Morningstar Indexes Calculation Methodology

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Overview

This document outlines the calculation methodology for the Morningstar Global Equity Indexes. An index level can be calculated using various methods to capture the composite performance of underlying securities while considering the impact of corporate events. Because there are different types of index weighting schemes, these calculations differ depending on how such events influence the price and shares of underlying securities. The Morningstar Global Equity Indexes are calculated using a modified version of the Laspeyres index—also known as a base-weighted index, since constituents' price change is weighted by the quantities (that is, index shares) in the base period. This document outlines the formulas and concepts used in the calculation of Morningstar's equity indexes.

Index Divisor

Morningstar Indexes use the concept of an "index divisor" to calculate daily index levels. The performance of the index is linked to change in the market value of its constituents. The portfolio market value of the index—which is the sum of its constituents' index market value—is adjusted by changing the index divisor to calculate the index levels. The index divisor for a given day (t) is defined as:

1) $$D(t) = \frac{Initial\ MV(t)}{I(t-1)}$$

Where:

t	= Time the index is calculated
D(t)	= Divisor at time (t)
Initial MV(t)	Initial market value of the index at time (t)
I(t-1)	= Index level at the close of day (t-1)

The index divisor remains unchanged unless there is a change in index composition, which can be due to corporate actions, changes in shares outstanding and the float factor, or the addition or deletion of securities from the index. In such cases, the divisor is adjusted to avoid distortions caused by such events and to keep the index level from changing because of factors that are not the result of stock market price action.

Market Capitalization and Float Market Capitalization Weighted Indexes

In market-cap-weighted indexes the weight of each constituent is determined by dividing its market capitalization by the total market capitalization of the index, without accounting for strategic holdings that may not be publicly traded. Float market-cap-weighted indexes adjust for shares that are not included in the public float in an attempt to better reflect the composition of the market available to investors. These indexes use float market capitalization (Total Shares Outstanding*Investable Weight Factor*Price) in place of total market capitalization. In both market capitalization and float market capitalization weighted indexes, the price movement of a larger security will have a larger impact than that of a small security.

The following formula is used to calculate the index level:

2) $$Index\ Level = \frac{\sum_i^n P_i * Q_i}{Index\ Divisor}$$

Where:

P_i	=	Share price of security i in index currency
Q_i	=	Total shares outstanding of security i (adjusted for float if float market-cap weighted)
n	=	Number of securities in the index

If the number of stocks in the index changes because of the addition or deletion of securities, the total market value of the index changes, but the index level should not change on such occasions. This is achieved by adjusting the divisor for the next day. Following similar terminology as stated in the Index Divisor section, we can write the following equation:

3) $$I(t) = \frac{Closing\ MV(t)}{D(t)}$$

Suppose there are n securities in the index out of which k securities will be deleted and replaced by an equal number of securities the next day. Then Equation (2) can be expanded to the following:

4) $$I(t) = \frac{(\sum_i^{n-k} P_i * Q_i) + (\sum_d^k P_d * Q_d)}{D(t)}$$

Now, this index should still open at I(t-1) on the next day (t). Assuming no corporate event and constant float and shares outstanding on the current constituents, the equation can be written as:

5) $$\frac{(\sum_i^{n-k} P_i * Q_i) + (\sum_d^k P_d * Q_d)}{D(t-1)} = I(t-1) = \frac{(\sum_i^{n-k} P_i * Q_i) + (\sum_a^k P_a * Q_a)}{D(t)}$$

Where P_d and Q_d represent security price and shares of deleted securities, while P_a and Q_a represent security price and shares of added securities.

The index divisor for the day (t) can, thus, be written as:

6) $$D(t+1) = D(t) * \frac{(\sum_i^n P_i(t) * Q_i(t)) + \Delta MV(t+1)}{(\sum_i^n P_i(t) * Q_i(t))}$$

Or:

7) $$D(t+1) = D(t) + \frac{\Delta MV(t+1)}{I(t)}$$

Where:

D(t+1)	= Divisor at time (t+1)
D(t)	= Divisor at time (t)
$P_i(t)$	= Share price of security i in index currency at time (t)
$Q_i(t)$	= Total shares outstanding of security i (adjusted for float if float market-cap weighted) at time (t)
n	= Number of securities in the index
ΔMV(t+1)=	Aggregate change in market value resulting from additions and deletions

The above equation can be generalized where ΔMV(t+1) can be computed for every stock in the index along with other corporate action adjustments, and the resulting sum can be used to calculate the index divisor for the next day. These adjustments are made after the market is closed for trading where aggregate market value change is calculated using the portfolios at the market close and the next market opening. As the calculation suggests, this divisor does not change as a result of any market-neutral event, such as a stock split.

Equal Weighted Indexes

Equal weighted indexes assign equal weightings to each constituent at rebalancing. The weights drift from their original assigned weights as the price of underlying stocks changes until the next index rebalance, when it is reset to equal weight.

Constituent weightings in an equal-weighted index are determined by the following formula:

8) $IW_i = \frac{1}{n}$

And the constructed shares for each constituent in the index can be calculated as:

9) $S_i(t) = \frac{\sum_j^n \left(P_j(t) * Q_j(t)\right) * IW_i * C}{P_i(t)}$

This can be further written in terms of the security's float-adjusted outstanding shares:

10) $S_i(t) = Q_i(t) * \frac{\sum_j^n Float\ Mcap_j(t) * IW_i * C}{Float\ Mcap_i(t)}$

Or:

11) $S_i(t) = Q_i(t) * AF_i$

Where:

$S_i(t)$	= Constructed shares of company i at time (t)
$Q_i(t)$	= Float-adjusted total outstanding shares of company i at time (t)
n	= Number of stocks in the index
t	= Time the index is calculated
P_i	= Share price of security i in index currency at time (t)
IW_i	= Company weight in index i at rebalancing time
C	= Index-specific constant used to limit index shares beyond its outstanding shares
Float $Mcap_i(t)$	= Float market cap of security i at time (t)
AF_i	= Adjustment factor of security i

It is important to note that the shares $S_i(t)$ for the index constituents are artificial constructs used for calculation purposes. Consequently, the constructed shares are linked to the actual shares of the company in terms of the total dividends paid by the company. Hence, the index-specific constant C can be assigned to normalize the index shares.

Dividend Dollar-Weighted Indexes

Dividend dollar-weighted indexes are those where the constituents are weighted according to the total dividends paid by the company to investors. Consequently, the available dividend dollar value is the product of the security's shares outstanding, free float factor, and annualized dividend per share.

Constituent weightings in a dividend dollar-weighted index are determined by the following formula:

12) $$IW_i(t) = \frac{d_i(t) * Q_i(t)}{\sum_{i=1}^{n} d_i(t) * Q_i(t)}$$

Where $d_i(t)$ is the dividend per share of the company (i) at time (t).

And the constructed shares $S_i(t)$ for each constituent in the index calculation formula can be calculated using the equations 9, 10, and 11:

9) $$S_i(t) = \frac{\sum_{j}^{n} \left(P_j(t) * Q_j(t)\right) * IW_i * C}{P_i(t)}$$

Or:

10) $$S_i(t) = Q_i(t) * \frac{\sum_{j}^{n} Float\ Mcap_j(t) * IW_i * C}{Float\ Mcap_i(t)}$$

Or:

11) $$S_i(t) = Q_i(t) * AF_i$$

The adjustment factor for each security on the rebalancing date (t) can be calculated by:

13) $$AF_i = \frac{IW_i(t)}{W_i(t)}$$

Where:

$IW_i(t)$	=	Capped weight of security i in index at rebalancing time (t)
$W_i(t)$	=	Uncapped weight of security i in index at rebalancing time (t) based on float market cap

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Capped-Weighted Indexes

Capped-weighted indexes constrain the maximum weight of a single constituent and/or the sum of the weights of all securities representing a defined group. These groups can be defined on parameters like: sectors, industries, countries, and individual securities. Such indexes are often designed to address the constraints imposed by UCITS or the U.S. Internal Revenue Code, and to improve diversification.

In such instances, the excess weight is distributed among the remaining constituents with an objective to preserve relative weights for a maximum number of stocks within the index. These weights may drift from their caps between rebalances, as the price of underlying stocks changes. Hence, an adjustment is required at rebalancing to assign appropriate weights to index constituents according to the capping algorithm.

The index calculation methodology for the capped indexes remains the same as in the float market-capitalization indexes, except that weights of individual stocks differ from those assigned by their float market cap.

The equations 9, 10, 11, and 13 can be used again from the previous section to calculate index shares:

9) $$S_i(t) = \frac{\sum_j^n \left(P_j(t) * Q_j(t)\right) * IW_i * C}{P_i(t)}$$

Or:

10) $$S_i(t) = Q_i(t) * \frac{\sum_j^n Float\ Mcap_j(t) * IW_i * C}{Float\ Mcap_i(t)}$$

This can be further written in terms of the adjustment factor as:

11) $$S_i(t) = Q_i(t) * AF_i$$

Where:

13) $$AF_i = \frac{IW_i(t)}{W_i(t)}$$

Capped-Weighting Adjustments

The capped-weight IW_i can be calculated with different capping methods, which can be further segregated into the following techniques:

Single Constituent Capping

This method is applied when a single constituent exceeds the maximum weight allowed.

Single Constituent and Group Capping

This method is applied to restrict the weight of a single constituent to a predefined weight, as well as weights of all constituents with a combined weight greater than a certain amount to a predefined group weight.

Any such capping can be written in terms of B-A-C capping (for example, the 5-20-50 capping rule). This means the maximum weight an individual security can receive is A (20%), and the weights of all securities with weight greater than or equal to B (5%) cannot sum to more than C (50%).

The procedure to cap weights is explained below.

The first step is to assign a weight to each security based on its weighting scheme, which is often based on float market cap. For a given set of weights, $w_1, w_2, \ldots, w_N$, with $w_1 \geq w_2 \geq \ldots \geq w_N$, and $\sum_{i=1}^{N} w_i = 1$, we test to see if the B-C rule holds as follows:

Let:

$$w_i^* = \begin{cases} w_i, & x \geq B \\ 0, & x < B \end{cases}$$

If $\sum_{i=1}^{N} w_i^* \leq C$, the B-C rule holds.

Let:

N	=	Number of stocks in the portfolio
Cap/A	=	A (that is, maximum weight allowed for any stock)
x_i	=	Original weight of the i[th] largest stock in the portfolio, $x_1 \geq x_2 \ldots \geq x_N$

$$\sum_{i=1}^{N} x_i = 1$$

If $x_1 \leq$cap and the B-C rule holds for $x_1, x_2, \ldots, x_N$,, we do not need any reweighting. If the B-C rule does not hold, the cap should be set to a value less than x_1 and the following algorithm should be tried. If we start with x_1>cap, we try the algorithm described below.

Morningstar reweights using a two-part linear function as follows:

$$14) \quad y_i = \begin{cases} y_K + \beta_1 (x_i - x_K), & \text{if } i \leq K \\ \beta_2 x_i, & \text{if } i \geq K \end{cases}$$

Where K is the index of the stock at which the function is kinked. Note that this reweighting preserves the relative weights of all stocks beginning from the Kth stock.

Given K, we need to set à1 and à2. From equation (13), it follows that:

$$15) \quad \beta_1 = \frac{y_1 - y_K}{x_1 - x_K}$$

And:

$$16) \quad \beta_2 = \frac{y_K}{x_k}$$

We set:

17) $y_1 = cap$

We need to set y_K so $\sum_{i=1}^{N} y_i = 1$. Some algebra shows that this occurs when:

18) $$y_K = \frac{1 - \gamma y_1}{(K-1) - \gamma + \frac{1-z}{x_K}}$$

Where:

19) $$z = \sum_{i=1}^{K-1} x_i$$

And:

20) $$\gamma = \frac{z - (K-1)x_K}{x_1 - x_K}$$

We chose K to maximize the number of stocks for which relative weights are preserved. This occurs at the lowest value of K for which yK≤y1. Hence, our reweighting algorithm is as follows:

1. Set z=0, y1=cap, and K=1
2. If K<N, set K=K+1; otherwise go to step 9
3. Set $z=z+x_{K-1}$
4. Set γ and y_K using equations (20) and (18) respectively
5. If $y_K > y_1$, go back to step 2
6. Set β_1 and β_2 using equations (15) and (16) respectively
7. For i = 1,…, N, set y_i using equation (14)
8. If the B-C rule holds for y1, y2, ,…, yN, this is the solution, so stop. Otherwise go back to step 2.
9. If K=N and BC rule doesn't hold, set y1 = y1-0.0001 and go to step 1 with a new y1.
10. There is no solution that meets the B-C rule with this cap

Liquidity Informed Weighting

The Liquidity Informed Weighting algorithm ensures that a portfolio of stocks can be traded in a specified number of days given the portfolio fund size and a daily trade limit based on the security's average daily traded volume (ADTV), while ensuring that the final security weights are close to their intended target weights.

The security weights are adjusted based on their liquidity such that:

$$21)\quad |w_i - cw_i| \leq \frac{Days\ to\ trade * \ ADTV_i \ * \ \%\ ADTV\ being\ traded\ in\ 1\ day}{AUM}$$

Where:

w_i	= final weight assigned to the i^{th} security in the index
cw_i	= current weight of the i^{th} security in the index
$ADTV_i$	= 3-month Average Daily Trading Volume of the i^{th} security
Days to trade	= maximum number of trade days available to trade into the target portfolio
AUM	= assumed hypothetical fund size
%ADTV being traded in one day	= maximum percentage of ADTV to be traded in a day for any security

For security additions, the current weight in the portfolio cw_i is 0. Security deletions are not taken into consideration.

Liquidity Informed Weighting Algorithm

Step 1: Assign Target Weight to each security which is equal to the weight of security before applying Liquidity Informed Weighting but after incorporating the weighting scheme as per the index methodology

Step 2: Calculate the Max Trade Limit (MTL) for each security in terms of its weight in the portfolio based on the below formula. Refer to above table for details on each term.

$$22)\quad MTL_i = \frac{Days\ to\ trade * \ ADTV_i \ * \ \%\ ADTV\ being\ traded\ in\ 1\ day}{AUM}$$

Step 3: Calculate the Max Weight and Min Weight for each security using its MTL calculated in step 2 as shown below:

$$Max\ Weight_i = \quad cw_i + \ MTL_i$$
$$Min\ Weight_i = \quad cw_i - \ MTL_i$$

Step 4: For securities with Target $weight_i$ between Max $Weight_i$ and Min $Weight_i$, the security weight (w_i) is set to the Target $weight_i$.

Step 5: For securities with Target $Weight_i$ below Min $Weight_i$ or above the Max $Weight_i$, the security weight (w_i) is set to Min $Weight_i$ or Max $Weight_i$ respectively and the sum of residual weights for all such 'n' securities are calculated as below:

$$23)\quad Residual\ Weights = \sum_{i=1}^{n}(Target\ Weight_i - \ w_i)$$

The individual security residual weight is positive for securities where there is shortfall in achieving the target weight and the residual weight is negative for securities where there is excess over the target weight. The sum of all residual weights can be positive or a negative number.

Step 6: The sum of residual weights from step 5 is redistributed to securities in step 4 in proportion of their existing security weights. The new weights after weight redistribution becomes the new Target Weight_i of the security i.

Step 7: If the assigned security weight (w_i) is between Max Weight_i and Min Weight_i for all securities then these will be the final security weights, else repeat steps 4 to 7

Target Volatility Indexes

Morningstar Target Volatility Indexes are designed to achieve a certain volatility target with variable exposure to the base index. The target exposure to the base index is based on the ratio of the target volatility to the measured historic volatility of the base index. The target exposure is monitored daily and is subject to both an exposure tolerance and a maximum exposure.

Determining the Target Exposure

The target exposure of the Morningstar target volatility indexes to the base index is determined by the formula below, with the aim of maintaining a target volatility. It is based on the ratio between the target volatility and the measured historic volatility of the base index and will vary between zero and the maximum allowable exposure.

24) $$w_{Target(t)} = \min\left(max\_exposure, \frac{target\_volatility}{measured\_volatility} \right)$$

Where:
max exposure = 150%
target volatility = Target volatility chosen for the index

To mitigate daily rebalancing of Target Volatility Indexes, the target exposure is updated only when there is a change that is greater than the exposure tolerance percentage. The current exposure of the index on the inception date shall be equal to the target exposure on the inception date.

25) $$w_0 = w_{Target(0)}$$

On any subsequent date t, the current exposure shall be determined as follows:

26) $$w_t = \begin{cases} w_{Target(t)} \; if \; w_{t-1} > (1+tolerance) \cdot w_{Target(t)} \\ w_{Target(t)} \; if \; w_{t-1} < (1-tolerance) \cdot w_{Target(t)} \\ w_{t-1} \; otherwise \end{cases}$$

Where tolerance = 10%

w_t	=	Realized exposure of the index on date t
$w_{Target}(t)$	=	Target exposure of the index on date t

Measuring Volatility

The measured volatility of the base index is taken as either the trailing 20-business-day historic volatility or the trailing 60-business-day historic volatility, whichever is greater.

27) $$measured\_volatility = \max(Vol20_t, Vol60_t)$$

Where:

28) $$\mathrm{Vol20}_t = \sqrt{252 \times \frac{20}{19} \times \left[\frac{1}{20} \sum_{k=1}^{20} \mathrm{Ln}^2\left(\frac{B_{t-k}}{B_{t-k-1}} \right) - \left(\frac{1}{20} \sum_{k=1}^{20} \mathrm{Ln}\left(\frac{B_{t-k}}{B_{t-k-1}} \right) \right)^2 \right]}$$

And:

29) $$\text{Vol60}_t = \sqrt{252 \times \frac{60}{59} \times \left[\frac{1}{60} \sum_{k=1}^{60} \text{Ln}^2\left(\frac{B_{t-k}}{B_{t-k-1}} \right) - \left(\frac{1}{60} \sum_{k=1}^{60} \text{Ln}\left(\frac{B_{t-k}}{B_{t-k-1}} \right) \right)^2 \right]}$$

Excess Return Calculation

The excess return is equal to the total return (described in the Total/Gross and Net Calculations section below) minus the cash borrowing cost associated with holding the base index. The simplest way to explain this is to view it as an opportunity cost of investing in the base index instead of a cash investment. Thus, the total return is "dragged" by the cash borrowing rate to arrive at the return in excess of the expected return of a pure cash investment. Morningstar uses the SOFR in USD as the cash borrowing rate.

The Excess return calculation equation is shown below:

If $w_{t-1} \leq 100\%$ then:

30) $$ER_t = ER_{t-1} \times \left[2 - \left(\frac{SOFR_t}{SOFR_{t-1}}\right)\right] \times \left[w_{t-1} \cdot \left(\frac{B_t}{B_{t-1}}\right) + (1 - w_{t-1}) \cdot \left(\frac{FFE_t}{FFE_{t-1}}\right)\right]$$

Else:

31) $$ER_t = ER_{t-1} \times \left[2 - \left(\frac{SOFR_t}{SOFR_{t-1}}\right)\right] \times \left[w_{t-1} \cdot \left(\frac{B_t}{B_{t-1}}\right) + (1 - w_{t-1}) \cdot \left(\frac{SOFR_t}{SOFR_{t-1}}\right)\right]$$

where:

I_t	=	Index level on date t
w_{t-1}	=	Realized exposure of the index on date t-1
B_t	=	Base index level on date t
FFE_t	=	Index capitalizing at the federal-funds effective rate on date t with a base value of 1 on the inception date of the base index, calculated daily using value from date t-1, on an (actual/360) day count basis. The underlying fed-funds rates follow the U.S. Fed calendar
$SOFR_t$	=	Index capitalizing at the SOFR rate on date t with a base value of 1 on the inception date of the base index, calculated daily using value from date t-1, on an (actual/360) day count basis. The underlying SOFR rates follow the U.S. Fed calendar

Trading Cost Adjustment Factor, or TCAF

To account for higher transaction and portfolio management costs associated with the target volatility strategy, a flat adjustment factor is applied to the calculated index level to arrive at the final, published index level for volatility indexes.

On any index business day, the final adjusted index level I_t, shall be calculated as follows:

32) $$I_t = I_{t-1} \times \left(\frac{ER_t}{ER_{t-1}} \right) \times \left[1 - TCAF \times \left(\frac{n}{360} \right) \right]$$

Where:

ER_t = Unadjusted index level on day t

n = Number of days between t and (t-1)

Exchange-Rate Rules

Most exchange rates are quoted against the U.S. dollar, as it is the most traded currency globally. Exchange rates are used to calculate indexes in different currencies other than the local currency and to convert the local prices of securities to a single currency in case of multicurrency exposure indexes. Morningstar Indexes typically computes the index level in U.S. dollars, which is the base currency.

Exchange-Rate Data Source

Morningstar sources exchange-rate data from WMR. WMR Closing Spot Rates are used for end-of-day index calculations. WMR Intraday Spot Rates are used for real-time index calculations. WMR Closing Forward Rates are used for end-of-day hedged index calculations.

As per WMR's practice, national holidays in the following four financial centers will be monitored: the United States, the United Kingdom, Germany, and Japan, for data service on a particular day. WMR closing spot and forward rates will be produced if two or more of these centers are open. WMR rates will not be produced if only one center is open. This affects the WMR exchange rates that are used in index calculations.

Standard Exchange-Rate Index Calculations

Unless otherwise specified in the index rulebook, Morningstar uses the U.K. 4 p.m. spot rate for most of its standard index calculations. However, in scenarios where the U.K. 4 p.m. rate is not available, Morningstar will use the U.K. 12 p.m. rate for its index calculations. On a typical business day, the rate published for that day will be used for Morningstar Indexes' calculations.

On a full no-service day with no WMR rates produced, Morningstar will use the previous day's rate of that specific cutoff time. For example, if Jan. 1 is a no-service day where neither the U.K. 4 p.m. rate nor the U.K. 12 p.m. rate is published, we use the Dec. 31 U.K. 4 p.m. rate.

On partial-day service, if the specific rate used for index calculations is not published, Morningstar will take the previously available (indicative) rate for that day. If that indicative rate is also not available, Morningstar will use the previous day's rate that would be the best fit.

For example, assuming Dec. 24 is a day when the foreign exchange market closes early, the rate for that day is published until 1 p.m. only. In this case, the U.K. 4 p.m. rate will not be published for Dec. 24 since it is beyond the service cutoff time (1 p.m.). However, the U.K. 12 p.m. rate would be available because it is within the cutoff for that day. So, Morningstar will use the U.K. 12 p.m. rate for its index calculations since it is the latest available indicative rate for that day. However, in the absence of the U.K. 12 p.m. rate on Dec. 24, Morningstar will use the previous day's rate—that is, the U.K. 4 p.m. rate of Dec. 23.

The same procedures will be followed for any other customized rate such as Japan 10 a.m., Singapore 5:30 p.m., and so on. In case of an unforeseen event or a service being halted for a few hours, partial-day service treatment will be followed.

JST FX Index Calculations

The JST FX variants of Morningstar indexes are calculated in Japanese yen by applying 10 a.m. Japan Standard Time spot exchange rates[1] on the previous day's underlying index levels.

33) $$Index\ Level_{JPY,t} = Index\ Level_{JPY,t-1} * \frac{Index\ Level_{USD,t-1}}{Index\ Level_{USD,t-2}} * \frac{FXRate_t}{FXRate_{t-1}}$$

Where:

Index Level JPY (t)	=	Index level in JST 10 a.m. at the close of day (t)
Index Level JPY (t-1)	=	Index level in JST 10 a.m. at the close of day (t-1)
Index Level USD (t-1)	=	Index level in USD at the close of day (t-1)
Index Level USD (t-2)	=	Index level in USD at the close of day (t-2)
FXRate (t)	=	Exchange rate of JPY/USD at 10 a.m. JST at day (t)
FXRate (t-1)	=	Exchange rate of JPY/USD at 10 a.m. JST at day (t-1)

The source data for exchange rates[2] used in the JST FX index calculation is WMR 10 a.m. JST fixing rates. In the event when 10 a.m. JST rates are not available, Morningstar will use the 4 p.m. London time exchange rates from the previous day.

[1] Morningstar reserves the right to change the exchange rates for calculating the JST 10 AM indexes.

[2] WMR 4PM London exchange rates are being used in calculations prior to November 2017.

Currency-Hedged Indexes

Currency-hedged indexes are long the benchmark index and short currency forwards whose notional amount is based on the weight of foreign currencies ("currency exposure") in the underlying index. The hedge ratio—the proportion of the portfolio's currency exposure that is hedged—can vary as per the Hedged Index specifications.

The index is rebalanced monthly, usually on the last trading day of the month,[3] using foreign currency weights and corresponding notional amounts determined as of one business day before the *rebalance date*. This approach ensures that index calculation closely resembles the actual implementation lag investors face.[4] New forward positions are effective at the rebalance effective date, which is at the opening on the next business day after the rebalancing day.

To account for the difference in the rebalance date and the date on which the notional amounts are determined, a monthly adjustment factor is applied in the hedge return calculation. The notional amounts hedged remain constant throughout the month and are not modified on account of price movement, corporate action, or rebalance and reconstitution of the underlying index. The daily index calculation marks to market the one-month forward contracts using a linear interpolation of spot and forward prices based on the one-month forwards. All the spot and forward rates are denominated in terms of foreign currency per unit of home currency. The underlying index levels and the hedged index levels are denominated in the home currency.

Monthly Currency Hedge Index Calculations

The monthly hedge ratio is calculated as follows:

34) $$HR = MAF * \sum_i^n p_i * \{W_{i1-1d} * FXRate_{i1-1d} * \left(\frac{1}{FFRate_{i1}} - \frac{1}{FFRate_{i2}}\right)\}$$

35) $$MAF = \frac{HedgedIndex_{1\text{-}1d}}{HedgedIndex_1}$$

36) $$HedgedIndex_2 = HedgedIndex_1 * \left(\frac{UnhedgedIndex_2}{UnhedgedIndex_1} + HR\right)$$

Where:

HR	=	Hedge Return
p_i	=	Hedge Ratio of currency i in the index (proportion of the foreign currency exposure hedged)
n	=	Number of foreign currencies underlying the index
W_{i1-1d}	=	Weight of currency i in the index as of one business day before the previous rebalance date, after incorporating corporate actions and rebalancing in the underlying index, effective at the open of

[3] Some indexes, like the Morningstar Developed Markets ex-US Factor Tilt Hedged Index and Morningstar Emerging Markets Factor Tilt Hedged Index, rebalance at the close of the third Friday of the month, coinciding with the rebalance schedule of the underlying indexes.

[4] For the purposes of showing back-tested performance, no lag is assumed.

		the rebalance effective date (if calculated by Cirrus), or at the open of the rebalance date (rebalance effective date t-1: if calculated by Amber).
$FXRate_{i1\text{-}1d}$	=	Spot rate of currency i as of one business day before the previous rebalance date
$FFRate_{i1}$	=	Forward rate of currency i as of the previous rebalance date
$FFRate_{i2}$	=	Forward rate of currency i as of the current rebalance date
MAF	=	Monthly adjustment factor to account for the one-day lag between the rebalance date and the date on which notional amounts are determined
$HedgedIndex_{1\text{-}1d}$	=	Hedged index level as of one business day before the previous rebalance date
$HedgedIndex_1$	=	Hedged index level as of the previous rebalance date
$HedgedIndex_2$	=	Hedged index level as of the current rebalance date
$UnhedgedIndex_1$	=	Underlying index level as of the previous rebalance date
$UnhedgedIndex_2$	=	Underlying index level as of the current rebalance date

Daily Currency Hedge Index Calculations

The daily hedge impact is calculated as follows:

37) $$HR_t = MAF * \sum_i^n p_i * \{W_{i1-1d} * FXRate_{i1-1d} * \left(\frac{1}{FFRate_{i1}} - \frac{1}{FFRateInterpolated_{i,t}}\right)$$

38) $$FFRateInterpolated_{i,t} = FXRate_{i,t} + \left(\frac{D-d_t}{D} * \left(FFRate_{i,t} - FXRate_{i,t}\right)\right)$$

39) $$MAF = \frac{HedgedIndex_{1\text{-}1d}}{HedgedIndex_1}$$

40) $$HedgedIndex_t = HedgedIndex_1 * \left(\frac{UnhedgedIndex_t}{UnhedgedIndex_1} + HR_t\right)$$

Where:

HR_t	=	Hedge Return on day t
t	=	Calculation date
D	=	Number of calendar days between next rebalance date and previous rebalance date
d_t	=	Number of calendar days between calculation date and previous rebalance date
$FFRateInterpolated_{i,t}$	=	Forward rate of currency i interpolated for intramonth performance of the hedge
$FFRate_{i,t}$	=	One-month forward rate of currency i on day t
$FXRate_{i,t}$	=	Spot rate of currency i on day t
$HedgedIndex_t$	=	Hedged index level as on day t
$UnhedgedIndex_t$	=	Underlying index level as on day t

Other notations are the same as above.

Data Source for FX Rate

The source data for forward and spot rates used in this methodology is WMR London 4 p.m. fixing rates. WMR foreign exchange rates are taken daily at 4 p.m. London time and used in the calculation of the indexes. Unless otherwise noted, this is applicable for all sections where FX Rate is used.

Total/Gross and Net Return Calculations

While price-return indexes gauge the change in prices of index constituents as explained in the previous sections, total-return indexes reflect the changes in both prices and reinvestment of dividends paid by the index constituents. The dividends distributed are reinvested in the index based on the weights of constituents as of the ex-date. Only cash dividends and regular capital repayments are included in the total return calculations but not the price returns. Other dividends, including special dividends and extraordinary capital repayments, are already considered in the calculation of price-return index variants.

For Morningstar Indexes, Total Return (TR) and Gross Return (GR) are used interchangeably. TR is used for U.S.-specific indexes and GR is used for the non-U.S.-specific indexes.

41) $$TR\ Return_t = \left(\frac{PR\ Index\ Level_t + TR\ Index\ Dividend_t}{PR\ Index\ Level_{t-1}} - 1\right)$$

Where:

42) $$TR\ Index\ Dividends_t = \frac{\sum_i^n Dividend_i * Shares_i}{D(t)}$$

The TR index level can be calculated by the formula below:

43) $$TR\ Index\ Level_t = TR\ Index\ Level_{t-1} * (1 + TR\ Return_t)$$

The above approach is also used to calculate the net total return (NR) indexes where dividends distributed are adjusted for the withholding tax rate (WTR) applicable to nondomestic investors who do not benefit from double taxation treaties.

Morningstar Withholding Tax Rates are available on the Morningstar Indexes website.

44) $$NR\ Index\ Dividends_t = \frac{\sum_i^n Dividend_i * (1 - WTR_i) * Shares_i}{D(t)}$$

45) $$NR\ Return_t = \left(\frac{Index\ Level_t + NR\ Index\ Dividend_t}{Index\ Level_{t-1}} - 1\right)$$

And:

46) $$NR\ Index\ Level_t = NR\ Index\ Level_{t-1} * (1 + NR\ Return_t)$$

Index Conversion Into Another Currency

Any index can be calculated into another currency by using the formula below:

47) $$Index\ Level\ in\ Curr_t = Index\ Level\ in\ Curr_{t-1} * \frac{Index\ Level\ in\ USD_t * FXRate_t}{Index\ Level\ in\ USD_{t-1} * FXRate_{t-1}}$$

Morningstar index base values are often set to 1,000. If the currency start date falls after the index start date, the index calculation starts from the currency start date.

48) $$IndexMarketValueinCurrency_t = IndexMarketValueinUSD_t * FXRate_t$$

Index Market Value Calculations

After Sept. 4, 2023, Morningstar Indexes standardized the index market value formula for any index variant to

49) $$IndexMarketValueinCurrency_t = IndexMarketValueinUSD_t * FXRate_t$$

Prior to Sept. 4, 2023, the market value of a non-USD index variant for select (internally calculated) equity indexes is not only a function of the exchange rate on that date, but also a function of the exchange rate on the index inception date.

This is because we started the base index level for the currency variants at 1,000. To do so, we need to adjust either the divisor or the market value, since

50) $$IndexLevel_t = \frac{IndexMarketValue_t}{IndexDivisor_t}$$

Morningstar Indexes have opted to adjust the market value of the index, to keep the same divisor for all currency variants, and for the index level on the inception date to be 1,000 for all currency and return variants. As such, the index market value is more accurately defined as an adjusted market value, as defined below:

51) $$IndexMarketValueinCurrency_t = IndexMarketValueinUSD_t * \frac{FXRate_t}{FXRate_{CurrBaseDate}}$$

Local Currency Return Calculation

The local-currency return calculation involves calculation of the weighted percentage change in the price of each constituent, which is further used to compute the index levels. This approach yields the same results as our divisor-based methodology. However, because of its simplicity, the local-currency return approach is preferred over divisor-based methodology when multiple currencies are involved in the calculation.

52) $$IW_{i,t-1} = \frac{P_i(t-1) * S_i(t-1) * FXRate_i(t-1)}{\sum_i^n P_i(t-1) * S_i(t-1) * FXRate_i(t-1)}$$

53) $$I(t) = I(t-1) * \sum_i^n \frac{P_i(t)}{P_i(t-1)} * IW_i(t-1)$$

Where:

I(t)	=	Index level at the close of day (t)
I(t-1)	=	Index level at the close of day (t-1)
$P_i(t)$	=	Price of security i in index at the close of day (t)
$P_i(t-1)$	=	Price of security i in index at the close of day (t-1)
$S_i(t-1)$	=	Shares of security i in index at the close of day (t-1)
$FXRate_i(t-1)$	=	Exchange rate of security i
$IW_i(t-1)$	=	Weight of security i in index at the close of day (t-1)

Real-Time Calculation

The methodology described above pertains to end-of-day calculations. Refer to the Morningstar Real-Time Calculation Methodology document for additional information about Morningstar real-time calculations.

Appendix

Appendix 1: Modifications to the Rulebook

Section	Description of Change	Update Date
Capped Weighting Adjustments	Capping constraints will be relaxed if a feasible solution cannot be obtained using the stated algorithm	April 2021
Morningstar Committee	Updated the Morningstar Indexes Product Committee & Morningstar Indexes Oversight Committee	June 2021
Target Volatility Index	Replaced 3-Months LIBOR rate with SOFR rate	November 2021
10 a.m. JST	Added a section outlining the calculation of the 10 a.m. JST Morningstar index variants.	September 2023
Exchange-Rate Rules	Added section	September 2023
Index Conversion Into Another Currency	Added section	September 2023
Entire Rulebook	Moved the rulebook to a new template	September 2023
Liquidity Informed Weighting	Added section	October 2023
Currency-Hedged Indexes	Hedge Ratio defined at individual currency level in the index	November 2023
Target Volatility Indexes	Added Excess Return Calculation section	January 2024

About Morningstar Indexes

Morningstar Indexes was built to keep up with the evolving needs of investors—and to be a leading-edge advocate for them. Our rich heritage as a transparent, investor-focused leader in data and research uniquely equips us to support individuals, institutions, wealth managers, and advisors in navigating investment opportunities across major asset classes, styles, and strategies. From traditional benchmarks and unique IP-driven indexes to index design, calculation, and distribution services, our solutions span an investment landscape as diverse as investors themselves.

Morningstar Indexes Methodology Committee

The Morningstar Indexes Methodology Committee oversees all new index development, index methodology changes, and cessation of indexes for any indexes where Morningstar owns the intellectual property. This committee is also charged with ensuring that indexes align with Morningstar Research principles and values. The group comprises members of the index team with index research, product development, product management, client service, index implementation, and operation expertise who provide the first layer of governance over index design and methodology.

Morningstar Indexes Operations Committee

The Morningstar Indexes Operations Committee governs the processes, systems, and exception handling of the day-to-day management of all live indexes, including index rebalancing and reconstitution, restatements, market classification, and contingency management. The committee oversees the annual review of index methodology (as required by U.K. and EU benchmark regulations, or BMR), ensuring that methodologies remain fit for purpose and continue to achieve their stated investment objectives. The group comprises members of the index team with data, operations, corporate actions, product development, index launch, client service, and index management experience who provide the first layer of governance over index operations.

Morningstar Indexes Oversight Committee

The Morningstar Indexes Oversight Committee is responsible for the index oversight function as per the requirements of the U.K. and European BMR, providing independent oversight of all aspects of the governance of benchmark administration as required by the relevant BMR. Its remit extends to all calculation and administration-related business activities of Morningstar Indexes, including administration of Morningstar-owned benchmarks as well as client-owned benchmarks and index calculation. The oversight function is part of the organizational structure of Morningstar but is separate and independent from the index business, index management, and the other index committees.

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