Understanding risk-based index construction

Risk-based indexes apply alternative weighting schemes to achieve improved levels of index-level diversification or risk reduction compared to traditional market capitalization weighted indexes. Risk-based indexes typically target reductions in constituent concentration, risk concentration, index-level volatility, or a combination of these features.

An earlier FTSE Russell Insights, titled “Targeting risk with smart beta indexes,” the first in a series of three, provided an introduction to risk-based indexes and their objectives. In this second article we dig further into the construction methods of risk-based indexes and compare approaches to achieving volatility reduction and/or improved diversification. We explore the implicit factor exposures of risk-based indexes and contrast this with the explicit factor exposure objectives of factor indexes. Finally, we note the importance of appropriate constraints in the construction of optimized indexes to achieve a balance between an index’s objective and usability. In the third Insights in this series we focus on a popular type of risk-based index, minimum variance.

Investors continue to focus on risk reduction

Results from the FTSE Russell Smart Beta Survey 2016 (see the following chart) show that risk reduction and improved diversification are two of the primary investment objectives cited by investors evaluating smart beta.
What investment objectives initiated your evaluation of smart beta strategies?

Source: FTSE Russell Smart Beta Survey 2016. The left scale shows the percentage of survey respondents citing the particular objective in response to a multi-choice question.

Risk-based indexes—a summary of approaches

These risk reduction and diversification objectives are met by risk-based indexes in different ways, which are typically described in the index’s name. In the table below we note the principal goals of different categories of risk-based index, such as increased constituent weight diversification, increased risk diversification, maximum expected risk-adjusted outcomes (Sharpe Ratio) or minimum levels of index volatility. At the same time, individual risk-based indexes may also exhibit undesirable features, such as a complex construction methodology. We note the potential drawbacks of risk-based index methodologies in the final column of the table.

Typical risk-based index methodologies

<table>
<thead>
<tr>
<th>Risk-based Index</th>
<th>Investment Objective(s)</th>
<th>Potential Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal-weighted</td>
<td>Increase/maximize weight diversification</td>
<td>Sensitivity to choice of the starting universe</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small cap bias</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high turnover</td>
</tr>
<tr>
<td>Equal Risk Contribution (ERC)</td>
<td>Increase/maximize risk diversification</td>
<td>More complex than equal weighting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively small reductions in volatility</td>
</tr>
<tr>
<td>Maximum Sharpe Ratio (risk efficient)</td>
<td>Maximize index’s Sharpe Ratio</td>
<td>Complex construction due to optimization techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concentrated outcomes in the absence of constraints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relatively high turnover</td>
</tr>
<tr>
<td>Minimum Variance</td>
<td>Minimize index-level risk</td>
<td>Complex construction due to optimization techniques</td>
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</tr>
</tbody>
</table>

Source: FTSE Russell.
Risk-based index features

As the table highlights, the index construction methodology is important in determining the outcomes of risk-based indexes, since differences in construction can produce subtly different results in terms of risk reduction or diversification. The following section describes some key characteristics of common risk-based indexes.

Equal-weighted

An equal-weighting approach is the simplest type of risk-based index. Under this approach, each stock comprises an equal proportion of the index by value, resulting in the most diversified index in terms of stock weightings. Potential drawbacks associated with the methodology include sensitivity to the choice of the starting universe, relatively high rebalancing costs and a bias towards relatively small stocks.

Equal Risk Contribution (ERC)

An equal risk contribution (ERC) index follows the logic of equal weighting, but rather than equalizing stock weights, an ERC index equalizes constituents’ contribution to risk. Every index has an aggregate level of risk (as measured by standard deviation), which is determined by the individual constituents’ volatility and correlations. Stock level volatility and correlations typically vary by sector, region or with stock-specific factors, and some constituents therefore contribute more to aggregate index risk than others. In order to address this imbalance, ERC indexes weight constituents such that their contribution to the overall index risk is the same.

Using optimization techniques (see optimization techniques and constraints section below), ERC indexes select low-volatility stocks with low correlations to each other. This results in a naturally diverse outcome, limiting the number of required constraints and increasing transparency.

Maximum Sharpe Ratio (risk-efficient)

Maximum Sharpe Ratio (or risk-efficient) indexes are designed with the aim of improving the return-to-risk ratio outcome using an optimization approach. The Sharpe Ratio is defined as the average return in excess of the risk-free interest rate per unit of risk. In this case, the optimization inputs are stocks’ volatilities, correlations and their estimated excess returns. The estimates of expected return used in the FTSE EDHEC Risk-Efficient Index Series, for example, are proportional to stocks’ downside volatility (i.e. their volatility measured using only negative past returns). In common with other risk-based index construction methodologies that rely on an optimization, constraints are used to avoid overly concentrated outcomes.

Minimum variance

Minimum variance indexes, which we explore in more detail in a third Insight in this series, seek to minimize the volatility of the index as a whole. Minimum variance indexes achieve this objective by utilizing the correlations and volatilities of each stock. A combination of the stocks and stock weightings that together produce the lowest possible index volatility (i.e., the minimum variance) is created. The minimum variance index is also calculated using an optimization algorithm and in practice requires a number of constraints to limit index concentration.
How do risk-based indexes differ from factor indexes?

There are differences between risk-based indexes and another popular type of smart beta index, factor indexes. All indexes, including risk-based indexes, have exposures to factors, which are best understood as variables that drive equity returns. In the third Insights of this series, which focuses on minimum variance indexes, we show the factor exposures over time of risk-based indexes that aim to reduce index-level volatility.

However, it’s important to note that, while factor exposures can be useful for describing a risk-based index, they are not the intended focus of the index methodology. The factor exposures of risk-based indexes can also change over time, while factor indexes aim to achieve consistent exposure to the targeted factor (or factors).

As an illustration of the differences in approach, it’s helpful to contrast a low-volatility factor index with a minimum variance index, a popular risk-based approach. The construction methodology of the hypothetical low-volatility factor index used for illustrative purposes in this article targets stocks that benefit from the low volatility factor risk premium. As highlighted above, the construction methodology of the minimum variance index focuses on minimizing index-level volatility.

As can be seen from the chart below, the Russell 1000 Minimum Variance Index achieves higher levels of volatility reduction relative to the capitalization-weighted Russell 1000® Index, compared to a hypothetical low volatility exposure matched factor index constructed from the Russell 1000 for illustrative purposes only.

**Volatility reduction compared to cap-weighted benchmark (Russell 1000)**

![Volatility Reduction Chart](image)

Source: FTSE Russell. The chart shows the reduction in annualized monthly volatility, calculated over rolling 24-month periods, relative to the (market cap-weighted) Russell 1000 Index, from December 1999 to August 2016. Past performance is no guarantee of future results. Returns shown of the Russell 1000 Minimum Variance Index before its inception date reflect hypothetical historical performance. The low volatility exposure matched factor index has been constructed for the purpose of illustration only and the returns shown of this index reflect hypothetical historical performance. Please see the end for important legal disclosures.

The primary goal of the low volatility factor index can therefore best be described as factor capture, whereas that of the risk-based minimum variance index is risk reduction.

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1 For an introduction to factors and the objectives of factor indexes, see [http://www.ftserussell.com/files/research/objectives-factor-indexes](http://www.ftserussell.com/files/research/objectives-factor-indexes).

2 The low volatility exposure matched factor index has been constructed for the purpose of illustration only - it is not a published index.
Optimization techniques and constraints

Several of the risk-based indexes described previously are calculated by means of a mathematical optimization. In mathematical terms, an optimization aims to maximize or minimize the value of a particular function, the objective function. In the construction of risk-based indexes, this process typically involves the following steps:

1. Define the index’s objective (for example, to minimize risk or maximize the index’s diversification or Sharpe Ratio)
2. Set appropriate constraints (a set of requirements that must be met in conjunction with meeting the index’s objective, such as absolute stock, sector or country exposures, or limits on turnover or transaction costs)
3. Run the optimization (this is an iterative process, meaning that the optimization proceeds via a series of steps to arrive at the desired outcome, with each step representing an approximate solution, and each step improving on the previous step in terms of meeting the outcome)

By contrast, in simpler risk-based index methodologies, such as equal weighting, index weights are determined directly.

Balancing desired risk/return outcomes and index constraints

As index users show an increasing interest in risk-based indexes, it is important to understand these indexes’ methodologies, central design features and the resulting risk/return outcomes. Risk-based indexes with similar descriptions may behave quite differently, a subject we return to in the third Insights of this series.

The diversification and volatility goals typically set by risk-based indexes—improved weight and risk contribution, diversification and volatility reduction—are related. An equal-weighted index maximizes weight diversification, but does not attempt to reduce volatility. A minimum variance index maximizes volatility reduction, but in the absence of constraints may result in concentrated outcomes. As the number of constraints and the tightness of those constraints is increased, correspondingly small volatility reductions arise. An ERC index aims to diversify constituents’ risk contributions, but results in relatively small reductions in overall index volatility.

More broadly, risk-based indexes frequently require a trade-off between the central objective and index capacity, liquidity and turnover to ensure that the index is suitable for use by market participants as a benchmark or as the underlying target for an index-replicating portfolio or financial product. A high quality index will meet all of these conditions.
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