Research

Factor Indexes and Factor Exposure Matching: Like-for-Like Comparisons

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Contents

1 Introduction

The academic literature tells us that for suitably diversified portfolios, factors drive risk and performance outcomes (see for example [1, 2]). If this is the case, then well-diversified portfolios with identical factor exposures should have similar performance characteristics despite originating from potentially very different construction methodologies. In this paper we test this hypothesis.

The simplest and most commonly employed factor portfolio construction technique is via selection and weighting (S&W). First one orders the stock universe by factor and then selects a proportion of the top rated stocks. The idea is that the more stringent the selection, the greater the factor characteristic captured. Stocks within this basket are then weighted according to the factor value itself or on some other criteria concerned with capacity (e.g. market cap weighting), diversification (e.g. equal weighting) or risk (e.g. risk weighting). This method has been employed by many practitioners and academics [9, 10, 11]. Indeed some claim that combining certain weighting schemes yields the most efficient construction methodology in terms of the tradeoff between rewarded factor exposure and the diversification away of unrewarded risk [10, 11].

In this paper we calculate the factor exposures of such S&W portfolios and then replicate those factor exposures using the FTSE Russell factor tilt methodology. This allows us to construct competing factor tilt portfolios that are substantially different in terms of construction and weight but have precisely matched factor exposures. The flexibility of our tilting approach has been employed by other practitioners where more precise control over on- and off-target exposures is required [12].

The objective of this approach is twofold. Firstly we highlight the incidental factor exposures of different construction approaches and the dangers of simplistic performance comparisons that do not relate performance directly to stated factor objectives. The performance outcomes pretty much confirm what the academics have told us – factor exposures matter. Secondly we demonstrate that, when we compare the diversification and implementation properties of rival portfolios, important differences emerge. The results provide direct empirical support for our earlier theoretical findings [3].

In what follows we concentrate on selecting the top 50% of stocks by factor score. This is merely a matter of convenience, since the results apply to more or less extreme stock selection parameters. We concern ourselves primarily with the FTSE USA Index universe and the FTSE Russell Quality factor. We illustrate the robustness of our findings by providing similar results for Value, Low Volatility and Momentum in the Appendix. The factor definitions that we use throughout this document are set out in the FTSE Global Factor Index Series Ground Rules [4].

In Section 2 we outline the mathematics behind factor exposure matching. In Sections 3, 4, 5 and 6 respectively we consider the robustness of our results to alternative weighting schemes ranging from equal weighting (Section 3), inverse volatility weighting (Section 4), weighting by financial statement metrics (Section 5) and capitalization weighting (Section 6). In Section 7 we consider a diversified multiple weighting scheme that corresponds to a composite of the equal and risk weighted portfolios. This is in the spirit of some academic/practitioner research [10, 11] that emphasizes the importance of diversified weighting schemes to limit “model” or non-rewarded risk. We shall see that such an approach introduces additional factor noise. In Section 8 we question whether selection and weighting is an appropriate way to build single factor portfolios. In section 9 we apply the exposure matching approach to a more complex smart beta portfolio, Minimum Variance. Finally, in Section 10 we present our conclusions.

2 The Mathematics of Exposure Matching

Define a set factor values f_i for each stock labelled by $i = 1, \ldots, N$. Since the factor values involve different sets of natural units and ranges, it is convenient but not essential, to rescale and truncate these factor values to form Z-scores according to:

$$Z_i = \frac{f_i - \mu}{\sigma} \tag{1}$$

where μ and σ are the cross sectional mean and standard deviation. Different factors may now be more readily compared since they all have a mean of zero and a standard deviation of one.

To assess how much of the factor characteristic is embedded in a given portfolio we define Factor Exposure as:

$$E[W] = \sum_{i=1}^{N} W_i * Z_i \tag{2}$$

where W_i is the set of portfolio weights. The Active Factor Exposure, relative to another set of weights $\widehat{W}$ is defined by:

$$AE\left[W, \widehat{W}\right] = E[W] - E\left[\widehat{W}\right] \tag{3}$$

Active exposure in this document will be relative to market capitalization weighting unless otherwise explicitly stated.

To assess the degree of concentration in portfolio, we employ the Herfindahl measure of concentration set out in [6]:

$$C[W] = \sum_{i=1}^{N} {W_i}^2 \tag{4}$$

The diversification, known as effective number of stocks or "Effective N", is defined by $1/C[W]$. Effective N attains its maximum under an equal weighting scheme when it is equal to the actual number of stocks. Hence, Effective N can be seen as a measure of "how far" a given portfolio is from this maximally diversified portfolio.

An alternative measure of diversification is the GLR ratio [7, 8]. This is defined as the ratio of portfolio variance to the weighted sum of individual stock variances:

$$GLR[W] = \frac{Var[\sum_{i=1}^{N} W_i * r_i]}{\sum_{i=1}^{N} W_i * \sigma_i} \tag{5}$$

where r_i and σ_i are the return and variance of the i^{th} stock. We calculate the GLR Ratio using six months of daily total return data in USD.

The active share is defined as half the sum of the absolute weight differences of two portfolios:

$$AS[W, \widehat{W}] = \frac{1}{2}\sum_{i=1}^{N} |W_i - \widehat{W}_i| \tag{6}$$

Portfolio capacity is defined as the reciprocal of the weighted sum of stock capacity ratios:

$$\mathrm{CAP}(W) = 1/\sum_{i=1}^{N} W_i * \frac{W_i}{M_i} \tag{7}$$

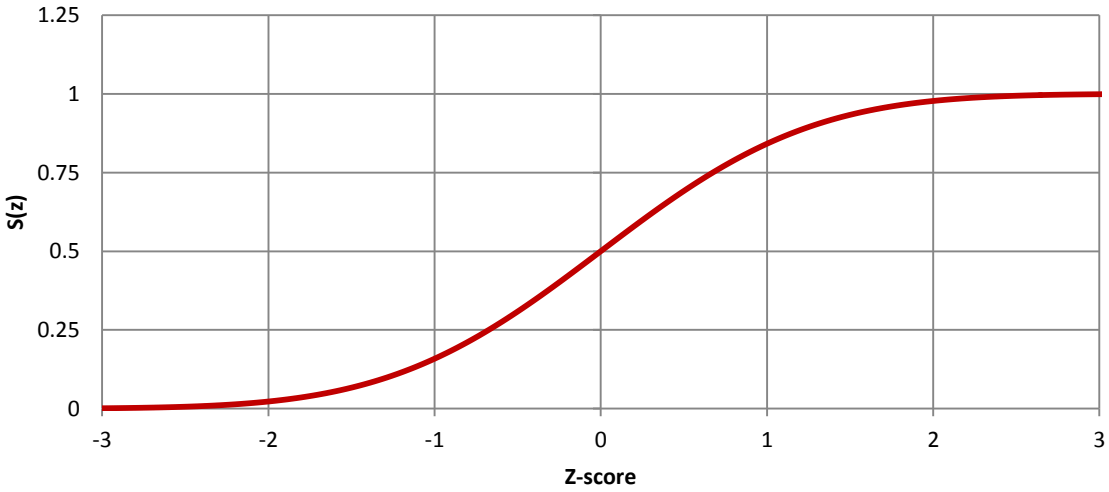
where M_i are the market capitalization weights. This yields a number between 0% and 100% and reflects the ease of investment relative to a market capitalization weighting (100%) scheme.

We construct all of our factor exposure matching portfolios using a multiple tilt. To do this we use the Cumulative Normal function:

$$S(Z) = \frac{1}{2}\left[1 + \mathrm{Erf}\left(\frac{Z}{\sqrt{2}}\right)\right] \tag{8}$$

to define a mapping from Z-scores to a real number between zero and one. The functional form is shown in Figure 1.

Figure 1: The Cumulative Normal Mapping Function



We then define the stock weights associated with a multiple tilt by:

$$W^T{}_i[p, q, \ldots, r] = \frac{{S_{1i}}^p * {S_{2i}}^q * \ldots * {S_{ni}}^r * W_i}{\sum_{j=1}^{N} {S_{1j}}^p * {S_{2j}}^q * \ldots * {S_{nj}}^r * W_j} \tag{9}$$

where $W^T{}_i[p, q, \ldots, r]$ is the weight of a stock in the multi-factor index, W_i is the weight in any underlying index (market capitalization weight, equal weight, risk weight etc.), S_{ni} is the output from the cumulative normal (between 0 and 1) associated with the n^{th} factor and $p, q, \ldots, r$ are real positive exponents that represent the strength of each tilt. To tilt away from a factor we replace S_{ni} by $1 - S_{ni}$ in the above equation as this is equivalent to reversing the sign of the Z-score.

We exercise complete control over the magnitude of the factor exposures by varying these exponents. Exposure matching is then achieved by finding the exponents $p, q, \dots, r$ that yield a set of stock weights that have identical portfolio level factor exposures to a given set of target factor exposures.

This corresponds to solving a set of simultaneous equations:

$$AE_K[W^T[p, q, \dots, r], W] = E_K \qquad K = 1, \dots, n \tag{10}$$

Where E_K is the target factor exposure of the K^{th} factor. This can be achieved through simple numerical techniques.

In general the target factor exposures can be specified as any set of numbers, but more specifically, they can arise as the factor exposures of another portfolio. In this way a tilt portfolio can be found that has exactly the same factor exposure profile as another portfolio which may have been constructed in an entirely differently way and for a completely different purpose.

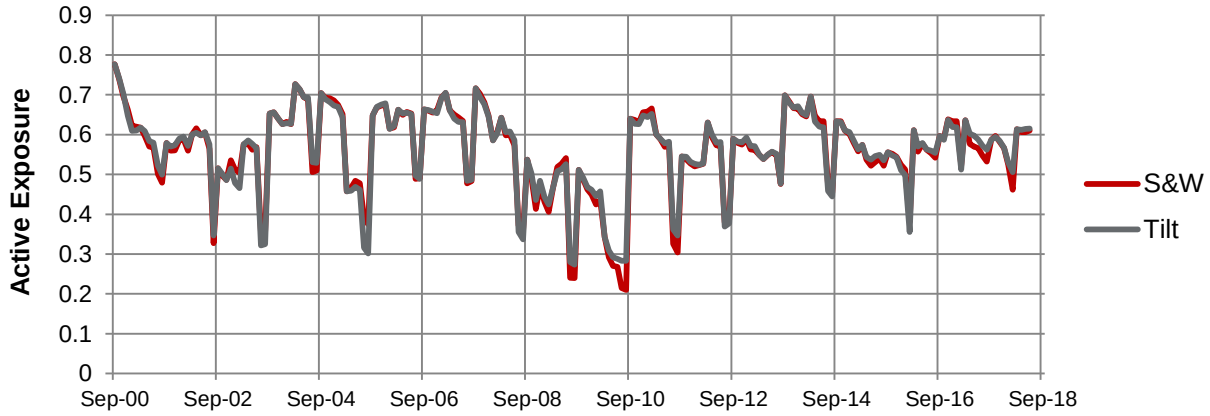
3 Selection and Equal Weighting

In this section we select the top 50% of the stock universe (FTSE USA Index) by Quality factor score and then equal weight constituents to maximize the level of weight diversification to form the S&W portfolio.

On a semi-annual basis in March and September, we construct the S&W portfolio and calculate its active factor exposures. We then create the factor exposure matching portfolio by multiple tilting from market capitalization weights as described in Section 2. In this way we are able to compare like-for-like portfolios that have identical levels of active factor exposures at each semi-annual rebalance. Note that we only aim to match factor exposures; we do not employ constraints or target other characteristics such as specific industry weights.

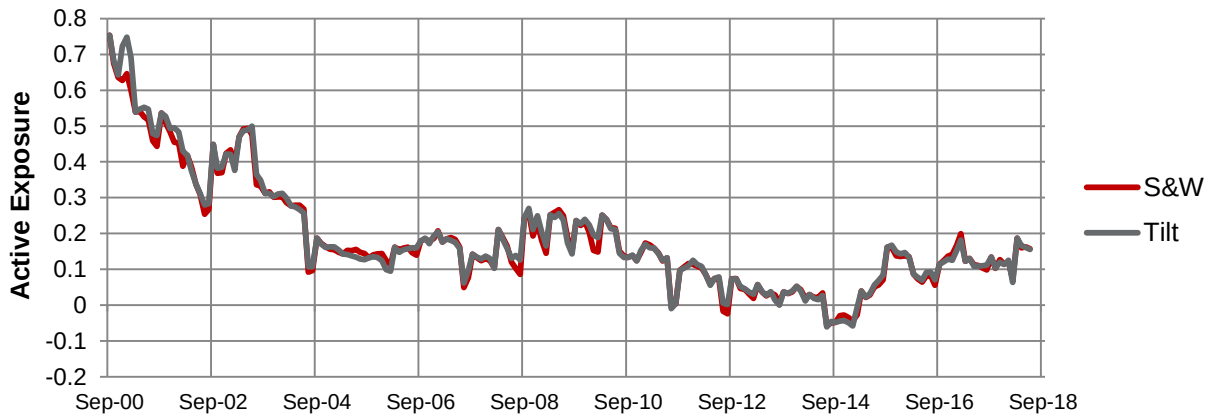
The first thing we observe is that the Quality S&W portfolio (and the exposure matched tilt portfolio by construction) has multiple factor exposures that vary through time. Figures 2 through 6 demonstrate its time varying active exposure to Quality, Value, Momentum, Low Volatility and Size. Note that factor exposures are matched at each semi-annual rebalance, so that the small exposure differences occur due to the drifting of weights between rebalances.

Figure 2: S&W Quality (Equal Weight) & Tilt Portfolios: Active Quality Exposure



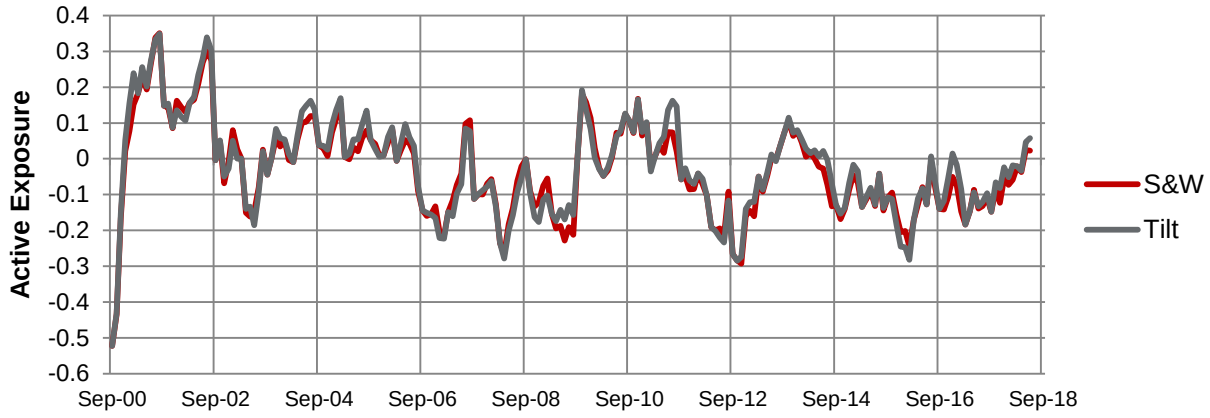
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 3: S&W Quality (Equal Weight) & Tilt Portfolios: Active Value Exposure



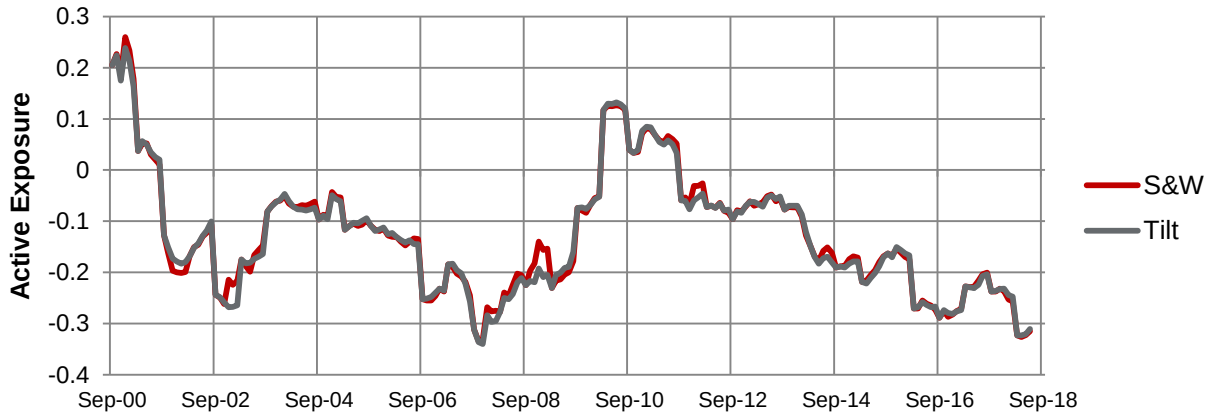
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 4: S&W Quality (Equal Weight) & Tilt Portfolios: Active Momentum Exposure



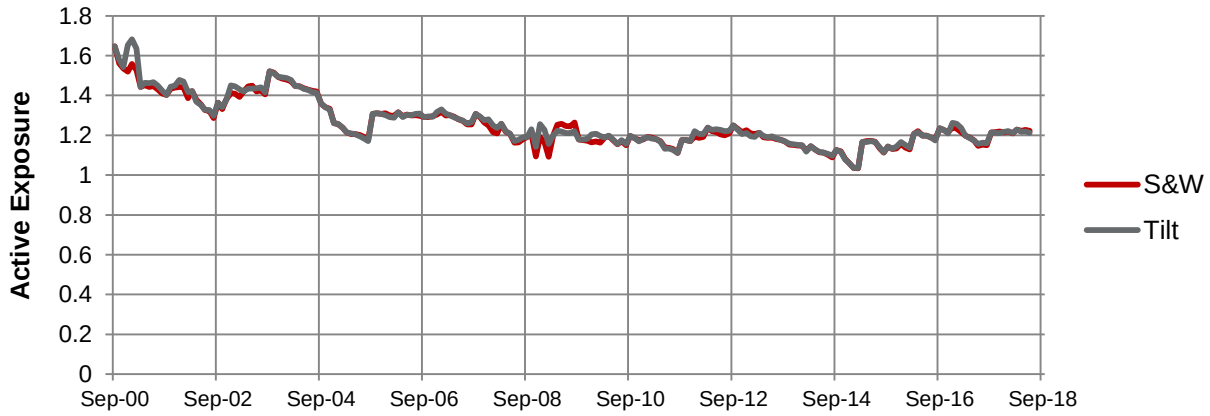
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 5: S&W Quality (Equal Weight) & Tilt Portfolios: Active Low Volatility Exposure



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

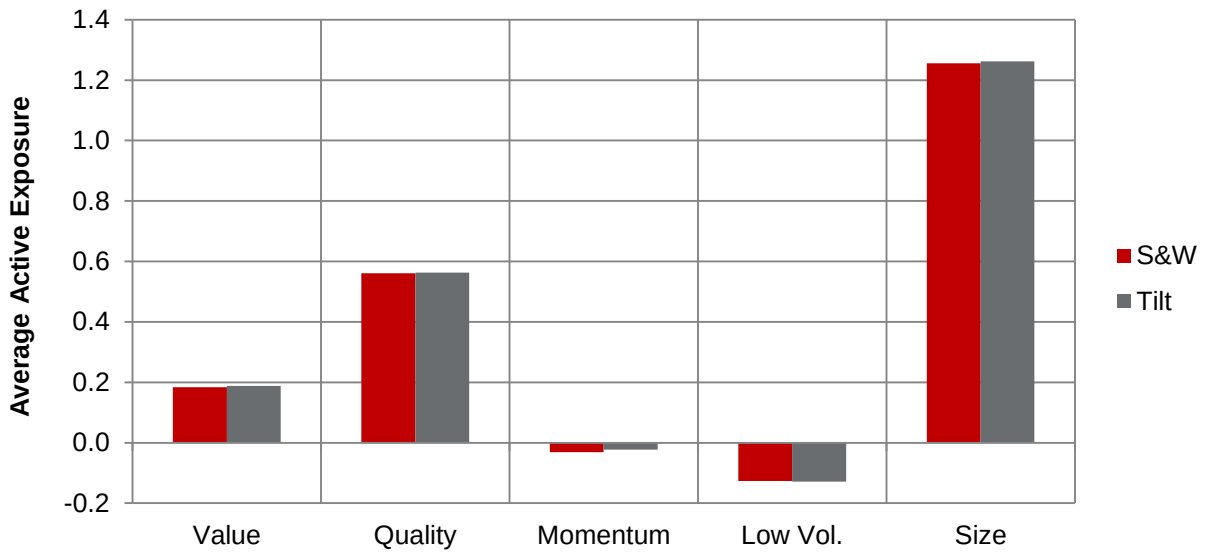
Figure 6: S&W Quality (Equal Weight) & Tilt Portfolios: Active Size Exposure



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 7 shows the average levels of active factor exposure through time. Clearly to characterize these outcomes as resulting from single factor Quality portfolios is misleading. The target Quality factor exposure is achieved through the selection mechanism; however the equal weighting scheme introduces a large Size exposure and non-zero exposures to Value and Low Volatility. A natural question is therefore to consider the performance implications of these significant unintended off-target factor exposures. This is addressed in Section 8.

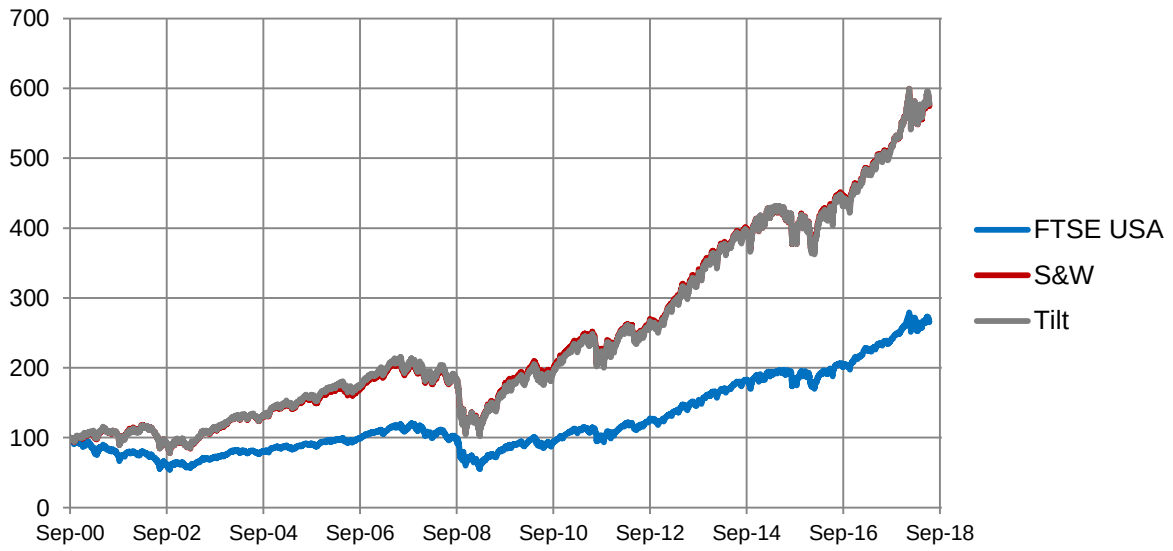
Figure 7: S&W Quality (Equal Weight) & Tilt Portfolios: Average Active Factor Exposures



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

In Figure 8 we plot the performance through time of each construction approach using the FTSE USA Index as a benchmark. The performance of the S&W portfolio is almost identical to the exposure matched Tilt portfolio.

Figure 8: Total Return USD Performance of FTSE USA, S&W and Tilt Indexes

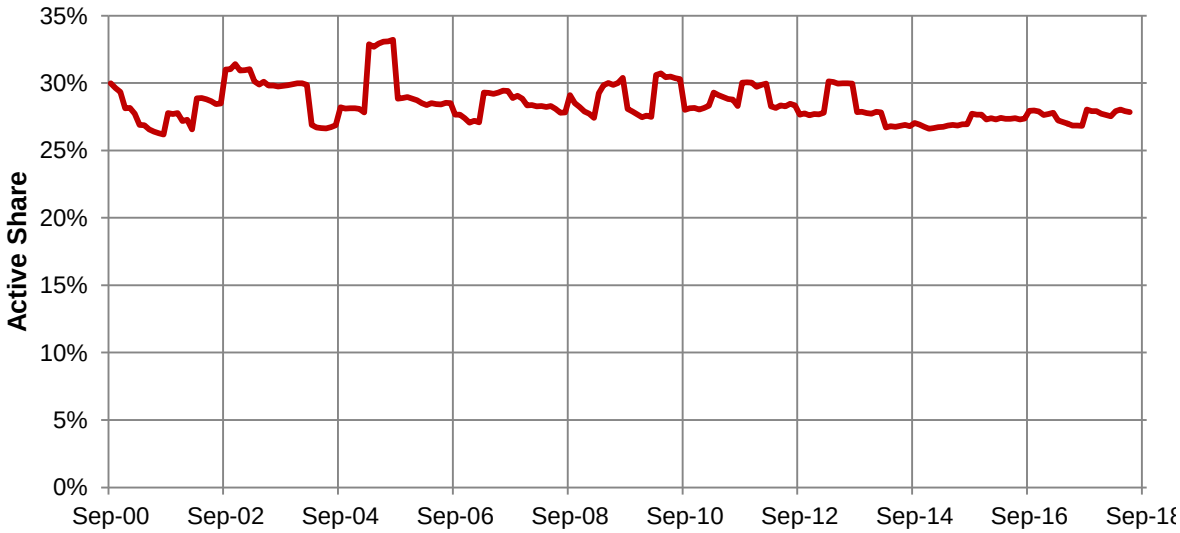


Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

This is precisely what the academics have been telling us for many years. For suitably diverse portfolios, factor exposures drive performance outcomes - in other words “match factor exposures and match performance”.

Note that this outcome does not arise because portfolio weights are “secretly” the same. Figure 9 demonstrates that they are significantly different portfolios by plotting their active share (defined as half the absolute weight difference) through time. The active share never falls below 25%.

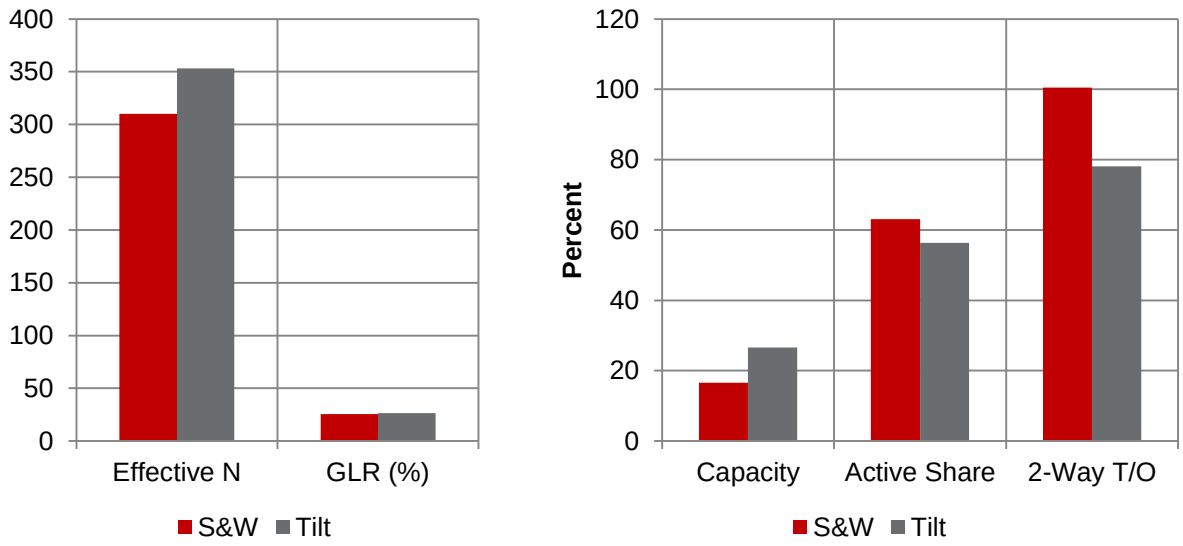
Figure 9: Active Share between S&W and Tilt Portfolios



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

The differences between the two portfolios are further emphasized when we consider the time averaged diversification and implementation metrics in Figure 10.

Figure 10: Diversification & Implementation Properties of S&W and Tilt Portfolios



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

It is noteworthy that the diversification and implementation figures for the exposure matched Tilt portfolio are as good as or superior to those of the S&W portfolio. The Effective N is 14% higher; GLR is the roughly the same; capacity is 60% higher; active share is 11% lower and the 2-way turnover is reduced by 22%. If transactions costs were folded into the performance calculation, the Tilt portfolio would have the clear advantage.

In summary, the Tilt portfolio more efficiently embeds the same factor exposures as the S&W portfolio, despite starting from an initial set of market capitalization weights. We remark that the starting point does not matter. Indeed it can be shown that similar results can be obtained when we use equal weights as a starting point for the Tilt portfolio.

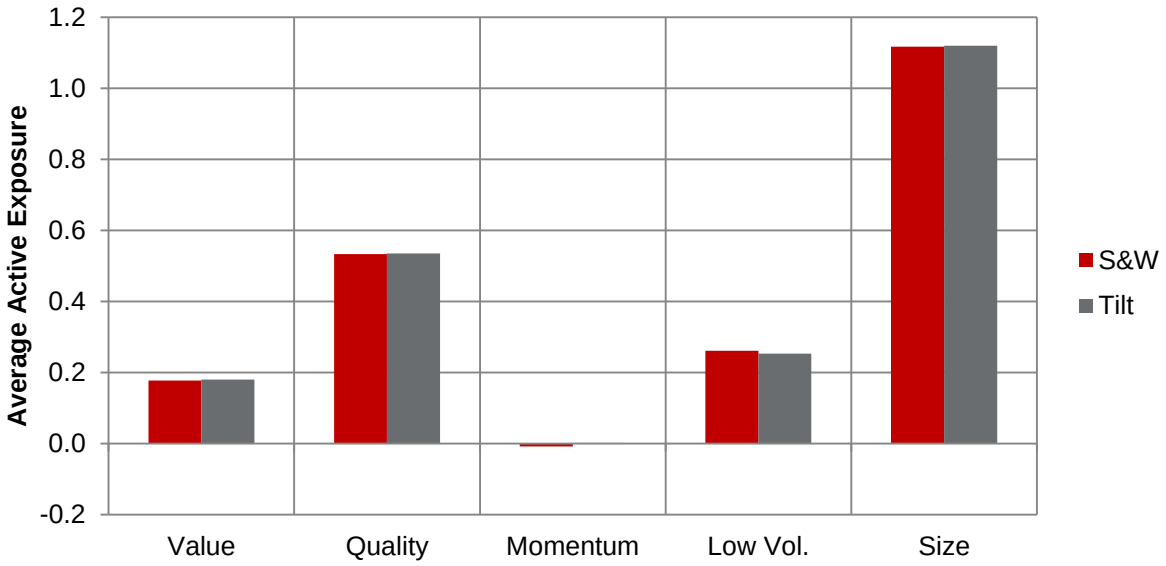
Finally we remark that the superior Effective N of the Tilt portfolio compared to the S&W portfolio for equivalent levels of factor exposure act as empirical validation of the theoretical results presented in previous FTSE Russell research [3].

4 Selection and Risk Weighting

In this section we again select the top 50% of the FTSE USA Index universe by Quality factor score, but assess the robustness of our earlier results by applying an inverse volatility weighting (or "risk" weighting) scheme based on two years of local daily total returns. On a semi-annual basis in March and September we construct the S&W portfolio and calculate its active factor exposures. Again we create the exposure matching Tilt portfolio by tilting from market capitalization weights.

Figure 11 shows the average active factor exposures of the two portfolios. The introduction of risk weighting has, unsurprisingly, resulted in a significant off-target exposure to low volatility.

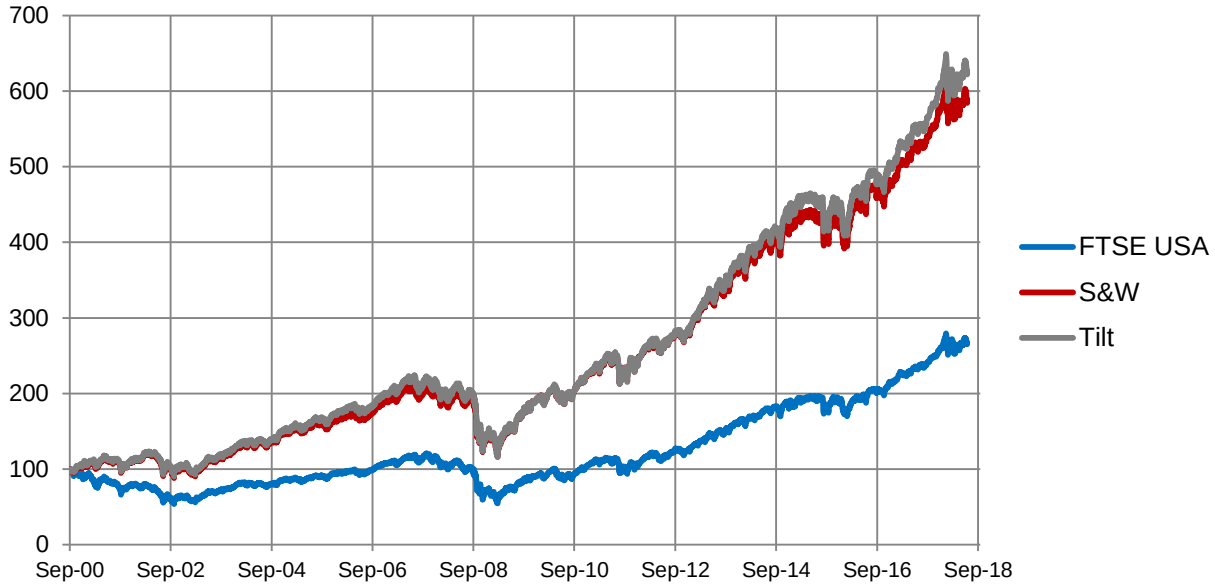
Figure 11: S&W Quality (Risk Weight) & Tilt Portfolios: Average Active Factor Exposures



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 12 plots the performance of the factor portfolios through time using the FTSE USA Index as a benchmark. The performance of the S&W portfolio is close to that of the factor exposure matched Tilt portfolio.

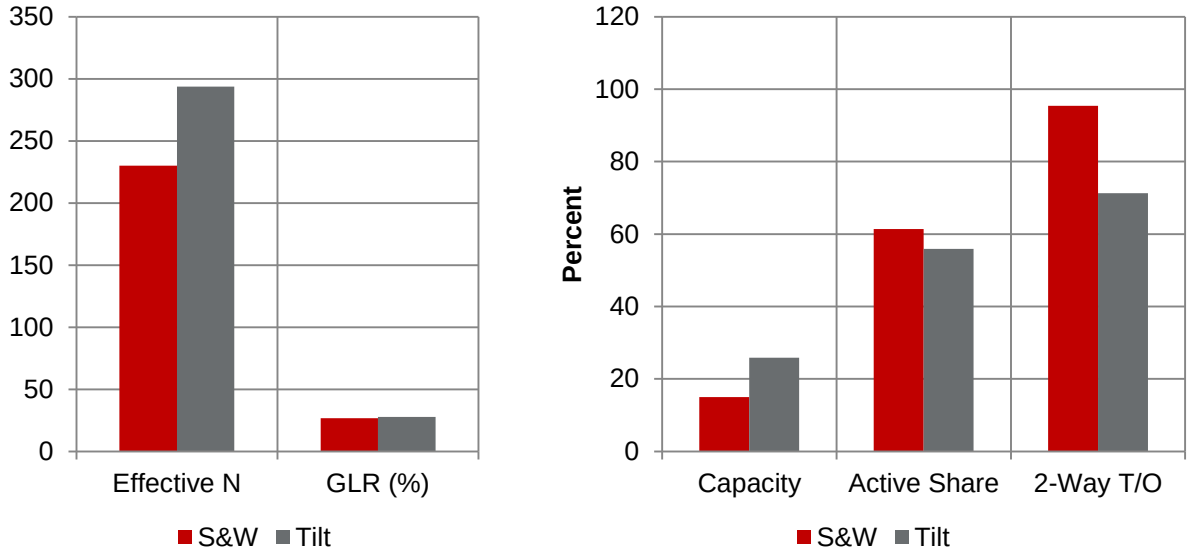
Figure 12: Total Return USD Performance of FTSE USA, S&W and Tilt Indexes



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

The two portfolios do not represent the same portfolio by weight; the time-averaged active share of one relative to the other is 32%. This difference is further emphasized when we examine measures of diversification and implementation in Figure 13.

Figure 13: Diversification & Implementation Properties of S&W and Tilt Portfolios



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

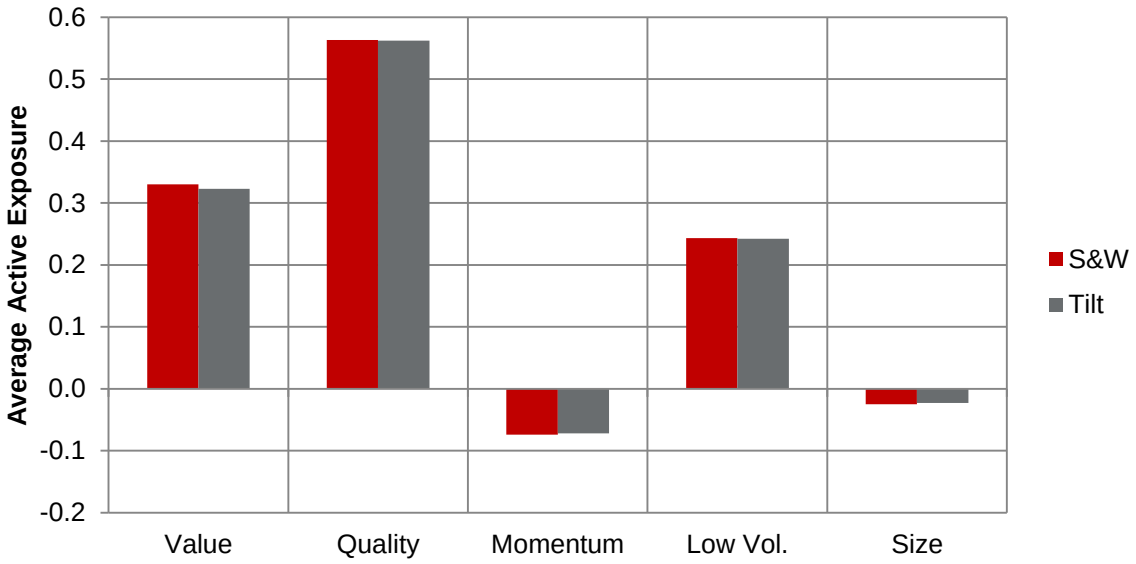
As was the case with selection and equal weighting, the diversification and implementation metrics of the factor matched Tilt Portfolio are the same or better than the portfolio based on factor selection and risk weighting.

5 Selection and Financial Statement Weighting

In this section we select the top 50% of the FTSE USA universe by Quality factor score and weight by a set of measures drawn from corporate financial statements. We do this by creating separate sub-indexes weighted in proportion to annual Book Value, Earnings, Cash Flow, Sales and Dividends respectively. Our "financial statement" weighted index is then formed by averaging the weights of these five indexes on a semi-annual basis. As before, the factor exposure matching Tilt portfolio is tilted from market capitalization weights.

Figure 14 shows the time averaged active factor exposures. Again Quality exposure is secured by the selection mechanism, but the weighting scheme introduces a large positive exposure to Value. The active Size exposure is negligible which facilitates positive exposure to Low Volatility due to its positive correlation with Quality.

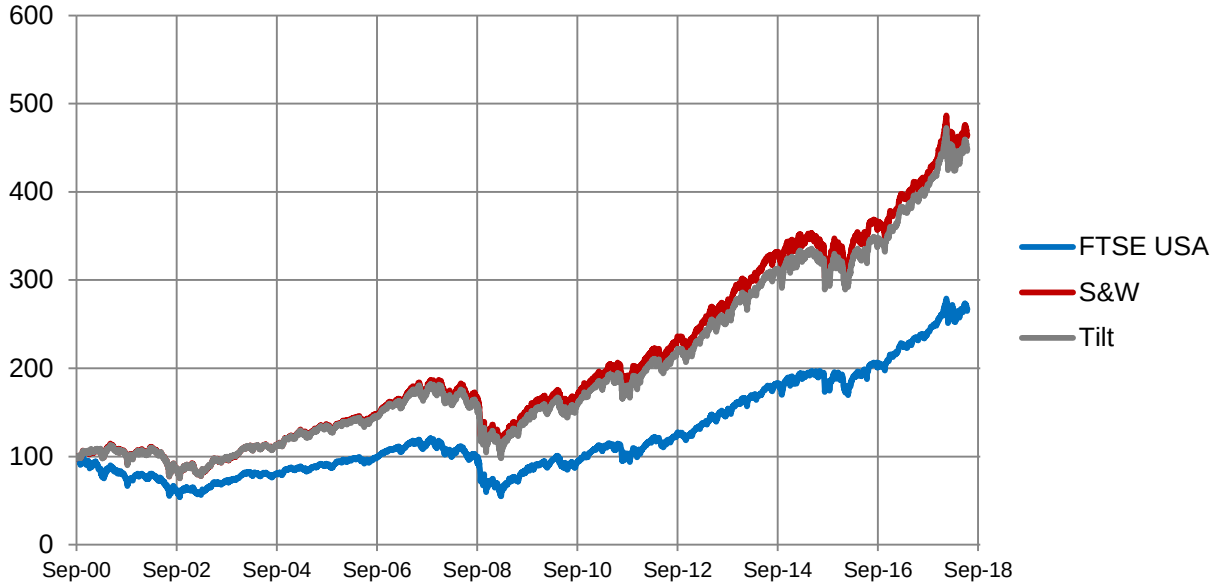
Figure 14: S&W Quality (Financial Statement Weight) & Tilt Portfolios: Average Active Factor Exposures



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 15 shows the performance of the factor portfolios through time using the FTSE USA Index as a benchmark.

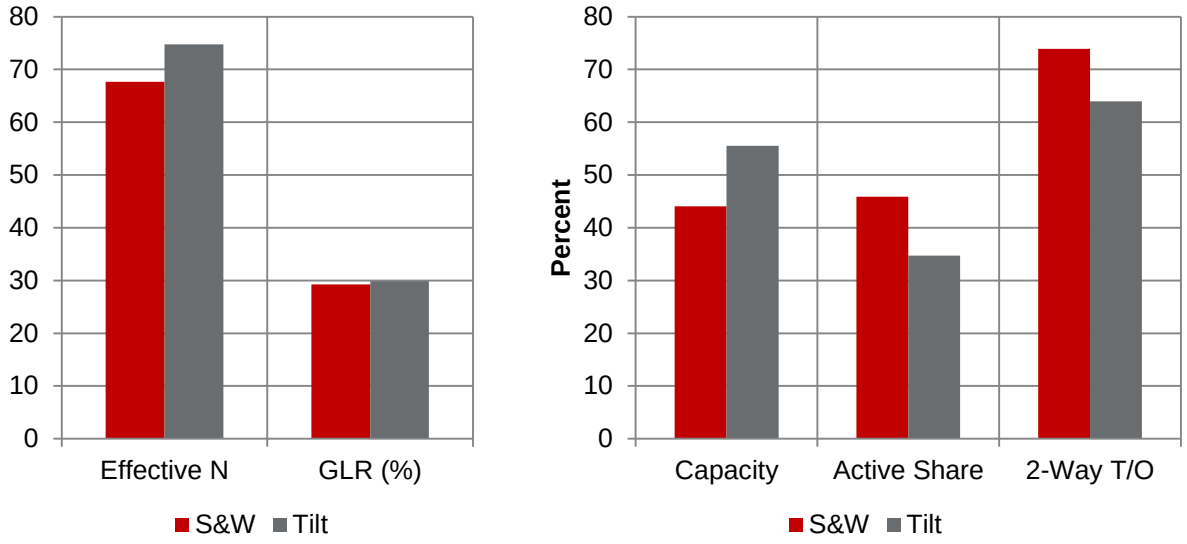
Figure 15: Total Return USD Performance of FTSE USA, S&W and Tilt Indexes



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Again the performance of the two factor portfolios is very similar. The time averaged active share between the two is 23%, so again they are materially different in weight terms. A comparison of the diversification and implementation properties is shown in Figure 16.

Figure 16: Diversification & Implementation Properties of S&W and Tilt Portfolios



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

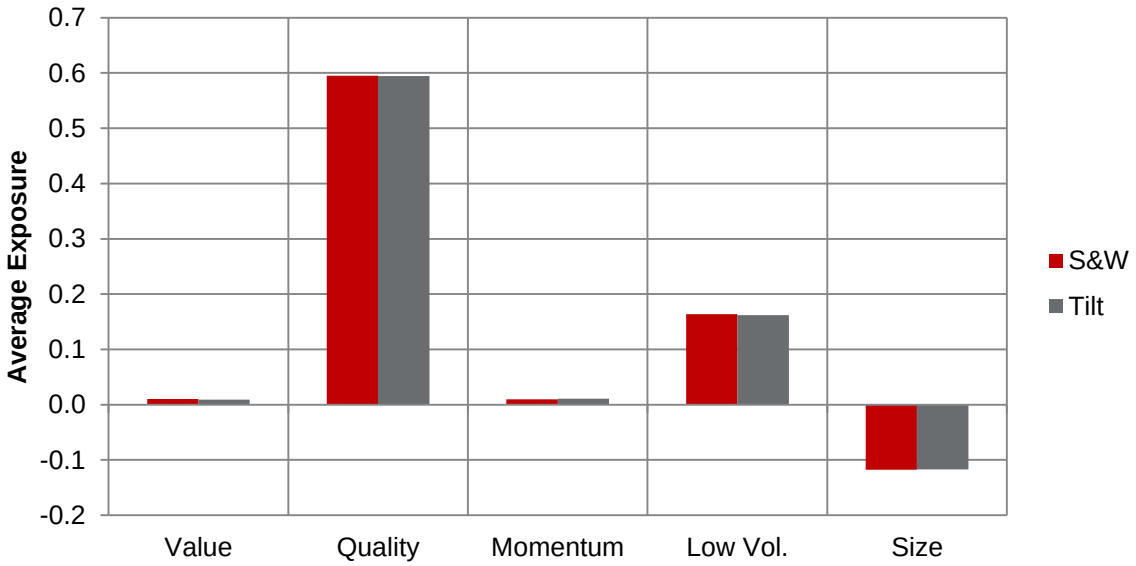
What was true for selection and either equal or risk weighting is also true for financial statement weighting. The factor exposure matched Tilt portfolio yields equivalent or superior diversification and implementation results to those of the S&W portfolio.

6 Selection and Market Capitalization Weighting

In this Section, we again select the top 50% of the FTSE USA Index universe by Quality factor score, and apply a market capitalization weighting scheme to the selected stocks. On a semi-annual basis we create the exposure matching Tilt portfolio by tilting from market capitalization weights.

Figure 17 shows the average active factor exposures of the two portfolios. It is interesting to note that capitalization weighting scheme introduces the smallest off target exposures of all the weighting schemes examined so far - that is a strong on-target quality exposure with relatively small off-target exposures.

Figure 17: S&W Quality (Market Capitalization Weight) & Tilt Portfolios: Average Active Factor Exposures

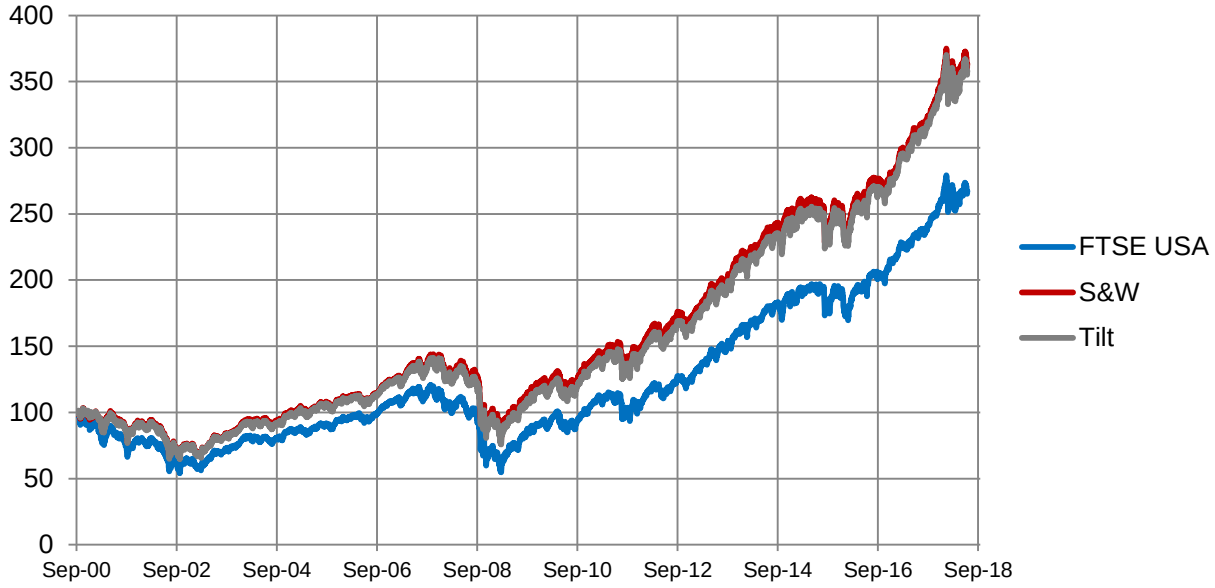


Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Selection and Weighting enthusiasts often neglect the use of market capitalization weighting in their index construction arguing that it suffers the same concentrated outcomes of the full capitalization weighted index [10, 11]. To eliminate the “non-rewarded risk” of such concentrated indexes their preference is to use “diversified” weighting schemes of which equal and risk weighting are particularly simple examples. However a comparison of the on- and off-target exposures of the three weighting schemes (Figures 7, 11 and 17) leads us to argue that capitalization weighting yields a “purer” index from a factor exposure perspective.

Indeed examining the performance outcomes in Figure 18, one questions whether the favored “diversified” weighting schemes are motivated by performance considerations as opposed to a desire to reduce idiosyncratic risk. The performance of the market capitalization weighted S&W portfolio and exposure matched Tilt portfolio are more or less identical, but poorer than those of the equal and risk weighting schemes (Figures 8 and 12). Is this really a consequence of some risk reducing property of these diversified weighting schemes, or is this attributable to relative levels of on-target (Quality) and off-target factor exposures? We will return to this question in Section 7.

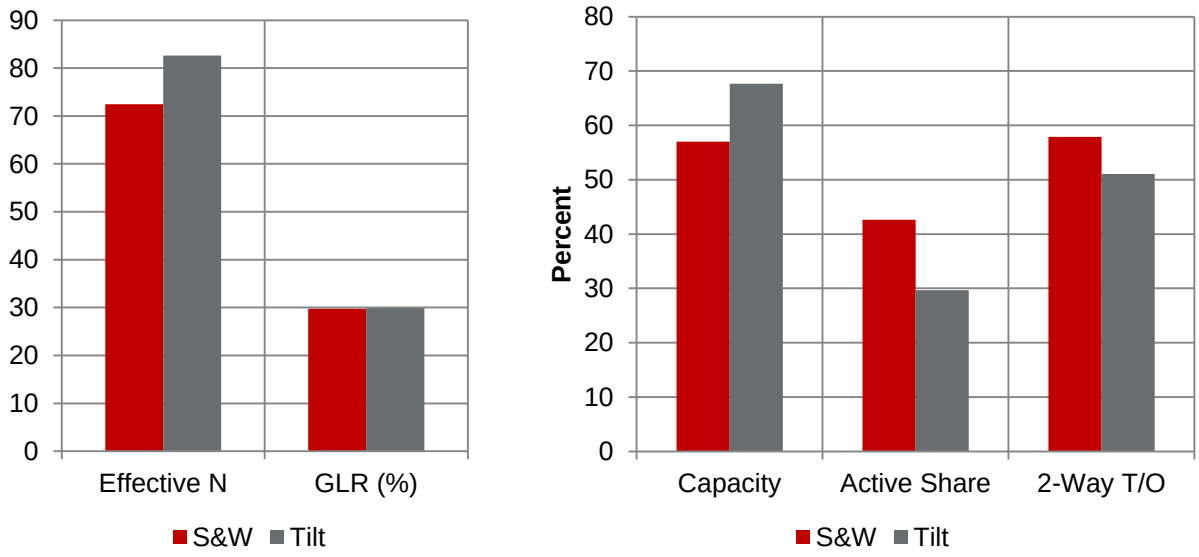
Figure 18: Total Return USD Performance of FTSE USA, S&W and Tilt Indexes



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

The time averaged active share between the S&W and Tilt portfolios is 20%. Even though both portfolios rely on a market capitalization weighting scheme, they have quite different compositions. This difference is further evident when we examine measures of diversification and implementation in Figure 19.

Figure 19: Diversification & Implementation Properties of S&W and Tilt Portfolios



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

As was the case with all previous weighting schemes, the diversification and implementation metrics of the factor exposure matched Tilt portfolio is equivalent to or better than those of the selection and market capitalization weighting portfolio.

7 Selection and Top-Down Diversified Weighting

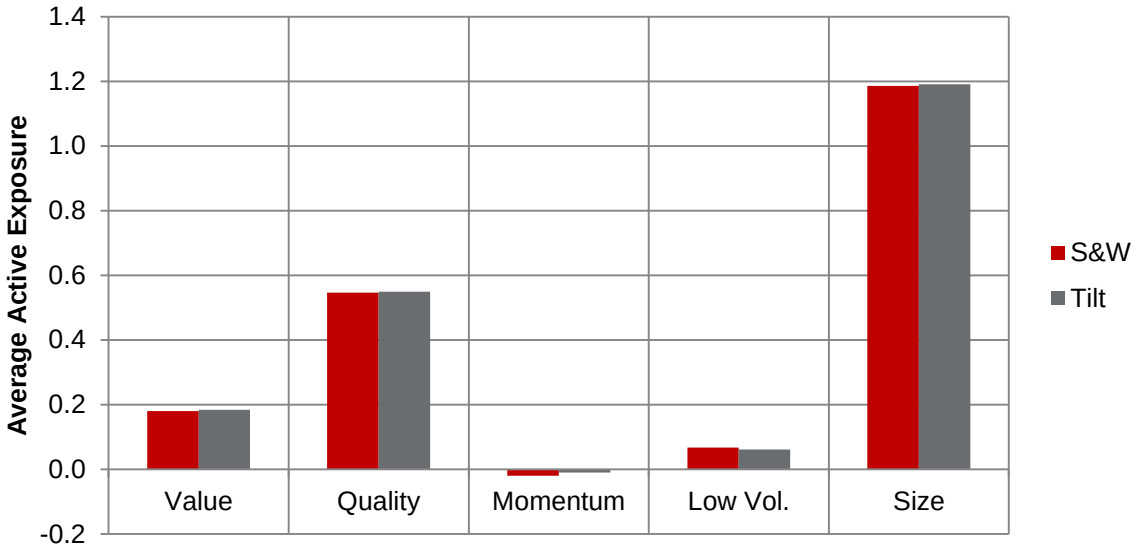
In this section we select the top 50% of the FTSE USA Index universe by Quality factor score and simulate a "diversified" weighting scheme that consists of the average of the weights resulting from the application of the equal and risk weighting schemes. This corresponds to a "Top-down" combination of two separate portfolio sleeves consisting of the equal and risk weighted S&W portfolios.

Some practitioners adopt this type of Top-down approach to improve the "robustness" of their weighting scheme(s) or to eliminate the "model risk" from a number of diversified weighting schemes [10, 11]. In practice we shall see such an approach merely introduces additional off-target and conflicting factor exposures.

We create a "Bottom-up" Tilt portfolio with matching levels of factor exposures to this Top-down portfolio, emphasizing again that we do this by tilting from a set of *market capitalization weights*.

The average levels of active factor exposure shown in Figure 20 reveal the extent to which off-target factor exposures have been introduced by combining weighting schemes. The target Quality factor exposure is present as expected, but significant unintended off-target Size, Value and Low Volatility active factor exposures are also evident. This is far from a single factor Quality portfolio.

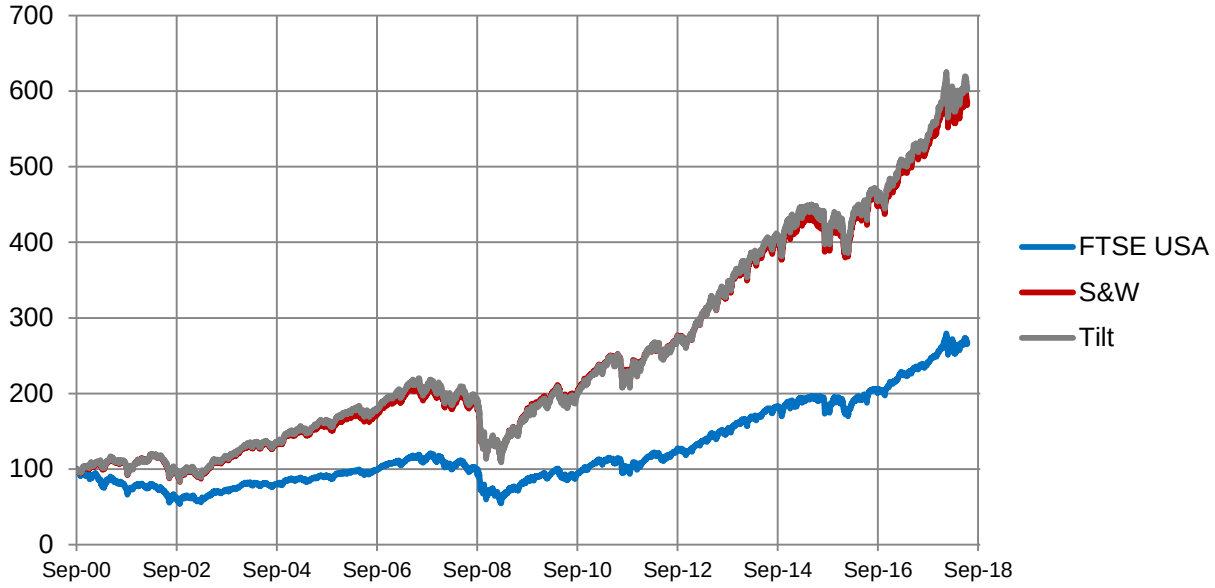
Figure 20: S&W Quality (Diversified Weight) & Tilt Portfolios: Average Active Factor Exposures



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 21 shows the performance of the S&W portfolio and the factor matching Tilt portfolio through time. As in the previous examples performance outcomes are virtually identical.

Figure 21: Total Return USD Performance of FTSE USA, S&W and Tilt Indexes

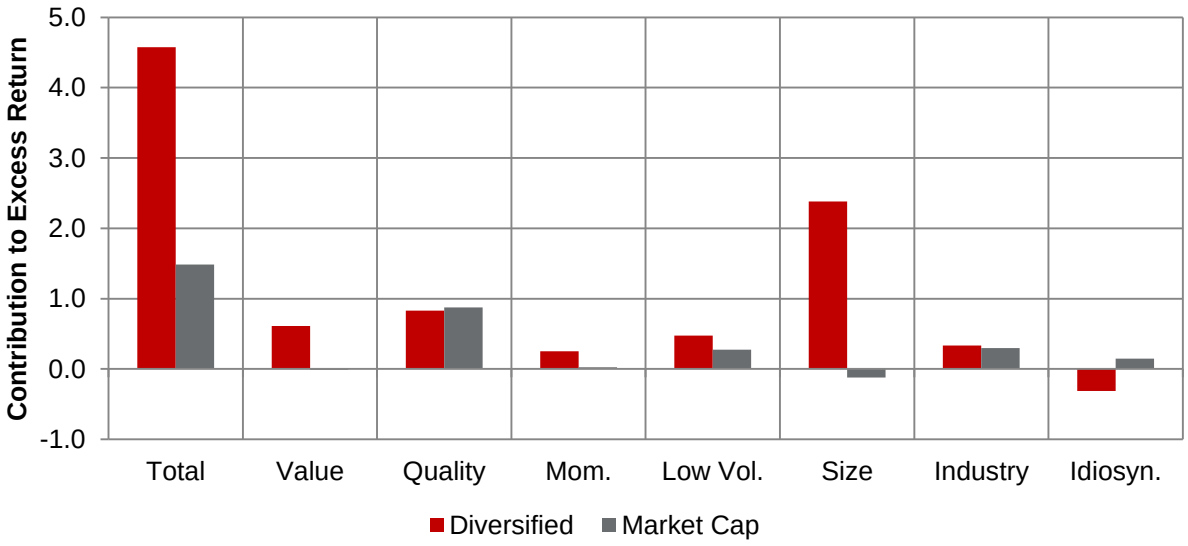


Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

This impressive performance, which is roughly 4.5% in excess of the benchmark, is frequently attributed to the "reduction of unrewarded risk" through the use of a diversified weighting scheme [10]. It is argued that the performance of such a Quality portfolio is not degraded by exposure to unrewarded risks and therefore will outperform another portfolio with the same degree of Quality exposure that employs a less diversified weighting scheme, for example market capitalization weighting.

With this in mind it is instructive to attribute the performance of the above S&W Quality portfolio employing a diversified weighting scheme and the S&W Quality portfolio employing market capitalization weights. This is done in Figure 22 – see [14] and [15] for factor attribution methodology.

Figure 22: Attribution of Excess Total Return USD; Diversified & Market Capitalisation Weighted S&W Portfolios



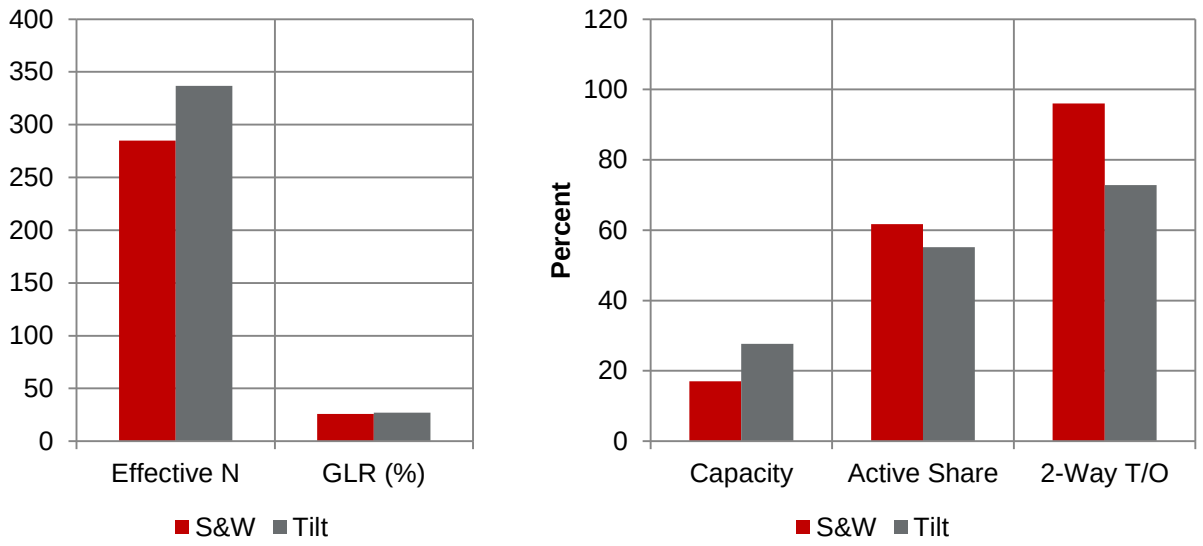
Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

It is true that the diversified weighting scheme portfolio out-performs the market capitalization weighted portfolio ("Total" bar). However, on examining Figure 22 it becomes clear why. The dominant contribution to the total excess return of the market capitalization portfolio is from Quality. There is a smaller contribution from Low Volatility and virtually no contribution from any other of the off-target factors. This is because, as we remarked in Section 6, it is a relatively "pure" factor portfolio.

On the other hand, the diversified weighting scheme results in something that is clearly not a single factor portfolio. The contribution to return from the on-target Quality exposure is dwarfed by the off-target contribution from Size. The sum of the off-target contributions from Value, Momentum and Low Volatility is actually bigger than contribution from Quality. The extra performance clearly comes from the off-target factor exposures and not as a result of eliminating "unrewarded risk". Indeed the idiosyncratic contribution to return is actually *bigger* in magnitude for the diversified weighting scheme than for the market capitalization weighting scheme.

Returning to the comparison between the diversified weighted S&W and factor matched Tilt portfolios we note that the time averaged active share is 30%. Furthermore, and again consistent with earlier results, Figure 23 shows that the diversification and implementation properties are the same or better for the Tilt portfolio.

Figure 23: Diversification & Implementation Properties of S&W and Tilt Portfolios



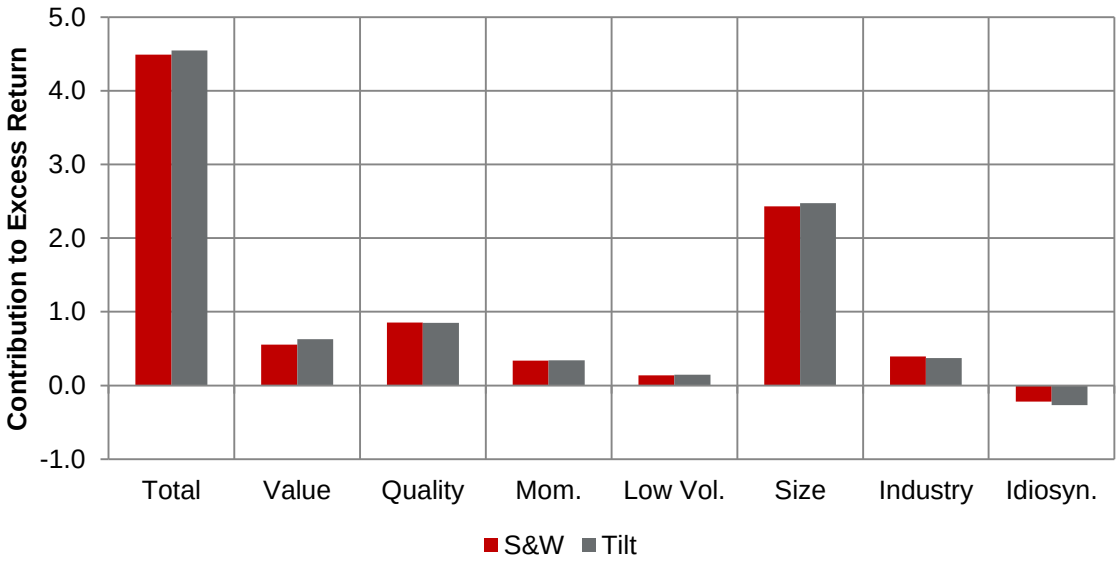
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Thus the factor exposure outcomes of this Top-down approach are readily replicated using the Bottom-up approach of multiple tilting. The matching of factor exposures results in near identical performance outcomes. However, this is achieved with higher Effective N, similar GLR and lower implementation costs, despite tilting from a "concentrated" base of market capitalization weights. This is in direct contrast to the results presented in [13], where little or no attempt is made to match factor exposures before comparing Top-down and Bottom-up portfolio outcomes.

8 S&W: A Good Way to Create a "Single Factor" Portfolio?

The results in previous Sections show that the use of S&W to create "single factor" portfolios results in outcomes that are not determined by exposure to a single factor. We highlight this more clearly by attributing the sources of excess portfolio return of each construction approach using the methodology set out in [14] and [15]. We focus on the S&W Quality portfolio that applies an equal weighting scheme in Figure 24 for the period September 2000 to June 2018.

Figure 24: Attribution of Excess Total Return USD: S&W Quality (Equal Weight) & Exposure Matching Tilt Portfolios

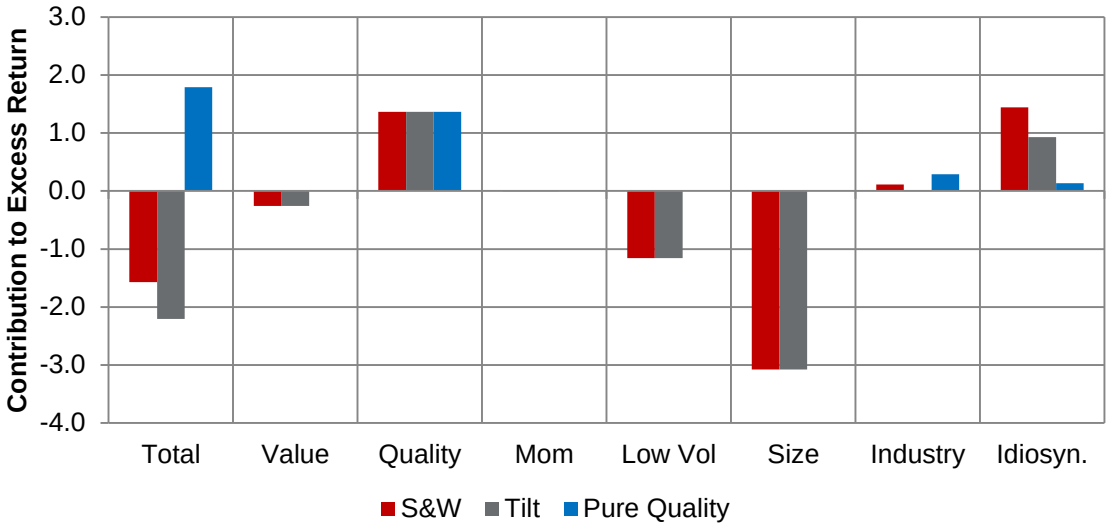


Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

The "Total" figure consists of the sum of the Factor, Industry and Idiosyncratic components. The Factor contributions are more or less identical by construction. Clearly the dominant performance contribution is from Size. The Quality factor contribution is very much of secondary importance and is actually less than the combined contributions from the off-target Value and Momentum factor exposures. This undermines the idea that a selection and diversified weighting approach can be used to create true single factor indexes.

Why is this important? The fact that the S&W portfolio is not a pure Quality portfolio would have had serious consequences during periods when such a portfolio was employed to provide downside protection. For example, what would be the result of holding this portfolio in September 2008 during the Global Financial Crisis? In Figure 25 we attribute the excess return of the S&W (equal weighting) Quality portfolio in red and the matching Quality Tilt portfolio in grey for September 2008.

Figure 25: Attribution of Excess Total Return USD: S&W Quality (Equal Weight), Exposure Matching Tilt & Pure Quality Portfolios



Source: FTSE Russell. Data from September 2008 to October 2008. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

The outcome is underperformance relative to the benchmark. The contribution of the Quality factor is positive as one would expect, but this is offset by negative contributions from Size, Low Volatility and Value. This portfolio would not provide the downside protection sought.

Recall, that the Tilt portfolio has been constructed to match *all* the factor exposures of the S&W portfolio, irrespective of whether they are targeted or not. We could equally have created a Tilt portfolio where the Quality exposure was precisely matched but all other factor exposures were set to zero – a "Pure Quality" portfolio. What would the outcome be here?

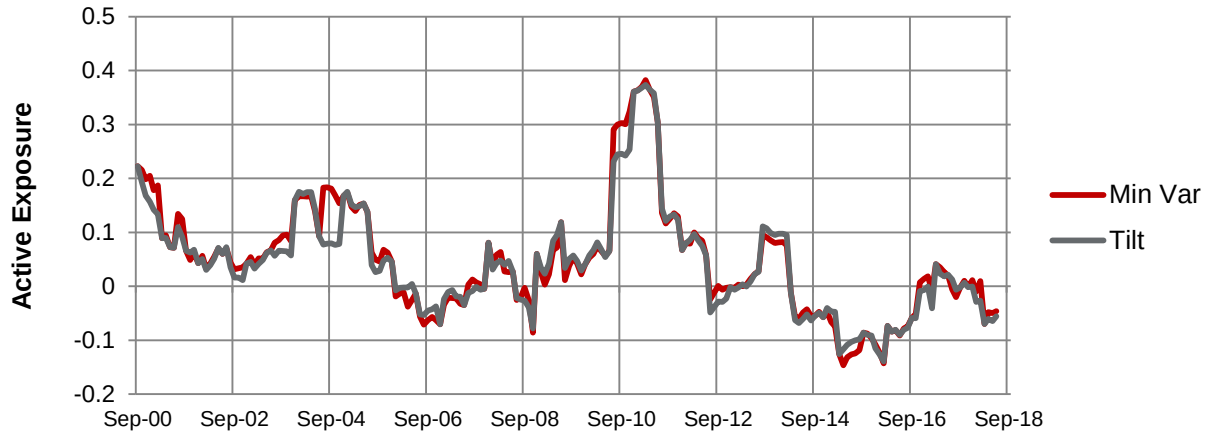
The outcome is outperformance relative to the benchmark (blue bar in Figure 25). Quality contributes positively as expected and there are no contributions from other factors. This is an example of where factor purity is important in obtaining the outcome sought and expected.

9 More Complex Smart Beta Portfolios

It could be argued that up to this point we have created tilt portfolios that match the factor exposures of portfolios that are relatively simple in nature. The fact that performance outcomes are similar may be a consequence of factor exposure being the only objective targeted and that is the only dimension of consequence for these portfolios. In this section we assess this by matching the active factor exposures of a Minimum Variance portfolio. The primary objective of a Minimum Variance portfolio is to minimize index level return volatility rather than exposure to rewarded risk factors. Any factor exposure outcomes are incidental to the primary goal of index risk reduction.

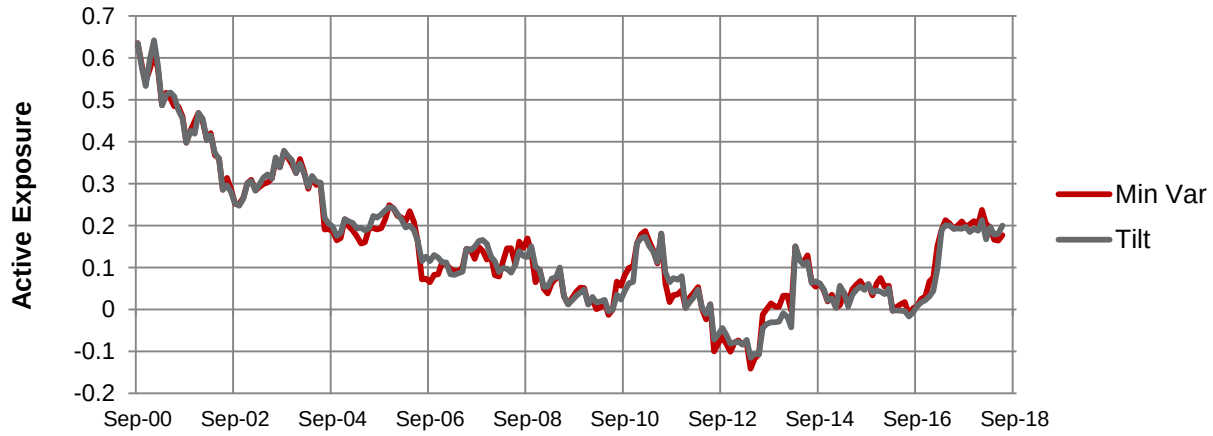
Figures 26 to 30 show the active factor exposures of FTSE USA Minimum Variance Index [5] through time and the factor matching Tilt portfolio. The latter is created through the application of a series of factor tilts to a set of market capitalization weights on the same rebalance schedule as the FTSE USA Minimum Variance Index.

Figure 26: FTSE USA Minimum Variance Index & Tilt Portfolio: Active Quality Exposure



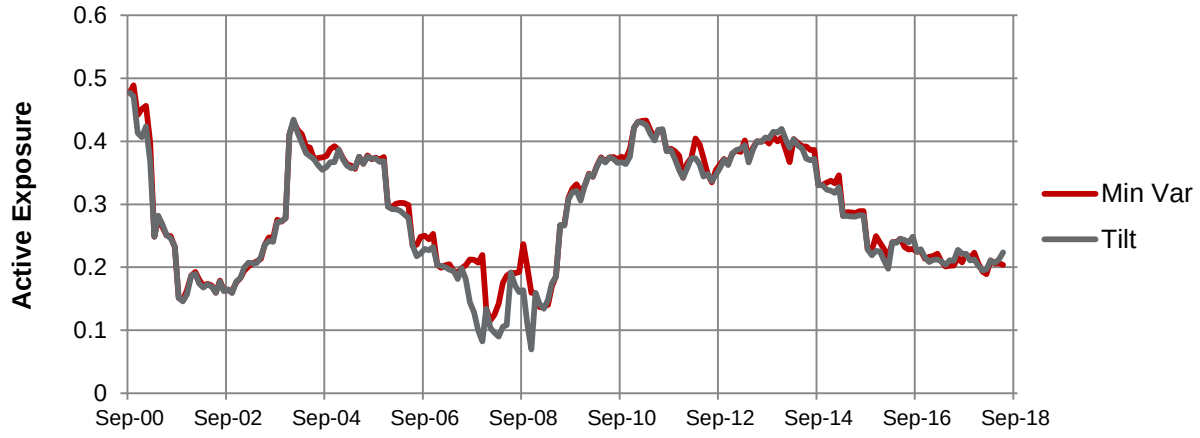
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 27: FTSE USA Minimum Variance Index & Tilt Portfolio: Active Value Exposure



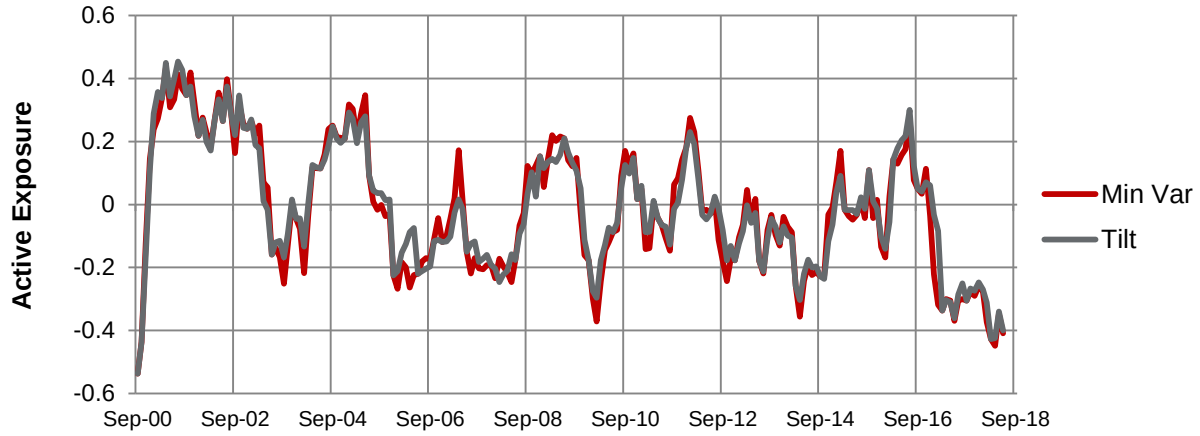
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 28: FTSE USA Minimum Variance Index & Tilt Portfolio: Active Low Volatility Exposure



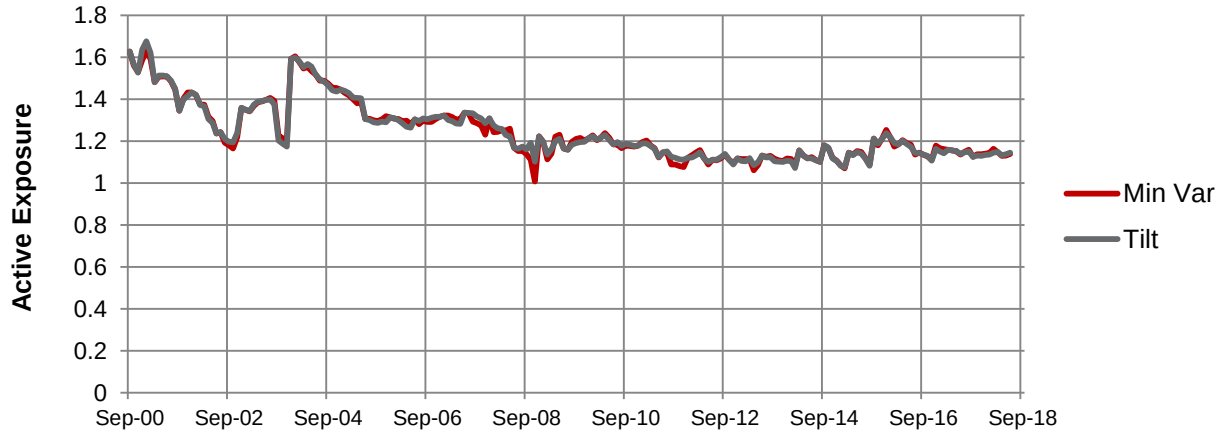
Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 29: FTSE USA Minimum Variance Index & Tilt Portfolio: Active Momentum Exposure



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

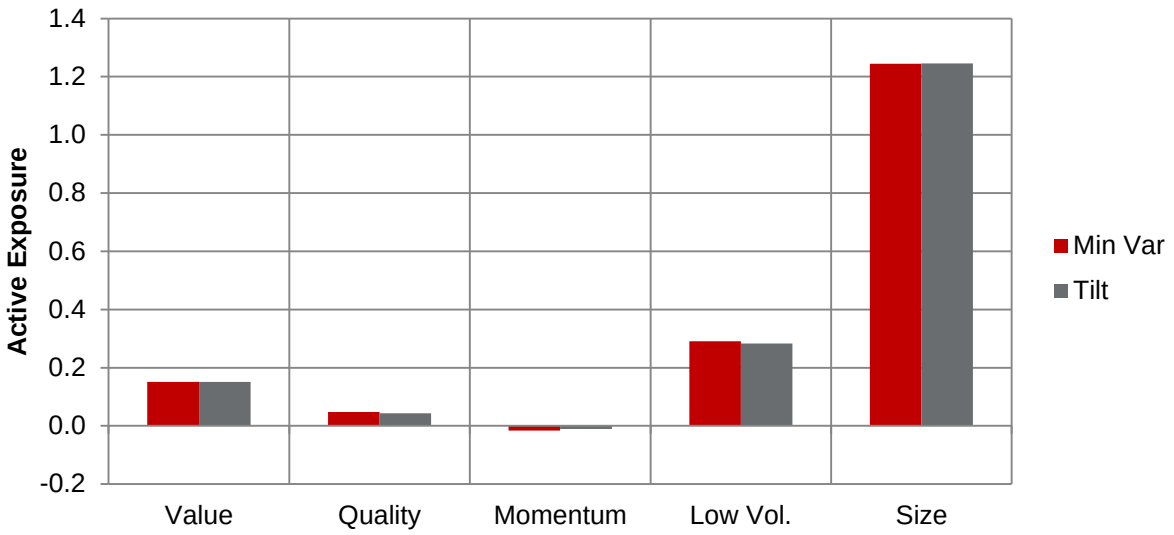
Figure 30: FTSE USA Minimum Variance Index & Tilt Portfolio: Active Size Exposure



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

The time-series average values of these active factor exposures are displayed in Figure 31. Unsurprisingly, there is a relatively large active Low Volatility exposure. The substantial active Size exposure is a consequence of the diversification constraint utilized in the Minimum Variance optimization. There are also significant positive factor exposures to Value and Quality. Although Momentum exposure fluctuates and may be relatively large in magnitude at points in time, it is approximately zero on average.

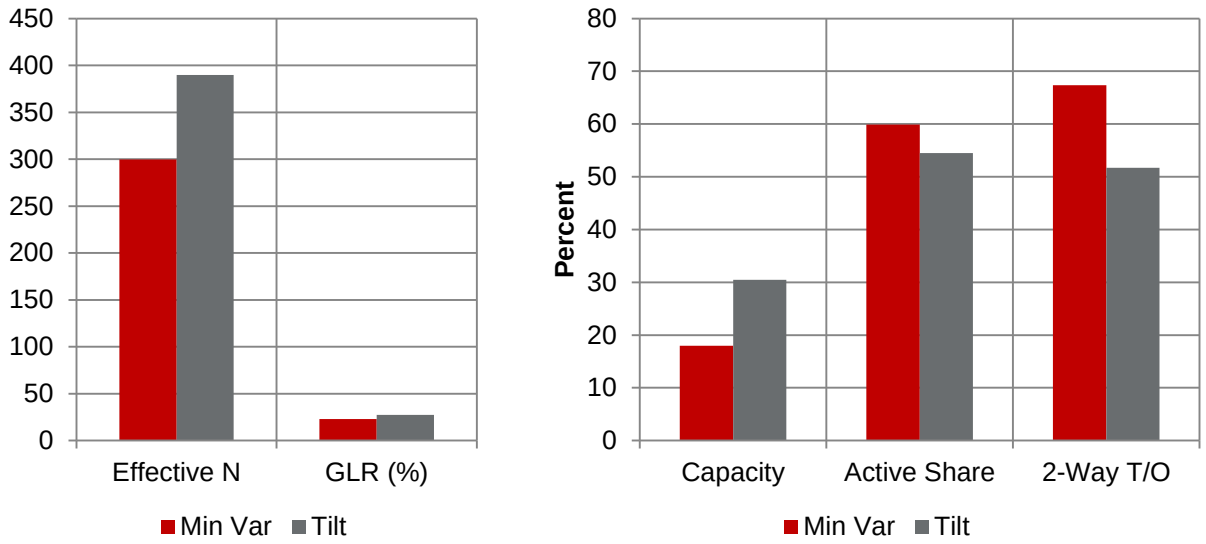
Figure 31: FTSE USA Minimum Variance Index & Tilt Portfolio: Average Active Factor Exposures



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

As we saw when comparing S&W and Tilt portfolios, the diversification and implementation properties favor the Tilt portfolio (Figure 32). Interestingly, the Effective N is higher for the Tilt portfolio even though the Minimum Variance portfolio employs a specific constraint that targets high levels of diversification. The average active share between the two is 33%.

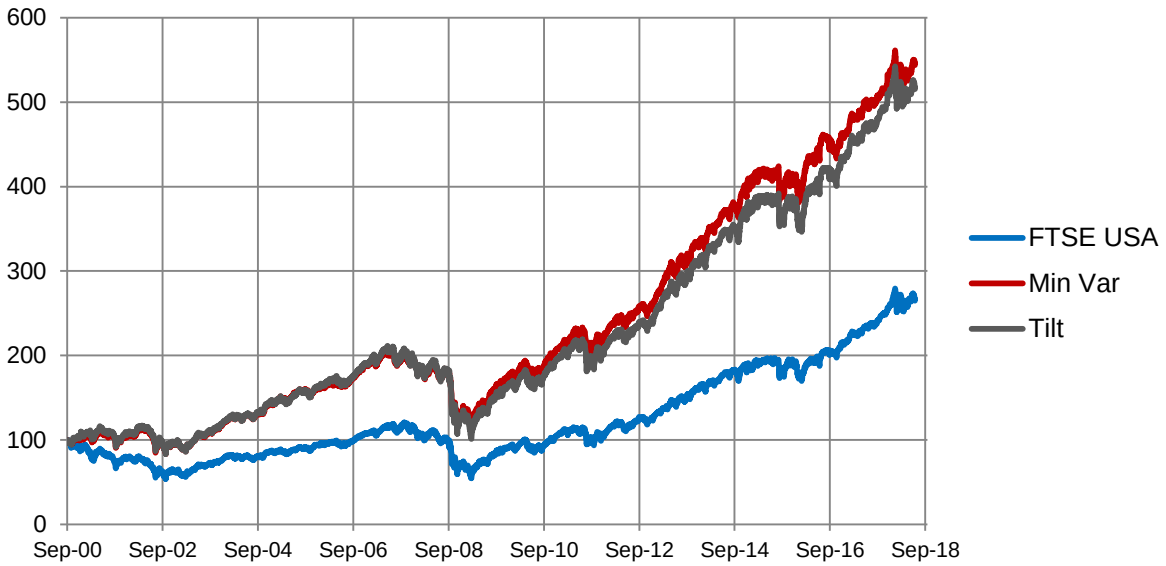
Figure 32: Diversification & Implementation Properties of FTSE USA Minimum Variance Index & Tilt Portfolio



Source: FTSE Russell. Data from September 2000 to June 2018. Data based on the FTSE USA Index Universe.

Figure 33 shows the performance of the FTSE USA Index, the FTSE USA Minimum Variance Index and the factor matched Tilt portfolio. The performances of the FTSE USA Minimum Variance Index and Tilt portfolio are very similar prior to the Global Financial Crisis in September 2008 but differ post Crisis.

Figure 33: Total Return USD Performance of FTSE USA, FTSE USA Minimum Variance Indexes & Tilt Portfolio



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the Tilt index is derived from the FTSE USA Index universe and represents hypothetical historical performance. Please see the end for important legal disclosures.

The relationship between the performances of the two approaches is more evident in Figure 34, which shows the performance of the FTSE USA Minimum Variance Index relative to the Tilt portfolio.

Figure 34: Relative Total Return USD Performance of FTSE USA Minimum Variance Index versus Tilt Portfolio

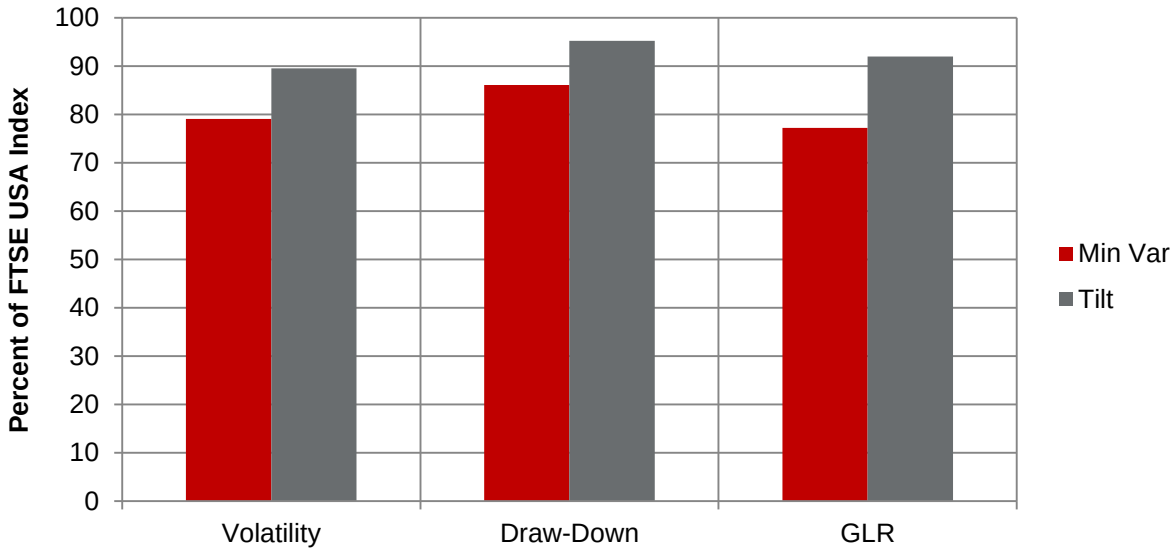
Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the Tilt index is derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Pre-Crisis the graph is ostensibly flat as it is post Crisis. The FTSE USA Minimum Variance Index therefore only consistently outperforms the factor matched Tilt index during the Crisis. Why is this?

A consideration of what extra information the FTSE USA Minimum Variance Index incorporates over the factor Tilt portfolio leads us to suppose that stock *correlation* may be responsible for this difference. Indeed, it was precisely this stock correlation that many analysts saw as important in governing outcomes in September 2008.

Furthermore, an examination of the risk characteristics in Figure 35, indicates that the FTSE USA Minimum Variance Index exhibits substantially lower volatility (and therefore lower volatility relative to the FTSE USA Index) and greater draw-down protection (relative to the drawdown of FTSE USA Index).

Figure 35: Relative Volatility & Relative Draw-Down of FTSE USA Minimum Variance Index & Tilt Portfolio

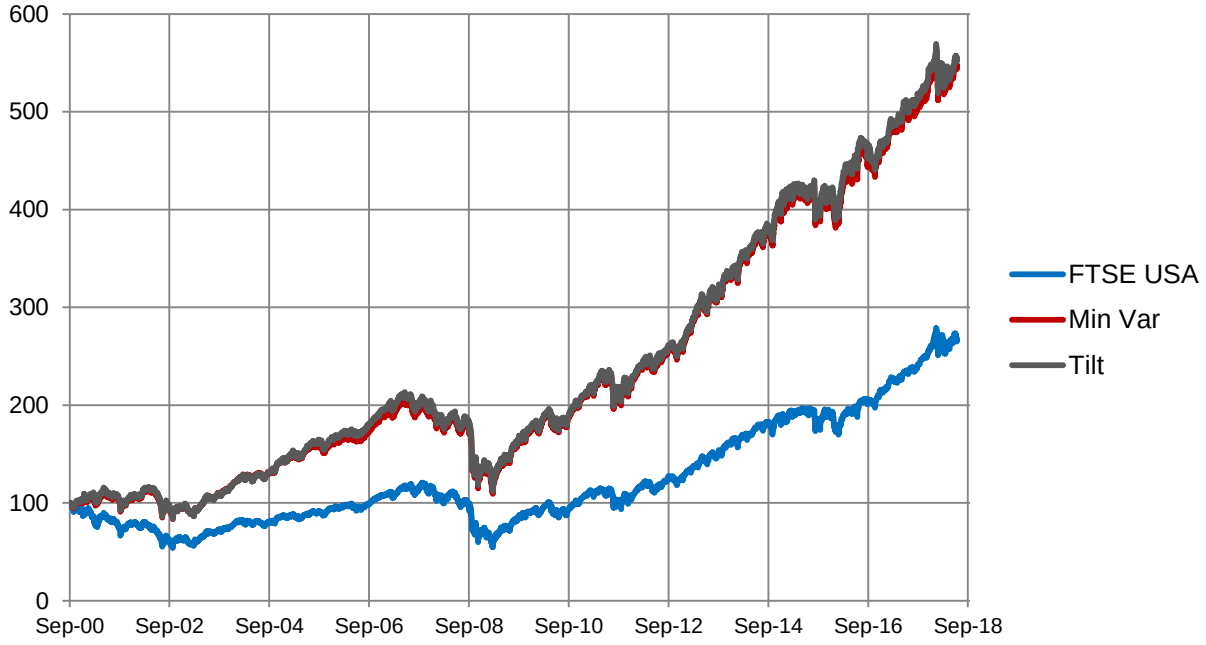


Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the Tilt index is derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

This leads us to the conclusion that in normal circumstances the performance of a minimum variance index is determined by factors, but in times of market stress, both factor exposure and stock correlation play a role.

We speculate that if we were to replace the Low Volatility factor by a Beta factor which incorporates correlation relative to the market, our results may be closer. Reproducing the factor matching results, and replacing Low Volatility with a Beta factor calculated using on two years of daily total returns, indicates that this is indeed the case as can be seen in Figure 36.

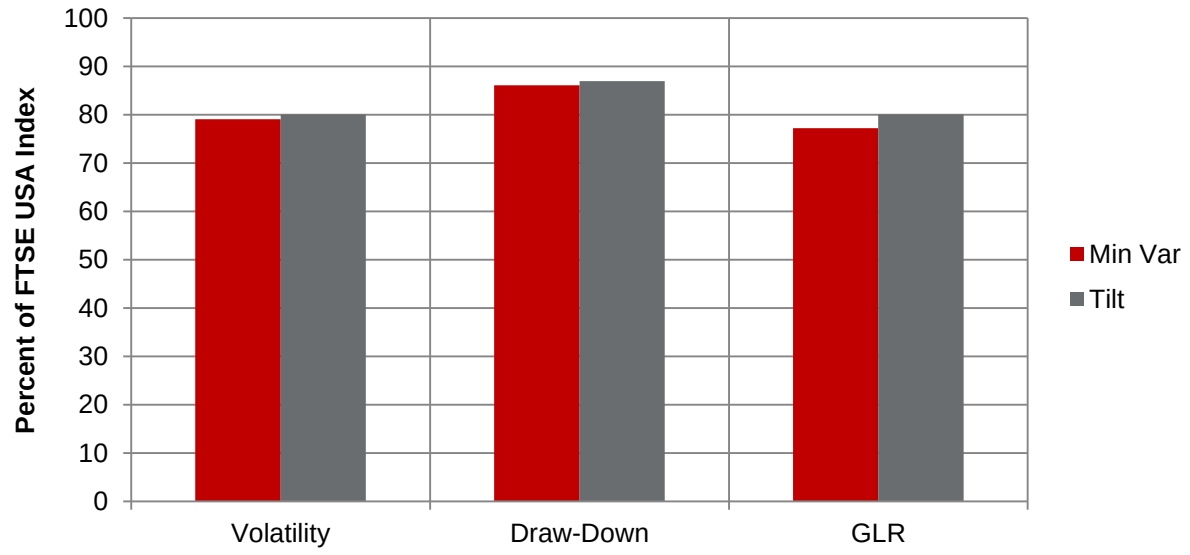
Figure 36: Total Return USD Performance of FTSE USA & FTSE USA Minimum Variance Indexes & Beta Matched Tilt Portfolio



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the Tilt index is derived from the FTSE USA Index universe and represents hypothetical historical performance. Please see the end for important legal disclosures.

The risk characteristics are now much closer as expected in Figure 37. Recall that these are *very different* portfolios. One aims to reduce index level volatility and is constructed via optimization with diversification, industry and stock weight constraints. The other is simply the result of multiplying a set of positive scores by a set of market capitalization weights and then renormalizing to get a final set of weights. The average active share between the two is 19%.

Figure 37: Relative Volatility & Relative Draw-Down of FTSE USA Minimum Variance Index & Beta Matched Tilt Portfolio



Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the Tilt index is derived from the FTSE USA Index universe and represents hypothetical historical performance. Please see the end for important legal disclosures.

10 Conclusion

In this paper we have provided a clear empirical demonstration of what the academics have been telling us for many years. That is factor exposures matter – they are important drivers of portfolio performance and in many practical cases are the dominant drivers. To rigorously test this thesis we have created simple, suitably diversified portfolios which differ substantially in terms of their construction and stock composition, but display identical factor exposures. When we examine the performance characteristics of the different approaches, we obtain very similar outcomes.

However the portfolios are not the same from the perspective of diversification and implementation. Portfolio construction therefore matters when one turns to the practical considerations of meeting stated objectives, replication, robustness and cost.

We have compared one popular construction technique, Selection and Weighting, with a Multiple Tilting technique. For a fifty percent selection rule, followed by equal, risk, financial statement and market capitalization weighting schemes, we have shown that the Multiple Tilt approach yields more efficient portfolio outcomes in terms of diversification and implementation metrics. Furthermore, when the equal and risk weighting schemes are combined as separate sleeves in a Top-down manner, the equivalent Bottom-up Multiple Tilt portfolio continues to deliver a more efficient capture of the same factor characteristics.

We have also demonstrated the role portfolio construction has in the control of both on-target *and* off-target factor exposures. Selection and Weighting introduces multiple, uncontrolled off-target factor exposures through the choice of a particular weighting scheme. In a single factor context this would be misleading and potentially dangerous, since the performance attributable to such an index arises from multiple factor sources, with the target factor playing possibly only a minor role.

Furthermore any advantage regarding the attributional transparency of a Top-down approach to multi-factor portfolio construction utilizing distinct Selection and Weighting “single” factor portfolio sleeves is lost as the individual sleeves themselves already consist of uncontrolled multi-factor exposures. Performance attribution to the individual sleeves is possible, but since the sleeves are inherently multi-factor, associating a sleeve with a particular factor is not.

If attributional transparency is an overriding objective, then a more sensible approach would be to create pure single factor sleeves and combine them in a Top-down manner. However it is hard to envisage how such pure single factor sleeves could be created in a way that avoids the use of Bottom-up techniques. Indeed it has recently been realized by some Top-down proponents that their single factor sleeves need to be adjusted to account for unintended factor biases [13]. Their proposed solution is to “correct” each sleeve portfolio using a composite multi-factor score which is a Bottom-up construct.

Finally, we have applied the concept of factor matching to more complex smart beta portfolios. When the exposure to five common factors of the FTSE USA Minimum Variance Index and a hypothetical Multiple Tilt portfolio are matched, the performance outcomes are again similar apart from during the Global Financial Crisis of 2008. Volatility reduction and drawdowns also differ. However, the five common factor characteristics do not incorporate information about stock correlation. Once, Low Volatility is replaced by Beta, performance characteristics become more closely aligned.

11 Appendix

Equal Weighting: Value, Quality, Momentum and Low Volatility

		Value		Quality		Momentum		Low Volatility	
	FTSE USA	S&W	Tilt	S&W	Tilt	S&W	Tilt	S&W	Tilt
Performance:									
Geo. Mean (%)	5.48	10.69	10.42	10.00	10.04	8.49	8.44	9.53	9.50
Volatility (%)	18.67	20.16	20.22	18.04	18.26	18.06	18.29	16.52	16.46
Sharpe Ratio	0.29	0.53	0.52	0.55	0.55	0.47	0.46	0.58	0.58
Excess (%)		4.94	4.68	4.29	4.32	2.86	2.81	3.84	3.81
Tracking Error (%)		6.24	6.09	4.39	4.33	4.88	4.81	5.39	5.49
Information Ratio		0.79	0.77	0.98	1.00	0.59	0.58	0.71	0.69
Diversification:									
Mean No. Stocks	620	310	620	310	620	310	620	310	620
Effective N	139	310	354	310	353	310	352	310	330
GLR (%)	30	26	26	26	26	29	28	29	28
Implementation:									
2-Way T/O (%)		114.52	93.69	100.47	78.07	158.86	128.50	67.36	50.87
Capacity (%)	100.00	13.61	20.84	16.59	26.55	18.72	28.58	17.97	27.32
Active Share (%)	0.00	68.14	60.77	63.12	56.35	62.89	55.42	60.52	56.16
Active Exposure:									
Value	0.00	0.77	0.77	0.18	0.19	-0.01	-0.01	0.17	0.17
Quality	0.00	-0.10	-0.10	0.56	0.56	-0.05	-0.05	0.00	-0.01
Momentum	0.00	-0.18	-0.17	-0.03	-0.02	0.49	0.49	-0.03	-0.03
Low Volatility	0.00	-0.17	-0.17	-0.13	-0.13	-0.16	-0.16	0.42	0.42
Size	0.00	1.44	1.45	1.26	1.26	1.23	1.23	1.18	1.18
Attribution:									
Arithmetic Excess		5.84	5.54	4.49	4.55	2.98	2.96	3.67	3.60
Value		1.17	1.17	0.56	0.63	0.32	0.34	0.48	0.51
Quality		0.04	0.04	0.85	0.85	0.02	0.00	0.11	0.11
Momentum		0.70	0.75	0.34	0.34	0.65	0.70	0.05	0.04
Low Volatility		0.36	0.36	0.14	0.15	-0.05	-0.09	0.70	0.68
Size		2.87	2.93	2.43	2.47	2.31	2.31	2.35	2.37
Industry		0.33	0.30	0.39	0.37	0.17	0.04	0.34	0.09
Idiosyncratic		0.37	-0.01	-0.22	-0.26	-0.44	-0.34	-0.36	-0.21

Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Risk Weighting: Value, Quality, Momentum and Low Volatility

		Value		Quality		Momentum		Low Volatility	
	FTSE USA	S&W	Tilt	S&W	Tilt	S&W	Tilt	S&W	Tilt
Performance:									
Geo. Mean (%)	5.48	11.05	10.91	10.11	10.48	9.42	9.45	9.72	9.63
Volatility (%)	18.67	17.28	17.89	15.59	16.24	15.94	16.63	15.17	15.55
Sharpe Ratio	0.29	0.64	0.61	0.65	0.65	0.59	0.57	0.64	0.62
Excess (%)		5.28	5.15	4.38	4.74	3.74	3.76	4.02	3.93
Tracking Error (%)		5.87	5.69	5.79	5.40	6.10	5.84	6.42	6.40
Information Ratio		0.90	0.90	0.76	0.88	0.61	0.64	0.63	0.61
Diversification:									
Mean No. Stocks	620	310	620	310	620	310	620	310	620
Effective N	139	230	304	230	294	231	304	259	265
GLR (%)	30	27	28	27	28	30	30	29	29
Implementation:									
2-Way T/O (%)		115.13	87.87	95.38	71.30	162.99	123.15	66.02	49.75
Capacity (%)	100.00	12.29	20.45	15.02	25.86	14.42	25.53	15.47	22.54
Active Share (%)	0.00	67.60	60.36	61.43	55.93	62.70	56.19	60.24	59.22
Active Exposure:									
Value	0.00	0.68	0.68	0.18	0.18	0.02	0.02	0.16	0.16
Quality	0.00	-0.08	-0.07	0.53	0.54	-0.02	-0.02	0.00	0.00
Momentum	0.00	-0.13	-0.12	-0.01	0.00	0.39	0.40	-0.02	-0.02
Low Volatility	0.00	0.22	0.21	0.26	0.25	0.23	0.22	0.55	0.54
Size	0.00	1.33	1.34	1.12	1.12	1.16	1.16	1.13	1.13
Attribution:									
Arithmetic Excess		5.37	5.38	4.11	4.57	3.50	3.62	3.58	3.53
Value		1.06	1.04	0.56	0.60	0.34	0.36	0.44	0.47
Quality		0.10	0.10	0.81	0.81	0.11	0.10	0.16	0.16
Momentum		0.45	0.51	0.09	0.14	0.42	0.46	-0.12	-0.13
Low Volatility		0.94	0.93	0.80	0.80	0.66	0.61	1.11	1.09
Size		2.78	2.81	2.26	2.29	2.27	2.28	2.27	2.30
Industry		-0.03	0.13	-0.04	0.22	0.06	-0.02	0.08	-0.17
Idiosyncratic		0.08	-0.14	-0.37	-0.29	-0.37	-0.17	-0.36	-0.19

Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Financial Statement Weighting: Value, Quality, Momentum and Low Volatility

		Value		Quality		Momentum		Low Volatility	
	FTSE USA	S&W	Tilt	S&W	Tilt	S&W	Tilt	S&W	Tilt
Performance:									
Geo. Mean (%)	5.48	9.47	9.10	8.70	8.50	6.58	7.16	7.00	7.25
Volatility (%)	18.67	19.72	19.73	16.61	16.78	17.34	17.41	16.73	16.63
Sharpe Ratio	0.29	0.48	0.46	0.52	0.51	0.38	0.41	0.42	0.44
Excess (%)		3.78	3.43	3.05	2.86	1.04	1.59	1.44	1.68
Tracking Error (%)		5.63	5.21	5.03	4.55	4.84	4.31	4.87	4.73
Information Ratio		0.67	0.66	0.61	0.63	0.22	0.37	0.29	0.35
Diversification:									
Mean No. Stocks	620	309	620	309	620	309	620	309	620
Effective N	139	74	94	68	75	72	99	75	81
GLR (%)	30	30	30	29	30	34	32	32	32
Implementation:									
2-Way T/O (%)		101.35	89.44	73.90	63.98	164.66	132.43	54.52	48.14
Capacity (%)	100.00	35.72	40.62	44.05	55.56	41.89	55.97	51.61	60.40
Active Share (%)	0.00	55.09	43.74	45.90	34.69	48.36	33.22	38.91	32.23
Active Exposure:									
Value	0.00	0.84	0.83	0.33	0.32	0.21	0.19	0.33	0.32
Quality	0.00	-0.14	-0.14	0.56	0.56	-0.06	-0.06	0.04	0.04
Momentum	0.00	-0.18	-0.18	-0.07	-0.07	0.37	0.38	-0.11	-0.10
Low Volatility	0.00	0.04	0.04	0.24	0.24	0.11	0.11	0.47	0.47
Size	0.00	0.21	0.22	-0.03	-0.02	0.07	0.06	-0.13	-0.13
Attribution:									
Arithmetic Excess		4.24	3.88	2.85	2.65	0.88	1.43	1.13	1.34
Value		1.31	1.30	0.32	0.34	0.35	0.43	0.44	0.49
Quality		-0.08	-0.08	0.82	0.83	-0.10	-0.11	0.10	0.10
Momentum		0.64	0.67	0.12	0.10	0.59	0.62	-0.06	-0.08
Low Volatility		0.65	0.67	0.57	0.56	0.32	0.29	0.76	0.74
Size		0.84	0.85	0.22	0.23	0.19	0.18	0.01	0.02
Industry		0.67	0.64	0.36	0.61	0.01	0.15	0.38	0.31
Idiosyncratic		0.20	-0.16	0.45	-0.02	-0.49	-0.13	-0.50	-0.23

Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Market Cap Weighting: Value, Quality, Momentum and Low Volatility

		Value		Quality		Momentum		Low Volatility	
	FTSE USA	S&W	Tilt	S&W	Tilt	S&W	Tilt	S&W	Tilt
Performance:									
Geo. Mean (%)	5.48	9.30	8.56	7.26	7.18	5.59	5.87	6.58	6.60
Volatility (%)	18.67	19.05	18.96	16.86	16.90	17.72	17.81	16.40	16.26
Sharpe Ratio	0.29	0.49	0.45	0.43	0.42	0.32	0.33	0.40	0.41
Excess (%)		3.62	2.92	1.68	1.60	0.10	0.37	1.04	1.06
Tracking Error (%)		4.56	4.07	3.99	3.63	4.49	4.03	4.75	4.54
Information Ratio		0.79	0.72	0.42	0.44	0.02	0.09	0.22	0.23
Diversification:									
Mean No. Stocks	620	310	620	310	620	310	620	310	620
Effective N	139	69	108	72	83	78	98	77	85
GLR (%)	30	31	31	30	30	33	32	32	32
Implementation:									
2-Way T/O (%)		107.21	78.12	57.87	51.03	150.84	127.60	41.97	34.27
Capacity (%)	100.00	42.90	55.42	57.03	67.67	54.09	65.55	63.41	72.29
Active Share (%)	0.00	54.42	34.12	42.66	29.68	44.81	29.79	36.18	26.30
Active Exposure:									
Value	0.00	0.62	0.61	0.01	0.01	-0.11	-0.11	0.07	0.07
Quality	0.00	-0.08	-0.08	0.60	0.59	0.02	0.02	0.12	0.12
Momentum	0.00	-0.13	-0.13	0.01	0.01	0.43	0.43	-0.04	-0.05
Low Volatility	0.00	0.07	0.07	0.16	0.16	0.03	0.03	0.46	0.46
Size	0.00	0.12	0.12	-0.12	-0.12	-0.01	-0.01	-0.21	-0.21
Attribution:									
Arithmetic Excess		3.83	3.15	1.49	1.39	-0.04	0.23	0.69	0.67
Value		1.02	0.98	-0.01	-0.02	-0.01	0.00	0.02	0.03
Quality		-0.05	-0.05	0.88	0.88	0.02	0.01	0.20	0.20
Momentum		0.54	0.56	0.03	0.00	0.52	0.56	-0.15	-0.15
Low Volatility		0.41	0.44	0.28	0.28	0.05	0.03	0.72	0.72
Size		0.63	0.63	-0.12	-0.12	-0.07	-0.08	-0.35	-0.35
Industry		0.77	0.63	0.30	0.42	-0.18	-0.15	0.54	0.33
Idiosyncratic		0.51	-0.04	0.15	-0.04	-0.37	-0.13	-0.29	-0.12

Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

Diversified Weighting: Value, Quality, Momentum and Low Volatility

		Value		Quality		Momentum		Low Volatility	
	FTSE USA	S&W	Tilt	S&W	Tilt	S&W	Tilt	S&W	Tilt
Performance:									
Geo. Mean (%)	5.48	10.91	10.66	10.08	10.27	8.98	8.99	9.63	9.62
Volatility (%)	18.67	18.65	19.09	16.75	17.27	16.94	17.48	15.82	15.95
Sharpe Ratio	0.29	0.58	0.56	0.60	0.59	0.53	0.51	0.61	0.60
Excess (%)		5.14	4.91	4.36	4.54	3.31	3.32	3.94	3.92
Tracking Error (%)		5.72	5.68	4.80	4.62	5.28	5.17	5.83	5.96
Information Ratio		0.90	0.86	0.91	0.98	0.63	0.64	0.67	0.66
Diversification:									
Mean No. Stocks	620	310	620	310	620	310	620	310	620
Effective N	139	285	344	285	337	285	340	295	295
GLR (%)	30	26	27	26	27	29	29	29	29
Implementation:									
2-Way T/O (%)		112.56	89.16	96.01	72.86	158.65	124.72	64.54	47.11
Capacity (%)	100.00	14.05	21.81	17.08	27.65	17.71	28.43	17.51	24.75
Active Share (%)	0.00	67.47	59.77	61.71	55.13	62.19	54.95	60.09	57.94
Active Exposure:									
Value	0.00	0.72	0.73	0.18	0.18	0.00	0.01	0.17	0.16
Quality	0.00	-0.09	-0.09	0.55	0.55	-0.04	-0.04	0.00	0.00
Momentum	0.00	-0.15	-0.15	-0.02	-0.01	0.44	0.45	-0.03	-0.02
Low Volatility	0.00	0.03	0.02	0.07	0.06	0.03	0.03	0.48	0.49
Size	0.00	1.39	1.40	1.19	1.19	1.19	1.19	1.16	1.16
Attribution:									
Arithmetic Excess		5.61	5.45	4.30	4.58	3.24	3.33	3.63	3.60
Value		1.11	1.11	0.56	0.61	0.33	0.35	0.46	0.50
Quality		0.07	0.07	0.83	0.83	0.06	0.05	0.13	0.13
Momentum		0.57	0.64	0.21	0.25	0.54	0.58	-0.04	-0.05
Low Volatility		0.65	0.64	0.47	0.48	0.30	0.25	0.91	0.90
Size		2.82	2.87	2.35	2.38	2.29	2.29	2.31	2.37
Industry		0.15	0.25	0.18	0.33	0.12	0.07	0.21	-0.07
Idiosyncratic		0.23	-0.13	-0.29	-0.31	-0.40	-0.27	-0.36	-0.18

Source: FTSE Russell. Data from September 2000 to June 2018. Past performance is no guarantee of future results. Data for the S&W and Tilt indexes are derived from the FTSE USA Index universe and represent hypothetical historical performance. Please see the end for important legal disclosures.

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