the breakdown shows that the majority of this comes from active exposure to Japan. This does not appear to be consistent with the concept of a single factor strategy.

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Purity and Superior Factor Replication

By aiming for efficient risk allocation, we are trying to deliver a return that replicates as closely as possible the theoretical “pure” return of a given systematic factor in equity returns. Due to the inefficiencies and practicalities of long-only beta portfolio construction, these factors are ultimately non-investible and therefore remain a theoretical concept. However, we can estimate their long-short returns, $f_{k,t}$, from the cross-sectional regression:

$$Return_{n,t} = \sum_{k=1}^{K} X_{n,k,t} f_{k,t} + \epsilon_{n,t}$$

where $X_{n,k,t}$ is the exposure of stock $n$ to factor $k$ at time $t$.

Once we have calculated these returns, we can run correlations with our HSBC Pure strategies to see how well we have harvested the factors given the level of purity achieved. Note that the Pure strategies are long-only, which will fundamentally reduce their ability to track the theoretical long-short factor returns. Specifically, our correlations use the active return of our Pure strategies in order to remove the impact of the market return component.

Figure 4: Understanding the link between purity and factor replication

In the chart above, we plot the average factor purity ratio versus the theoretical factor long-short return correlation for the period May 2012 to December 2016. There appears to be a positive relationship between factor purity and the correlations. That is to say, the purity the strategy, the better it appears to harvest the desired factor, as well as protecting the client from unnecessary systematic risk.

Note that size is a special case in that does not quite conform with this trend. Size exposure and market capitalization exhibit strong negative correlation across stocks, trivially. Constraint of non-target systematic and idiosyncratic exposures will inevitably bring stock weights a little closer to the market cap benchmark, leading to a slight decrease in the strategy’s correlation with regressed factor returns (0.6). However, the FPR remains high at 63%, demonstrating the strength of a pure, robust implementation approach.

Source: HSBC Global Asset Management, Thompson Reuters, IBES, Worldscope and MSCI as of end of December 2016
The Right Way to Assess Factor Purity

There is a right way and a wrong way to compare the purity of different factor products. It is important to have a good feel for the characteristics of the FPR ratio in order to assess strategies fairly. In this section, we highlight two important aspects of appropriate risk allocation evaluation.

Purity is indicative of superior implementation

FPR is a powerful metric for comparing construction methodologies across different providers, but it is inappropriate to use it to choose between the factor premia themselves. Some factors exhibit more intrinsic volatility than others. It is these factors that will tend to dominate risk attribution profiles if exposure is sufficiently high. This means that products targeting such factors will harvest premia more efficiently even if no purification measures are taken.

As an example, let us compare our Pure factors against two arrays of MSCI indices: their High Capacity range as well as their High Exposure range. The former impose tilts on the full cap-weighted index to increase investability. If we interpret the FPR ratios appropriately, the HSBC Pure strategies appear to be more ‘pure’ than both MSCI ranges as of the end of December 2016. Moreover, this level of purity is achieved whilst exhibiting target factor active exposures competitive with the MSCI High Exposure range.

Figure 5: Comparison of Factor Purity Ratios
FPRs as of December 2016

Figure 6: Comparison of active exposures
Active Exposures as of December 2016

Source: HSBC Global Asset Management, Thompson Reuters, IBES, Worldscope and MSCI as of end of December 2016

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However, it would be inappropriate to criticise the low FPRs of the quality indices in comparison to the high FPRs of the momentum indices. Ex-ante active risk depends on a series of factor-specific metrics. It is a product of exposure, factor volatility and correlations, so any of these can influence the active risk composition. Momentum is well known to be a factor with significant intrinsic and realised volatility. Somewhat ironically, the “low volatility” factor also exhibits significant volatility in its long-short returns driven primarily by market risk. Both momentum and low volatility demonstrate high FPR ratios. At the opposite end of the spectrum, quality and size show relatively stable returns and have relatively low FPR ratios. The Pure factor construction methodology does a particularly good job of enhancing the factor purity of size, but quality also demonstrates marked improvement relative to MSCI.

Quality has the lowest average factor purity of all the factors. So what is contributing the majority of its strategies’ active risk? Quality might be harder to capture as a pure factor because it is naturally skewed in terms of exposures to countries and industries. We examine this by looking at snapshots of the quality index active risk decomposition at different points in time. A substantial part of active risk appears to come from countries in 2009 and industries in 2016 (see figure 7).

Figure 7: Pure quality index active risk decomposition

Source: HSBC Global Asset Management, Thompson Reuters, IBES, Worldscope and MSCI as of end of December 2016

The purity of the Pure Quality could be improved through the direct control of country and industry exposures. However this would inevitably reduce exposure to the factor as the additional constraints would shrink the set of feasible solutions. Given the implementation challenges caused by the very nature of this factor, we would not recommend investing in a quality strategy in isolation. After all, quality demonstrates its greatest potential when used in combination with other factors, such as value.
Purity needs to be evaluated over time

The dependence of factor purity on active risk expands not only across different factors but also over time. Constant monitoring of factor purity is important. It is not necessarily stable; factors can undergo periods of increased volatility and this can cause the purity of some construction methodologies to vary significantly over time.

The charts in figure 8 examine the fluctuations in the factor purity of our Pure strategies, for which we have full constituent and weight data history. We are unable to do the same for the full range of our competitors’ indexes due to the lack of data, but in Figures 9 to 11 we present what we are able.

Figure 8: 12 month rolling FPRs

We expect the factor purity ratio of the Pure strategies to be higher over time. This is because the evaluation of active risk is a product of exposure and marginal contribution to risk. Pure strategies explicitly constrain exposure to other style factors so the risk contribution of the main factor of interest should be proportionally higher.

Source: HSBC Global Asset Management, Thompson Reuters, IBES, Worldscope and MSCI as of end of December 2016

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Figures 9 and 10 chart the changes in factor purity ratios over time for competitors’ factor indexes. They imply that if the weight allocation process does not change over time, FPR ratios should stay within an expected range.

Even in the case of quality, the hardest factor to harvest in a pure manner, we consistently demonstrate higher FPR ratios than MSCI’s High Exposure alternative. If the difference in the factor purity ratios depicted is representative of the entire factor range, it is natural to conclude that our Pure strategies appear to be more efficient than the series of MSCI indexes. This demonstrates the benefit portfolio construction process that minimises exposures to other factors, indirectly causing a decrease in active risk contribution from styles.

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Conclusion

Factor purity ratios are a simple way of determining the purity of smart beta strategies. There have been concerns that smart beta products actually capture unintended factor, country, industry or currency risks. FPR ratio is an effective way of quantifying the calibre of active risk budget allocation, allowing investors to distinguish between strategies with undesirable or perhaps unforeseen risks from those that are truly desirable.

This note highlights the importance of focusing on criteria beyond simple factor exposure when buying a smart beta product. More sophisticated construction techniques, although more complicated than simple sorting and weighting, can significantly improve the overall purity of smart beta strategies.
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