

MSCI GLOBAL MINIMUM VOLATILITY INDEXES METHODOLOGY

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1 INTRODUCTION

Minimum-variance and managed volatility equity strategies have been around since the early 1990s but have recently gained popularity. Since minimum variance strategies do not require return forecasts, in some cases they may be more efficient than strategies that trade off expected risk and return. Moreover, new pension regulations in the US and elsewhere have led to increased aversion to asset volatility. MSCI has developed a global minimum volatility index that can serve as a transparent and relevant benchmark for managed volatility equity strategies.

The theoretical minimum variance (MV) portfolio has been widely known since Markowitz's seminal paper in 1952¹. The MV portfolio is positioned on the very left tip of a mean-variance efficient frontier and describes an equity portfolio with the lowest return-variance for a given covariance matrix of stock returns. While all other portfolios on the efficient frontier minimize risk for a given expected return, the MV portfolio minimizes risk without an expected return input.

The MSCI Minimum Volatility Indexes are calculated by optimizing a parent MSCI Index by using an estimated security co-variance matrix to produce an index that has the lowest absolute volatility for a given set of constraints. The starting universe to determine a Minimum Volatility Index is an MSCI Equity Index and the estimated security co-variance matrix is based on the relevant Barra multi-factor equity model. Details about the Barra multi-factor risk models are available at <http://www.ms cibarra.com/products/analytics/models/>.

This methodology book describes a generic methodology that can be applied to create Minimum Volatility Indexes from any of the existing MSCI equity indexes (herein, "Parent Indexes"). Some of the optimization constraints applied to determine the MSCI Minimum Volatility Index may vary based on the Parent Index on which the optimization is performed.²

¹ See Markowitz, H. (1952), Portfolio Selection, Journal of Finance, 7

² A detailed description of Practical Convex Quadratic Programming can be found at www.msci.com/research-archive

2 CHARACTERISTICS OF MSCI MINIMUM VOLATILITY INDEXES

The MSCI Minimum Volatility Indexes historically demonstrate the following characteristics across markets:

- Low Beta relative to the Parent Index
- Lower Volatility than the Parent Index
- Lower cap bias
- Bias towards stocks with low idiosyncratic risk

3 CONSTRUCTING THE MSCI MINIMUM VOLATILITY INDEXES

Constructing the MSCI Minimum Volatility Indexes involves the following steps:

- Defining the Parent Index and the base currency for optimization
- Defining the optimization constraints
- Determining the optimized portfolio

Each step is described below.

3.1 DEFINING THE PARENT INDEX AND THE BASE CURRENCY FOR OPTIMIZATION

Constructing the MSCI Minimum Volatility Indexes begins with selecting the Parent Index to perform total risk minimizing optimization. The Parent Indexes serve as the universe of eligible securities for optimization. The optimization is performed from a base currency perspective and does not allow short selling of securities.

The optimization relies on the factor exposures for all the securities in the Parent Index and the factor co-variance matrix of the relevant Barra Equity Model.

3.2 DEFINING THE OPTIMIZATION CONSTRAINTS

At each semi-annual index review, the following optimization constraints are employed, which aim to ensure replicability and investability while achieving the lowest volatility for a given set of constraints.

- The maximum weight of an index constituent will be restricted to the lower of 1.5% or 20 times the weight of the security in the Parent Index.
- The minimum weight of an index constituent will be 0.05%.
- For countries with weight greater than 2.5% in the Parent Index, the weight in the MSCI Minimum Volatility Index will not deviate more than +/-5% from the country weight in the Parent Index.
- For countries with weight less than 2.5% in the Parent Index, the weight in the MSCI Minimum Volatility Index will be capped at 3 times their weight in the Parent Index.
- The sector weights of the MSCI Minimum Volatility Index will not deviate more than +/-5% from the sector weights of the Parent Index.
- No constraint will be applied on the exposure of the MSCI Minimum Volatility Index to the Barra Volatility risk index factor. Exposure to all other Barra risk index factors will be restricted to +/-0.25 standard deviations relative to the Parent Index.

- The one way turnover of the MSCI Minimum Volatility Index is constrained to a maximum of 10%.

3.3 DETERMINING THE OPTIMIZED PORTFOLIO

The MSCI Minimum Volatility Index is constructed using the most recent release of the Barra Open Optimizer in combination with the relevant Barra Equity Model. The optimization uses the Parent Index as the universe of eligible securities and the specified optimization objective and constraints to determine the optimal MSCI Minimum Volatility Index. The Barra Open Optimizer determines the optimal solution, i.e. the portfolio with the lowest total risk, using an estimated security co-variance matrix under the applicable investment constraints. The MSCI Minimum Volatility Index seeks to have the lowest absolute volatility based on the set of constraints.

4 MAINTAINING THE MINIMUM VOLATILITY INDEXES

4.1 SEMI-ANNUAL INDEX REVIEWS

The changes resulting from the index review of the MSCI Minimum Volatility indexes will be made as of the close of the last business day of May and November, coinciding with the May and November semi-annual index review of the Parent Indexes.

The pro forma indexes are in general announced nine business days before the effective date.

The security co-variance matrix used to determine the MSCI Minimum Volatility Indexes is maintained on a monthly basis. For the May and the November semi-annual MSCI Minimum Volatility Index reviews, the security covariance matrices as of the end of April and the end of October are used respectively.

At each rebalancing, a constraint factor is calculated for each constituent in the MSCI Minimum Volatility Index. The constraint factor is defined as the weight in the MSCI Minimum Volatility Index at the time of the rebalancing divided by the weight in the Parent Index. The constraint factor as well as the constituents in the index remains constant between index reviews except in case of corporate events as described below.

4.2 ONGOING EVENT RELATED CHANGES

The general treatment of corporate events in the MSCI Minimum Volatility Indexes aims to minimize turnover outside of Index Reviews. The methodology aims to appropriately represent an investor's participation in an event based on relevant deal terms and pre-event weighting of the index constituents that are involved. Further, changes in index market capitalization that occur as a result of corporate event implementation will be offset by a corresponding change in the Variable Weighting Factor (VWF) of the constituent.

Additionally, if the frequency of Index Reviews in the Parent Index is greater than the frequency of Index Reviews in the MSCI Minimum Volatility Index, the changes made to the Parent Index during intermediate Index Reviews will be neutralized in the MSCI Minimum Volatility Index.

The following section briefly describes the treatment of common corporate events within the MSCI Minimum Volatility Indexes.

No new securities will be added (except where noted below) to the Index between Index Reviews. Parent Index deletions will be reflected simultaneously.

EVENT TYPE

EVENT DETAILS

New additions to the Parent Index

A new security added to the parent index (such as IPO and other early inclusions) will not be added to the index.

Spin-Offs

All securities created as a result of the spin-off of an existing Index constituent will be added to the Index at the time of event implementation. Reevaluation for continued inclusion in the Index will occur at the subsequent Index Review.

Merger/Acquisition

For Mergers and Acquisitions, the acquirer's post event weight will account for the proportionate amount of shares involved in deal consideration, while cash proceeds will be invested across the Index.

If an existing Index constituent is acquired by a non-Index constituent, the existing constituent will be deleted from the Index and the acquiring non-constituent will not be added to the Index.

Changes in Security Characteristics

A security will continue to be an Index constituent if there are changes in characteristics (country, sector, size segment, etc.) Reevaluation for continued inclusion in the Index will occur at the subsequent Index Review.

Further detail and illustration regarding specific treatment of corporate events relevant to this Index can be found in the MSCI Corporate Events Methodology book under the sections detailing the treatment of events in Capped Weighted and Non-Market Capitalization Weighted indexes.

The MSCI Corporate Events methodology book is available at:
<https://www.msci.com/index-methodology>

APPENDIX I: TRANSITION

The MSCI World Minimum Volatility Index and MSCI USA Minimum Volatility Index were based on the previous Barra Global Equity Model (GEM). As of the November 2009 Semi-Annual Index Review, the MSCI Minimum Volatility Indexes are based on the new Barra Global Equity Model (GEM2).

The transition was done without applying a turnover constraint using the GEM2 model, with a goal to achieve a similar number of securities as the existing MSCI Minimum Volatility Indexes.

APPENDIX II: OPTIMIZATION SETTINGS FOR CONSTRUCTING MSCI MINIMUM VOLATILITY INDEXES

The MSCI Minimum Volatility Indexes are currently constructed using the latest version of the Barra Open Optimizer in combination with the relevant Barra Equity Model. The following optimization settings are applied to construct the MSCI Minimum Volatility Indexes.

1.0 Specify “Initial Portfolio” and “Trade Universe” settings on the Barra Open Optimizer

- “Initial Portfolio” is set as the current MSCI Minimum Volatility Index, using the constituent weights as of the close of the Rebalancing Date (before the rebalancing) updated for corporate actions up to the effective date of the rebalancing. When there is no current MSCI Minimum Volatility Index (for example, when no optimization has been applied to the Parent Index yet), the Initial Portfolio is set to be the Parent Index.
- “Trade Universe” is set to be the index constituents of the Parent Index.

2.0 Specify Risk Model

- The factor exposures for all the securities in the Trade universe are set using the most recent release of factor exposure data of the relevant Barra Equity Model.
- The common factor co-variances are set using the most recent release of factor co-variance data of the relevant Barra Equity Model.
- The specific co-variances of all securities in the Trade Universe are set using the most recent monthly release of specific co-variances data of the relevant Barra Equity Model.

3.0 Setup Utility function

The optimization objective is to find a pro forma Minimum Volatility Index that minimizes the total risk of Parent Index, as determined by the relevant Barra Equity Model. The risk aversion parameters used in the optimization are as follows:

Common factor risk aversion = 0.0075

Specific risk aversion = 0.075

4.0 Setup constraints

- The maximum weight of an index constituent will be restricted to the lower of 1.5% or 20 times the weight of the security in the Parent Index.
- The minimum weight of an index constituent will be 0.05%.
- For countries with weight greater than 2.5% in the Parent Index, the weight in the MSCI Minimum Volatility Index will not deviate more than +/-5% from the country weight in the Parent Index.
- For countries with weight less than 2.5% in the Parent Index, the weight in the MSCI Minimum Volatility Index will be capped at 3 times their weight in the Parent Index.
- The sector weights of the MSCI Minimum Volatility Index will not deviate more than +/-5% from the sector weights of the Parent Index.
- No constraint will be applied on the exposure of the MSCI Minimum Volatility Index to the Barra Volatility risk index factor. Exposure to all other Barra risk index factors will be restricted to +/-0.25 standard deviations relative to the Parent Index.
- The one way turnover of the MSCI Minimum Volatility Index is constrained to a maximum of 10%.
- The optimization process for creating MSCI Minimum Volatility Indexes based on MSCI Small Cap Indexes³ uses different parameters for the turnover and the asset weight constraints, as explained in Appendix IV.

³ Please refer to MSCI Small Cap Indexes in the MSCI Global Investable Market Indexes methodology located at www.msci.com/index-methodology

APPENDIX III: HANDLING INFEASIBLE OPTIMIZATIONS

During the semi-annual index review, in the event that there is no optimal solution that satisfies all the optimization constraints defined in Section 3.2, the following constraints will be relaxed, until an optimal solution is found:

- Relax the turnover constraint in steps of 5%, up to a maximum of 30%
- Relax the minimum weight constraint in steps of 0.01% up to a minimum of 0.01%.

For MSCI Regional/Country Indexes which have relatively lower number of stocks, the standard optimization parameters may lead to an infeasible solution. MSCI may apply relaxed constraints relative to the standard set of constraints based on the following guidelines:

Order of Relaxation	Maximum Asset Weight	Sector Weight
1.	Lower of 3% or 20 times the weight of the security in the Parent Index.	+/-5% from the sector weights of the Parent Index
2.	Lower of 3% or 20 times the weight of the security in the Parent Index.	+/-7.5% from the sector weights of the Parent Index
3.	Lower of 5% or 20 times the weight of the security in the Parent Index.	+/-5% from the sector weights of the Parent Index
4.	Lower of 5% or 20 times the weight of the security in the Parent Index.	+/-7.5% from the sector weights of the Parent Index

In the event that no optimal solution is found after the above constraints have been relaxed, the relevant MSCI Minimum Volatility Index will not be rebalanced for that semi-annual index review.

APPENDIX IV: OPTIMIZATION PARAMETERS FOR MINIMUM VOLATILITY INDEXES BASED ON MSCI SMALL CAP INDEXES

The following table contains an illustrative list of parameters which are used for some of the Minimum Volatility Indexes based on MSCI Small Cap Indexes:

Region/Country	Weight Multiplier	Turnover Constraint*
ACWI	10X	20%
AC Asia ex Japan	10X	30%
Australia	10X	20%
EM	10X	30%
Europe	10X	20%
Japan	10X	20%
UK	10X	20%
USA	10X	20%
World ex Japan	10X	20%
World	10X	20%

*Semi Annual One Way Index Turnover

APPENDIX V: METHODOLOGY FOR MSCI AUSTRALIA IMI SELECT MINIMUM VOLATILITY (AUD) INDEX

The MSCI Australia IMI Select Minimum Volatility (AUD) Index is constructed from the MSCI Australia IMI (the “Parent Index”). MSCI Australia IMI Select Minimum Volatility (AUD) Index uses the Australian Dollar as the optimization currency. The methodology for constructing this index differs from the standard MSCI Global Minimum Volatility Indexes methodology in the following optimization constraints:

- The maximum weight of an index constituent will be restricted to the lower of 10% or 20 times the weight of the security in the Parent Index.

The following sections have been modified since December 2013:

- Added Appendix IV containing different asset weight multiplier and turnover constraints that are used for creating Minimum Volatility Indexes based on MSCI Small Cap Indexes
- Included a reference to Appendix IV in Appendix II

The following sections have been modified since June 2016:

- Added Appendix V containing index specific parameters for the MSCI Australia IMI Select Minimum Volatility (AUD) Index

The following sections have been modified since September 2016:

- The details on the Corporate Events treatment are now included in Section 4.2.

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* = toll free

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