S&P Dow Jones Indices

A Division of S&P Global

Index Mathematics
Methodology

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Introduction

This document covers the mathematics of equity index and other quantitative rules-based calculations and assumes some acquaintance with mathematical notation and simple operations. The calculations are presented principally as equations, which have largely been excluded from the individual index methodologies, with examples or tables of results to demonstrate the calculations.

Different Varieties of Equity Indices

S&P Dow Jones Indices' (S&P DJI) index calculation and corporate action treatments vary according to the categorization of the indices. At a broad level, indices are defined into two categorizations; Market Capitalization Weighted and Non-Market Capitalization Weighted Indices.

A majority of S&P DJI's equity indices are market capitalization weighted and float-adjusted, where each stock's weight in the index is proportional to its float-adjusted market value. S&P DJI also offers capped versions of a market capitalization weighted index where single index constituents or defined groups of index constituents, such as sector or geographical groups, are confined to a maximum weight.

Non-market capitalization weighted indices include those that are not weighted by float-adjusted market capitalization and generally are not affected by notional market capitalization changes resulting from corporate events. Examples include indices that apply equal weighting, factor weighting such as dividend yield or volatility, strategic tilts, thematic weighting, or other alternative weighting schemes.

S&P DJI offers a variety of indices and index attribute data calculated according to various methodologies which are covered in this document:

- Market Capitalization Indices:
  - Market-capitalization indices – where constituent weights are determined either by total or float-adjusted market capitalization.
  - Capped market-capitalization indices − where single index constituents or defined groups of index constituents, such as sector or geographical groups, are confined to a maximum index weight.
- Non-Market Capitalization Indices:
  - Price weighted indices − where constituent weights are determined solely by the prices of the constituent stocks in the index.
  - Equal weighted indices − where each stock is weighted equally in the index.
- Derived Indices:
  - Total return indices − index level reflect both movements in stock prices and the reinvestment of dividend income.
  - Leveraged and inverse indices − which return positive or negative multiples of their respective underlying indices.
  - Weighted return indices − commonly known as index of indices, where each underlying index is a component with an assigned weight to calculate the overall index of indices level.
  - Indices that operate on an index as a whole rather than on the individual stocks − these include calculations of various total return methodologies and index fundamentals.
  - Dividend Point indices − which track the total dividend payments of index constituents.

    o   Risk control, decrement, excess return, currency, currency hedged, domestic currency return, special opening quotation, turnover and fundamental data calculations.

The Index Divisor

The purpose of the index divisor is to maintain the continuity of an index level following the implementation of corporate actions, index rebalancing events, or other non-market driven actions.

The simplest capitalization weighted index can be thought of as a portfolio consisting of all available shares of the stocks in the index. While one might track this portfolio's value in dollar terms, it would probably be an unwieldy number – for example, the S&P 500 float-adjusted market value is a figure in the trillions of dollars. Rather than deal with ten or more digits, the figure is scaled to a more easily handled number (e.g., 2000). Dividing the portfolio market value by a factor, usually called the divisor, does the scaling.

An index is not exactly the same as a portfolio. For instance, when a stock is added to or deleted from an index, the index level should not jump up or drop down; while a portfolio's value would usually change as stocks are swapped in and out. To assure that the index's value, or level, does not change when stocks are added or deleted, the divisor is adjusted to offset the change in market value of the index. Thus, the divisor plays a critical role in the index's ability to provide a continuous measure of market valuation when faced with changes to the stocks included in the index. In a similar manner, some corporate actions that cause changes in the market value of the stocks in an index should not be reflected in the index level. Adjustments are made to the divisor to eliminate the impact of these corporate actions on the index value.

Supporting Documents

This methodology is meant to be read in conjunction with supporting documents providing greater detail with respect to the policies, procedures and calculations described herein. References throughout the methodology direct the reader to the relevant supporting document for further information on a specific topic. The list of the main supplemental documents for this methodology and the hyperlinks to those documents is as follows:

Supporting Document	URL
S&P Dow Jones Indices' Equity Indices Policies & Practices Methodology	Equity Indices Policies & Practices
S&P Dow Jones Indices' Float Adjustment Methodology	Float Adjustment Methodology

Capitalization Weighted Indices

Many of S&P DJI's equity indices are capitalization-weighted indices. Sometimes these are called value-weighted or market cap weighted instead of capitalization weighted. Examples include the S&P 500, the S&P Global 1200 and the S&P BMI indices.

In the discussion below most of the examples refer to the S&P 500 but apply equally to a long list of S&P DJI's cap-weighted indices.

Definition

The formula to calculate the S&P 500 is:

$$Index\ Level = \frac{\sum_i P_i * Q_i}{Divisor} \tag{1}$$

The numerator on the right hand side is the price of each stock in the index multiplied by the number of shares used in the index calculation. This is summed across all the stocks in the index. The denominator is the divisor. If the sum in the numerator is US\$ 20 trillion and the divisor is US\$ 10 billion, the index level would be 2000.

This index formula is sometimes called a "base-weighted aggregative" method.[1] The formula is created by a modification of a *LasPeyres* index, which uses base period quantities (share counts) to calculate the price change. A *LasPeyres* index would be:

$$Index = \frac{\sum_i P_{i,1} * Q_{i,o}}{\sum_i P_{i,0} * Q_{i,o}} \tag{2}$$

In the modification to (2), the quantity measure in the numerator, Q_0, is replaced by Q_1, so the numerator becomes a measure of the current market value, and the product in the denominator is replaced by the divisor which both represents the initial market value and sets the base value for the index. The result of these modifications is equation (1) above.

Adjustments to Share Counts

S&P DJI's market cap-weighted indices are float-adjusted – the number of shares outstanding is reduced to exclude closely held shares from the index calculation because such shares are not available to investors.

For more information on shares outstanding, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices Methodology.

S&P DJI's rules for float adjustment are described in more detail in *S&P Dow Jones Indices' Float Adjustment Methodology* or in some of the individual index methodology documents. As discussed there,

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[1] This term is used in one of the earlier and more complete descriptions of S&P Dow Jones Indices' index calculations in Alfred Cowles, *Common Stock Indices*, Principia Press for the Cowles Commission of Research in Economics, 1939. The book refers to the "Standard Statistics Company Formula;" S&P was formed by the merger of Standard Statistics Corporation and Poor's Publishing in 1941.

for each stock S&P DJI calculates an Investable Weight Factor (IWF) which is the percentage of total shares outstanding that are included in the index calculation.

When the index is calculated using equation (1), the variable Q_i is replaced by the product of outstanding shares and the IWF:

$$Q_i = IWF_i * Total\ Shares_i \tag{3}$$

At times there are other adjustments made to the share count to reflect foreign ownership restrictions or to adjust the weight of a stock in an index. These are combined into a single multiplier in place of the IWF in equation (3). In combining restrictions, it is important to avoid unwanted double counting. Let FA represent the fraction of shares eliminated due to float adjustment, FR represent the fraction of shares excluded for foreign ownership restrictions and IS represent the fraction of total shares to be excluded based on the combination of FA and FR.

If FA > FR then IS = 1- FA

If FA < FR then IS = 1-FR

and equation (3) can be written as:

$$Q_i = IS_i * Total\ Shares_i$$

Note that any time the share count or the IWF is changed, it will be necessary to adjust the index divisor to keep the level of the index unchanged.

Divisor Adjustments

The key to index maintenance is the adjustment of the divisor. Index maintenance – reflecting changes in shares outstanding, corporate actions, addition or deletion of stocks to the index – should not change the level of the index. If the S&P 500 closes at 2000 and one stock is replaced by another, after the market close, the index should open at 2000 the next morning if all of the opening prices are the same as the previous day's closing prices. This is accomplished with an adjustment to the divisor.

Any change to the stocks in the index that alters the total market value of the index <u>while holding stock prices constant</u> will require a divisor adjustment. This section explains how the divisor adjustment is made given the change in total market value. The next section discusses what index changes and corporate actions lead to changes in total market value and the divisor.

Equation (1) is expanded to show the stock being removed, stock r, separately from the stocks that will remain in the index:

$$Index\ Level_{t-1} = \frac{(\sum_i P_i * Q_i) + P_r Q_r}{Divisor_{t-1}} \tag{4}$$

Note that the index level and the divisor are now labeled for the time period t-1 and, to simplify this example, that we are ignoring any possible IWF and adjustments to share counts. After stock r is replaced with stock s, the equation will read:

$$Index\ Level_t = \frac{(\sum_i P_i * Q_i) + P_s Q_s}{Divisor_t} \tag{5}$$

In equations (4) and (5) t-1 is the moment right before company r is removed from and s is added to the index; t is the moment right after the event. By design, *Index Level$_{t-1}$* is equal to *Index Level$_t$*. Combining (4) and (5) and re-arranging, the adjustment to the Divisor can be determined from the index market value before and after the change:

$$\frac{(\sum_i P_i * Q_i) + P_r Q_r}{Divisor_{t-1}} = Index \; Level = \frac{(\sum_i P_i * Q_i) + P_s Q_s}{Divisor_t}$$

Let the numerator of the left hand fraction be called MV_{t-l}, for the index market value at (t-1), and the numerator of the right hand fraction be called MV_t, for the index market value at time t. Now, MV_{t-1}, MV_t and $Divisor_{t-1}$ are all known quantities. Given these, it is easy to determine the new divisor that will keep the index level constant when stock r is replaced by stock s:

$$Divisor_t = (Divisor_{t-1}) * \frac{MV_t}{MV_{t-1}} \qquad\qquad (6)$$

As discussed below, various index adjustments result in changes to the index market value. When these adjustments occur, the divisor is adjusted as shown in equation (6).

In some implementations, including the computer programs used in S&P DJI's index calculations, the divisor adjustment is calculated in a slightly different, but equivalent, format where the divisor change is calculated by addition rather than multiplication. This alternative format is defined here. Rearranging equation (1) and using the term *MV* (market value) to replace the summation gives:

$$Divisor = \frac{MV}{Index \; Level}$$

When stocks are added to or deleted from an index there is an increase or decrease in the index's market value. This increase or decrease is the market value of the stocks being added less the market value of those stocks deleted; define *CMV* as the Change in Market Value. Recalling that the index level does not change, the new divisor is defined as:

$$Divisor_{New} = \frac{MV + CMV}{Index \; Level}$$

or

$$Divisor_{New} = \frac{MV}{IndexLevel} + \frac{CMV}{IndexLevel}$$

However, the first term on the right hand side is simply the Divisor value before the addition or deletion of the stocks. This yields:

$$Divisor_{New} = Divisor_{Old} + \frac{CMV}{IndexLevel} \qquad\qquad (7)$$

Note that this form is more versatile for computer implementations. With this additive form, the second term (*CMV/Index Level*) can be calculated for each stock or other adjustment independently and then all the adjustments can be combined into one change to the Divisor.

Necessary Divisor Adjustments

Divisor adjustments are made "after the close" meaning that after the close of trading the closing prices are used to calculate the new divisor based on whatever changes are being made. It is, then, possible to provide two complete descriptions of the index – one as it existed at the close of trading and one as it will exist at the next opening of trading. If the same stock prices are used to calculate the index level for these two descriptions, the index levels are the same.

With prices constant, any change that changes the total market value included in the index will require a divisor change. For cataloging changes, it is useful to separate changes caused by the management of the index from those stemming from corporate actions of the constituent companies. Among those changes driven by index management are adding or deleting companies, adjusting share counts and changes to IWFs and other factors affecting share counts.

Index Management Related Changes. When a company is added to or deleted from the index, the net change in the market value of the index is calculated and this is used to calculate the new divisor. The market values of stocks being added or deleted are based on the prices, shares outstanding, IWFs and any other share count adjustments. Specifically, if a company being added has a total market cap of US$ 1 billion, an IWF of 85% and, therefore, a float-adjusted market cap of US$ 850 million, the market value for the added company used is US$ 850 million. The calculations would be based on either equation (6) or equation (7) above.

For most S&P DJI equity indices, IWFs and share counts updates are applied throughout the year based on rules defined in the methodology. Typically, small changes in shares outstanding are reflected in indices once a quarter to avoid excessive changes to an index. The revisions to the divisor resulting from these are calculated and a new divisor is determined. Equation (7) shows how the impact of a series of share count changes can be combined to determine the new divisor.

Corporate Action Related Changes.

For information on the treatment of corporate actions, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices document. For more information on the specific treatment within an index family, please refer to that index methodology.

Capped Market Capitalization Indices

Definition

A capped market capitalization weighted index (also referred to as a capped market cap index, capped index or capped weighted index) is one where single index constituents or defined groups of index constituents are confined to a maximum weight and the excess weight is distributed proportionately among the remaining index constituents. As stock prices move the weights will shift and the modified weights will change. Therefore, a capped market cap weighted index must be rebalanced from time to time to re-establish the proper weighting. The methodology for capped indices follows an identical approach to market cap weighted indices except that the indices apply an additional weight factor, or "AWF", to adjust the float-adjusted market capitalization to a value such that the index weight constraints are satisfied. For capped indices, no AWF change is made due to corporate actions between rebalancings except for daily capped indices where the corporate action may trigger a capping. Therefore, the weights of stocks in the index as well as the index divisor will change due to notional market capitalization changes resulting from corporate events.

The overall approach to calculate capped market cap weighted indices is the same as in the pure market-cap weighted indices; however, the constituents' market values are re-defined to be values that will meet the particular capping rules of the index in question.

$$Index\ Level = \frac{Index\ Market\ Value}{Divisor} \tag{1}$$

and

$$IndexMarketValue = \sum_i P_i * Shares_i * IWFi * FxRatei$$

To calculate a capped market cap index, the market capitalization for each stock used in the calculation of the index is redefined so that each index constituent has the appropriate weight in the index at each rebalancing date.

In addition to being the product of the stock price, the stock's shares outstanding, and the stock's float factor (IWF), as written above – and the exchange rate when applicable – a new adjustment factor is also introduced in the market capitalization calculation to establish the appropriate weighting.

$$AdjustedStock\ Market\ Value_i = P_i * Shares_i * IWFi * FxRatei * AWFi$$

where AWF_i is the adjustment factor of stock i assigned at each index rebalancing date, $t,$ which adjusts the market capitalization for all index constituents to achieve the user-defined weight, while maintaining the total market value of the overall index.

The AWF for each index constituent, i, on rebalancing date, t, is calculated by:

$$AWF_{i,t} = \frac{CW_{i,t}}{W_{i,t}}$$

where $W_{i,t}$ is the uncapped weight of stock i on rebalancing date t based on the float-adjusted market capitalization of all index constituents; and $CW_{i,t}$ is the capped weight of stock i on rebalancing date t as determined by the capping rule of the index in question and the process for determining capped weights as described in Different Capping Methods below.

The index divisor is defined based on the index level and market value from equation (1). The index level is not altered by index rebalancings. However, since prices and outstanding shares will have changed since the last rebalancing, the divisor will change at the rebalancing.

So:

$$(Divisor)_{after\ rebalancing} = \frac{(Index\ Market\ Value)_{after\ rebalancing}}{(Index\ Value)_{before\ rebalancing}}$$

where:

$$Index\ Market\ Value = \sum_i P_i * Shares_i * IWF_i * FxRate_i * AWF_i$$

Corporate Actions and Index Adjustments

All corporate actions for capped indices affect the index in the same manner as in market capitalization weighted indices.

For more information on the treatment of corporate actions, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices document.

Different Capping Methods

Capped indices arise due to the need for benchmarks which facilitate diversification rules. Capping may apply to single stock concentration limits or concentration limits on a defined group of stocks. At times, companies may also be represented in an index by multiple share class lines. In these instances, maximum weight capping will be based on company float-adjusted market capitalization, with the weight of multiple class companies allocated proportionally to each share class line based on its float-adjusted market capitalization as of the rebalancing reference date. Some common, but not an exhaustive list of, examples of the standard S&P DJI methodologies for determining the weights of capped indices using the most popular capping methods are described below.

Single Company Capping. In a single company capping methodology, no company in an index is allowed to breach a certain pre-determined weight as of each rebalancing period. The procedure for assigning capped weights to each company at each rebalancing is as follows:

1. With data reflected on the rebalancing reference date, each company is weighted by float-adjusted market capitalization.

2. If any company has a weight greater than X% (where X% is the maximum weight allowed in the index), that company has its weight capped at X%.

3. All excess weight is proportionally redistributed to all uncapped companies within the index.

4. After this redistribution, if the weight of any other company(s) then breaches X%, the process is repeated iteratively until no companies breach the X% weight cap.

Single Company and Concentration Limit Capping. In a single company and concentration limit capping methodology, no company in an index is allowed to breach a certain pre-determined weight and all companies with a weight greater than a certain amount are not allowed, as a group, to exceed a pre-determined total weight. One example of this is 4.5%/22.5%/45% capping (B/A/C in the following example). No single company is allowed to exceed 22.5% of the index and all companies with a weight greater than 4.5% of the index cannot exceed, as a group, 45% of the index.

Method 1:

The procedure for assigning capped weights to each company at each rebalancing is as follows:

1. With data reflected on the rebalancing reference date, each company is weighted by float-adjusted market capitalization.

2. If any company has a weight greater than A% (where A% is the maximum weight allowed in the index), that company has its weight capped at A%.

3. All excess weight is proportionally redistributed to all uncapped companies within the index.

4. After this redistribution, if the weight of any other company(s) then breaches A%, the process is repeated iteratively until no companies breach the A% weight cap.

5. The sum of the companies with weight greater than B% cannot exceed C% of the total weight.

6. If the rule in step 5 is breached, all the companies are ranked in descending order of their weights and the company with the lowest weight that causes the C% limit to be breached is identified. The weight of this company is, then, reduced either until the rule in step 5 is satisfied or it reaches B%.

7. This excess weight is proportionally redistributed to all companies with weights below B%. Any stock that receives weight cannot breach the B% cap. This process is repeated iteratively until step 5 is satisfied or until all stocks are greater than or equal to B%.

8. If the rule in step 5 is still breached and all stocks are greater than or equal to B%, the company with the lowest weight that causes the C% limit to be breached is identified. The weight of this company is, then, reduced either until the rule in step 5 is satisfied or it reaches B%.

9. This excess weight is proportionally redistributed to all companies with weights greater than B%. Any stock that receives weight cannot breach the A% stock cap. This process is repeated iteratively until step 5 is satisfied.

For indices that use capping rules across more than one attribute, S&P DJI will utilize an optimization program to satisfy the capping rules. The stated objective for the optimization will be to minimize the difference between the pre-capped weights of the stocks in the index and the final capped weights. This is done by using an optimization procedure that chooses final weights in such a way to minimize the sum of the squared difference of capped weight and uncapped weight, divided by uncapped weight for each stock.

Method 2:

A second method of single company and concentration limit capping utilized by S&P DJI for assigning capped weights to each company at each rebalancing is as follows:

1. With data reflected on the rebalancing reference date, each company is weighted by float-adjusted market capitalization.

2. If either of the defined single company or concentration index weight limits are breached, the float-adjusted market capitalization of all components are raised to a power such that:

   $$Index\ Market\ Cap_t = W_t^{1-0.01n}$$

   where:

   W_t = Float-adjusted market capitalization of component t.

   n = Number of capping iterations.

3. This process is repeated iteratively until the first iteration where the capping constraints are satisfied.

Non-Market Capitalization Weighted Indices

Definition

A non-market capitalization weighted index (also referred to as a non-market cap or modified market cap index) is one where index constituents have a user-defined weight in the index. Between index rebalancings, most corporate actions generally have no effect on index weights, as they are fixed through the processes defined below. As stock prices move, the weights will shift and the modified weights will change. Therefore, a non-market cap weighted index must be rebalanced from time to time to re-establish the proper weighting.

The overall approach to calculate non-market cap weighted indices is the same as in the cap-weighted indices; however, the constituents' market values are set to a value to achieve a specific weight at each rebalancing that is divergent from a purely free-float-adjusted market capitalization weighting. Recall two <u>basic</u> formulae:

$$Index\ Level = \frac{Index\ Market\ Value}{Divisor} \qquad (1)$$

and

$$IndexMarketValue = \sum_{i} P_i * Shares_i * IWFi * FxRatei$$

To calculate a non-market cap weighted index, the market capitalization for each stock used in the calculation of the index is redefined so that each index constituent has the appropriate user-defined weight in the index at each rebalancing date.

In addition to being the product of the stock price, the stock's shares outstanding, and the stock's float factor (IWF), as written above – and the exchange rate when applicable – a new adjustment factor is also introduced in the market capitalization calculation to establish the appropriate weighting.

$$AdjustedStock\ Market\ Value_i = P_i * Shares_i * IWF_i * FxRate_i * AWF_i$$

where AWF_i is the adjustment factor of stock i assigned at each index rebalancing date, t, which adjusts the market capitalization for all index constituents to achieve the user-defined weight, while maintaining the total market value of the overall index.

The AWF for each index constituent, i, on rebalancing date, t, is calculated by:

$$AWF_{i,t} = \frac{Z}{FloatAdjustedMarketValue_{i,t}} * W_{i,t} \qquad (2)$$

where Z is an index specific constant set for the purpose of deriving the AWF and, therefore, each stock's share count used in the index calculation (often referred to as modified index shares). $W_{i,t}$ is the user-defined weight of stock i on rebalancing date t.

The index divisor is defined based on the index level and market value from equation (1). The index level is not altered by index rebalancings. However, since prices and outstanding shares will have changed since the last rebalancing, the divisor will change at the rebalancing.

So:

$$(Divisor)_{after\ rebalancing} = \frac{(Index\ Market\ Value)_{after\ rebalancing}}{(Index\ Value)_{before\ rebalancing}}$$

where:

$$Index\ Market\ Value = \sum_{i} P_i * Shares_i * IWF_i * FxRate_i * AWF_i$$

Corporate Actions and Index Adjustments

For information on the treatment of corporate actions, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices document. For more information on the specific treatment within an index family, please refer to that index methodology.

Price Weighted Indices

Definition

In a price weighted index, such as the Dow Jones Industrial Average, constituent weights are determined solely by the prices of the constituent stocks. Shares outstanding are set to a uniform number throughout the index. Indices using this methodology will adjust the index divisor for any price impacting corporate action on one of its member stocks; this includes price adjustments, special dividends, stock splits and rights offerings. The index divisor will also adjust in the event of an addition to or deletion from the index.

All other index calculation details follow the standard divisor-based calculation methodology detailed in the previous *Capitalization Weighted Indices* section.

For information on the treatment of corporate actions, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices Methodology.

Equal Weighted Indices

Definition

An equal weighted index is one where every stock, or company, has the same weight in the index, and a portfolio that tracks the index will invest an equal dollar amount in each applicable instrument. As stock prices move, the weights will shift and exact equality will be lost. Therefore, an equal weighted index must be rebalanced from time to time to re-establish the proper weighting.[2]

The overall approach to calculate equal weighted indices is the same as in the cap-weighted indices; however, the constituents' market values are re-defined to be values that will achieve equal weighting at each rebalancing. Recall two <u>basic</u> formulae:

$$Index\ Level = \frac{Index\ Market\ Value}{Divisor} \tag{1}$$

and

$$IndexMarketValue = \sum_i P_i * Shares_i * IWFi * FxRatei$$

To calculate an equal weighted index, the market capitalization for each stock used in the calculation of the index is redefined so that each index constituent has an equal weight in the index at each rebalancing date. In addition to being the product of the stock price, the stock's shares outstanding, and the stock's float factor (IWF), as written above – and the exchange rate when applicable – a new adjustment factor is also introduced in the market capitalization calculation to establish equal weighting.

$$AdjustedStockMarketValuei = P_i * Shares_i * IWFi * FxRatei * AWFi \tag{2}$$

where AWF_i (Additional Weight Factor) is the adjustment factor of stock i assigned at each index rebalancing date, t, which makes all index constituents modified market capitalization equal (and, therefore, equal weight), while maintaining the total market value of the overall index. The AWF for each index constituent, i, at rebalancing date, t, is calculated by:

$$AWFi, t = \frac{Z}{N * FloatAdjustedMarketValuei, t} \tag{3}$$

where N is the number of stocks in the index and Z is an index specific constant set for the purpose of deriving the AWF and, therefore, each stock's share count used in the index calculation (often referred to as modified index shares).

The index divisor is defined based on the index level and market value from equation (1). The index level is not altered by index rebalancings. However, since prices and outstanding shares will have changed since the last rebalancing, the divisor will change at the rebalancing.

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[2] In contrast, a cap-weighted index requires no rebalancing as long as there aren't any changes to share counts, IWFs, returns of capital, or stocks added or deleted.

So:

$$(Divisor)_{after\ rebalancing} = \frac{(Index\ Market\ Value)_{after\ rebalancing}}{(Index\ Value)_{before\ rebalancing}}$$

where:

$$Index\ Market\ Value = \sum_i P_i * Shares_i * IWF_i * FxRate_i * AWF_i$$

Modified Equal Weighted Indices

There are some equal weighted indices that place further restrictions on stocks included in the index. An example restriction might be a cap on the weight allocated to one sector or a cap on the weight of a single country or region in the index. The rules could also stipulate a maximum weight for a stock if the index applies additional liquidity factors (e.g. basket liquidity) when determining the index weights. In any of these situations, if a cap is applied to satisfy the restrictions, the excess weight leftover by the cap would be distributed equally amongst the uncapped companies.

Corporate Actions and Index Adjustments

For more information on the treatment of corporate actions, please refer to S&P Dow Jones Indices' Equity Indices Policies & Practices document. For more information on the specific treatment within an index family, please refer to that index methodology.

Multi-Day Rebalancing

A multi-day rebalancing allows indices to transition from the current index constituent weights to a set of target weights over a pre-determined number of days. The weight increments/decrements from day to day within the rebalancing period (i.e. smoothed weights) will be equal in size unless the exchange for a security is closed while it is still an index business day. Day 1 of the rebalancing period will be the standard effective rebalancing date as stated in the index methodology.

The formula to calculate the **smoothed weight** for each stock is:

$$smoothed\ weight_{t,i} = \left(\frac{(target\ weight_{r,i} - reference\ weight_{r,i})}{rebalancing\ length} \times number\ rebalancing\ day_t \right) + reference\ weight_{r,i}$$

where:

smoothed weight$_{t,i}$	= The weight for stock *i* on day *t*.
target weight$_{i,r}$	= The weight of stock *i* that corresponds to the weighting determined by rebalancing *r*. If stock *i* is dropping out of the index due to the selection criteria during rebalancing *r* then *target weight$_{i,r}$* is 0.
reference weight$_{i,r}$	= The weight for stock *i* for the reference date for rebalancing *r*. If stock *i* is not part of the composition of the index on the reference date then *reference weight$_{i,r}$* is 0.
rebalancing length	= The number of days in a multi-day rebalancing. This number is variable, and is defined by the index methodology.
number rebalancing day$_t$	= The number of rebalancing days on day *t* from 1 to *rebalancing length*.

After the set of smoothed weights for each stock on each rebalancing date is calculated, index shares are set for each stock by utilizing a standard AWF calculation that accounts for forward looking corporate actions throughout the rebalancing period:

$$AWF_{i,t} = \frac{(smoothed\ weight_{t,i} * z\ factor)}{(stock\ price_{r,i} * fx\ rate_{r,i} * shares\ outstanding_{t,i} * IWF_{r,i} * Price\ Adjustment\ Factor)}$$

The $Price\ Adjustment\ Factor_{t,i}$ will account for any corporate actions for $stock_i$ between the reference date and the rebalance date in question. For example, if there is a 2 for 1 stock split on rebalance day 3 of a 5 day rebalancing period, the AWF calculated for the stock on the reference date will use an adjustment factor of .5. The AWF calculated for days 1 and 2 of the rebalance will use an adjustment factor of 1.

Day to day calculation of multi-day rebalancings will be conducted using the standard calculation methodology for weighted indices.

Index shares and AWFs will remain static at their originally announced values throughout the pro-forma period unless there are corporate actions announced after the pro-forma date and effective prior to the end of the rebalancing period.

Exchange Holidays

Except for the first and penultimate days of the rebalancing period, exchange holidays occurring during the rebalancing period that do NOT result in an index closure will adjust the individual smoothed weights

of each individual security on holiday. Stocks on holiday on day t will have their smoothed weight frozen on day $t+1$. On the first day, stocks will always carry the first smoothed weight of the rebalancing period. If there is a holiday on the penultimate day of the rebalancing, impacted stocks will smooth to their target weight a day early and carry that weight over to the final day unless they are being removed from the index. In the case of a stock removal with an exchange holiday on the penultimate day of the rebalancing period, the stock weight will be smoothed over the remaining trading days. Similarly, if there are multiple exchange holidays towards the close of the rebalancing period, the smoothing period will be further condensed to the remaining trading days within the rebalancing period. If an exchange holiday is announced after the reference date or there is an unexpected exchange closure, the glide path will be re-established for the remaining days according to examples 2 and 3 below.

Please see the examples below. All weights in the example are as of the open on the effective date.

Example 1:

Index Weight on Reference Date = 1.2%; Target weight = 1.7%; No. of Rebalancing Days = 5; Weight Delta = 0.5%; Daily Increment = 0.1%; **Day 2** is an exchange holiday.

1. Day 1 weight = 1.2%+0.1%*1 = 1.3%
2. Day 2 weight = 1.2%+0.1%*2 = 1.4%
3. Day 3 weight = Day 2 weight
4. Day 4 weight = 1.2%+0.1%*4 = 1.6%
5. Day 5 weight = 1.2%+0.1%*5 = 1.7%

Example 2:

Index Weight on Reference Date = 1.2%; Target weight = 1.7%; No. of Rebalance Days = 5; Weight Delta = 0.5%; Daily Increment = 0.1%; **Day 4** is an exchange holiday.

1. Day 1 weight = 1.2%+0.1%*1 = 1.3%
2. Day 2 weight = 1.2%+0.1%*2 = 1.4%
3. Day 3 weight = 1.2%+0.1%*3 = 1.5%
4. Day 4 weight = 1.2%+0.1%*5 = 1.7%
5. Day 5 weight = Day 4 weight

Example 3:

Index Weight on Reference Date = 1.2%; Target weight = 0.0% (stock removal); No. of Rebalance Days = 5; Weight Delta = -1.2%; Daily Increment = -0.3%; **Day 4** is an exchange holiday.

1. Day 1 weight = 1.2%-0.3%*1 = 0.9%
2. Day 2 weight = 1.2%-0.3%*2 = 0.6%
3. Day 3 weight = 1.2%-0.3%*3 = 0.3%
4. Day 4 weight = 1.2%-0.3%*4 = 0.0% = Removed from index
5. Day 5 weight = Removed from index

Freeze Date

A multi-day rebalancing process may be put on hold on any given day by utilizing a *Freeze Date.* On a freeze date, the target weights for a given day in the rebalancing period are carried over from the previous day. If a freeze date occurs, the rebalancing period is extended by the total number of freeze

dates during the rebalancing period. A freeze date will not increase the *rebalance length*, it will only move the rebalancing end date.

Multi-day rebalancing capabilities are compatible with standard weighted and equal weighted methodologies.

Total Return Calculations

The preceding discussions were related to price indices where changes in the index level reflect changes in stock prices. In a total return index changes in the index level reflect both movements in stock prices and the reinvestment of dividend income. A total return index represents the total return earned in a portfolio that tracks the underlying price index and reinvests dividend income in the overall index, not in the specific stock paying the dividend.

The total return construction differs from the price index and builds the index from the price index and daily total dividend returns. The first step is to calculate the total dividend paid on a given day and convert this figure into points of the price index:

$$TotalDailyDividend = \sum_i Dividend_i * Shares_i \tag{1}$$

Where *Dividend* is the dividend per share paid for stock *i* and *Shares* are the index specific shares. This is done for each trading day. *Dividend$_i$* is generally zero except when it goes ex-dividend for a dividend payment.[3] Stocks may commonly issue dividends on a monthly, quarterly, semi-annual, or annual basis. Some stocks do not pay a dividend and *Dividend* is always zero. *TotalDailyDividend* is measured in dollars. This is converted to index points by dividing by the divisor for the underlying price index:

$$IndexDividend = \frac{TotalDailyDividend}{Divisor} \tag{2}$$

The next step is to apply the usual definition of a total return from a financial instrument to the price index. Equation (1) gives the definition, and equation (2) applies it to the index:

$$TotalReturn = (\frac{P_t + D_t}{P_{t-1}}) - 1$$

and

$$DTR_t = (\frac{IndexLevel_t + IndexDividend_t}{IndexLevel_{t-1}} - 1)$$

where the *TotalReturn* and the daily total return for the index (*DTR*) is stated as a decimal. The *DTR* is used to update the total return index from one day to the next:

$$Total\ Return\ Index_t = (Total\ Return\ Index_{t-1}) * (1 + DTR_t)$$

The Index Value for the Total Return Index can also be calculated as follows:

Total Return Index$_t$= (Total Return Index$_{t-1}$)*(Price Return Index$_t$ + Index Dividend) / Price Return Index$_{t-1}$

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[3] *Dividend$_i$* can be negative if a dividend correction is applied to a particular stock. In such cases, a total return can have a value lower than the price return. For more information on dividend corrections please refer to *S&P Dow Jones Indices' Equity Indices Policies & Practices Methodology.*

Net Total Return Calculations

To account for tax withheld from dividends, a net total return calculation is used. The calculation is identical to the calculations detailed in the previous Total Return section, except each dividend is adjusted to account for the tax taken out of the payment.

Inserting the withholding rate into the calculation at the first step is all that needs to be done − the calculation can follow identically from that point forward:

$$TotalDailyDividend = \sum_i Dividend_i * Shares_i * (1 - WithholdingRate_i)$$

The tax rates used for S&P DJI's global indices are from the perspective of a Luxembourg investor. However, in domestic index families, tax rates from the perspective of a domestic investor will be applied.

For more information on the Withholding Rates used for Net Total Return Calculations, please refer to the Withholding Tax Rates by Markets document, available at www.spglobal/spdji.com.

Post Ex-Dividend Adjustment: Total and Net Total Return Calculation

When S&P DJI recognizes a regular dividend different than the final dividend amount confirmed by the company, or for specific markets where companies do not typically confirm cash dividend amounts prior to the ex-dates, S&P DJI may recognize a post ex-date dividend adjustment.

First, an estimated dividend is reinvested into the index on the dividend's Ex-Date, following the process defined in the *Total and Net Total Return Calculation* section, where is the dividend is converted to index dividend points by dividing by the divisor for the underlying price index.

Second, a Post-Ex Dividend Adjustment is applied, determined by S&P DJI calculating the difference between the dividend amount recognized on the original ex-date and the actual dividend amount announced by the company. Once determined, the adjustment amount is applied, in dividend points, to all relevant indices using the following formula:

$$\textit{Index Dividend Point Adjustment} = (D_{dt} * S_{at}) / \textit{Divisor}_{\textit{Ex-Date}}$$

where:

D_{dt} = the difference between the original and actual dividend amounts. Foreign exchange conversion, if applicable, is based on the exchange rate on the ex-date, calculated as:

$$\textit{Correction Amount} * FX_{\textit{ on the Reference Ex-Date}}$$

where:

$\textit{Correction Amount}^{4}$ = the dividend amounts relative to all the data as of the original dividend ex-date

S_{at} = Index shares on the Reference Ex-Date

The adjustment is added to the calculation of the Total Return and Net Total Return indices on the dividend's effective date. If there are multiple dividend payments with an ex-date of the current day and/or multiple dividend adjustments, separate index dividend points are calculated for each dividend payment and aggregated on Index Dividend as follows:

$$\textit{TotalDailyDividend} = \sum \textit{IndexDividendPointAdjustment} + \textit{IndexDividend}\, t$$

For currency indices, the Index Dividend point adjustment calculated for the headline index is converted to the corresponding currency in the index calculation, using the foreign exchange rate on the effective date.

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[4] For the Index Dividend Point Adjustment, D_{dt} must be as indicated in the Index Corporate Events – .SDE file for the Index, where the *Reference Date* column shows the date of the original dividend ex-date.

Franking Credit Adjusted Total Return Indices

Additional total return indices are available for a number of S&P/ASX Indices that adjust for the tax effect of franking credits attached to cash dividends. The indices utilize tax rates relevant to two segments of investors: one version incorporates a 0% tax rate relevant for tax-exempt investors and a second version uses a 15% tax rate relevant for superannuation funds. The franking credits attached to both regular and special cash dividends are included in the respective calculations.

To calculate the gross dividend points reinvested in the Franking Credit Adjusted Total Return Indices:

Grossed-up Dividend = [As Reported Dividend * (1 – % Franked) + (As Reported Dividend * % Franked / (1 – Company Tax Rate))]

The Net Tax Effect of the franking credit is then calculated based on the investor tax rate (i.e. 0% for tax-exempt investors and 15% for superannuation funds).

Net Tax Effect = [Grossed-up Dividend * (1 – Investor Tax Rate)] – As Reported Dividend

The Net Tax Effect of each dividend is then multiplied by the index shares of that company to calculate the gross dividend market capitalization.

Gross Dividend Market Cap = Net Tax Effect * Index Shares

Tax – Exempt = [(Grossed-Up Dividend - Dividend Amount) * Index Shares $_t$]

Superannuation = [(Grossed-Up Dividend Superannuation - Dividend Amount) * Index Shares $_t$]

Grossed-Up Dividend and *Gross Dividend Market Cap* must be calculated for all dividend payments effective on date *T*.

These are then summed for all dividends going ex on that date and converted to dividend points by dividing by the index divisor.

The only difference between *Tax Exempt* and *Superannuation* is the incorporation of tax rates relevant for superannuation funds (currently 15%), hence only the steps detailed above differ in each Index Calculation. Once the *Gross Dividend Market Cap* is calculated, the following steps are exactly the same for both *Tax-Exempt* and *Superannuation* versions.

Gross Dividend Points = Sum of Gross Dividend Market Caps / Underlying Index Close Divisor

Gross Dividend Points calculate daily, to account for the impact of dividends issued by constituents with an ex-date of date *T*.

Franking Credit Adjusted Annual Total Return Indices. This index series accrues a pool of gross dividend points on a daily basis and reinvests them across the index annually after the end of the financial year. Reinvestment occurs at market close on the first trading day after June 30th. The gross dividend points are derived by taking the value of the gross dividend market capitalization (less the as reported dividend market capitalization) and dividing it by the index divisor effective on the ex-date of the respective dividend.

Annual Total Return Index Level is calculated as follows:

1. FCA Index Dividend:

On the first trading day after June 30th =

$$(Accrued\ Gross\ Dividend_{t-1} + Underlying\ Index\ Dividend_t)$$

The Accrued Gross Dividend comes from the S&P Franking Credit Adjusted Annual Total Return Index on day *T-1*, for the corresponding version, either Tax-Exempt or Superannuation.[5]

On any other trading day = *Underlying Index Dividend* $_t$

2. FCA Annual Total Return Index $_t$ =

$$\frac{\left(FCA\ Annual\ Total\ Return\ Index_{t-1} * (Underlying\ Index_t + FCA\ Index\ Dividend_t)\right)}{Underlying\ Index_{t-1}}$$

The annual series accrues a pool of gross dividend points (adjusted for the net tax effect of franking credits) on a daily basis, but only reinvests the gross dividend points annually, after the end of the financial year.

Therefore, provided it is not the first trading day after June 30th, the Index Dividend for the Franking Credit Adjusted Daily Total Return Indices is the same as the Index Dividend of the Underlying Index.

Franking Credit Adjusted Daily Total Return Indices. Rather than allowing a separate accrual of gross dividend points, this index series reinvests the gross dividend amount across the index at the close of the ex-date on a daily basis.

Daily Total Return Index Level is calculated as follows:

1. FCA Daily Total Return Index t =

$$\frac{\left(FCA\ Daily\ Total\ Return\ Index_{t-1} * (Underlying\ Index_t + Underlying\ Index\ Dividend_t + Grossed\ Dividend\ Points_t)\right)}{Underlying\ Index_{t-1}}$$

The net tax effect of franking credits compounds daily over the entire calendar year, therefore, the Index Dividends for the Franking Credit Adjusted Daily Total Return Indices differ from the Index Dividends of the Underlying Index on a daily basis.

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[5] The accrued value of gross dividend points is provided on the corresponding Franking Index Levels File.

Currency and Currency Hedged Indices

A currency-hedged index is designed to represent returns for those global index investment strategies that involve hedging currency risk, but not the underlying constituent risk.[6]

Investors employing a currency-hedged strategy seek to eliminate the risk of currency fluctuations and are willing to sacrifice potential currency gains. By selling foreign exchange forward contracts, global investors are able to lock in current exchange forward rates and manage their currency risk. Profits (losses) from the forward contracts are offset by losses (profits) in the value of the currency, thereby negating exposure to the currency.

Return Definitions

S&P DJI's standard currency hedged indices are calculated by hedging beginning-of-period balances using rolling one-month forward contracts. The amount hedged is adjusted on a monthly basis.

Returns are defined as follows:

$$Currency\ Return\ =\ \left(End\ Spot\ Rate \middle/ Beginning\ Spot\ Rate \right) - 1$$

$$Unhedged\ Return\ =\ (1 + Local\ Total\ Return) * (1 + Currency\ Return) - 1$$

$$Currency\ Return\ on\ Unhedged\ Local\ Total\ Return\ =\ (Currency\ Return) * (1 + Local\ Total\ Return)$$

$$Forward\ Return\ =\ \left(Beginning\ one\text{-}month\ Forward\ Rate \middle/ Beginning\ Spot\ Rate \right) - 1$$

$$Hedge\ Return\ =\ HedgeRatio * (Forward\ Re\,turn - Currency\ Re\,turn)$$

$$Hedged\ Index\ Return\ =\ Local\ Total\ Return + Currency\ Return\ on\ Unhedged\ Local\ Total\ Return + Hedge\ Return$$

$$Hedged\ Index\ Level\ =\ Beginning\ Hedged\ Index\ Level * (1 + Hedged\ Index\ Return)$$

To facilitate index replication, S&P DJI determines the amount of foreign exchange forward contracts sold using an index rebalance reference date.[7] On the index reference date, which occurs one business day prior to the last business day of prior month, the rebalance forward amounts and currency weights are determined. As a result of the forward amounts and currency weights determination occurring one business day prior to the month end rebalance, an adjustment factor is utilized in the calculation of the hedge return to account for the performance of the S&P Dow Jones Indices Currency-Hedged Index on the last business day of the month. Please refer to the index computation section for further details.

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[6] By currency risk, we simply mean the risk attributable to the security trading in a currency different from the investor's home currency. This definition does not incorporate risks that exchange rate changes can have on an underlying security's price performance.

[7] Prior to March 1, 2015 S&P Dow Jones Indices' Currency-Hedged Indices utilized the month-end for both index reference and index rebalance date.

For the standard single-currency monthly currency hedged indices that are on holiday on the last business day of the month, this holiday treatment is functionally equivalent to months when the last day of the month falls on a weekend.

If the hedging currency market is on holiday on the last business day of the month and the S&P DJI Underlying Index is not, as long as the spot rate in foreign currency per local currency (Sm) and one month forward spread used to calculate the forward rate (1MF) are not on holiday, the currency and currency hedged indices will be calculated with no changes to the relevant dates used for Currency Hedged Calculation.

Currency weights are established based on the composition of the underlying index as of the reference date. Any changes to the currency weights due to composition changes are not reflected until the calculation of currency weights on the next reference date.

S&P DJI also offers daily currency hedged indices for clients who require benchmarks with more frequent currency hedging. The daily currency hedged indices differ from the standard currency hedged indices by adjusting the amount of the forward contracts that mature at the end of month, on a daily basis, according to the performance of the underlying index. This further reduces the currency risk from under-hedging or over-hedging resulting from index movement between two monthly rolling periods.

Details of the formulae used in computing S&P DJI's currency-hedged indices are below.

The Hedge Ratio

The hedge ratio is simply the proportion of the portfolio's currency exposure that is hedged.

- **Standard Currency-Hedged Index.** In a standard currency-hedged index, we simply wish to eliminate the currency risk of the portfolio. Therefore, the hedge ratio used is 100%.

- **No Hedging.** An investor who expects upside potential for the local currency of the index portfolio versus the home currency, or does not wish to eliminate the currency risk of the portfolio, will use an unhedged index. In this case, the hedge ratio is 0, and the index simply becomes the standard index calculated in the investor's home currency. Such indices are available in major currencies as standard indices for many of S&P Dow Jones Indices' indices.

  In contrast to a 100% currency-hedged standard index, which seeks to eliminate currency risk and has passive equity exposure, over- or under-hedged portfolios seek to take active currency risks to varying degrees based on the portfolio manager's view of future currency movements.

- **Over Hedging.** An investor who expects significant upside potential for the home currency versus the local currency of the index portfolio might choose to double the currency exposure. In this case, the hedge ratio will be 200%.

- **Under Hedging.** An investor who expects some upside potential for the local currency of the index portfolio versus the home currency, but wishes to eliminate some of the currency risk, might choose to have half the currency exposure hedged using a 50% hedge ratio.

S&P Dow Jones Indices calculates indices with hedge ratios different from 100% as custom indices.

Calculating a Currency-Hedged Index

Using the returns definitions on prior pages, the Hedged Index Return can be expressed as:

Hedged Index Return = Local Total Return + Currency Return*(1 + Local Total Return) + Hedge Return

Rearranging yields:

Hedged Index Return = (1 + Local Return) * (1 + Currency Return) -1 + Hedge Return

Again, using the returns definitions on prior pages with a hedge ratio of 1 (100%), the expression yields:

Hedged Index Return = Unhedged Index Return + Hedge Return

Hedged Index Return = Unhedged Index Return + Forward Return - Currency Return

This equation is more intuitive since when you do a 100% currency hedge of a portfolio, the investor sacrifices the gains (or losses) on currency in return for gains (or losses) in a forward contract.

From the equation above, we can see that the volatility of the hedged index is a function of the volatility of the unhedged index return, the forward return, and the currency return, and their pair-wise correlations. These variables will determine whether the hedged index return series' volatility is greater than, equal to, or less than the volatility of the unhedged index return series.

Currency Hedging Outcomes

The results of a currency-hedged index strategy versus that of an unhedged strategy vary depending upon the movement of the exchange rate between the local currency and home currency of the investor.

S&P Dow Jones Indices' standard currency hedging process involves eliminating currency exposure using a hedge ratio of 1 (100%).

1. The currency-hedged index does not necessarily give a return exactly equal to the return of the index available to local market investor. This is because there are two additional returns − currency return on the local total return and hedge return. These two variables usually add to a non-zero value because the monthly rolling of forward contracts does not result in a perfect hedge. Further, the local total return between two readjustment periods remains unhedged. However, hedging does ensure that these two returns remain fairly close.

2. The results of a currency-hedged index strategy versus that of an unhedged strategy varies depending upon the movement of the exchange rate between the local currency and home currency of the investor. For example, a depreciating euro in 1999 resulted in an unhedged S&P 500 return of 40.0% for European investors, while those European investors who hedged their U.S. dollar exposure experienced a return of 17.3%. Conversely, in 2003 an appreciating euro in 2003 resulted in an unhedged S&P 500 return of 5.1% for European investors, while those European investors who hedged their U.S. dollar exposure experienced a return of 27.3%.

Index Computation

Monthly Return Series (For Monthly Currency Hedged Indices)

m	=	The month in the calculation, represented as 0, 1, 2, etc..
m-1	=	The last business day of the prior month.
mr-1	=	Reference Date. S&P DJI's standard index reference date for hedged indices is one business day prior to the last business day of the prior month.
d	=	Day d for month m.
D	=	The number of days in month m, counted as calendar days to the last business day.
SPI_EH_d	=	The S&P DJI Currency-Hedged Index level on day t, where t can be defined as d, m-1, or mr-1.
SPI_MAF	=	Monthly Index Adjustment Factor to account for the performance of the S&P Dow Jones Indices Currency-Hedged Index between the index reference and month end rebalance dates. It is calculated as the ratio of the S&P Dow Jones Indices Currency-Hedged Index level on the reference date and the S&P Dow Jones Indices Currency-Hedged Index level at the end of the month.

$$SPI\_MAF = \left(\frac{SPI\_EH_{mr-1}}{SPI\_EH_{m-1}} \right)$$

SPI_EM_d = The S&P Dow Jones Indices Index level, in foreign currency, on day t, where t can be defined as d or $m-1$.

HR_d = The hedge return (%) over month m.

S_d = The spot rate in foreign currency per local currency (*FC/LC*), on day t, where t can be defined as d or $mr-1$.

$1MF_d$ = The one-month forward spread used to calculate the forward rate, at day t of month d.

F_d = The first front-month forward rate in foreign currency per local currency (*FC/LC*), on day t, where t can be defined as d or $m-1$; calculated as $S_d + 1MF_d$.

Monthly Hedged Calculation for day t of month m:

1. HR_d = The hedge return (%) over month m for Monthly Currency Indices

USD to Currency (FX):

$$HR_d = \left(\frac{S_{mr-1}}{F_{m-1}} - \frac{S_{mr-1}}{S_d + \left(\frac{D-d}{D}\right) * (F_d - S_d)} \right) * (SPI\_MAF)$$

Currency to USD (FX):

$$HR_d = \left(\frac{F_{m-1}}{S_{mr-1}} - \frac{S_d + \left(\frac{D-d}{D}\right) * (F_d - S_d)}{S_{mr-1}} \right) * (SPI\_MAF)$$

2. SPI_EH_d = S&P Dow Jones Indices Currency-Hedged Index level

$$SPI\_EH_d = SPI\_EH_{m-1} * \left(\frac{SPI\_EM_d}{SPI\_EM_{m-1}} + HR_d \right)$$

Monthly Return Series (For Monthly Multi - Currency Hedged Indices)

S&P DJI indices can be composed of securities listed on multiple exchanges using multiple foreign exchange rates for daily index calculation.

Monthly Multi - Currency Hedged Indices follow a standard Monthly Hedged Calculation, following the main differences listed below:

- The spot rate (S_d) used for the currency return and the first front-month forward rate (F_d) used to hedge the currency position need to be converted from each of the currencies included in the underlying index to the hedging currency, i.e. EUR.

The Hedged Return (HR_d) is calculated following the same procedure detailed above, but the hedged return is weighted based on the Adjusted Currency Weights of the underlying index as of the Reference Date.

1. HR_d = The hedge return (%) over month m for Monthly Currency Indices, for each of the currencies on underlying Index.

USD to Currency (FX):

$$HR_d = \left(\frac{S_{mr-1}}{F_{m-1}} - \frac{S_{mr-1}}{S_d + (\frac{D-d}{D}) * (F_d - S_d)} \right)$$

Currency to USD (FX):

$$HR_{d,Currency} = \left(\frac{F_{m-1}}{S_{mr-1}} - \frac{S_d + \left(\frac{D-d}{D}\right) * (F_d - S_d)}{S_{mr-1}} \right)$$

2. Weighted Hedged Return for Monthly Multi - Currency Indices:

$$WHR_m = \sum \left(W_{mr-1,Currency} * HR_{d,Currency} \right) * SPI\_MAF$$

where:

$W_{mr-1,Currency}$ = Weight for each of the currencies of the underlying S&P DJI Index as of the Reference Date. S&P DJI's standard index reference date for hedged indices is one business day prior to the last business day of the prior month.

$HR_{d,Currency}$ = The hedge return (%) over month m for Monthly Currency, for each of the currencies on the underlying S&P Dow Jones Index.

WHR_m = Weighted Hedged Return for Monthly Multi Currency Indices.

3. SPI_EHd = S&P DJI Currency-Hedged Index level for Multi - Currency Indices:

$$SPI\_EH_d = SPI\_EH_{m-1} * \left(\frac{SPI\_EM_d}{SPI\_EM_{m-1}} + WHR_m \right)$$

For Monthly Multi-Currency Hedged Indices, on any day that is both an underlying index holiday and an index calculation day, the closing price of the constituents on the holiday day is used for index calculation. In this case, there is no change to the last business day of the prior month nor the prior month index reference date.

Daily Return Series (For Monthly Currency Hedged Indices and Daily Currency Hedged Indices)

The daily return series are computed by interpolating between the spot price and the forward price.

For each month m, there are d = 1, 2, 3…D calendar days.

m = The month in the calculation, represented as 0, 1, 2, etc..

$m-1$ = The last business day of the prior month.

d = Day d for month m.

$d-1$ = Previous day for month m.

D = The number of days in month m, counted as calendar days to the last business day.

SPI_EH_d = The S&P Dow Jones Indices Currency-Hedged Index level on day t, where t can be defined as d or $m-1$.

SPI_EM_d = The S&P DJI Index level, in foreign currency, on day t, where t can be defined as d or $m-1$.

SPI_EL_d = The S&P Dow Jones Indices Index level, in local currency, on day t, where t can be defined as $d-1$ or $m-1$.

HR_d = The hedge return (%) from end of month to *day d*.

S_d = The spot rate in foreign currency per local currency (*FC/LC*), on day t, where t can be defined as d or $m-1$.

$1MF_d$ = The one month forward spread used to calculate the forward rate, at day d of month m.

F_d = The first front-month forward rate in foreign currency per local currency (*FC/LC*), on day *t*, where *t* can be defined as *d* or *d-1*, calculated as $S_d + 1MF_d$.

F_I_{md} = The interpolated forward rate on day *t*, where *t* can be defined as *d* or *d-1*.

AF_d = The adjustment factor for daily hedged indices as of day *d* of month *m*

Daily Hedged Calculation for day *T* of month m =

1. The interpolated forward rate as of day d of month m (F_I md)

   When day d is the last business day of month m =

   $$F\_I_{md} = FM_d = (S_d + 1MF_d)$$

2. When day d is other than the last business day of month m =

   $$F\_I_{md} = S_d + \left(\frac{D - d}{D}\right) * (F_d - S_d)$$

3. The adjustment factor for daily hedged indices as of day d of month m (AFmd)

   $$AF_{md} = \frac{SPI\_EL_{d-1}}{SPI\_EL_{m-1}}$$

When day *d* is the first business day of month *m*, *AFmd* = 1

The hedge return for daily currency hedged indices is calculated as follows:

When day *d* is any other day than the first business day of month *m*:

$$HR_d = AF_{md} * \left(\frac{F\_I_{md-1}}{S_{m-1}} - \frac{F\_I_{md}}{S_{m-1}}\right) * HR_{d-1}$$

When day *d* the first business day of month *m*:

$$HR_d = AF_{md} * \left(\frac{F_{d-1}}{S_{m-1}} - \frac{F\_I_{md}}{S_{m-1}}\right)$$

S&P DJI Daily Currency Hedged Index Level at day d:

$$SPI\_EH_d = SPI\_EH_{m-1} * \left(\frac{SPI\_EM_d}{SPI\_EM_{m-1}} + HR_d\right)$$

Dynamic Hedged Return Indices

Dynamic hedged return indices are rebalanced at a minimum on a monthly basis as per the monthly series described above, but include a mechanism to ensure that the index does not become over-hedged or under-hedged beyond a certain percentage threshold. This is measured by taking the percent change of the current value of the hedged index versus the value of the hedged index on the previous reference date. If that percentage threshold is crossed during the month an intra-month adjustment is triggered. If triggered, the hedge is reset to the value of the hedged index on the day the threshold is breached, effective after the close on the following business day, using the current interpolated value of the forward expiring at the end of the month. Thus the formulas for dynamic hedged indices become:

SPI_EH_d = The S&P Dow Jones Indices Currency-Hedged Index level as of day d

SPI_EH_{rb} = The S&P Dow Jones Indices Currency-Hedged Index level at the prior rebalancing date

SPI_EH_{rf} = The S&P Dow Jones Indices Currency-Hedged Index level on the prior reference day. S&P Dow Jones Indices' standard index reference date for hedged indices is one day prior to the rebalancing date.

SPI_AF	= Index Adjustment Factor to account for the performance of the S&P Dow Jones Indices Currency-Hedged Index between the index reference date and rebalance date. It is calculated as the ratio of the S&P Dow Jones Indices Currency-Hedged Index level on the reference date and the S&P Dow Jones Indices Currency-Hedged Index level at the rebalancing date.
SPI_E_d	= The S&P Dow Jones Indices Index level, in foreign currency, as of date d
SPI_E_{rb}	= The S&P Dow Jones Indices Index level, in foreign currency, at the prior rebalancing date
HR_d	= The hedge return (%) as of day d since the prior rebalancing date
S_d	= The spot rate in foreign currency per local currency (FC/LC) as of date d
S_{rf}	= The spot rate in foreign currency per local currency (FC/LC) as of the prior index reference date
F_d	= The forward rate in foreign currency per local currency (FC/LC), as of day d
F_I_d	= The interpolated forward rate as of day d
F_I_{rb}	= The interpolated forward rate as on prior rebalancing date

The formula for determining if an intra-month rebalancing is triggered is:

$$If\ (abs((SPI\_EH_d\ /SPI\_EH_{rf}\ )-1)) > TH$$

where:

TH = Percentage threshold for the index

Then a rebalancing is triggered.[8]

For the purposes of the Dynamic Rebalancing and determining the hedge absolute deviation from notional, when day *d* is a rebalancing date, the hedged index on reference updates on rebalance date *d*.[9]

The interpolated forward rate as of day d is calculated as:

$$F\_I_d = S_d + (F_d - S_d) * \left(\frac{Days(d,nrb)}{Days(d,exp)}\right)$$

where,

$Days(d,nrb)$ = Days between date d and next scheduled rebalancing date

$Days(d,exp)$ = Days between date d and expiry date of the forward rate used

Whenever applicable a standard FX market settlement conventions are applied to both the Spot Rate and Forward Rate to determine the exact settlement dates to be used in the interpolation.

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[8] Prior to November 30, 2021, a Dynamic Rebalancing cannot be triggered on two consecutive days. If the prior day signaled a dynamic rebalancing, a current day dynamic rebalancing signal was ignored.

[9] Prior to November 30, 2021, for the purposes of the Dynamic Rebalancing and determining the hedge absolute deviation from notional, when day *d* is a rebalancing date the hedged index on reference updates on rebalancing date *d* + 1.

The hedge return for dynamic currency hedged indices is:

$$HR_d = \left(\frac{F\_I_{rb}}{S_{rf}} - \frac{F\_I_d}{S_{rf}} \right) * SPI\_AF$$

For index value on day d is:

$$SPI\_EH_d = SPI\_EH_{rb} * \left(\frac{SPI\_E_d}{SPI\_E_{rb}} + \boldsymbol{HR_d} \right)$$

Currency Hedged Excess Return Indices

Since an excess return index calculates the return on an investment in an index where the investment was made through the use of borrowed funds, currency risk can be hedged by borrowing funds in the currency of the investment. In this scenario the initial value of the index at each hedge period will not be affected by currency returns, but the amount gained or lost during the period will be affected by returns in the currency.

When the gain and loss at each hedge period is not hedged, returns are defined as follows:

$$Hedged\ Excess\ Return = Local\ Excess\ Return\ + Currency\ Return\ on\ Unhedged\ Local\ Excess\ Return$$

When the gain and loss at each hedge period is hedged, returns are defined as follows:

$$Hedged\ Excess\ Return$$
$$= Local\ Excess\ Return\ + Currency\ Return\ on\ Unhedged\ Local\ Excess\ Return + Hedge\ Return$$

For non-convertible currencies, currency return on unhedged local excess return is calculated using the current forward rate based on first front-week forward contract rather than a spot rate for some cases. In this case, the returns of daily currency hedged excess return indices are calculated as follows (note that currency rates are quoted in local currency per foreign currency in the case of non-convertible currencies):

$$Hedged\ Excess\ Return = Local\ Excess\ Return\ + \left(Local\ Excess\ Return * \frac{F\_week_{m0}^{NC}}{F\_week_{md}^{NC}} \right) + Hedge\ Return$$

The hedged return for daily currency hedged excess return indices is calculated as follows:

When day *d* is the first business day of month *m*,

$$HR_{md} = 0$$

When day *d* is not the first business day of month *m*,

$$HR_{md} = AF\_ER_{md} * \left(\frac{F\_week_{m0}^{NC}}{F\_I_{md-1}^{NC}} - \frac{F\_week_{m0}^{NC}}{F\_I_{md}^{NC}} \right) + HR_{md-1}$$

where

$F\_week_{md}^{NC}$ = The first front-week forward rate in local currency per foreign currency (*LC/FC*) as of day *d* of month *m*

$F\_week_{m0}^{NC}$ = The first front-week forward rate in local currency per foreign currency (*LC/FC*), at the end of prior month, *m-1*

$F\_I_{md}^{NC}$ = The interpolated forward rate in local currency per foreign currency (*LC/FC*), as of day d of month *m*

$$F\_I_{md}^{NC} = S_{md}^{NC} + \left(\frac{D-d}{D}\right) * (F_{md}^{NC} - S_{md}^{NC})$$

S_{md}^{NC} = The spot rate in local currency per foreign currency (*LC/FC*), as of day *d* of month *m*

F_{md}^{NC} = The first front-month forward rate in local currency per foreign currency (*LC/FC*), as of day *d* of month *m*

D = number of business days in month *m*

AF_ER_{md} = The adjustment factor for daily currency hedged excess return indices as of day *d* of month *m*

$$AF\_ER_{md} = \frac{SPERI\_EL_{md-1}}{SPERI\_EL_{m0}} - 1$$

where:

$SPERI\_EL_{md}$ = The S&P Dow Jones Excess Return Index level, in local currency, as of day d of month m

$SPERI\_EL_{m0}$ = The S&P Dow Jones Excess Return Index level, in local currency, at the end of the prior month, *m-1*

Quanto Currency Adjusted Index

A quanto currency adjusted index represents the return of an underlying index from the perspective of a foreign party, and incorporates the respective currency pair return with the underlying index return. It differs from simply expressing an index in foreign currency because it represents borrowing in the index currency to fund an investment in assets represented by the index.

For example, suppose a U.S. investor does the following on a daily basis:

1. Borrow 100 GBP in London, secured by the equivalent amount of USD in a U.S. bank

2. Invest 100 GBP in U.K. index stocks in proportion to their index weights

The investor would generate profit or loss equal to the U.K. index return. They would also earn the combined index return and the currency pair return on the profit/loss. The combined index/currency return would not be earned on their principal because the U.K. assets can be sold to satisfy the U.K. loan and close the position.

Arithmetically, a quanto currency adjusted index can be represented as follows:

$$SPI\_QA(t+1) = SPI\_QA(t) \times \left(\frac{SPI\_E(t+1)}{SPI\_E(t)} + \left(\frac{SPI\_E(t+1)}{SPI\_E(t-n)} - 1\right) \times \left(\frac{S(t+1)}{S(t)} - 1\right)\right)$$

where:

$SPI\_QA(t+1)$ = Quanto Currency-Adjusted Index level, as of day (t+1)

$SPI\_QA(t)$ = Quanto Currency-Adjusted Index level, as of day (t)

$SPI\_E(t+1)$ = Underlying Index level, as of day (t+1)

$SPI\_E(t)$ = Underlying Index level, as of day (t)

$SPI\_E(t-n)$ = Underlying Index level, as of day (t-n), where n = (0 or 1), corresponding to the difference in trading days between the foreign party and the underlying index[10]

$S(t+1)$ = Spot rate for the currency pair as of date (t+1)

$S(t)$ = Spot rate for the currency pair as of date (t)

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[10] For example, for foreign parties in an APAC time zone employing such a strategy to acquire U.S. assets, n=1 to account for the trading day difference between the party and the index.

The index returns can also be expressed as:

$$\text{Quanto Currency Adjusted Index Returns} = \text{Index Returns} + \left(\text{Index Returns}'\right) \times \left(Currenct\ Returns\right)$$

Negative/Zero Index Levels. For more information regarding the possibility of negative or zero index levels, refer to the *Negative/Zero Index Levels* section.

Domestic Currency Return Index Calculation

Background

Domestic Currency Return (DCR) calculations are used to calculate the return of an index without taking any exchange rate movements into account. This may be done as a way to perform an attribution on an index containing constituents which do not all trade in the same currency. By comparing the performance of the float-adjusted market capitalization weighted index against the performance of the same index calculated using DCR one can derive the performance due to the exchange rate movements.

In DCR one calculates the period-to-period percentage change of the index from the weighted percentage change of each security's local price and then constructs the index levels from the percentage changes. This is in contrast to a divisor-based index where the process is reversed: the index level is calculated as total market value divided by the divisor and the period-to-period percentage change is calculated from the index levels. Both approaches require an initial base period or divisor value for normalization. For an index where all of the constituents trade in the same currency both approaches give the same results.

In the DCR calculation, we calculate the percentage change in each security price, weight the percentage changes by the security's weight in the index at the start of the period, and then combine the weighted price changes to calculate the index price change for the time period. The change in the index is, then, applied to the index level in the previous period to determine the current period index level.

Equivalence of DCR and Divisor Calculations

The equivalence of the two approaches – DCR and divisor based – can be understood in two ways. First, except for the initial base value of an index, it can be defined by either the index levels or the percentage change from one period to the next. If we defined an index by a time series of index levels (100, 101.2, 103, 105…) we can derive the period to period changes (1.2%, 1.78%, 1.94%...). Given these changes and assuming the index base is a value of 100 allows us to calculate the index levels. Except for the base, the two series are equivalent. DCR calculates the changes; the divisor approach calculates the levels.

This can be shown mathematically:

The divisor calculation approach defines an index as:

$$\frac{\sum_i price_{i,t} * share_i}{divisor}$$

Since the initial divisor is defined by the base value and date of the index, we can replace it with the value of the index market cap at time *t=0*:

$$\frac{\sum_i price_{i,t} * share_i}{\sum_i price_{i,0} * share_i}$$

Now we can multiply and divide the term in the summation in the numerator by the price at time *t=0* without changing its value.

$$\frac{\sum_i \frac{price_t}{price_0} * price_0 * shares_i}{\sum price_{i,o} * shares_i}$$

If we look at the term in the numerator for a single stock in the index (i.e. no summation, as there is only one stock) and rearrange we get:

$$\left(\frac{price_{i,t}}{price_{i,0}}\right) * \frac{price_{i,0} * shares_i}{\sum price_{i,0} * share_i} \tag{1}$$

which is equivalent to the relative price performance for each stock multiplied by its weight in the index. When this is combined across all constituent stocks, the result is the price performance for the index.

The DCR approach uses the summation of equation (1) across all the stocks in the index to calculate the daily price performance of the index. Once the daily index performance is calculated, the index level can be updated from the previous day's index level.

DCR Calculation

$$Index_t = (Index_{t-1}) * \sum_i \frac{P_{i,t}}{P_{i,t-1}} * weight_{i,t-1}$$

where:

$Index_t$ = Index level at date t

P_t = Security price at the close of date t

$weight_t$ = Security weight in the index at close of date t

and

$$weight_{i,t-1} = \frac{P_{i,t-1} * S_{i,t-1} * FX_{i,t-1}}{\sum_i P_{i,t-1} * S_{i,t-1} * FX_{i,t-1}}$$

where:

$S_{i,t-1}$ = Shares of stock i

$FX_{i,t-1}$ = Exchange rate of stock i for currency conversion

Essential Adjustments

The share count ($S_{i,t-1}$) includes the adjustment for float by multiplying by the investable weight factor (*IWF*) and for index weight by multiplying by the additional weight factor (*AWF*) where necessary. Further, when an adjustment to shares is made due to a secondary offering, share buyback or any other corporate action, this adjustment must be included in $S_{i,t-1}$ if the adjusted share count takes effect on date t. A price adjustment due to a corporate action which takes effect on date t should be reflected in $P_{i,t-1}$.

Risk Control Indices

S&P Dow Jones Indices' Risk Control Indices are designed to track the return of a strategy that applies dynamic exposure to an underlying index in an attempt to control the level of volatility.

The index includes a leverage factor that changes based on realized historical volatility. If realized volatility exceeds the target level of volatility, the leverage factor will be less than one; if realized volatility is lower than the target level, the leverage factor may be greater than one, assuming the index allows for a leverage factor of greater than one. A given Risk Control Index may have a maximum leverage factor that cannot be exceeded. There are no guarantees that the index shall achieve its stated targets.

The return of the index consists of two components: (1) the return on the position in the underlying index and (2) the interest cost or gain, depending upon whether the position is leveraged or deleveraged.

A leverage factor greater than one represents a leveraged position, a leverage factor equal to one represents an unleveraged position, and a leverage factor less than one represents a deleveraged position. The leverage factor may change periodically, on a set schedule, or may change when volatility exceeds or falls below predetermined volatility thresholds.

For equity indices, the leverage factor will not change at the close of any index calculation day in which stocks representing 15% or more of the total weight of the underlying index are not trading due to an exchange holiday. At each underlying index's rebalancing, and using each stock's weight at that time, a forward looking calendar of such dates is determined and posted on S&P Dow Jones Indices' Web site at *www.spglobal/spdji.com*.

The formula for calculating the Risk Control Index is as follows:

Risk Control Index Return$_t$ =

$$K_{rb} * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}} - 1 \right) + (1 - K_{rb}) * \left[\prod_{i=rb+1}^{t} (1 + InterestRate_{i-1} * D_{i-1,i} / 360) - 1 \right] \quad (1)$$

The Risk Control Index Value at time *t* can, then, be calculated as:

RiskControlIndexValue$_t$ =

$$(RiskControlIndex\ Value_{rb}) * (1 + RiskControlIndex\ Return_t) \quad (2)$$

Substituting equation (1) into (2) and expanding yields:

Risk Control Index Value$_t$ =

*Risk Control Index Value$_{rb}$ ***

$$\left[1 + \left[K_{rb} * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}} - 1 \right) + (1 - K_{rb}) * \left[\prod_{i=rb+1}^{t} (1 + InterestRate_{i-1} * D_{i-1,i} / 360) - 1 \right] \right] \right] \quad (3)$$

Excess Return versions of Risk Control Indices are calculated as follow:

Risk Control ER Index Value$_t$ =

$$RiskControl\ ER\ Index\ Value_{rb} *$$

$$\left[1 + \left[K_{rb} * \left(\frac{UnderlyingIndex_t}{UnderlyingIndex_{t-1}} - 1\right) - K_{rb} * \left[\prod_{i=rb+1}^{t} \left(1 + InterestRate_{t-1} * \frac{D_{i-1,i}}{360}\right) - 1\right]\right]\right]$$

where:

UnderlyingIndex$_t$	=	The level of the underlying index on day *t*
UnderlyingIndex$_{rb}$	=	The level of the underlying index as of the previous rebalancing date
rb	=	The last index rebalancing date[11]
K$_{rb}$	=	The leverage factor set at the last rebalancing date, calculated as:
		Min(Max K, Target Volatility/Realized Volatility$_{rb-d}$)
Max K	=	The maximum leverage factor allowed in the index
d	=	The number of days between when volatility is observed and the rebalancing date (e.g. if *d* = 2, the historical volatility of the underlying index as of the close two days prior to the rebalancing date will be used to calculate the leverage factor *K$_{rb}$*)
Target Volatility	=	The target level of volatility set for the index
Realized Volatility$_{rb-d}$	=	The historical realized volatility of the underlying index as of the close of *d* trading days prior to the previous rebalancing date, *rb,* where a trading day is defined as a day on which the underlying index is calculated
Interest Rate$_{i-1}$	=	The interest rate set for the index[12]

For indices that replicate a rolling investment in a three-month interest rate the above formula is altered to:

Risk Control Index Value$_{rb}$ *

Risk Control Index Value$_t$ =

$$\left[1 + \left[K_{rb} * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}} - 1\right) + (1 - K_{rb}) * \left[\prod_{i=rb+1}^{t}(1 + InterestRate_{i-1}) - 1\right]\right]\right]$$

where:

$$InterestRate_{i-1} = \qquad (D_{i-1,t} * IR3M_{i-1} - \left(IR3M_{i-1} - IR3M_{i-2} - D_{i-1,t} * (IR3M_{i-1} - IR2M_{i-1}) * \left(\frac{1}{30}\right)\right) * 90)/360$$

where:

D$_{i-1, t}$	=	The number of calendar days between day *i-1* and day *t*
IR3M$_{i-1}$	=	Three-month interest rate on day *i-1*
IR2M$_{i-1}$	=	Two-month interest rate on day *i-1*[13]

For indices that are rebalanced daily, the leverage factor is not recalculated at the close of any index calculation day when stocks representing 15% or more of the total weight of the underlying index are not trading due to an exchange holiday. If *rb* is a holiday, then *K$_{rb}$* is calculated as follows:

---

[11] The inception date of each risk control index is considered the first rebalancing date of that index.
[12] The interest rate may be an overnight rate, such as SOFR or ESTR, or a daily valuation of a rolling investment in a three-month interest rate, or zero. A 360-day year is assumed for the interest calculations in accordance with U.S. banking practices.
[13] Effective 12/03/2018, the interest rate for EUR-based Risk Control indices is a one-month rate instead of a two-month rate. Therefore, those indices' interest rate is depicted as: *IR2M$_{i-1}$* = One-month interest rate on day *i-1*.

$$K_{rb} = K_{rb-1} * \left(\frac{Underlying\ Index_{rb}}{Underlying\ Index_{rb-1}} \right) / \left(\frac{RiskContorlIndexValue_{rb}}{RiskcontrolIndexValue_{rb-1}} \right)$$

This shows what the effect will be on *rb*, given that no adjustment of positions is allowed to occur on such days. The leverage factor will adjust solely to account for market movements on that day.

For periodically rebalanced risk control indices, K_{rb} is calculated at each rebalancing and held constant until the next rebalancing.

For large position moves, some investors like to rebalance risk control indices intra-period, when the periodicity is longer than daily. This feature is incorporated in the risk-control framework by introducing a barrier, K_b, on the leverage factor. Intra-period rebalancing is allowed only if the absolute change of the equity leverage factor K_t, at time *t*, is larger than the barrier K_b from the value at the last rebalancing date.

The equity leverage factor K_t is calculated as:

K_t = Min(Max K, Target Volatility/Realized Volatility*t-d*)

If no barrier is provided for the index, then intra-period rebalancing is not allowed.

Dynamic Rebalancing Risk Control Index

The index calculates the theoretical leverage factor on daily basis. If the difference between the theoretical leverage factor and the leverage factor on the last rebalancing date is less than the Minimum Daily Allocation Change, the index will not rebalance.

The theoretical leverage factor is determined as:

thK_t = the theoretical leverage factor on day *t*, calculated daily as:

$$thK_t = Min(Max\ K, \frac{Target\ Volaility}{Realized\ Volatility_{t-d}})$$

where:

d = Lag to Rebalancing Date, defined as the number of days between when volatility is observed and the date which the theoretical leverage factor is calculated for (e.g. if d = 2, the historical volatility of the underlying index as of the close two days prior to the date which the theoretical leverage factor is calculated for will be used to calculate the leverage factor thK_t)

The trade decision is based on the difference between the theoretical leverage factor and the leverage factor on the last rebalancing date:

If $|thK_t - K_{t-1}| > \theta$,

Then

$\quad$ *t* is a rebalancing day, and

$\quad$ $K_t = thK_t$

Else

$\quad$ *t* is not a rebalancing day

$\quad$ $K_t = K_{t-1}$

where:

θ $\quad$ = Minimum Daily Allocation Change

K_t $\quad$ = the actual leverage factor on day *t*

Dynamic rebalancing can be combined with monthly rebalancing. In this case, besides intra-monthly rebalancing triggered by breach of Minimum Daily Allocation Change, the risk control index rebalances after the close of the last business day of the month.

Capped Equity Weight Change

For daily rebalanced or dynamic rebalanced risk control indices, some investors like to control for excessive position change. This feature is incorporated in the risk-control framework by introducing a Maximum Daily Allocation Change , $\bar{\theta}$.

The theoretical leverage factor is determined in the same way as in a Dynamic Rebalanced Risk Control Index. The trade decision is based on the difference between the theoretical leverage factor and the leverage factor on the last rebalancing date:

If $|thK_t - K_{t-1}| > \theta$,

Then:

> t is a rebalancing day, and
>
> $$K_t = \begin{cases} Min(K_{t-1} + \bar{\theta} , thK_t), & if \ thK_t - K_{t-1} > 0 \\ Max(K_{t-1} - \bar{\theta} , thK_t), & if \ thK_t - K_{t-1} \leq 0 \end{cases}$$

Else

> t is not a rebalancing day
>
> $K_t = K_{t-1}$

where:

- θ = Minimum Daily Allocation Change (θ >0 for dynamic rebalanced risk control indices, and θ = 0 for daily rebalanced risk control indices).

- $\bar{\theta}$ = Maximum Daily Allocation Change

- K_t = the actual leverage factor on day t

Dynamic rebalancing can be combined with monthly rebalancing. In this case, besides intra-monthly rebalancing triggered by breach of Minimum Daily Allocation Change, the risk control index rebalances after the close of the last business day of the month.

Excess Return Indices

S&P Dow Jones Indices' Excess Return Indices are designed to track an unfunded investment in an underlying index. In other words, an excess return index calculates the return on an investment in an index where the investment was made through the use of borrowed funds. Thus the return of an excess return index will be equal to that of the underlying index less the associated borrowing costs. Most S&P Dow Jones Indices calculate an excess return index level to mirror an unfunded position.

The formula for calculating the Excess Return Index is as follows:

$$ExcessReturn = \left(\frac{Underlying \ Index_t}{Underlying \ Index_{t-1}} - 1 \right) - \left(\frac{Borrowing \ Rate}{360} \right) * D_{t,t-1} \tag{4}$$

The Excess Return Index Value at time t can be calculated as:

$$ExcessReturn \ IndexValue_t = (ExcessReturn \ Index \ Value_{t-1}) * (1 + Excess \ Return) \tag{5}$$

Substituting (4) into (5) and expanding the right hand side of (5) yields:

$ExcessReturn IndexValue_t =$

$ExcessReturn IndexValue_{t-1} * \left[1 + \left[\left(\dfrac{UnderlyingIndex_t}{UnderlyingIndex_{t-1}} - 1 \right) - \left[\dfrac{Borrowing\ Rate}{360} \right] * D_{t,t-1} \right] \right]$

where:

Borrowing Rate	=	The investment funds borrowing rates, which will differ for each excess return index[14]
$D_{t,\ t-1}$	=	The number of calendar days between date *t* and *t-1*

Exponentially-Weighted Volatility

The realized volatility is calculated as the maximum of two exponentially weighted moving averages, one measuring short-term and one measuring long-term volatility.

$RealizedVolatility_t = Max\left(RealizedVolatility_{S,t}, RealizedVolatility_{L,t} \right)$

where:

S,t = The short-term volatility measure at time *t*, calculated as:

(6)

$RealizedVolatility_{S,t} = \sqrt{\dfrac{252}{n} * Variance_{S,t}}$

for $t > T_0$

$Variance_{S,t} = \lambda_S * Variance_{S,t-1} + (1 - \lambda_S) * \left[\ln\left(\dfrac{UnderlyingIndex_t}{UnderlyingIndex_{t-n}} \right) \right]^2$

for $t = T_0$

$Variance_{S,T_0} = \sum_{i=m+1}^{T_0} \dfrac{\alpha_{S,i,m}}{WeightingFactor_S} * \left[\ln\left(\dfrac{UnderlyingIndex_i}{UnderlyingIndex_{i-n}} \right) \right]^2$

L,t = The long-term volatility measure at time *t*, calculated as:

(7)

$RealizedVolatility_{L,t} = \sqrt{\dfrac{252}{n} * Variance_{L,t}}$

for $t > T_0$

$Variance_{L,t} = \lambda_L * Variance_{L,t-1} + (1 - \lambda_L) * \left[\ln\left(\dfrac{UnderlyingIndex_t}{UnderlyingIndex_{t-n}} \right) \right]^2$

for $t = T_0$

$Variance_{L,T_0} = \sum_{i=m+1}^{T_0} \dfrac{\alpha_{L,i,m}}{WeightingFactor_L} * \left[\ln\left(\dfrac{UnderlyingIndex_i}{UnderlyingIndex_{i-n}} \right) \right]^2$

---

[14] Generally, an overnight rate, such as SOFR overnight in the U.S. or ESTR in Europe, will be used. However, in some cases other interest rates may be used. A 360-day year is assumed for the interest calculations in accordance with U.S. banking practices.

where:

T_0 =   The start date for a given risk control index

n =   the number of days inherent in the return calculation used for determining volatility[15]

m =   the Nth trading date prior to T_0

N =   the number of trading days observed for calculating the initial variance as of the start date of the index

λ_S =   The short-term decay factor used for exponential weighting[16]

λ_L =   The long-term decay factor used for exponential weighting[10]

$\alpha_{S,m,i}$ =   Weight of date t in the short-term volatility calculation, as calculated based on the following formula:

$$\alpha_{S,t} = (1 - \lambda_S) * \lambda_S^{N+m-i}$$

$$WeightingFactor_S = \sum_{i=m+1}^{T_0} \alpha_{S,i,m}$$

$\alpha_{L,m,i}$ =   Weight of date t in the long-term volatility calculation, as calculated based on the following formula:

$$\alpha_{L,t} = (1 - \lambda_L) * \lambda_L^{N+m-i}$$

$$WeightingFactor_L = \sum_{i=m+1}^{T_0} \alpha_{L,i,m}$$

The interest rate, maximum leverage, target volatility and the lambda decay factors are defined in relation to each index and are generally held constant throughout the life of the index. The leverage position changes at each rebalancing based on changes in realized volatility. There is a two-day lag between the calculation of the leverage factor, based on the ratio of target volatility to realized volatility, and the implementation of that leverage factor in the index.

The above formulae can be used for simpler models by the appropriate choice of parameters. For example, if the short-term and long-term decay factors, λ_S and λ_L are set to the same value (e.g. 5%) than there are no separate considerations for short-term and long-term volatility.

Exponentially-Weighted Volatility Based on Current Allocations

The index calculations are the same as described in the Exponentially Weighted Volatility section above, except that realized volatility is calculated using the returns derived from the levels of hypothetical underlying index based on the current allocations within the underlying index and historical returns of those constituents, rather than the historical levels of the underlying index.

Underlying Index$_t$ = Hypothetical underlying index level on day t, calculated as

$$Underlying\ Index_t = Underlying\ Index_{t-1} * \left(1 + \sum_{i=i}^{K} w_i * r_{i,t}\right)$$

---

[15] If n = 1 daily returns are used, while if n = 2 two day returns are used, and so forth.
[16] The decay factor is a number greater than zero and less than one that determines the weight of each daily return in the calculation of historical variance.

where:

K = number of constituents in current underlying index as of day t

$r_{i,t}$ = return of the i-th constituent in the underlying index on day t

w_i = weight of the i-th constituent in current underlying index

Simple-Weighted Volatility

The realized volatility is calculated as the maximum of two simple-weighted moving averages, one measuring short-term volatility and one measuring long-term volatility.

$$RealizedVolatility_t = Max(RealizedVolatility_{S,t}, RealizedVolatility_{L,t})$$

where:

S,t = The short-term volatility measure at time t, calculated as:

$$RealizedVolatility_{S,t} = \sqrt{\frac{252}{n} * Variance_{S,t}}$$

$$Variance_{S,t} = 1/N_S * \sum_{i=t-Ns+1}^{t} \ln\left(\frac{UnderlyingIndex_i}{UnderlyingIndex_{i-n}}\right)^2$$

L,t = The long-term volatility measure at time t, calculated as:

$$RealizedVolatility_{L,t} = \sqrt{\frac{252}{n} * Variance_{L,t}}$$

$$Variance_{L,t} = 1/N_L * \sum_{i=t-Nl+1}^{t} \ln\left(\frac{UnderlyingIndex_i}{UnderlyingIndex_{i-n}}\right)^2$$

where:

n = The number of days inherent in the return calculation used for determining volatility[17]

N_S = The number of trading days observed for calculating variance for the short-term volatility measure

N_L = The number of trading days observed for calculating variance for the long-term volatility measure

Underlying Index_t is defined as in the "Exponentially-Weighted Average Volatility" section.

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[17] If n = 1 daily returns are used, while if n = 2 two day returns are used, and so forth.

Futures-Based Risk Control Indices

When the underlying index is based on futures contracts, most of the Risk Control methodology follows the details on the prior six pages. However, there are some differences as detailed below, particularly as it relates to the cash component of the index.

For such an index, it includes a leverage factor that changes based on realized historical volatility. If realized volatility exceeds the target level of volatility, the leverage factor will be less than one; if realized volatility is lower than the target level, the leverage factor may be greater than one. A given risk control index may have a maximum leverage factor that cannot be exceeded.

For equity risk control indices, the return consists of two components: (1) the return on the position in the underlying S&P Dow Jones Indices index and (2) the interest cost or gain, depending upon whether the position is leveraged or deleveraged. For futures-based risk control indices, there is no borrowing or lending to achieve investment objectives in the underlying index. Therefore, the cash component of the Index does not exist.

Again, a leverage factor greater than one represents a leveraged position, a leverage factor equal to one represents an unleveraged position, and a leverage factor less than one represents a deleveraged position. The leverage factor may change at regular intervals, in response to changes in realized historical volatility, or when the expected volatility exceeds or falls below predetermined volatility thresholds, if such thresholds were in place.

The formula for calculating the Risk Control Excess Return Index largely follows that detailed beginning with equation (1). However, since there is no funding for such indices (as opposed to the case with equity excess return indices, where it is assumed the initial investment is borrowed and excess cash is invested), the interest rate used in the calculation is eliminated:

$$Risk\ Control\ Excess\ Return\ Index\ Return_t = K_{rb} * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}} - 1 \right) \tag{8}$$

The Risk Control Excess Return Index Value at time *t* can, then, be calculated as:

$$RiskControlExcessReturnIndexValue_t = $$
$$(RiskControlExcessReturnIndex\ Value_{rb}) * (1 + RiskControlExcessReturnIndex\ Return_t)$$

The formula for calculating the Risk Control Total Return Index, which includes interest earned on Treasury Bills, is as follows:

$$Risk\ Control\ Total\ Return\ Index\ Return_t = $$

$$K_{rb} * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}} - 1 \right) + \left[\prod_{i=rb+1}^{t} (1 + InterestRate_{i-1} * D_{i-1,i} / 360) - 1 \right] \tag{9}$$

The Risk Control Total Return Index Value at time *t* can, then, be calculated as:

$$RiskControlTotalReturnIndexValue_t = $$
$$(RiskControlTotalReturnIndex\ Value_{rb}) * (1 + RiskControlTotalReturnIndex\ Return_t) \tag{10}$$

Substituting equation (9) into (10) and expanding yields:

Risk Control Total Return Index Value_t =

*Risk Control Index Value$_{rb}$ ***

$$\left[1+\left[K_{rb} *\left(\frac{Underlying\ Index_t}{Underlying\ Index_{rb}}-1\right)+\left[\prod_{i=rb+1}^{t}(1+InterestRate_{i-1}*D_{i-1,i}/360)-1\right]\right]\right]$$

(11)

where all variables in equations (8)-(11) are the same as those defined for (1)-(3) except:

Interest Rate$_{i-1}$ = The interest rate set for the index[18]

Exponentially-Weighted Volatility for Futures-Based Risk Control Indices

Please refer to the *Risk Control 2.0 Indices* section of this document for information on Exponentially-Weighted Volatility. However, for futures-based risk control indices there is a three (3)-day lag between the calculation of the leverage factor, based on the ratio of target volatility to realized volatility, and the implementation of that leverage factor in the index.

Dynamic Volatility Risk Control Indices

In dynamic volatility risk control indices, the volatility target is not set as a definition of the index. Rather it is set at various levels based on the moving average of VIX computed over a predetermined number of days (e.g. 30-day moving average).

Variance Based Risk Control Indices

In variance-based risk control indices, a target level of variance is set rather than a target volatility level. This allows for faster leveraging or deleveraging of allocations based on changes in volatility or variance in the market. For these indices:

K_{rb} = Min(Max K, Target Variance/Realized Variance$_{rb-d}$)

where variance is defined as per above.

All other index calculations remain the same.

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[18] In accordance with the S&P GSCI approach, the interest rate for these indices is the 91-day U.S. Treasury rate. A 360-day year is assumed for the interest calculations in accordance with U.S. banking practices.

Risk Control 2.0 Indices

S&P Dow Jones Indices' Risk Control 2.0 Indices are Risk Control indices, where the cash portion of the investment in the standard Risk Control strategy is replaced with a liquid bond index.

The index portfolio consists of two assets, the index for a risky asset *A*, with weight *W,* and the corresponding bond index *B*, with weight of (1-*W*). Weight *W* lies between 0 and 100%. There is no shorting or leverage allowed in the strategy.

Constituent Weighting

The formula to assign weights to the underlying indices is determined by the following:

$$W^2 * \sigma_A^2 + (1-W)^2 * \sigma_B^2 + 2*W*(1-W)*\rho*\sigma_A*\sigma_B = \sigma_{Target}^2 \qquad (1)$$

where:

W = The weight of the risky asset *A*

σ_A = The volatility of the risky asset *A*

σ_B = The volatility of the bond index *B*

ρ = The correlation of Index *A* and *B*

σ_{Target} = The target volatility

The calculation of volatility and correlation follows the same procedure and conventions as outlined in the prior section for the standard Risk Control strategy.

The quadratic equation above has two solutions to the weight allocated the index A:

$$W_1 = (-b + \sqrt{b^2 - 4a*c})/2a$$

$$W_2 = (-b - \sqrt{b^2 - 4a*c})/2a \qquad (2)$$

where:

$$a = \sigma_A^2 + \sigma_B^2 - 2*\rho*\sigma_A*\sigma_B$$

$$b = 2\rho\sigma_A\sigma_B - 2\sigma_B^2$$

$$c = \sigma_B^2 - \sigma_{Target}^2$$

The fallback mechanism for the solutions of weight *W*:

1. If none of the solutions in equation (2) above falls between 0 and 100%, then the strategy falls back to standard Risk Control, where the maximum leverage is capped at 100%.

2. If both solutions to the equation (2) are valid weights that are greater than 0, then the larger of the two, max(*W1*, *W2*), becomes the weight of the risky asset A where the maximum leverage is capped at the level defined by the indices risk control parameters.

The final weights of the underlying assets are determined using the following steps:

Step 1: Determine the weights under the short term parameters

a) Determine the short-term variance for assets A and B using the short term exponential parameter with the same formulae as described in equation (6) under the section *Risk Control Indices*, with the returns for assets A and B used in determining the short-term variance for assets A and B.

b) Determine the short-term covariance for assets A and B using similar formulae as described for short-term covariance calculations in equation (6) under the section *Risk Control Indices*, but replacing the squared equity returns with the product of the returns of risky assets A and B.

c) Determine the short-term volatility measure for the risky assets A and B from their respective variance measures in the same manner as described in equation (6) under the section *Risk Control Indices*.

d) Determine the short-term correlation of A and B from the short-term covariance and the short-term volatility measures.

e) Determine the possible levels for the weights for A and B using equations (1) and (2) above.

Step 2: Determine the weights under the long term parameters

Repeat (*a*) to (*e*) in Step 1 above with long-term parameters as described in equation (7) under the section *Risk-Control Indices*.

Step 3: Determine the final weight W.

The weight for risky asset *A* is set equal to the lower of the weight of *A* as determined in Step 1 and Step 2.

The excess return of the Risk Control 2.0 Indices is calculated as:

$$RiskControl2.0ExcessReturn_t = W * Index_A ExcessReturn + (1 - W) * Index_B ExcessReturn$$

and the Risk Control 2.0 Index value is:

$$RiskControl2.0IndexValue_t = RiskControl2.0IndexValue_{rb} * (1 + RiskControl2.0ExcessReturn_t)$$

where:

$RiskControl2.0IndexValue_{rb}$ = The value of the index at the last rebalancing

Risk Control 2.0 total return indices are calculated in a similar way, where the total return is a weighted sum of total returns of the underlying indices.

Risk Control 2.0 is an extension of standard Risk Control described in detail in the previous section. The parameters used in Risk Control 2.0 follow exactly the way they are calculated in the standard Risk Control methodology.

Risk Control 2.0 with Minimum Variance

In Risk Control 2.0 indices with minimum variance, when the quadratic equation (1) has no real solution for W_A and W_B, the fallback mechanism does not switch to standard Risk Control.

$$W_A^2 * \sigma_A^2 + W_B^2 * \sigma_B^2 + 2 * W_A * W_B * \rho * \sigma_A * \sigma_B = \sigma_{Target}^2 \qquad (1)$$

where,

$$W_A + W_B = 1 \qquad (2)$$

Instead, the strategy finds the portfolio with minimum variance and then rescales the weight of the risky asset A and risky asset B to reach the target volatility. The remaining weight is allocated to cash in order that total asset weights sum 100%.

If using (1) and (2) for a given asset weight x with standard deviation σ_A, the portfolio variance is defined as a function of x as the following:

$$f(x) = x^2 * \sigma_A^2 + (1-x)^2 * \sigma_B^2 + 2 * x * (1-x) * \rho * \sigma_A * \sigma_B$$ Calculating the first the derivative of (3) results in:

$$\frac{df}{dx} = 2 * x * (\sigma_A^2 + \sigma_B^2 - 2 * \rho * \sigma_A * \sigma_B) + 2 * \rho * \sigma_A * \sigma_B - 2 * \sigma_B^2$$

Equating the first derivative to zero results in:

$$x^* = \frac{\sigma_B^2 - \rho * \sigma_A * \sigma_B}{\sigma_A^2 + \sigma_B^2 - 2 * \rho * \sigma_A * \sigma_B}$$

Deriving again, the second derivative is always positive and hence, the asset weight x^* is a local minimum.

$$\frac{d^2 f}{dx^2} = 2 * (\sigma_A^2 + \sigma_B^2 - 2 * \rho * \sigma_A * \sigma_B) \geq 2 * (\sigma_A - \sigma_B)^2 \geq 0$$

Moreover, given that function (3) is convex over $[0,1]$, x^* is also a global minimum. Therefore, the asset weights of the minimum variance portfolio for two risky assets A and B are:

$$W_A^{Min} = \frac{\sigma_B^2 - \rho * \sigma_A * \sigma_B}{\sigma_A^2 + \sigma_B^2 - 2 * \rho * \sigma_A * \sigma_B} \qquad (4)$$

$$W_B^{Min} = 1 - W_A^{Min} \qquad (5)$$

However, given that equation (1) had no real solution, the portfolio volatility $\sigma_{Minimum}$ using weights (4) and (5) is greater that the target volatility. Therefore, (4) and (5) must be rescaled to reach the target volatility by a scalar θ as follows:

$$\theta = \frac{\sigma_{Target}}{\sigma_{Minimum}} \qquad (6)$$

Then the portfolio asset weights are:

$$W_A = \theta * W_A^{Min}$$
$$W_B = \theta * W_B^{Min}$$

Given that $\theta < 1$, the remaining portfolio weight is allocated to cash to get 100% allocation:

$$W_C = 1 - W_A - W_B$$

Equity with Futures Leverage Risk Control Indices

S&P Dow Jones Indices' Equity with Futures Leverage Risk Control Indices measure the performance of a strategy that combines constant representation of the underlying index with a dynamic weighting to the corresponding Futures Excess Return Index in order to target a specific level of volatility. When the underlying index volatility decreases below the target, futures are added to the risk control index to increase the market exposure and vice versa.

The index includes a leverage factor that represents the target exposure to the underlying index as a result of both the equity and futures positions. Since representation of the equity position remains constant at 100%, the resultant dynamic weighting to the futures index equals the leverage factor minus 100%.

The return of the index consists of two components: (1) the return in the underlying index and (2) the return of a dynamic long or short position in the corresponding Futures Excess Return Index, depending on whether the index is leveraging or deleveraging in an attempt to achieve the target volatility.

The formula for calculating the Equity with Futures Leverage Risk Control Index Return is as follows:

$Equity\ with\ Futures\ Leverage\ Risk\ Control\ Index\ Return_t =$

$$\left(\frac{UnderlyingIndex_t}{UnderlyingIndex_{rb}} - 1\right) + (K_{rb} - 100\%) * \left(\frac{FuturesERIndex_t}{FuturesERIndex_{rb}} - 1\right)$$

where:

$FuturesERIndex_t$ = The level of the Futures Excess Return Index on day t

$FuturesERIndex_{rb}$ = The level of the Futures Excess Return Index as of the

last rebalancing date

The leverage factor, K_{rb}, changes based on a 20 trading-day realized historical volatility of the underlying index. For details on the calculation of the historical volatility please see formulae as described for short-term, simple-weighted realized volatility under the section *Risk Control Indices.*

All other parameters are as described in the standard *Risk Control Indices* section of this document.

Weighted Return Indices

S&P Dow Jones Indices' Weighted Return Indices combine the returns of two or more underlying indices using a specified set of weighting rules to create a new unique index return series. An index that uses the Weighted Return methodology might also be referred to as an "Index of Indices." Weighted Return indices may include a cash component which for the purposes of these indices is treated as an underlying index. S&P Dow Jones Indices offers both daily and periodic rebalance approaches for weighted return indices.

Based on the specification in the individual index methodologies, weighted return indices will be calculated using one of the below formulas:

Daily Rebalancing:

$$Index_t = Index_{t-1} \times \left(1 + \sum_{i=1}^{N}\left(weight_{i,t} \times \left(\frac{ComponentIndex_{i,t}}{ComponentIndex_{i,t-1}} - 1\right)\right) + CashWeight_t \times InterestReturn_t\right)$$

Periodic Rebalancing, accruing interest:

$$Index_t = Index_r \times \left(1 + \sum_{i=1}^{N}\left(weight_{i,r} \times \left(\frac{ComponentIndex_{i,t}}{ComponentIndex_{i,r}} - 1\right)\right) + CashWeight_r \times \left(\prod_{d=r+1}^{t}(1 + InterestReturn_d) - 1\right)\right)$$

Interest Return Options:

$$InterestReturn_t = \begin{cases} \frac{InterestRate_{t-1}}{AccountingDays} \times ACT(t, t-1), \text{for simple daily accrual} \\[2em] \left(\left(1 + \frac{InterestRate_{t-1}}{AccountingDays}\right)^{ACT(t,t-1)} - 1\right), \text{for accrual compounding over an index noncalc day} \\[2em] \left(\frac{1}{\left(1 - \frac{91}{AccountingDays} \times RiskFree\ Rate_{t-1}\right)}\right)^{\frac{ACT(t,t-1)}{91}} - 1, \text{for 3 month RiskFree Rate accrual} \end{cases}$$

where:

$Index_t$	= the value of the top level index on day t
$Index_r$	= the value of the top level index at the previous rebalancing date r[19]
$weight_{i,t}$	= the weight of component index i on day t
$weight_{i,r}$	= the weight of component index i on the previous rebalancing date r
$ComponentIndex_{i,t}$	= the value of the component index i on day t
$ComponentIndex_{i,r}$	= the value of the component index i on the previous rebalancing date r[20]
N	= the number of component indices within the top level index
$CashWeight_t$	= the weight of the cash component on day t
$CashWeight_r$	= the weight of the cash component on the previous rebalancing date r
$InterestReturn_t$	= the return from the interest rate (see *Interest Return Options* above)

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[19] Note that the value is as of the close of the rebalancing date.
[20] Note that the value is as of the close of the previous rebalancing date.

InterestReturn*t - 1*   = the interest rate from the previous calculation date t -1^{21}

Accounting Days   = the day count convention for *InterestRate*$_{t-1}$. Days counts are typically 252, 360, or 365.

ACT(t, t - 1)   = the calendar day between calculation day t -1 and calculation day t, expressed as the day $(t) - (t - 1)$.

RiskFree Rate$_{t-1}$ = S&P DJI typically uses the three-month (3M) T-Bill rate published weekly by *treasurydirect.gov.*

Component Indices Weightings and Returns:

Daily Rebalancing:

$$Weight_{i,t} = \frac{ADJ\ Weight_{i,t-1} * (1 + Daily\ Return_{i,t})}{(1 + Index\ Return_t)}$$

$$Daily\ Return_{i,t} = \frac{Component\ Index_{i,t}}{Component\ Index_{i,t-1}} - 1$$

$$Index\ Return_t = \frac{Index_t}{Index_{t-1}} - 1$$

Periodic Rebalancing, accruing interest:

$$Weight_{i,t} = \frac{ADJ\ Weight_{i,r} * (1 + Daily\ Return_{i,t})}{(1 + Index\ Return_t)}$$

$$Daily\ Return_{i,t} = \frac{Component\ Index_{i,t}}{Component\ Index_{i,r}} - 1$$

$$Index\ Return_t = \frac{Index_t}{Index_r} - 1$$

where:

Weight $_{i,t}$ = the weight of component index *i* on day *t*

ADJ Weight $_{i,t-1}$ = the Adjusted close weight of component index *i* on day *t-1*

N   = the number of component indices within the top-level index

Daily Return $_{i,t}$ = daily return of component index *i* on day

Index Return $_t$ = the return of the weighted return index on day *t*.

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[21] Note that this can also be a flat rate.

Leveraged and Inverse Indices

Leveraged Indices for Equities

S&P Dow Jones Indices' Leveraged Indices are designed to generate a multiple of the return of the underlying index in situations where the investor borrows funds to generate index exposure beyond his/her cash position. The approach is to first calculate the underlying index, then calculate the daily returns for the leveraged index and, finally, to calculate the current value of the leveraged index by incrementing the previous value by the daily return. There is no change to the calculation of the underlying index.

The daily return for the leveraged index consists of two components: (1) the return on the total position in the underlying index less (2) the borrowing costs for the leverage.

The formula for calculating the Leveraged Index is as follows:

$$Leveraged\ Index\ Return = K*\left(\frac{Underlying\ Index_t}{Underlying\ Index_{t-1}} - 1\right) - (K-1)*\left(\frac{Borrowing\ Rate}{360}\right)*D_{t,t-1} \qquad (1)$$

In equation (1) the borrowing rate is applied to the leveraged index value because this represents the funds being borrowed. Given this, the Leveraged Index Value at time t can be calculated as:

$$Leveraged\ IndexValue_t = (Leveraged\ Index\ Value_{t-1})*(1 + Leveraged\ Index\ Return) \qquad (2)$$

Substituting (1) into (2) and expanding the right hand side of (2) yields:

$$Leveraged\ IndexValue_t =$$

$$Leveraged\ IndexValue_{t-1}*\left[1 + \left[K*\left(\frac{UnderlyingIndex_t}{UnderlyingIndex_{t-1}} - 1\right) - (K-1)*\left[\frac{Borrowing\ Rate}{360}\right]*D_{t,t-1}\right]\right] \qquad (3)$$

where:

K $(K \geq 1)$ = Leverage Ratio

- K = 1, no leverage
- K = 2, Exposure = 200%
- K = 3, Exposure = 300%

Borrowing Rate = SOFR Overnight in the U.S. or EURO SHORT TERM RATE (ESTR) in Europe are two common examples

$D_{t,\ t-1}$ = the number of calendar days between date t and $t-1$

In the absence of leverage (K=1),

$$Leveraged\ Index\ Value_t = Leveraged\ Index\ Value_{t-1}*\left[\frac{Underlying\ Index_t}{Underlying\ Index_{t-1}}\right]$$

The leverage position is rebalanced daily. This is consistent with the payoff from futures-based replication.

Leveraged Indices without Borrowing Costs for Equities

In some cases, leveraged indices that do not account for costs incurred to finance the associated leverage are calculated. For these indices, the borrowing rate in formulas (1) and (3) is set to zero and the calculation follows as above.

Inverse Indices for Equities

S&P Dow Jones Indices' Inverse indices are designed to provide the inverse performance of the underlying index; this represents a short position in the underlying index. The calculation follows the same general approach as the leveraged index with certain adjustments: First, the return on the underlying index is reversed. Second, while the costs of borrowing the securities are not included, there is an adjustment to reflect the interest earned on both the initial investment and the proceeds from selling short the securities in the underlying index. These assumptions reflect normal industry practice.[22]

The general formula for the return to the inverse index is

$$Inverse\ Index\ Return = -K * \left(\frac{Underlying\ Index_t}{Underlying\ Index_{t-1}} - 1 \right)$$
$$+ (K+1) * \left(\frac{Lending\ Rate}{360} \right) D_{t,t-1}$$

(4)

Where the first right hand side term represents the return on the underlying index and the second right hand side term represents the interest earned on the initial investment and the shorting proceeds.

Expanding this as done above for the leveraged index yields:

$$InverseIndexValue_t =$$
$$Inverse\ IndexValue_{t-1} * \left[1 - \left[K * \left(\frac{UnderlyingIndex_t}{UnderlyingIndex_{t-1}} - 1 \right) - (K+1) * \left[\frac{LendingRate}{360} \right] * D_{t,t-1} \right] \right]$$

(5)

where:

$K\ (K \geq 1)$ = Leverage Ratio

- K = 1, Exposure = -100%
- K = 2, Exposure = -200%
- K = 3, Exposure = -300%

Lending Rate = SOFR Overnight in the U.S. or ESTR in Europe are two common examples

$D_{t,\ t-1}$ = the number of calendar days between date *t* and *t-1*

In the absence of leverage (K =1),

$$InverseIndexValue_t =$$
$$Inverse\ IndexValue_{t-1} * \left[1 - \left[\left(\frac{UnderlyingIndex_t}{UnderlyingIndex_{t-1}} - 1 \right) - (2) * \left[\frac{LendingRate}{360} \right] * D_{t,t-1} \right] \right]$$

The inverse position is rebalanced daily. This is consistent with the payoff from futures-based replication.

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[22] Straightforward adjustments can be made to either to include the costs of borrowing securities or to exclude the interest earned on the shorting proceeds and the initial investment.

Inverse Indices without Borrowing Costs for Equities

In some cases, inverse indices that do not account for any interest earned are calculated. For these indices, the lending rate in formulas (4) and (5) is set to zero and the calculation follows as above.

Leveraged and Inverse Indices for Futures

S&P Dow Jones Indices' futures-based Leveraged Indices are designed to generate a multiple of the return of the underlying futures index in situations where the investor borrows funds to generate index exposure beyond his/her cash position.

S&P Dow Jones Indices' futures-based Inverse indices are designed to provide the inverse performance of the underlying futures index; this represents a short position in the underlying index.

The approach is to first calculate the underlying index, then calculate the daily returns for the leveraged or inverse index. There is no change to the calculation of the underlying futures index.

The leveraged or inverse index may be rebalanced daily or periodically.

Daily Rebalanced Leverage or Inverse Futures Indices

If the S&P Dow Jones Indices futures-based leveraged or inverse index is rebalanced daily, the index excess return is the multiple of the underlying index's excess return and calculated as follows:

$$IndexER_t = IndexER_{t-1} * \left(1 + \left(K * \left(\frac{UnderlyingIndexER_t}{UnderlyingIndexER_{t-1}} - 1\right)\right)\right)$$

where:

K ($K \neq 0$) = Leverage/Inverse Ratio

- $K = 1$, no leverage
- $K = 2$, leverage exposure = 200%
- $K = 3$, leverage exposure = 300%
- $K = -1$, inverse exposure = -100%

A total return version of each of the indices is calculated, which includes interest accrual on the notional value of the index based on a specified interest rate (e.g. 91-day U.S. Treasury rate), as follows:

$$IndexTR_t = IndexTR_{t-1} * \left(\left(\frac{IndexER_t}{IndexER_{t-1}}\right) + TBR_t\right) \tag{6}$$

where:

$IndexTR_{t-1}$ = The Index Total Return on the preceding business day

TBR_t = Treasury Bill Return, as determined by the following formula:

$$TBR_t = \left[\frac{1}{1 - \frac{91}{360} * TBAR_{t-1}}\right]^{\frac{Delta_t}{91}} - 1 \tag{7}$$

$Delta_t$ = The number of calendar days between the current and previous business days

$$TBAR_{t-1} = \text{The most recent weekly high discount rate for 91-day U.S. Treasury bills effective on the preceding business day}^{23}$$

Periodically Rebalanced Leverage or Inverse Futures Indices

If the S&P Dow Jones Indices futures-based leveraged or inverse index is rebalanced periodically (e.g. weekly, monthly, or quarterly), the index excess return is the multiple of the underlying index excess return since last rebalancing business day and shall be calculated as follows:

$$IndexER_t = IndexER_{t\_LR} * \left(1 + \left(K * \left(\frac{UnderlyingIndexER_t}{UnderlyingIndexER_{t\_LR}} - 1\right)\right)\right)$$

where:

$IndexER_{t\_LR}$ = The Index Excess Return on the last rebalancing business day, t_LR

$UnderlyingIndexER_{t\_LR}$ = The Underlying Index Excess Return value on the last rebalancing business day, t_LR

t_LR = The last rebalancing business day

K ($K \neq 0$) = Leverage / Inverse Ratio

- K = 1, no leverage
- K = 2, leverage exposure = 200%
- K = 3, leverage exposure = 300%
- K = -1, inverse exposure = -100%

A total return version of each of the indices is calculated, which includes interest accrual on the notional value of the index based on the 91-day U.S. Treasury rate. The formulae are the same as (6) and (7) above.

Negative Index Levels. For more information regarding the possibility of negative or zero index levels, refer to Negative/Zero Index Levels section later in this document.

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[23] Generally, the rates are announced by the U.S. Treasury on each Monday. On Mondays that are bank holidays, Friday's rates apply.

Fee Indices/Decrement Indices

S&P DJI calculates fee indices that are meant to alter the index value of a given underlying index according to a fixed percentage rate or fixed index points that is applied on a daily basis. This alteration can be either positive or negative. Fee indices are often also described as Decrement Indices. Decrement Indices measure the performance of an underlying index with a reduction to the return of the index representing a fixed, pre-determined synthetic dividend amount.

Fee indices can be calculated in a number of ways. The fee can be applied to the index after the return of the underlying index is calculated, or it can be applied along with the return of the underlying index. The different calculations are as follows:

Fixed Percentage Fee Reduction. A fixed percentage fee reduction multiplies the index level by a daily portion of an annual fee with no regard for day counts. The formula is as follows:

$$IndexValue_t = IndexValue_{t-1} \times \frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} \times \left(1 - \frac{Fee}{N}\right)$$

where:

$IndexValue_t$	=	The fee reduced index value on day t
$IndexValue_{t-1}$	=	The fee reduced index value on day t-1
$ParentIndexValue_t$	=	The index value of the parent index without fees on day t
$ParentIndexValue_{t-1}$	=	The index value of the parent index without fees on day t-1
Fee	=	The annual fee percentage
N	=	The number of days in a year

Standard Fee Reduction from the Base Date. A standard fee reduction from the base date multiplies the index level by a pro-rated fee accounting for time since the base date. The formula is as follows:

$$IndexValue_t = IndexValue_0 \times \frac{ParentIndexValue_t}{ParentIndexValue_0} \times \left(1 - \frac{Fee}{N} \times ACT(t, t_0)\right)$$

where:

$IndexValue_t$	=	The fee reduced index value on day t
$IndexValue_0$	=	The fee reduced index value on the base date
$ParentIndexValue_t$	=	The index value of the parent index without fees on day t
$ParentIndexValue_0$	=	The index value of the parent index without fees on the base date
Fee	=	The annual fee percentage
N	=	The number of days in a year
$ACT(t,t_0)$	=	The actual calendar days between day t (exclusive) and the base date (inclusive)

Standard Fee Reduction. A standard fee reduction multiplies the index level by a daily fee pro-rated to account for non-calculation days (including weekends and holidays). The formula is as follows:

$$IndexValue_t = IndexValue_{t-1} \times \frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} \times \left(1 - \frac{Fee}{N} \times ACT(t, t-1)\right)$$

where:

IndexValue$_t$	=	The fee reduced index value on day *t*
IndexValue$_{t-1}$	=	The fee reduced index value on day *t-1*
ParentIndexValue$_t$	=	The index value of the parent index without fees on day *t*
ParentIndexValue$_{t-1}$	=	The index value of the parent index without fees on day *t-1*
Fee	=	The annual fee percentage
N	=	The number of days in a year
ACT(t,t-1)	=	The actual calendar days between day *t* (exclusive) and day *t-1* (inclusive)

Exponentially Compounding Fee Reduction. An exponentially compounding fee reduction multiplies the index level by a daily fee exponentially pro-rated to account for non-calculation days (including weekends and holidays). The formula is as follows:

$$IndexValue_t = IndexValue_{t-1} \times \frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} \times \left(\left(1 - \frac{Fee}{N}\right)^{ACT(t, t-1)}\right)$$

where:

IndexValue$_t$	=	The fee reduced index value on day *t*
IndexValue$_{t-1}$	=	The fee reduced index value on day *t-1*
ParentIndexValue$_t$	=	The index value of the parent index without fees on day *t*
ParentIndexValue$_{t-1}$	=	The index value of the parent index without fees on day *t-1*
Fee	=	The annual fee percentage
N	=	The number of days in a year
ACT(t,t-1)	=	The actual calendar days between day *t* (exclusive) and day *t-1* (inclusive)

Standard Synthetic Dividend. A standard synthetic dividend multiplies the parent index level by an exponentially pro-rated fee accounting for time since the base date. This fee reduction is a function of the parent index value and necessarily requires the same base value. The formula is as follows:

$$IndexValue_t = ParentIndexValue_t \times \left(\left(1 - \frac{Fee}{N}\right)^{ACT(t, t_0)}\right)$$

where:

IndexValue$_t$	=	The fee reduced index value on day *t*
ParentIndexValue$_t$	=	The index value of the parent index without fees on day *t*
Fee	=	The annual fee percentage
N	=	The number of days in a year
ACT(t,t$_0$)	=	The actual calendar days between day *t* (exclusive) and the base date (inclusive)

Standard Fee Subtracted from Return. The standard fee subtracted from return is a fee reduction that subtracts the fee from the return instead of multiplying the accumulated index level by (1 − *Fee*). The formula is as follows:

$$IndexValue_t = IndexValue_{t-1} \times \left(\frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} - \frac{Fee}{N} \times ACT(t, t-1) \right)$$

where:

IndexValue$_t$	=	The fee reduced index value on day *t*
IndexValue$_{t-1}$	=	The fee reduced index value on day *t-1*
ParentIndexValue$_t$	=	The index value of the parent index without fees on day *t*
ParentIndexValue$_{t-1}$	=	The index value of the parent index without fees on day *t-1*
Fee	=	The annual fee percentage
N	=	The number of days in a year
ACT(t,t-1)	=	The actual calendar days between day *t* (exclusive) and day *t-1* (inclusive)

Fixed Index Point Subtracted from Return. The fixed index point subtracted from return is a fee reduction that subtracts the fee represented as a constant number of index points. The formula is as follows:

$$IndexValue_t = IndexValue_{t-1} \times \frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} - \frac{Fee}{N} \times ACT(t, t-1) \times IndexValue_0$$

where:

IndexValue$_t$	=	The fee reduced index value on day *t*
IndexValue$_{t-1}$	=	The fee reduced index value on day *t-1*
ParentIndexValue$_t$	=	The index value of the parent index without fees on day *t*
ParentIndexValue$_{t-1}$	=	The index value of the parent index without fees on day *t-1*
Fee	=	Percentage of fee reduced index base value corresponding to specified number of index points
N	=	The number of days in a year
ACT(t,t-1)	=	The actual calendar days between day *t* (exclusive) and day *t-1* (inclusive)
IndexValue$_0$	=	The fee reduced index value on the base date

Net of Repo Rate Decrement Indices. Net of Repo Rate Decrement Indices apply an additional variable performance deduction atop a standard fixed percentage or fixed index points decrement index. The modification to the fixed decrement is based on the quoted spread of a specified Total Return Futures (TRF) contract, which represents the implied equity repo rate.

The additional decrement modification is established once per year at the contract expiry based on the ASK value of the TRF with the corresponding maturity of the subsequent year. The additional decrement modification amount is deducted on a daily basis throughout the following 12-month period.

The formula for Standard Fee and Fixed Index Point Subtracted from Returns are as follows:

Standard Fee Subtracted from Return:

$$IndexValue_t = IndexValue_{t-1} \times \left(\frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} - \frac{\left(Fee + TRF_{(r)}\right)}{N} \times ACT(t, t-1) \right)$$

Fixed Index Point Subtracted from Return:

$$IndexValue_t = IndexValue_{t-1} \times \left(\frac{ParentIndexValue_t}{ParentIndexValue_{t-1}} - \frac{\left(TRF_{(r)}\right)}{N} \times ACT(t, t-1) \right) - \frac{Fee}{N} \times ACT(t, t-1) \times IndexValue_0$$

For index specific parameters, please refer to S&P Dow Jones Decrement Indices Parameters document, available at www.spglobal/spdji.com.

Negative/Zero Index Levels. For more information regarding the possibility of negative or zero index levels, please refer to the *Negative/Zero Index Levels* section.

Capped Return Indices

In a capped return index, the index return from the prior rebalancing is capped at a pre-defined level. The overall approach is to first calculate an uncapped index and then compare its return-since-last-rebalancing-day with the return cap. The capped index return takes the smaller value of these two. The approach can be expressed mathematically as:

$$Index\ Level_t = Index\ Level_{LR} * \left(1 + \min\left(ReturnCap, \frac{Uncapped\ Index\ Level_t}{Uncapped\ Index\ Level_{LR}}\right)\right)$$

where:

$index\ level_t$ = Index level at date t

$index\ level_{LR}$ = Index level at the last rebalancing business day

$ReturnCap$ = Cap on the index return between rebalance dates

Dividend Point Indices

S&P Dow Jones Indices' Dividend Point Indices are designed to track the total dividend payments from the constituents of an underlying index. The level of the index is based on a running total of dividends of the constituents of the underlying index. Some indices reset to zero on a periodic basis, generally quarterly or annually. Thus, the index measures the total dividends paid in the underlying index since the previous rebalancing date, or the base date for indices that do not reset on a periodic basis. For quarterly indices, the index resets to zero after the close on the third Friday of the last month of the quarter, to coincide with futures and options expiration. For annual indices, the index resets to zero after the close on the third Friday of December, to coincide with futures and options expiration.

The formula for calculating the dividend point index on any date, *t,* for a given underlying index, *x,* is:

$$DividendIndex_{t,x} = \sum_{i=r+1}^{t} ID_{i,x}$$

where:

> $ID_{i,x}$ = The index dividend of the underlying index *x* on day *i*.
>
> *t*   = The current date.
>
> *r+1* = The trading date immediately following the reset date of the index (or base date if the index does not reset periodically).

The index dividend (*ID*) of the underlying index is calculated on any given day as the total dividend value for all constituents of the index divided by the index divisor. The total dividend value is calculated as the sum of dividends per share multiplied by index shares outstanding for all constituents of the index which have a dividend going ex on the date in question. For more detail concerning the calculation of index dividends please refer to the *Total Return Calculations* section of this methodology.

Alternative Pricing

S&P DJI Indices uses alternative pricing for the calculation and publication of certain indices and data points. Alternative pricing is applied to indices using the approaches outlined below. Details of the pricing type and application of the pricing for index calculation purposes is indicated in the specific index methodology.

1. Official Calculation: The daily official index calculation always leverages the alternative price methodology.

2. Hybrid Calculation: The alternative price is used in certain instances when calculating the official index value (e.g. VWAP pricing used for official daily index calculation on the rebalance implementation while the official close is used for all non-rebalance date calculations)

3. Supplementary Calculation: A supplementary calculation of the index is performed with the alternative price and is published alongside the official closing calculation (e.g. Special Open Quotation).

Alternative pricing may be captured through vendors or calculated internally by S&P DJI. The formulas defined in this section are specific to internally calculated alternative pricing. This approach is more commonly applied to derivative based indices calculated by S&P DJI. S&P DJI leverages exchange provided prices for official end-of-day index calculations. For each exchange, S&P Dow Jones Indices will use the relevant price (e.g. last trade, auction, VWAP, official close) as defined in the S&P Dow Jones Indices' Global Equity Close Prices guide available on https://us.spindices.com/.

Special Opening Quotation (SOQ)

The special opening quotation ("SOQ") is calculated using the same methodology as the underlying index except that the price used for each index constituent is the open price at which the security first trades upon the opening of the exchange on a given trading day. SOQ is calculated using only the opening prices from the primary exchange, which occur at various times, of all stocks in the index and may occur at any point during the day. For any stock that has not traded during the regular trading session, the previous day's closing price is used for the SOQ index calculation. SOQ may be higher than the high, lower than the low and different from the open, as the SOQ is a special calculation with a specific set of parameters. The open, high, low and close values are continuous calculations, while the SOQ waits until all stocks in the index are open.

- **U.S. Markets.** In the case of a market disruption and if the exchange is unable to provide official opening prices, the official closing prices utilized are determined based on SEC Rule 123C as outlined in the *Unexpected Exchange Closures* chapter of *S&P Dow Jones Indices' Equity Indices Policies and Practices document*.

- **Non-U.S. Markets.** In the case of a market disruption and if the exchange is unable to provide official opening prices, the official closing prices are utilized. If the exchange is unable to provide official opening or closing prices, the previous closing price adjusted for corporate actions is used in the calculation of the SOQ.

For M&A target stocks that are suspended or halted from trading on an exchange but are still in indices, S&P Dow Jones Indices will synthetically derive an SOQ for the suspended security using the deal ratio terms and the opening price of the acquiring company if the acquirer is issuing stock as part of the merger. If the acquirer is paying cash only, the lower of the previous official close price and the cash amount are used in the calculation of the SOQ. Similarly, S&P DJI will synthetically derive an SOQ for spun-off stocks that have not yet begun trading.

Fair Value Indices

Fair Value indices are designed to provide an updated valuation for indices that have ceased calculating earlier in a given day. The indices are calculated using fair value adjustment factors applied on a stock by stock basis to each stock in the index. The factors are provided by a pricing service which calculates fair value adjustments. There may be multiple fair value indices for a given underlying index, due to the use of different pricing services for each particular index. S&P Dow Jones currently has indices using ICE Data Services (ICE) and Virtu Financial, Inc. (formerly provided by ITG).

For all stocks in the index the constituents, prices and index shares effective as of the following trading date (i.e. the adjusted close data for today) of the relevant underlying index are taken. The price for each stock is multiplied by the fair value adjustment for that stock to arrive at a fair value price. The index is then calculated in the same fashion as the underlying index, using the same index shares and index divisor as the underlying index. Note that the value of a fair value index on a given day, unlike other indices, is not dependent on the value of that fair value index on the prior day. Rather it is only dependent on the value of the relevant underlying index and on today's fair value adjustments.

Volume-Weighted Average Price (VWAP)

Some indices will use VWAP in a specified time window, instead of reported closing values.

Volume Weighted Pricing uses a weighted average price instead of a single closing value. Prices with bigger trading volumes are assigned higher weights. VWAP is calculated by multiplying the price of trades by their volume, summing that for the applicable time window, and then dividing by the total volume of trades within that time window, as calculated below:

$$VWAP_{i,t} = \frac{\sum_{j=1}^{N} TradeVolume_{i,j} \times TradePrice_{i,j}}{\sum_{j=1}^{N} TradeVolume_{i,j}}$$

where:

$VWAP_{i,t}$	= the VWAP for security i on day t over the VWAP observation window
N	= the number of trades in the VWAP observation window
$TradeVolume_{i,j}$	= the volume of trade j
$TradePrice_{i,j}$	= the price of trade j

Time-Weighted Average Price (TWAP)

TWAP indicates the Average Price, or Bid Price or Ask Price, that a security is traded at during a specified time window, rather than its end of day price.

TWAP is calculated by taking a simple average of various snapshots of the price throughout the time window, written formulaically below:

$$TWAP_{i,t} = \frac{\sum_{j=1}^{N} TradePrice_{i,j}}{N}$$

where:

$TWAP_{i,t}$	= the TWAP for security i on day t over the TWAP observation window
N	= the number of trades in the TWAP observation window
$TradePrice_{i,j}$	= the price of trade j

Negative/Zero Index Levels

A negative index level is possible for certain types of indices including hedged, decrement, leveraged, and inverse indices, particularly for inverse indices that apply leverage.

- For indices calculated in real-time, in the event an intraday index calculation results in a zero or negative value, S&P DJI will publish the zero or negative value as calculated.

- In the event an end-of-day index calculation results in a zero or negative value, S&P DJI will publish an official closing index value of zero on that day. Index levels will only be assessed after the close of trading for purposes of this determination and will not take into consideration intraday levels for those indices calculated in real-time.

Any index assigned a level of zero will be reviewed by the Index Committee to determine if the index will be discontinued or the index will be restarted with a new base value. In the event the index is restarted, S&P DJI will announce such action and will treat these indices as two separate series. Until the Index Committee has made this determination, the index level will continue to be published with a value of zero.

Index Turnover

Index turnover is a measure of weight changes to an index resulting from corporate events or rebalancing of an index. Weight changes resulting from market value changes due to market driven price increases or decreases are not accounted for in an index turnover calculation. All turnover figures provided by S&P Dow Jones Indices are one-way turnover figures. One-way turnover only views turnover from the perspective of either buying or selling assets. One-way turnover is therefore limited to a maximum amount of 100% which would be equivalent to the deletion of all current index constituents or the addition of all new constituents. To differentiate between a one-way and two-way turnover approach, a two-way turnover approach would reflect both the buying and selling of assets. Two-way index turnover would be 200% in the above scenario. A formula of index turnover is provided below. All turnover calculations are provided by S&P Dow Jones Indices upon request.

$$Index\ Turnover = \frac{\sum_i Constituent\ Weight\ Change}{2}$$

$$Constituent\ Weight\ Change = |Constituent\ Weight\ CLS - Constituent\ Weight\ ADJ|$$

where:

Constituent Weight CLS = Weight of constituent as of the close of business on day T.

Constituent Weight ADJ = Weight of constituent prior to the open on day T+1. This weight will reflect any adjustments due to corporate events or rebalancing. If the index had no corporate events or rebalancing, the Constituent Weight CLS will be equal to Constituent Weight ADJ.

End-of-Month Global Fundamental Data

The purpose of this section is to give an overview of the End-of-Month ("EOM") Global Fundamental Data filings. This section outlines the file types along with their descriptions, general data information, and formulas used to calculate the ratios present in these data files. EOM fundamentals do not include the U.S. Fundamental Data Package.

Global EOM Fundamental Data is disseminated via the following files:

Frequency	File Type	File Name	File Name Extension
Monthly	Index Level	yyyyMMdd_SPTOURUP_EOM.SDL	.SDL
Monthly	Constituent Level	yyyyMMdd_SPTOURUP_EOM.SDC	.SDC

Monthly Files

File Extensions. The following table details the file extensions:

File Extension	Description
EOM.SDL	End-of-Month S&P Dow Jones Indices Index Level Files
EOM.SDC	End-of-Month S&P Dow Jones Indices Constituent Level Files

File Delivery. Monthly files are delivered to clients by the third business day of the following month. For example, the file 20171031_SPTOURUP_EOM.SDL is delivered to clients no later than November 3, 2017. Files are generated for the last trading day of the month. Therefore, the file name reflects the last trading day (e.g. October 31, 2017) as shown above.

The EOM.SDL file format details are available in the UFF 2.0 Specifications document available *here*.

About the Data

For calculation of the Global EOM Fundamental Data values, S&P Dow Jones Indices obtains raw data from multiple vendors as of the 25th of every month. The raw data is then validated and used in the calculation of the ratios listed below.

S&P Dow Jones Indices has 10 Index Level Ratios which are reflected in EOM.SDL files:

Ratio[24]	Description	Period
FY0 P/E	Latest reported fiscal year's price-to-earnings ratio	Latest reported fiscal year
1 YR FWD P/E	One year forward (estimated) price-to-earnings ratio	Latest reported fiscal year + one year
2 YR FWD P/E	Two year forward (estimated) price-to-earnings ratio	Latest reported fiscal year + two years
12 MO TRAILING P/E	12-month trailing price-to-earnings ratio	12-month trailing
P/BV	Latest reported fiscal year's price-to-book value ratio	Latest reported fiscal year
P/CF	Latest reported fiscal year's price-to-cash flow ratio	Latest reported fiscal year
P/S	Latest reported fiscal year's price-to-sales ratio	Latest reported fiscal year
ROE	Latest reported fiscal year's return on equity	Latest reported fiscal year
DIV YLD	Dividend yield using reported dividend	As per latest reported
IND YLD	Indicated yield using forward looking dividend	As per latest reported

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[24] Name as per file.

S&P Dow Jones Indices has five Constituent Level Ratios which are reflected in EOM.SDC files:

Ratio[25]	Description	Period
PRICE-EARNINGS RATIO (P/E)	12-month trailing price-to-earnings ratio	12-month trailing
PRICE-BOOK VALUE RATIO (P/BV)	Latest reported fiscal year's price-to-book value ratio	Latest reported fiscal year
P/CF	Latest reported fiscal year's price-to-cash flow ratio	Latest reported fiscal year
PRICE/SALES	Latest reported fiscal year's price-to-sales ratio	Latest reported fiscal year
IND YLD	Indicated yield using forward looking dividend	As per latest reported

Output Files

The file naming convention, templates, and field specifications are described below.

There are five EOM file templates included in the Global Fundamental Data Package:

- EOM.SDL – End-of-month index level file

- EOM.SDC – End-of-month constituent level file

    o NC_EOM.SDC – End-of-month Constituent file (No Cusip)

    o NS_EOM.SDC – End-of-month Constituent file (No Sedol)

    o NCS_EOM.SDC – End-of-month Constituent file (No Cusip or Sedol)

Fundamental Data Points

Underlying data point values used for fundamental index level ratio calculations are described below: [26]

1. **Basic EPS − Continuing Operations (FY0).** This is a given company's basic earnings-per-share excluding extra items for the latest reported fiscal year and is calculated as:

   Basic EPS – Continuing Operations (FY0) = (Net Income − Preferred Dividend and Other Adjustments − Earnings of Discontinued Operations − Extraordinary Item & Accounting Change) / Weighted Average Basic Shares Outstanding

2. **Basic Weighted Average Shares Outstanding (FY0).** This is a given company's basic weighted average shares outstanding for the latest reported fiscal year.

3. **Estimate EPS (FY1).** This is a given company's one year forward estimated earnings-per-share and represents the aggregated mean of all latest reported fiscal year plus one year estimates provided by third-party vendor analysts.

4. **Estimate EPS (FY2).** This is a given company's two year forward estimated earnings-per-share and represents the aggregated mean of all latest reported fiscal year plus two year estimates provided by third-party vendor analysts.

5. **Basic EPS − Continuing Operations (LTM).** This is a given company's basic earnings-per-share excluding extra items over the last 12 months and is calculated as:

   Basic EPS – Continuing Operations (LTM) = (Net Income − Preferred Dividend and Other Adjustments − Earnings of Discontinued Operations − Extraordinary Item & Accounting Change) / Weighted Average Basic Shares Outstanding

6. **Basic Weighted Average Shares Outstanding (LTM).** This is a given company's basic weighted average shares outstanding over the last 12 months.

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[25] Name as per file.
[26] All stocks with ADRs are adjusted per the depository receipt ratio except for EPS and Dividend data points.

7. **Total Common Equity (FY0).** This is a given company's total common equity for the latest reported fiscal year and is calculated as:

> *Total Common Equity (FY0) = Common Stock & APIC + Retained Earnings + Treasury Stock & Other.*

8. **Cash from Operations (FY0).** This is the given company's cash from operations for the latest reported fiscal year and is calculated as:

> *Cash from Operations (FY0) = Net Income + Depreciation and Amortization, Total + Amortization of Deferred Charges, Total − (CF) + Other Non-Cash Items, Total + Change in Net Operating Assets*

9. **Total Revenue (FY0).** This is the given company's total revenue for the latest reported fiscal year and is calculated as:

> *Total Revenue (FY0) = Revenue + Other Revenue*

10. **Shares Outstanding.** This is the given company's shares outstanding and provides total company level shares, as reported by stock exchanges, company press releases, and financial documents. Treasury shares are excluded and the number is adjusted for corporate actions such as splits, merger related share issuances, rights offerings, etc.

11. **Indicated Annualized Dividend.** This is the given company's latest annualized dividend per share. It is a forward looking number and is calculated by multiplying the latest dividend paid per share by the number of dividend payments per year.

Calculations

Monthly calculation of the fundamental data for a given index is done as of the last calendar day of the month.[27]

Terminology. Various terms are used in the calculations below and are defined as follows:

- **AWF.** The Additional Weight Factor (AWF) is the adjustment factor of a stock assigned at each index rebalancing date which adjusts the market capitalization for all index constituents to achieve the user-defined weight, while maintaining the total market value of the overall index.

- **IWF.** A stock's Investable Weight Factor (IWF) is based on its free float. Free float can be defined as the percentage of each company's shares that are freely available for trading in the market. For further details, please refer to *S&P Dow Jones Indices' Float Adjustment Methodology*.

- **SO.** The shares outstanding of a company.

- **Style.** For details, please refer to the S&P U.S. Style Indices Methodology available here.

Index Level Ratios. The formulas below are used to calculate index level ratios:[28]

1. **FY0 P/E**

$$Normalized\ Per\ Share\ Data = \frac{Basic\ EPS\ Excl\ (FY0) * Basic\ Weight\ Avg\ SO\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Normalized\ Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ Price\ to\ Earnings = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ Data\ Value}$$

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[27] The calculation of fundamental ratios is done based on the index's current composition as of the date of the fundamental ratio calculation.

[28] With the exception of Dividend Yield and Indicated Dividend Yield, any stock which does not have an underlying value is excluded from the index level calculation.

2. **1 YR FWRD P/E**

$$Normalized\ Per\ Share\ Data = \frac{Estimate\ EPS\ FY1 * Sharesoutstanding * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Normalized\ Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ 1yr\ Fwrd\ Price\ to\ Earnings = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ Data\ Value}$$

3. **2 YR FWRD P/E**

$$Normalized\ Per\ Share\ Data = \frac{Estimate\ EPS\ FY2 * Sharesoutstanding * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Normalized\ Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ 2yr\ Fwrd\ Price\ to\ Earnings = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ Data\ Value}$$

4. **12 Month Trailing P/E**

$$Normalized\ Per\ Share\ Data = \frac{Basic\ EPS\ Excl\ (LTM) * Basic\ Weight\ Avg\ SO\ (LTM) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Normalized\ Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ 12\ Month\ trailing\ Price\ to\ Earnings = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ Data\ Value}$$

5. **Price-Book Value (FY0)**

$$Per\ Share\ Data = \frac{Total\ Common\ Equity\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ Price\ to\ Book\ Value = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ DataValue}$$

6. **Price-Cash Flow (FY0)**

$$Per\ Share\ Data = \frac{Cash\ from\ Operations\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ Price\ to\ Cash\ Flow = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ DataValue}$$

7. **Price to Sales (FY0)**

$$Per\ Share\ Data = \frac{Total\ Revenue\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Value = Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ Price\ to\ Sales = \frac{\sum_i Index\ Market\ Cap}{\sum_i Float\ Adjusted\ Data\ Value}$$

8. **Return on Equity**

$$Normalized\ Per\ Share\ Data = \frac{Basic\ EPS\ Excl\ (FY0) * Basic\ Weight\ Avg\ SO\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Earnings = Normalized\ Per\ Share\ Data\ * SO * IWF * FXRate * AWF * Style$$

$$Per\ Share\ Data = \frac{Total\ Common\ Equity\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Book\ Value = Per\ Share\ Data * SO * IWF * FXRate * AWF * Style$$

$$Index\ ROE = \frac{\sum_i Float\ Adjusted\ Earnings}{\sum_i Float\ Adjusted\ Book\ Value}$$

9. **Dividend Yield**

$$Index\ Dividend = \sum_i (Dividend\ of\ a\ stock * Index\ Shares\ of\ a\ stock)$$

$$Price\ Index\ Value = The\ closing\ index\ value\ of\ a\ given\ stock$$

$$DIV\ YLD = \frac{Total\ Index\ Dividend}{Price\ Index\ Value}\ X\ 100$$

10. **Indicated Yield (IND YLD)**

$$Float\ Adjusted\ Data = Indicated\ Annual\ Dividend\ Per\ Share * SO * IWF * FXRate * AWF * Style$$

$$Index\ Indicated\ Yield = \left(\frac{\sum_i Float\ Adjusted\ Data * Dilution\ Factor}{\sum_i Index\ Market\ Cap}\right) * 100$$

Constituent Level Ratios. The formulas below are used to calculate constituent level ratios:

1. **Price-Earnings Ratio (P/E)**

$$Normalized\ Per\ Share\ Data\ Item =$$
$$\frac{Basic\ EPS\ Excl\ (LTM) * Basic\ Weight\ Avg\ SO\ (LTM) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$P/E = \frac{Close\ Price}{Normalized\ Per\ Share\ Data\ Item\ Value}$$

2. **Price-Book Value Ratio (P/BV)**

$$Per\ Share\ Data\ Item\ Value = \frac{Total\ Common\ Equity(FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Item = Per\ Share\ Data\ Item\ Value * SO * IWF * FXRate * AWF * Style$$

$$Price\ to\ Book\ Value = \frac{Constituent\ Index\ Market\ Cap}{Float\ Adjusted\ Data\ Item\ Value}$$

3. **Price-Cash Flow (P/CF)**

$$Per\ Share\ Data\ Item\ Value = \frac{Cash\ from\ operations\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Item = Per\ Share\ Data\ Item\ Value * SO * IWF * FXRate * AWF * Style$$

$$Price\ to\ Cash\ Flow = \frac{Constituent\ Index\ Market\ Cap}{Float\ Adjusted\ Data\ Item\ Value}$$

4. **Indicated Yield (IND YLD)**

$$Ind\ Yld = \left(\frac{Indicated\ Annual\ Dividend\ Per\ Share * Dilution\ Factor}{Close\ Price} \right) * 100$$

5. **Price to Sales**

$$Per\ Share\ Data\ Item\ Value = \frac{Total\ Revenue\ (FY0) * Multiclass\ factor * 1000000}{S\&P\ Shares\ Outstanding}$$

$$Float\ Adjusted\ Data\ Item = Per\ Share\ Data\ Item\ Value * SO * IWF * FXRate * AWF * Style$$

$$Price\ to\ Sales = \frac{Constituent\ Index\ Market\ Cap}{Float\ Adjusted\ Data\ Item\ Value}$$

Note: Company level data received from vendors is proportionally assigned to each class of stock. For example, Altice SA has two classes of stock (Altice SA A and Altice SA B). In order to proportionally assign company level data to each of these two stock classes, a multiclass factor is used and is determined as follows:

$$Multiclass\ factor\ of\ Stock\ A = \frac{Shares\ of\ stock\ A}{\sum_i Shares\ of\ stocks\ A\ and\ B}$$

$$Multiclass\ factor\ of\ Stock\ B = \frac{Shares\ of\ stock\ B}{\sum_i Shares\ of\ stocks\ A\ and\ B}$$

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