

Research

Multi-factor indexes: The power of tilting

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It wasn't too long ago that the concept of factors in investing was the exclusive province of professors of finance and a few active "quant" managers. Mainstream portfolio construction was focused primarily on asset allocation. Within equities, that meant achieving the right balance in allocation to various segments such as large cap and small cap, country and sector, and perhaps value and growth styles.

Today, factor allocation has entered the mainstream as a complementary approach to portfolio construction, alongside traditional asset allocation. An important driver of this development has been the creation of a new array of indexes that sharply focus on one factor at a time. This has opened up new possibilities for asset owners and advisors, including investing in index-replicating financial products, both to seek a desired factor exposure at low cost and to benchmark active managers to assess their value added.

One thing that followers of single factor indexes quickly realize is that the payoff for exposure to any one factor is highly variable. Factors typically follow different return patterns: value usually exhibits pro-cyclical performance, while quality is often countercyclical, for example. Market participants who do not employ a factor-timing or factor-rotation strategy are increasingly looking at strategic combinations of factors to gain potential improvements in risk-adjusted outcomes as compared to single-factor outcomes.

A lively debate has emerged regarding what is the best way to combine several factors into a single index. Roughly speaking, there are two camps in the debate: those who advocate a top-down "mixed" composite of individual factors and those who advocate a bottom-up "integrated" approach which results in an index of stocks that have simultaneous factor exposures. Each side argues that their approach produces strong factor exposures with high diversification.

FTSE Russell stands squarely in the bottom-up "integrated" camp. In this paper we will illustrate the FTSE Russell sequential tilting or "tilt-tilt" methodology, which is very much a bottom-up approach. After a brief overview of alternative methodologies, we will walk through a simple three-stock example of how we build a single factor and multi-factor index. We will contrast it with the most common and straightforward of composite "mixed" methods using the same factors. Then we will illustrate the alternative approaches with a large universe of stocks. We will augment the empirical illustration with some recent theoretical results on the tradeoff with diversification which are independent of any particular data set. Finally, we will show how our multi-factor methodology can be extended to encompass environmental, social and governance (ESG) considerations.

Multi-factor indexes: Combining factors with meaningful levels of factor exposures

The industry discussion concerning factor combinations focuses on delivering targeted factor exposures and the associated factor premia whilst maintaining adequate diversification. We will focus on how we construct our multi-factor indexes and contrast it with a simple composite index. But before we do, it's worth mentioning a couple of other common approaches.

A lively debate has emerged regarding what is the best way to combine several factors into a single index.

Optimization has been an important tool in portfolio construction ever since Markowitz introduced its use in 1952.¹ The important characteristic of using an optimizer for constructing factor indexes is that in theory one can maximize the strength of factor exposures while satisfying targets on risk, diversification, liquidity, etc. Once the objective function and constraints are set, just let the optimizer run and find a solution. The trouble with this approach is that the optimizer appears to be a “black box” without transparency: it knows why certain stocks are selected and weighted a certain way but humans might find its choices mysterious. The growth in indexing has been driven in part by a desire for increased transparency. This is one of the reasons why FTSE Russell does not use optimizers in constructing its factor indexes.

Another common approach is to create a “characteristic basket” by using percentile cutoffs on stocks ranked by factor characteristics to select stocks for the index. For example, one might select the top 50% of stocks ranked by some factor characteristic and then weight them by some method, such as capitalization weight, equal weight or characteristic strength. A multi-factor version of this approach would be to create an “intersection basket” of stocks that simultaneously rank highly on all factors. The intersection basket is an alternative bottom-up approach that we will discuss further in the paper.

FTSE Russell “factor tilting” starts with a set of weights, most commonly capitalization weights, but it could also be equal weights or some other weighting scheme. The weights are then perturbed or tilted in the direction of increased factor exposure. This is achieved by multiplying the initial weights by a factor score ranging from 0 to 1, with 0 being the weakest, 1 being the strongest, and 0.5 being average exposure. The appendix contains a summary of the construction of the FTSE Global Factor Index Series single factor scores.

In the next section, we will walk through a three-stock, two-factor example of how we construct single factor indexes and compare two versions of multi-factor indexes, a composite and the FTSE Russell “tilt-tilt” approach.

A multi-factor composite index. The most common and simplest way to construct a multi-factor index is to take a weighted average of two or more single factor indexes, say 50% value and 50% quality. The advantage of this approach is its top-down simplicity. In principle, this is no different than replicating single factor indexes in the chosen weights. An advantage in having both factors together in one index is that the index provider maintains the fixed weights, relieving the market participant of having to adjust index-replicating products. The main concern is that the averaging process could dilute the factor exposures. We will show this is a valid concern.

The FTSE Russell “tilt-tilt” multi-factor methodology. FTSE Russell constructs a multi-factor index as a multiplicative tilt of one factor on another, rather than as an arithmetic averaging of the factors. This multiplicative approach, also called sequential tilting, in our view has the best chance of achieving the multi-factor objectives of strong factor exposures with high diversification.

A three-stock example. We will illustrate the mechanics of the two approaches to making a quality and value multi-factor index using just three stocks. First we create a hypothetical capitalization-weighted index, plus hypothetical single factor quality and value indexes for later reference. Then we illustrate the two ways of combining these two factors into a hypothetical multi-factor index. We base the capitalization weights on the actual capitalization levels in the FTSE Developed Index as at March 30, 2017. Likewise, the quality and value factor scores are the actual scores for these stocks as at March 30, 2017.

We chose three well-known company names with roughly the same capitalization levels so as to better illustrate the effects of tilting away from the cap weights. The first column of numbers in Table 1 shows what a three-stock cap-weighted index would look like based on the actual capitalization of these stocks as at March 30, 2017, adjusted for free float. The quality scores are a metric from 0 to 1, with 1 indicating a high quality stock based on measures of profitability, efficiency, earnings stability and leverage, and 0 a low quality stock based on the same measures. A score of 0.50 indicates a stock that has exactly average quality characteristics relative to the universe of the FTSE Developed Index.

¹ Markowitz, H.M., (1952) “Portfolio Selection,” *Journal of Finance*, Vol. 7 pp. 77-91.

We can see that all three stocks have below average quality scores relative to the FTSE Developed Index universe. But what matters for this simple index are the scores relative to each other: Occidental Petroleum has the highest quality score while Barclays has the lowest. We next multiply the cap weight of each stock by its value score to get the unadjusted weights of a single factor value index. We then divide the unadjusted weights by the sum 25.5% to gross-up final weights to sum to 100%.

Table 1. Creation of a quality index

	Cap weight index	X Quality score	= Unadjusted weights	Final normalized Quality weights
Occidental Petroleum	33.6%	X 0.40	= 13.4%	52.4%
Ford Motor	33.3%	X 0.31	= 10.2%	40.0%
Barclays	33.1%	X 0.06	= 1.9%	7.6%
Total	100.0%		25.5%	100.0%

Source: FTSE Russell. Data as of March 30, 2017. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Figures may not add up due to rounding. Please see the end for important legal disclosures.

In Table 2 we construct a hypothetical single factor value index in exactly the same way. Ford Motor is strongly value, i.e., considered “cheap” in terms of valuation metrics, while the other two stocks are relatively “expensive.” The value scores have low correlation with the quality scores, which is typical for these two factors. This results in the two single factor indexes having very different weights.

Table 2. Creation of a value index

	Cap weight index	X Value score	= Unadjusted weights	Final normalized Value weights
Occidental Petroleum	33.6%	X 0.13	= 4.6%	11.5%
Ford Motor	33.3%	X 1.00	= 33.2%	83.5%
Barclays	33.1%	X 0.06	= 2.0%	5.1%
Total	100.0%		39.8%	100.0%

Source: FTSE Russell. Data as of March 30, 2017. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Figures may not add up due to rounding. Please see the end for important legal disclosures.

In Table 3 we show the construction of a hypothetical composite index combining quality and value. We assume equal weighting of the two factor indexes but in principle one could choose unequal weights as well. The composite index weights are given in the last column.

Table 3. Creation of a composite index

	(Quality weight + Value weight)/2	= Quality + Value composite index weight
Occidental Petroleum	(52.4% + 11.5%)/2	= 31.9%
Ford Motor	(40.0% + 83.5%)/2	= 61.7%
Barclays	(7.6% + 5.1%)/2	= 6.4%
Total	100.0%	100.0%

Source: FTSE Russell. Data as of March 30, 2017. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Figures may not add up due to rounding. Please see the end for important legal disclosures.

Table 4 shows the construction of a hypothetical tilt-tilt quality and value multi-factor index. The scores are multiplied rather than averaged. The unadjusted weights are divided by the sum 12.1% to gross-up the final tilt-tilt weights to sum to 100%.

Table 4. Creation of a tilt-tilt multi-factor index

	Cap weights	X Quality score	X Value score	= Unadjusted weights	Final normalized Value weights
Occidental Petroleum	33.6%	X 0.40	X 0.13	= 1.8%	15.0%
Ford Motor	33.3%	X 0.31	X 1.00	= 10.2%	84.0%
Barclays	33.1%	X 0.06	X 0.06	= 0.1%	1.0%
Total	100.0%			12.1%	100.0%

Source: FTSE Russell. Data as of March 30, 2017. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Figures may not add up due to rounding. Please see the end for important legal disclosures.

We have now gone through the simple mechanics of constructing these hypothetical indexes, and we now have two sets of quality and low value multi-factor weights. So what difference does it make? Table 5 summarizes the active weights, with the market capitalization weights subtracted from the index weights. In this form, the contrast between the tilt-tilt methodology and the composite approach is brought out more clearly. In this example both indexes have the same signs and rank ordering of active weights. This isn't always the case. More noteworthy is that the absolute values of the tilt-tilt active weights are all greater than the absolute values of the composite weights. This is not an unusual comparison and drives a lot of the differences in exposures, as we shall see.

Table 5. Active weights of quality-value multi-factor indexes

	Composite index	Tilt-tilt index
Occidental Petroleum	-1.7%	-18.6%
Ford Motor	28.4%	50.8%
Barclays	-26.8%	-32.1%
Total	0.0%	0.0%

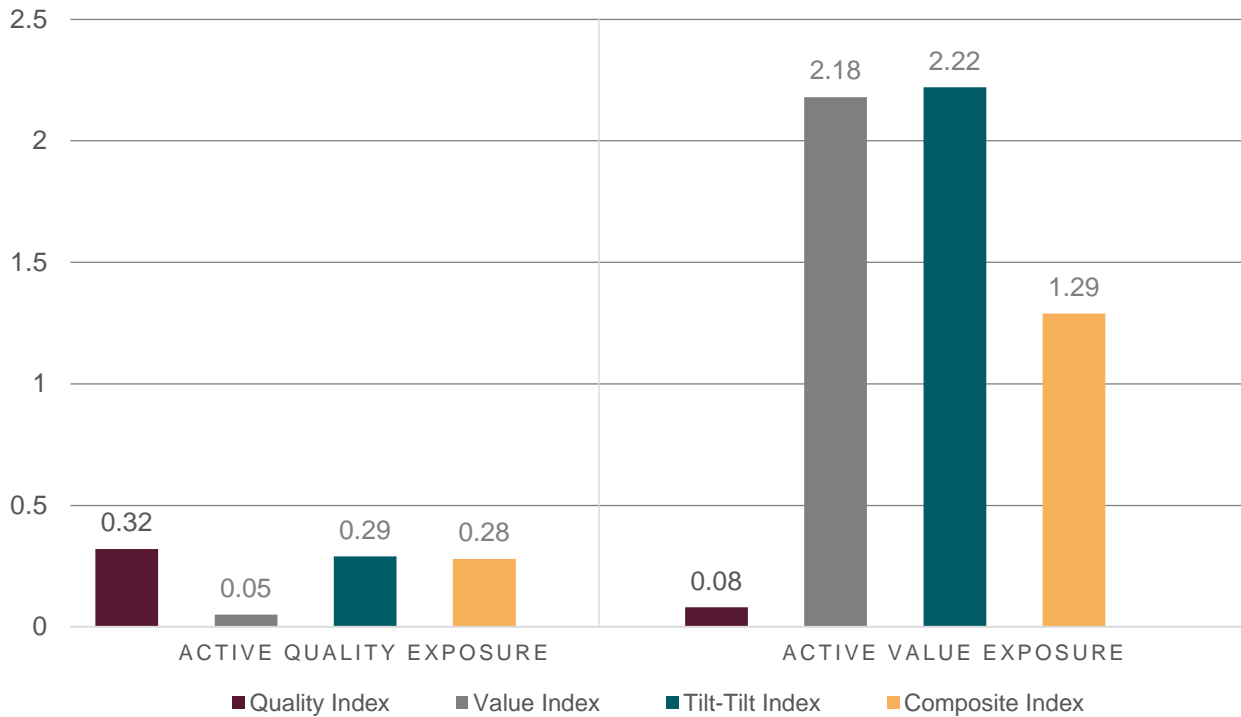
Source: FTSE Russell. Data as of March 30, 2017. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Figures may not add up due to rounding. Please see the end for important legal disclosures.

The difference the weightings make is evaluated by the “active exposures” of the factors within each index, i.e., exposures to the factors over what naturally comes with a cap-weighted benchmark index. The quality and low volatility scores, which are a 0 to 1 cumulative normal metric, are converted back to their underlying factor Z-scores and weighted by the active weights:

$$Active\ factor\ exposure = \sum_{i=1}^3 (w_i - cw_i) * Z_i$$

The active factor exposures are thus measured in Z-score units: the number of standard deviations from a mean of zero. Chart 1 displays the active exposures of our hypothetical three-stock indexes. The active exposures of the tilt-tilt index are greater than the active exposures of the composite index for both factors, although just barely for the quality factor. But the active value exposure is substantially larger in the tilt-tilt index compared to the composite. This is just a three-stock example, of course, and as such might not be very meaningful – except that these qualitative results generalize to a whole stock universe, as we shall see.

Chart 1. Active quality and value exposures of single factor and multi-factor indexes (three stock example)



Source: FTSE Russell. Data as of March 30, 2017. This chart is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Tilt-tilt compared to composite indexes applied to a whole index universe

We employ the FTSE Developed Index universe of stocks to generalize the previous example. The universe includes the top 90% in capitalization weight of all listed stocks in all Developed countries. We wish to create a combination of high quality, low volatility, and value factors. In the combination, the high quality and low volatility factors are positively correlated and are together often referred to as a “defensive” combination, skewing weights to the higher-quality, and less-volatile corner of a stock universe. Value tends to be negatively correlated with the other two factors. We construct two hypothetical multi-factor indexes: a composite index and a multiple tilt-tilt index.

The weights for each stock i in the quality-volatility-value composite index would be:

$$W_{Composite,i} = (W_{Quality,i} + W_{Volatility,i} + W_{Value,i})/3,$$

where the right-hand-side weights are from single factor indexes. The multiple tilt-tilt (unadjusted) index weights are:

$$Unadjusted W_{Tilt,i} = QualityScore_i * VolatilityScore_i * ValueScore_i * CapWeight_i$$

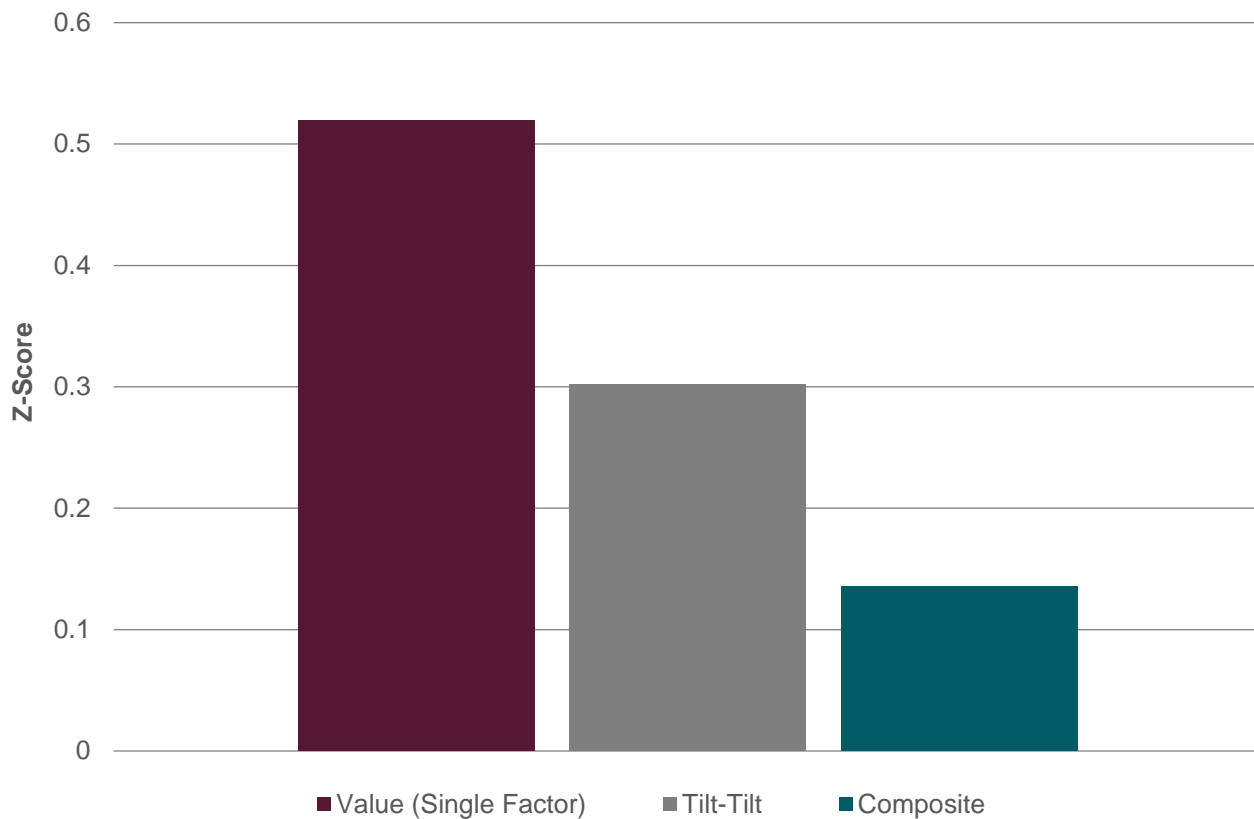
Recall that the scores range from zero to one from a cumulative normal distribution mapping from the factor Z-scores. The adjusted weight is the unadjusted weight normalized to sum to 100%:

$$W_{Tilt,i} = \frac{Unadjusted W_{Tilt,i}}{\sum Unadjusted W_{Tilt,j}}$$

Charts 2, 3 and 4 display the average active exposures over the period September 2000 through January 2017. Active exposures are measured in the same way as in the three-stock example, the active weighted average of the factor Z-scores. Usually both a tilt-tilt and composite multi-factor index have reduced factor exposures compared to a single factor index, but the tilt-tilt index gives up less than the composite index. In the case of the low volatility factor exposure in Chart 4, not only is the exposure of the tilt-tilt index greater than the exposure of the composite index, it's even greater than that of the single factor index.

One might ask, so what? Charts 2-4 indicate that a market participant would have to allocate 2 or 3 times the capital to a composite-index-replicating product to match the factor exposures of a tilt-tilt-index-replicating product. The cost efficiency of the tilt-tilt methodology is one of its strongest attributes, as our research has shown.²

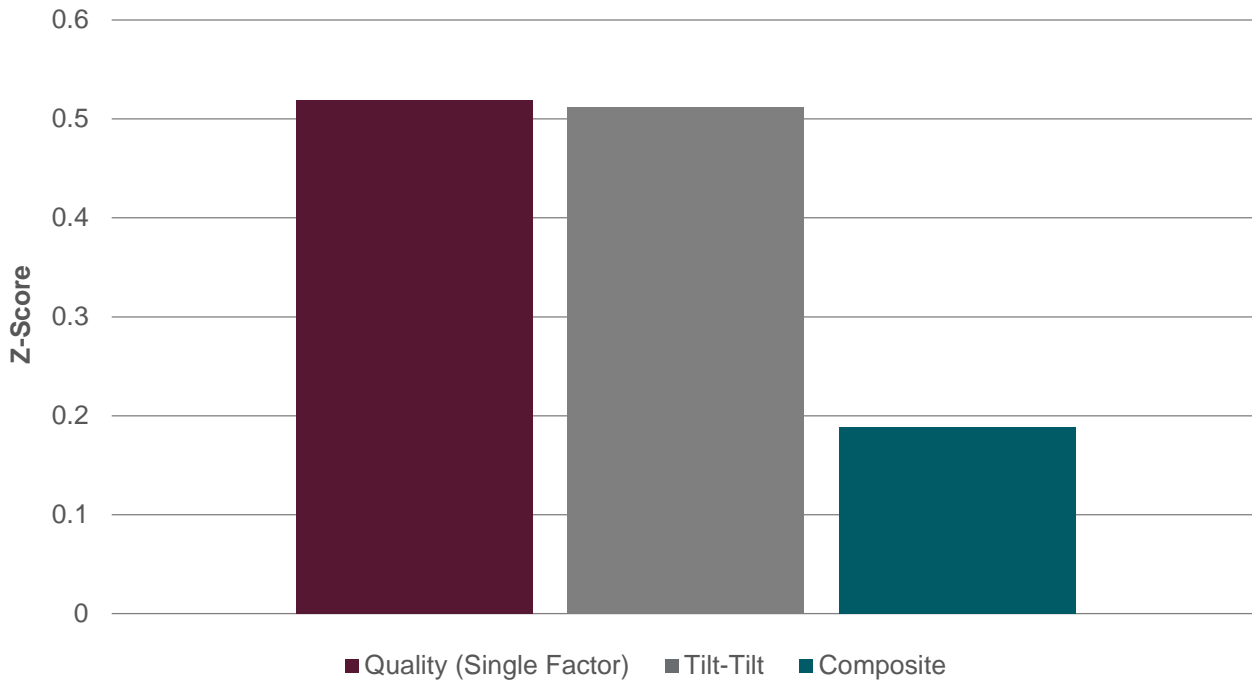
Chart 2. Active value factor exposures, September 2000-January 2017



Source: FTSE Russell. Data as of January 20, 2017. Hypothetical data has been used. This chart is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

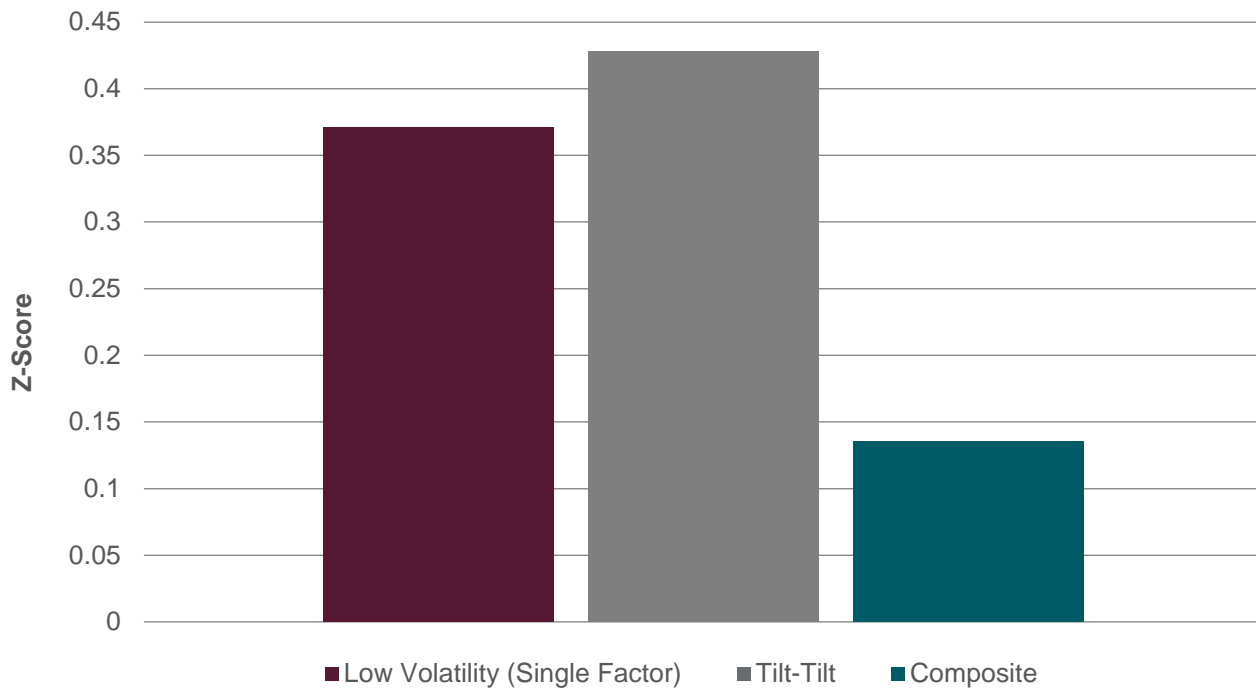
² FTSE Russell, *Leveraging Factors Without Using Leverage*, 2017.

Chart 3. Active quality factor exposures, September 2000-January 2017



Source: FTSE Russell. Data as of January 20, 2017. Hypothetical data has been used. This chart is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 4. Active low volatility factor exposures, September 2000-January 2017



Source: FTSE Russell. Data as of January 20, 2017. Hypothetical data has been used. This chart is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

We can see that the factor exposures of the tilt-tilt index are visually larger than the factor exposures of the composite index, but are the differences statistically significant? To find out, we conducted pairwise t-tests on the null hypothesis that the monthly active factor exposures in the tilt-tilt and composite indexes were on average no different. Table 6 shows that the null hypothesis is rejected for all three factors, i.e., the differences in factor exposures are indeed statistically significant.

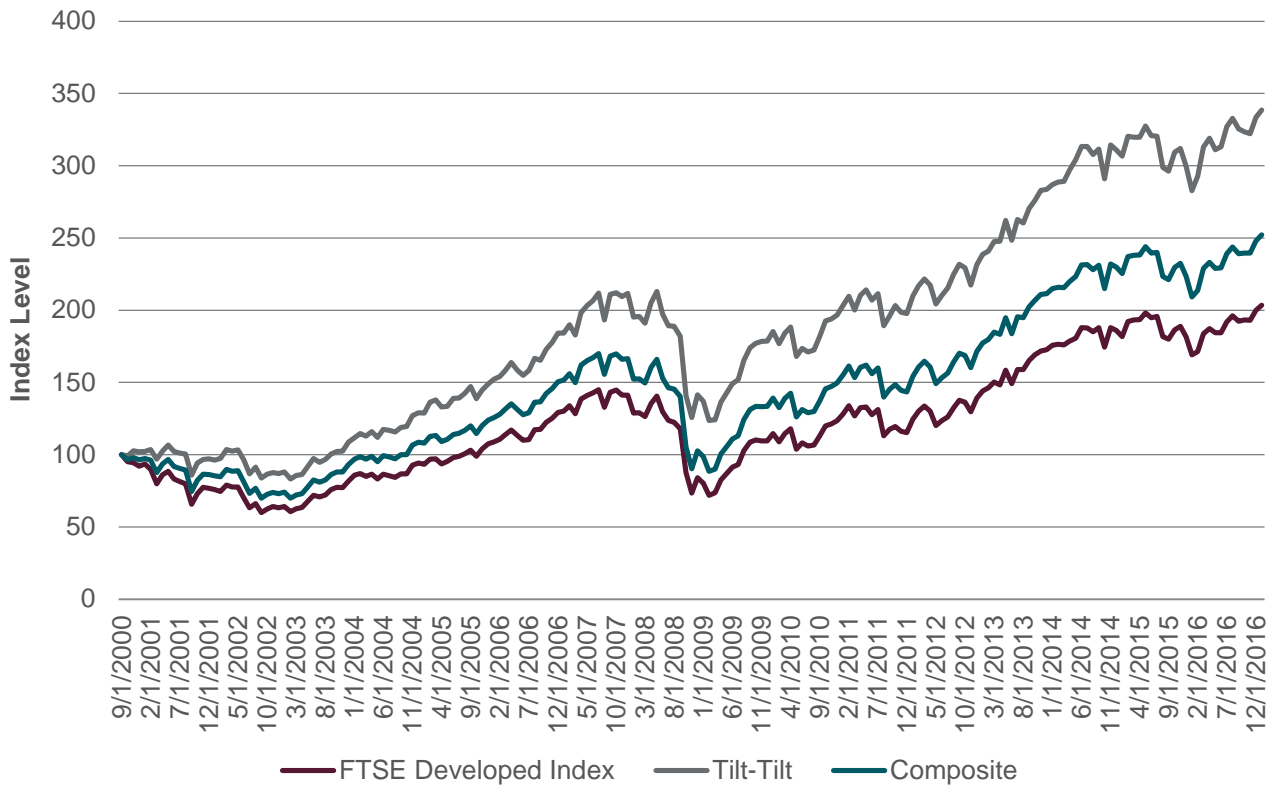
Table 6. Pairwise t-tests of differences in factor exposures

	Mean difference in exposures: multiple tilt compared with a composite index	T-statistic
Value	0.16	40.97
Quality	0.32	81.19
Low Volatility	0.26	86.92

Source: FTSE Russell. Data as of January 20, 2017. Hypothetical data has been used. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 5 shows how the differences in exposures between the tilt-tilt and composite indexes would have manifested in performance. The dilution of the factor exposures in the composite construction would have resulted in an index that is less distinguishable from the cap-weighted FTSE Developed Index.

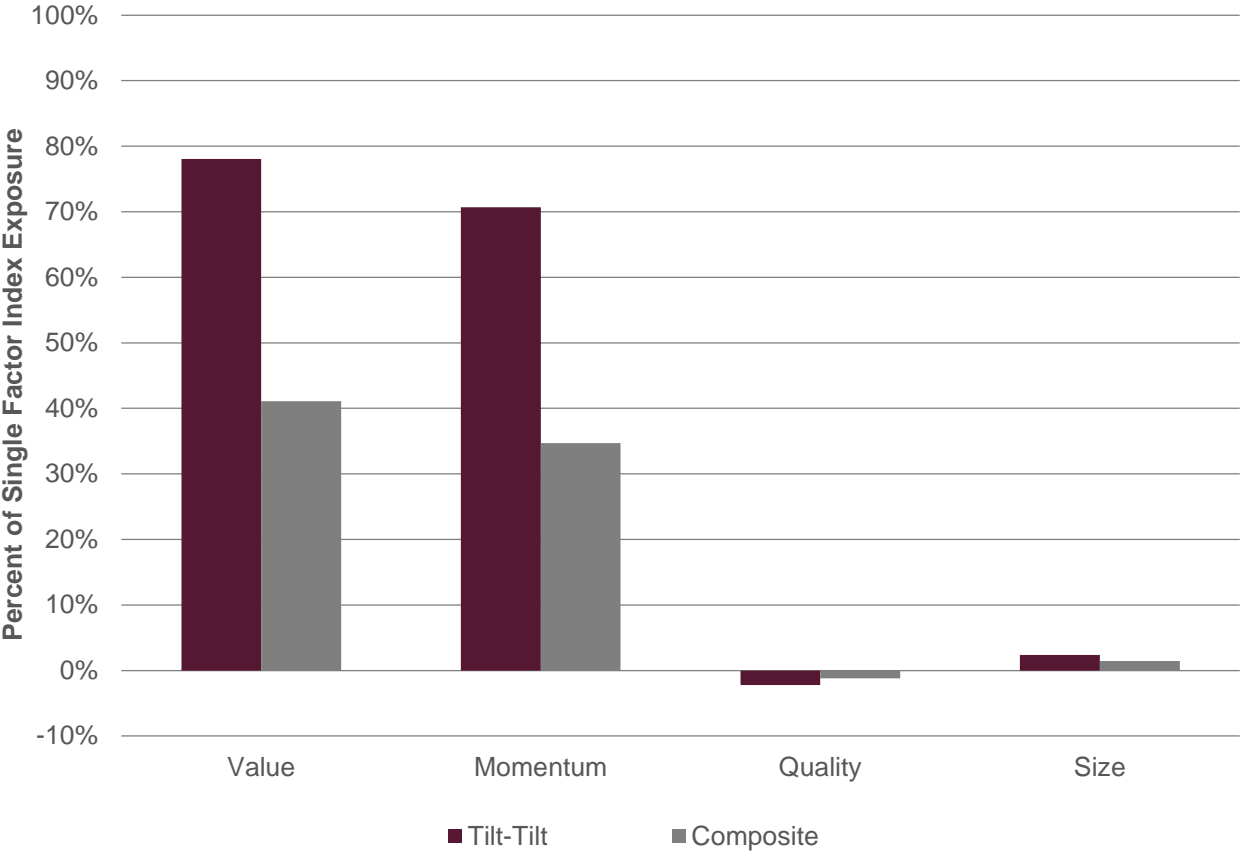
Chart 5. Quality, low volatility and value: tilt-tilt and composite



Source: FTSE Russell. Data as of January 20, 2017. Past performance is no guarantee of future results. Returns shown reflect FTSE Developed Index and hypothetical historical performance in relation to the hypothetical tilt-tilt and composite indexes. Data for the hypothetical tilt-tilt and composite indexes is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

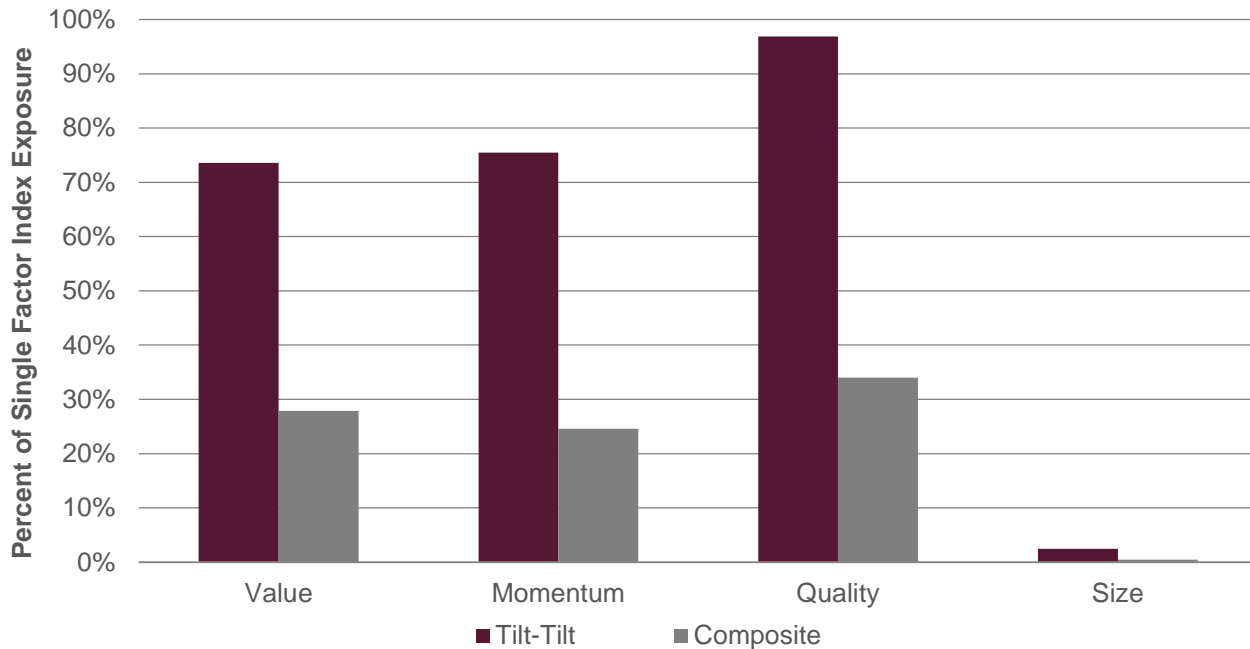
Moreover, the gap in factor exposures between tilt-tilt and composite indexes increases directly with the number of factors, as Charts 6, 7 and 8 show. Using the FTSE Developed Index universe, the charts show a progression of adding factors one a time, starting with a value-momentum combination and adding on quality and then size. As more factors are added, the percentage of single factor exposures captured steadily decreases for the composite index. That’s because a linear combination of factors tends toward dilution of factor strength, while the multiplicative combination of factors in the tilt-tilt index maintains meaningful levels of factor exposure. Put another way, the cost *inefficiency* of the composite approach grows with the number of factors.

Chart 6. Value + Momentum



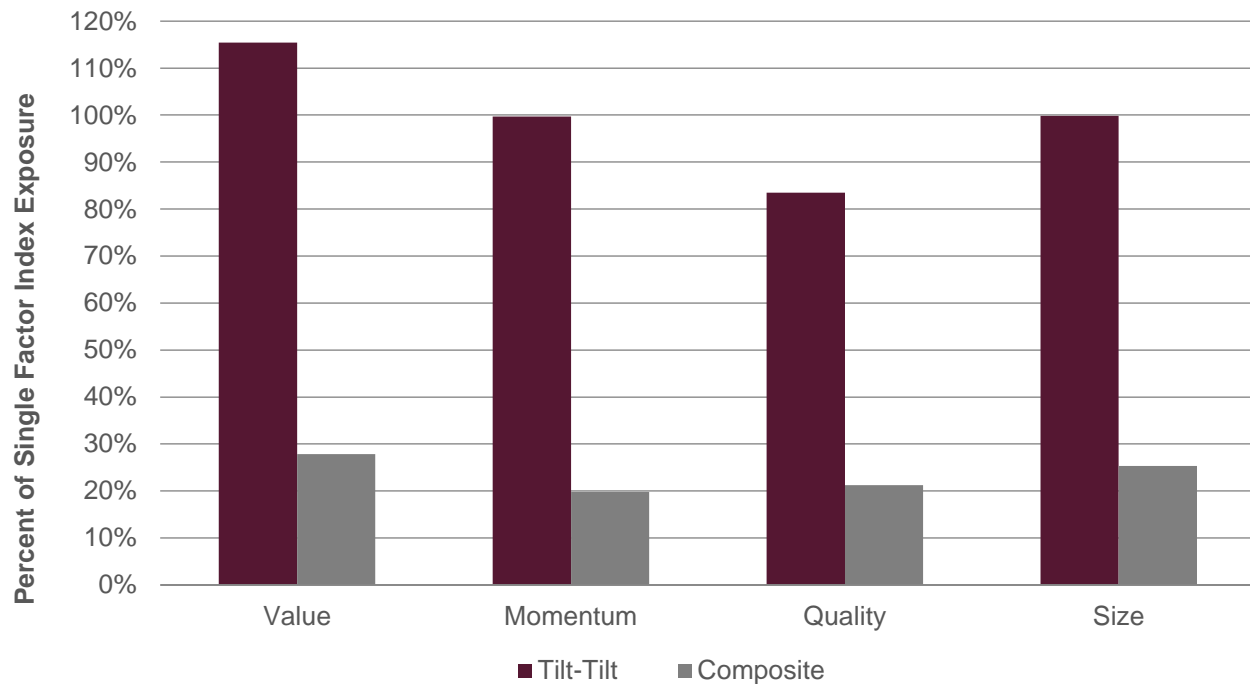
Source: FTSE Russell. Data as of January 20, 2017. Past performance is no guarantee of future results. Returns shown reflect FTSE Developed Index and hypothetical historical performance for the hypothetical tilt-tilt and composite indexes. Data for the hypothetical tilt-tilt and composite indexes is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 7. Value + Momentum + Quality



Source: FTSE Russell. Data as of January 20, 2017. Past performance is no guarantee of future results. Returns shown reflect FTSE Developed Index and hypothetical historical performance for the hypothetical tilt-tilt and composite indexes. Data for the hypothetical tilt-tilt and composite indexes is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 8. Value + Momentum + Quality + Size



Source: FTSE Russell. Data as of January 20, 2017. Past performance is no guarantee of future results. Returns shown reflect FTSE Developed Index and hypothetical historical performance for the hypothetical tilt-tilt and composite indexes. Data for the hypothetical tilt-tilt and composite indexes is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Factor exposure strength and diversification

The previous section demonstrated that the tilt-tilt methodology delivers higher factor exposures than a simple composite, but what about the factor exposures of characteristic baskets? Chart 9 illustrates the characteristic baskets of value and quality using a 33rd percentile cutoff. The value basket would be all stocks in the top 1/3 of ranking in value characteristics, regardless of quality characteristics (the three vertical red boxes). Likewise, the quality basket would contain the top 1/3 of all stocks ranked by quality characteristics, regardless of value characteristics (the three horizontal red boxes).

The multi-factor version of a basket approach would be the intersection basket shown in Chart 9, where all stocks are simultaneously ranked in the top 1/3 in both quality and value characteristics. In contrast to the employment of sharp cutoffs, the tilt-tilt methodology employs a continuous simultaneous multi-factor ranking of stocks as illustrated in Chart 10.

Chart 9. Intersection basket approach

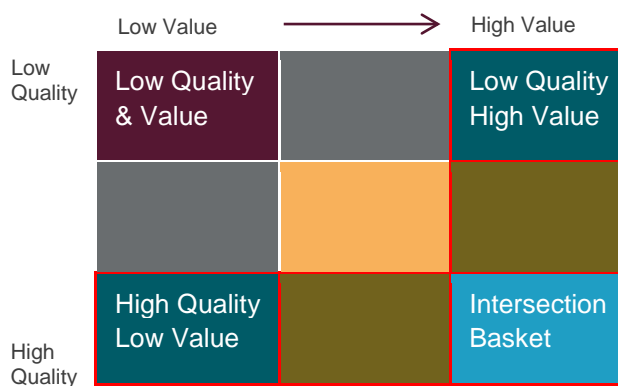
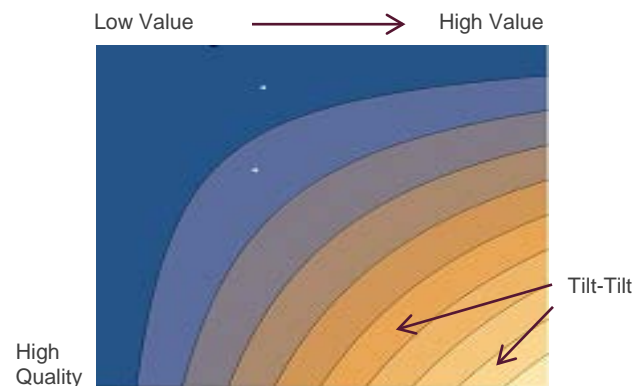


Chart 10. Tilt-tilt approach



Which methodology delivers the stronger factor exposures? There is not a clear answer to this question because both methodologies can be adjusted to almost any factor exposure strength desired. The intersection basket's factor exposures can be increased by changing the percentile cutoffs. For example, changing the cutoff from 33rd to 10th percentile would most certainly raise factor exposure strength. Likewise, factor exposure strength can be increased in the tilt-tilt methodology by a double tilt on the factors or, more generally, by raising the exponents of the factor scores above the default values of 1.0.

If factor exposure strength can be dialed up, why not dial it way up? That is because there is an inherent tradeoff between factor exposure strength and diversification. One can easily imagine the portfolio with the strongest value-quality combination having only 3 or 4 stocks. So the relevant comparison between methodologies is: which methodology produces the strongest factor exposures for a given level of diversification? Equivalently: which methodology produces the most diversification for a given level of factor exposure strength?

FTSE Russell recently published a theoretical paper on this subject.³ The strength of the paper is that the conclusions are based on mathematical proofs and are not dependent on any back-tested data. We will try to summarize the results here, because the conclusions are very important. The paper uses Effective N as the measure of diversification. This is the inverse of the Herfindahl measure of concentration:

$$Effective\ N = 1 / \sum_{i=1}^N W_i^2$$

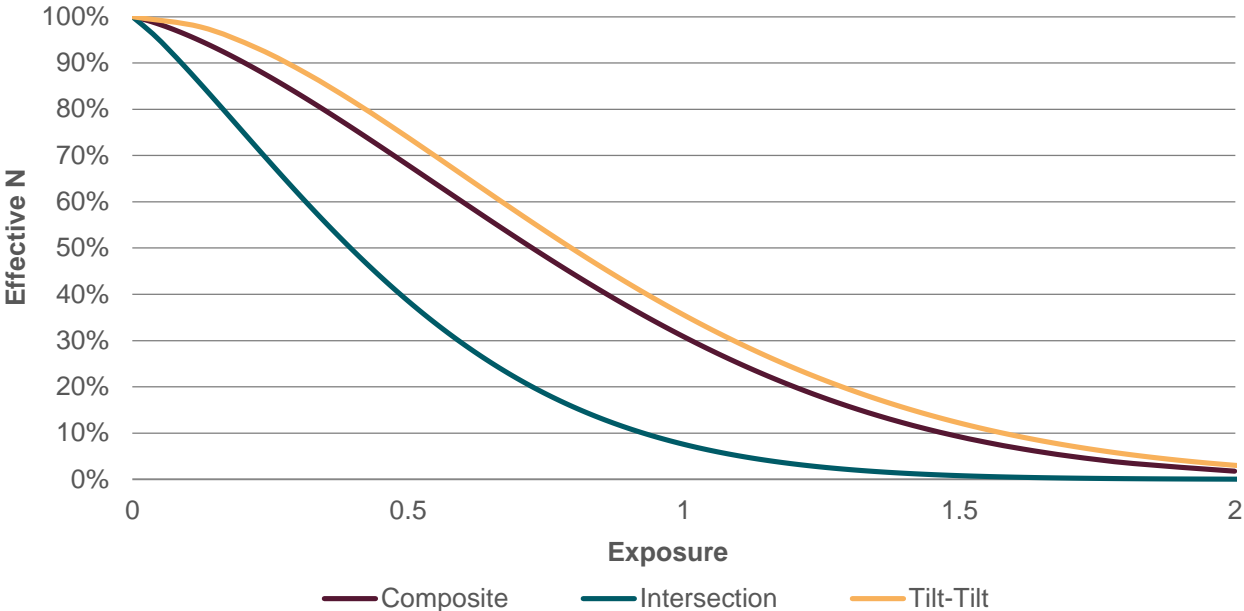
³ FTSE Russell, *Factor Exposure and Portfolio Concentration*, 2017.

The maximum Effective N is the number of stocks in the index, N. This occurs when the index is equal-weighted. This is sometimes known as the maximum diversification or least concentrated index. The minimum Effective N is 1, which occurs if all the index weight is on one stock. No single measure encompasses all aspects of diversification of course but concentration is perhaps the most important aspect when constructing an index of factor exposures, as highly concentrated factor indexes produce strong factor exposures. High concentration can lead to high stock-specific risk and high turnover in a factor index.

Charts 11-13 show the results from the theoretical paper for the case of two factors. Chart 11 shows the tradeoffs when the two factors are positively correlated, e.g., quality and volatility. Chart 12 shows the tradeoffs with zero correlation and Chart 13 shows the tradeoffs when the two factors are negatively correlated, e.g., value and momentum. The Y-axis shows Effective N as a percent of the total number of stocks, N, in the theoretical benchmark universe, so the higher the percent the less concentrated (more diversified) the index is. The X-axis shows the active exposures for both factors. An easy way to read the charts is to look at the varying levels of Effective N when active exposures are 0.5, which is a realistic goal as we saw in Charts 2-4.

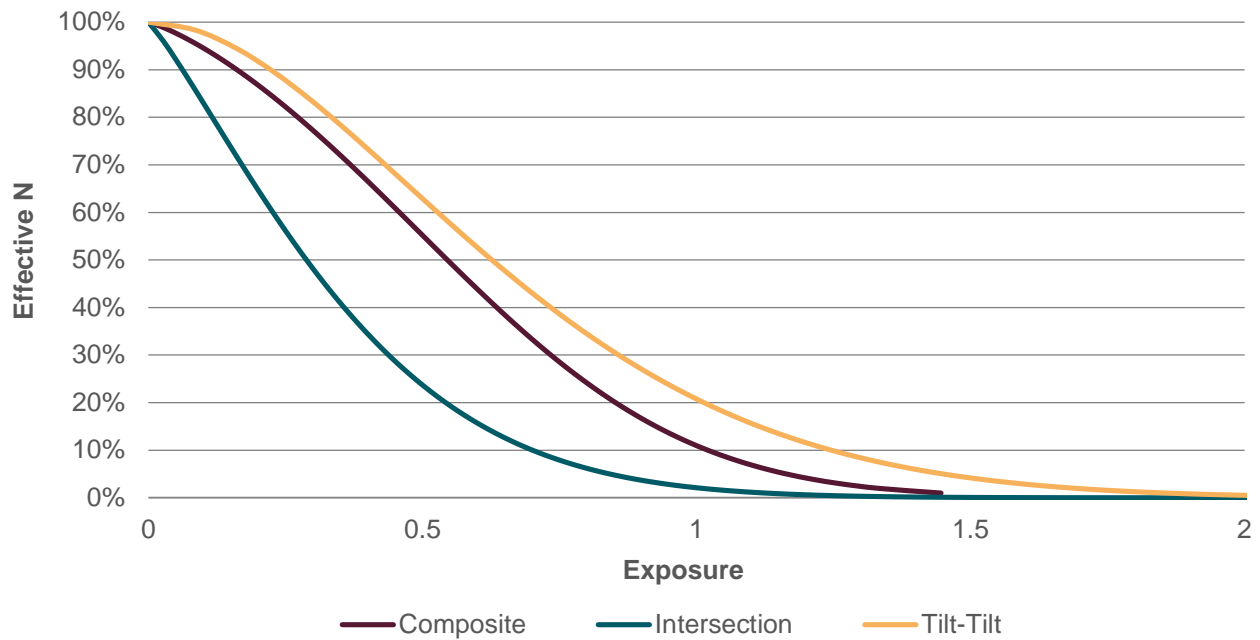
The tilt-tilt index is more diversified than both the composite and intersection basket indexes for all correlations. The difference with a composite index is small when correlation is positive but that difference becomes greater as the correlation moves into negative territory. The intersection basket is much more concentrated (less diversified) than tilt-tilt at any level of active exposure. The theoretical paper goes on to examine the three factor case and then any number of factors. The qualitative results continue to hold in all cases. In fact, the difference in diversification between tilt-tilt and the two other approaches increases with the number of factors. Clearly, the tilt-tilt methodology provides the best tradeoff between the strength of factor exposures and diversification for a given weighting scheme.

Chart 11. Active exposure compared with Effective N for the composite basket, intersection basket and tilt-tilt indexes: Correlation = +0.5



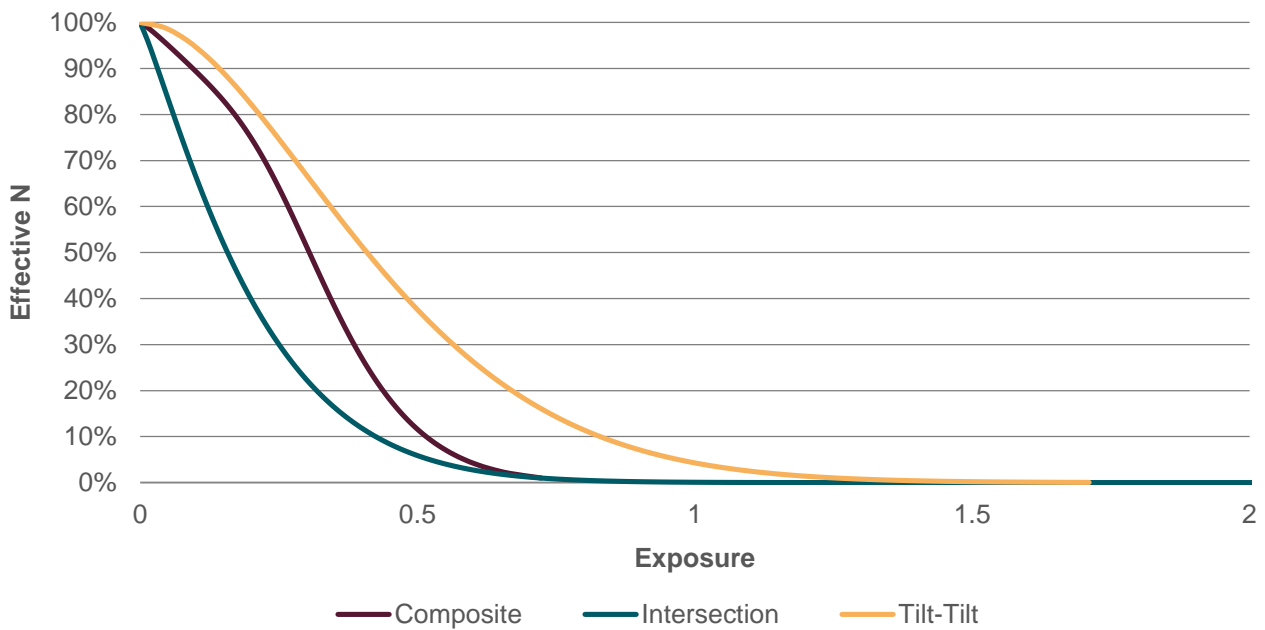
Source: FTSE Russell. No data has been used. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 12. Active exposure compared with Effective N for the composite basket, intersection basket and tilt-tilt indexes: Correlation = 0.0



Source: FTSE Russell. No data has been used. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Chart 13. Active exposure compared with Effective N for the composite, intersection basket and tilt-tilt: Correlation = -0.5



Source: FTSE Russell. No data has been used. This table is purely for illustrative purposes and does not reflect the constitution or performance of a FTSE Russell index. Please see the end for important legal disclosures.

Integrating ESG considerations into a multi-factor index – smart sustainability

Interest in integrating environmental, social and governance (ESG) objectives in investing has risen in recent years. A survey conducted by FTSE Russell in 2017 of close to 200 asset owners from around the world revealed that 41% of those that have, or are interested in, smart beta strategies, anticipate applying ESG considerations. Furthermore, the most common motivation (69%) for applying ESG considerations was to “avoid long-term risk,” rather than “societal good.”⁴ The focus on risk reduction as a prime motivation has driven demand for benchmarks that help investors to align ESG beliefs alongside investment objectives, and a movement away from a reliance on negative screens, as they can at times “throw the baby out with the bathwater.”

Thinking in ESG has evolved to the idea of tilting positively toward company activities that manage ESG risk exposures effectively, while at the same time tilting away from those companies that are behind the curve. The tilting idea naturally suggests analogues to factor scores: drawing on FTSE Russell’s extensive database on a wide range of ESG-related metrics to create scores from 0 to 1 that can be used as additional “factors” in a multi-factor index. With this approach, stocks that may have been excluded by a negative screen are instead down-weighted to the degree that the company demonstrates weak ESG practices. At the same time, those companies that have engaged in strong ESG practices would be up-weighted.

Case study: A multi-factor climate risk-aware index

Recently FTSE Russell worked with a large institutional asset owner to develop an index that combined our multi-factor methodology with ESG considerations. The starting universe was the FTSE All-World Developed Index with a minimal negative screen of fewer than 10 companies that are involved in the production of “controversial weapons (CW)”, such as anti-personnel landmines, cluster munitions, chemical and biological weapons.

We then applied the standard tilt-tilt methodology to a combination of value, quality, volatility, and size factors. Value, quality and volatility factors were given the default exponents of 1.0. The size factor was down-weighted with an exponent of 0.25. This kept the active exposure of size roughly in line with the active exposures of the other factors. This produced the FTSE All-World ex CW Balanced Factor Index.

Next we constructed a climate risk-aware index by combining three distinct climate measures: fossil fuel reserves reduction, operational carbon emissions, and green revenues. The fossil fuel reserves measure had the net effect of excluding coal, underweighting oil, and tilting toward gas amongst oil & gas producers. The operational emissions measure tilted toward the most “efficient” polluters by sector and away from the “least efficient” polluters. The green revenues measure tilts toward those companies providing green product solutions. These three measures produced the FTSE All-World ex CW Climate Index.

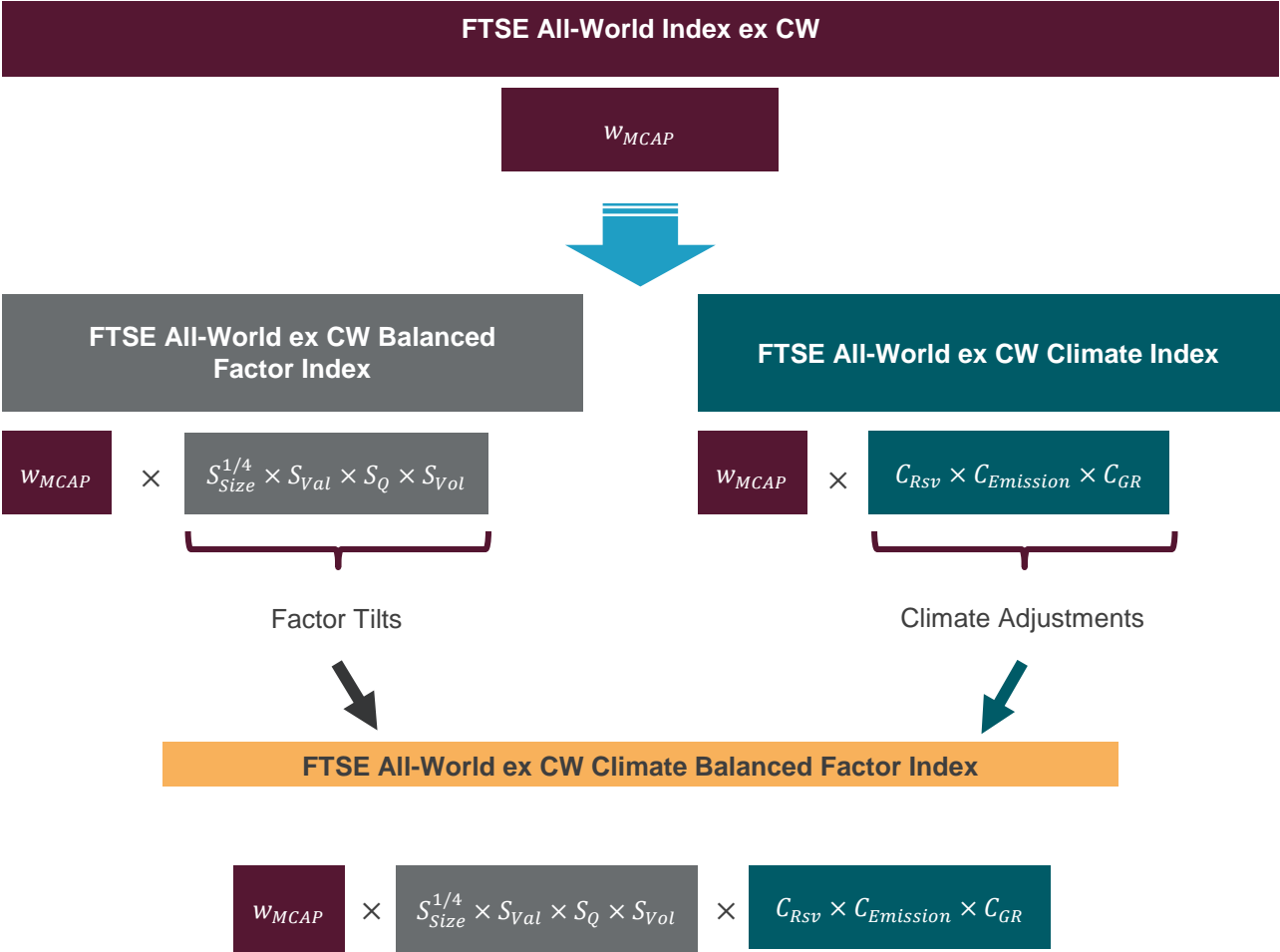
Finally, the two sets of factors and climate measures are brought together to form FTSE All-World ex CW Climate Balanced Factor Index (Chart 14). Chart 15 shows the active factor and climate exposures for the Climate, Balanced Factor, and Climate Balanced Factor indexes. The top panel shows that the Balanced Factor index has a positive tilt on green

Thinking in ESG has evolved to the idea of tilting positively toward company activities that manage ESG risk exposures effectively, while at the same time tilting away from those companies that are behind the curve.

⁴ FTSE Russell, *Smart beta: 2017 global survey findings from asset owners*.

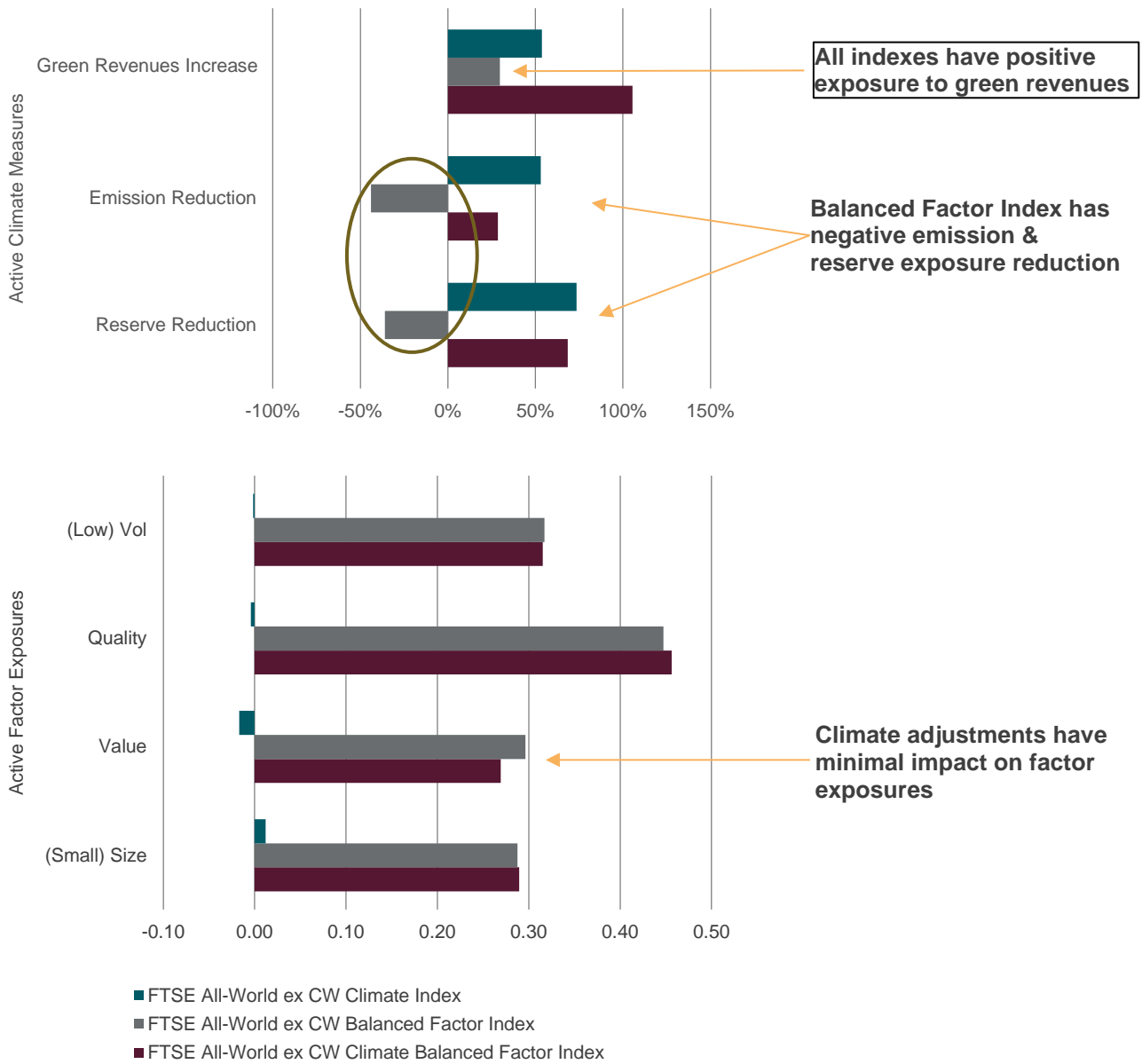
revenues but a negative exposure to emission reduction and reserve reduction. The combined Climate Balanced Factor index achieves a positive tilt on all three measures. The bottom panel shows that the climate adjustments had minimal impact on the factor exposures. This was the desired index outcome from the client's point of view. In general, we would expect that other ESG adjustments may affect the strength of these or other factor exposures and require further adjustments to the factor exponents to keep them in line with the client's objectives.

Chart 14. Multi-factor Climate Risk-Aware Index detailed construction



CW = anti-personnel landmines, cluster munitions, chemical and biological weapons

Chart 15. Active factor exposures and climate measures



Source: FTSE Russell. Data as of March 2012 to March 2016. Past performance is no guarantee of future results. Exposures shown may reflect hypothetical historical data. Please see the end for important legal disclosures.

Conclusion: A holistic approach to factor investing

A multi-factor index should embrace a holistic approach by targeting multiple outcomes simultaneously, rather than approaching each individual factor component separately. And it should do so in such a way that the dilution of the competing factor objectives is kept to a minimum. Simply averaging factors can only satisfy preferences for weaker exposure to all target factors.

We believe the FTSE Russell tilt-tilt approach provides an effective and general means of pursuing multiple factor objectives via strong factor capture with high diversification. ESG measures can be easily integrated into the methodology. This is a powerful mechanism for integrating investment objectives in the index.

Appendix: Single factor index construction

Factors are variables that drive equity returns. These variables are common to all stocks or a group of stocks, and cannot be easily diversified away. The relevant individual factors, their numbers and their definitions vary somewhat from one index provider to the next, but they are typically based on a broad academic and practitioner consensus. In the FTSE Global Factor Index Series, FTSE Russell uses the following definitions for six single factor measures:

- **Value:** Combination of trailing cash-flow yield, earnings yield and country-relative sales-to-price ratio
- **Size:** Natural logarithm of full market capitalization
- **Momentum:** Total return in local currency terms over the previous year, ex most recent month
- **Low Volatility:** Standard deviation of 5 years of weekly (Wednesday to Wednesday) local total returns
- **Quality:** Combination of profitability (return on assets), efficiency (change in asset turnover), earnings quality (accruals) and leverage
- **Yield:** Natural logarithm of each company's 12-month trailing dividend yield

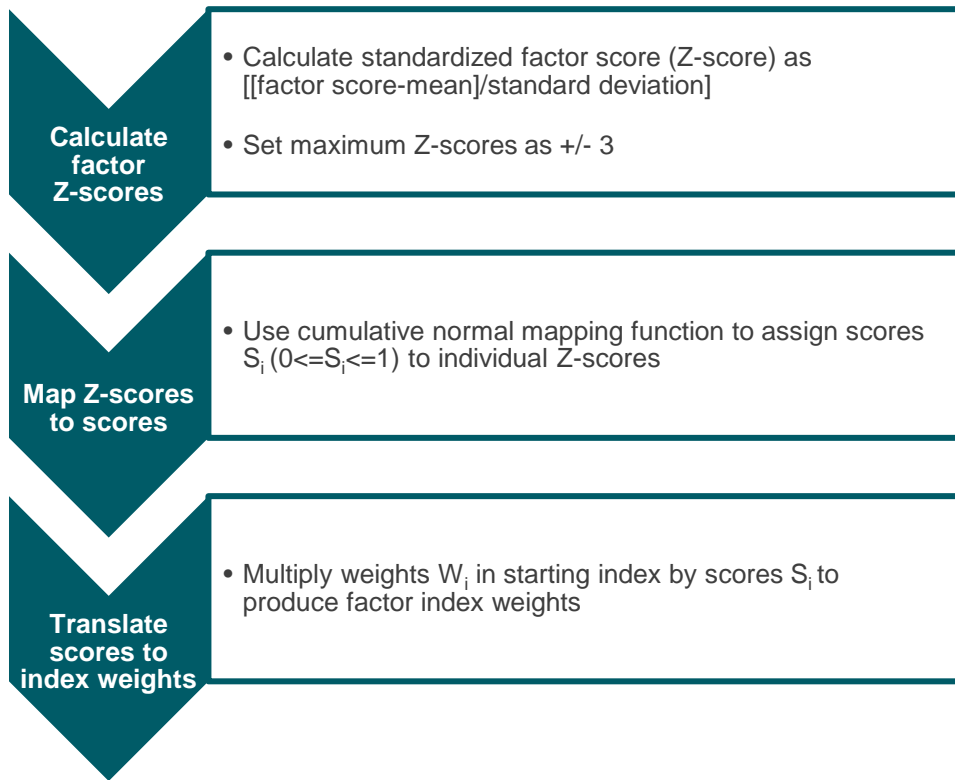
There remains the question of how to map the above definitions into factor exposures in an index form. The factor index should provide a strong but controlled exposure to the factor by use of a common, transparent and rules-based methodology. In order to serve as both a benchmark for particular factor strategies and the basis for index-replicating financial products, the methodology needs to pay attention to liquidity, capacity, diversification and turnover. There is often a trade-off between these objectives.

The FTSE Global Factor Index Series follows two design steps intended to strike a balance between these objectives:

- Factor characteristics are converted to Z-scores and kept within a range of +/- 3 standard deviations from the mean factor Z-score of 0
- Factor Z-scores are mapped into factor scores that range from 0 to 1 using a cumulative normal distribution function

Together, these two steps have the effect of limiting the impact of the smallest and largest factor scores while avoiding an extreme concentration of the index in a few stocks with high factor scores. The final step multiplies the factor score with the starting weights (usually capitalization or equal weights) to produce the factor index weights. The process is summarized in the accompanying illustration.

Constructing single factor indexes



Finally, factor capture is sometimes strengthened by universe truncation or “narrowing,” i.e., by removing the stocks with the smallest contribution to the index factor exposure. This is done sequentially to maximize exposures while satisfying capacity, turnover and sector diversification constraints.

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