

# **S&P DJI Digital Assets Indices Policies & Practices and Index Mathematics *Methodology***

July 2023

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# Introduction

## Overview

The first section of this document outlines S&P Dow Jones Indices' (S&P DJI) policies and practices pertaining to digital assets indices, including digital asset event treatment, index applications, pricing guidelines, market disruptions, recalculations, and other policies outlined below. However, please note that if an index methodology specifies a different approach than the general approach stated within this document, the rules stated in the index methodology take precedence.

The second section of this document defines the mathematical calculations used in the digital asset indices and assumes some acquaintance with mathematical notation and operations. The calculations are presented principally as equations, which have largely been excluded from the individual index methodologies, but please note that if an index methodology specifies a different calculation approach than the general approach stated within this document, the rules stated in the index methodology take precedence.

*Please refer to the specific index methodology for further policies and procedures applicable to each index.*

# Additions and Deletions

Additions and deletions of digital asset constituents may occur for a number of reasons. Some types of digital asset events are described below, and they may or may not result in additions or deletions to digital asset indices depending on the index objective, index rules, and circumstances around a particular event.

**Hard Fork.** Hard fork assets can be significant in size and importance in the marketplace. In the case a fork creates two or more assets, the determination of which of the post-fork assets correspond to the original will follow the treatment applied by the majority of the exchanges in which the assets trade. If there is no clear agreement among the exchanges, the asset with the largest market capitalization will be considered the original asset. This original asset will inherit the historical prices and liquidity, and the other assets will be considered new coins.

The new asset(s) will initially be included in the index at a zero price. When S&P receives a price from its price provider, S&P will recognize the value of the asset in the index. Once it is determined which is the surviving asset for index purposes, S&P DJI will drop the non-surviving asset(s) with a divisor adjustment if it does not meet inclusion criteria. For index back-testing, only the surviving asset is included.

**Soft Fork.** Soft forks do not impact the indices. (see *Glossary*).

**Airdrop.** Airdrops require agency on the part of digital asset holders to claim and are generally reviewed for index inclusion at the subsequent index rebalancing.

**Staking Rewards.** The S&P Digital Asset Indices generally do not recognize staking rewards for index calculation purposes.

**Other Rewards.** Certain coins offer rewards that do not require action on the part of the holder. This will be evaluated on a case by case basis depending upon size.

**New Listings.** New digital assets that meet the index eligibility criteria, will be assessed for addition at rebalancing dates.

**Coin Burning.** Coin burning will adjust the effective coin supply at rebalancing.

**Delistings.** A digital asset is generally dropped from all the indices it is a constituent of on or around its expected delisting date. Digital assets removed from an index due to voluntary delisting or failure to meet listing requirements are removed at a zero price if no primary exchange price is available.

# Recalculation Policy

S&P DJI reserves the right to recalculate an index at its discretion in the event one of the following occurs:

- Incorrect or revised closing price of one or more constituent assets;
- Incorrect or revised descriptive data of one or more constituent assets;
- Missed or misapplied digital asset event;
- Late announcement of a digital asset event;
- Incorrect calculation or data entry error;
- Incorrect application of an index methodology, as described below in *Index Methodology Event*.

A general description of how S&P DJI handles such events is provided in the table below.

The decision to recalculate an index is made at the discretion of the applicable Index Manager and/or Index Committee, as set forth herein. The potential market impact or disruption resulting from a recalculation is considered when making any such decision.

In the event one of the following recalculation events is discovered within two trading days of its occurrence, generally the index is recalculated. In the event any such recalculation event is discovered beyond the two-trading-day period, the applicable Index Committee shall decide whether the index should be recalculated.

Recalculation Events	Treatment in S&P DJI' Digital Assets Indices
Closing Price	Incorrect constituent closing prices are generally corrected and reposted.
Missed or Misapplied Digital Asset Event	Missed or misapplied digital asset actions may be corrected & reposted.
Late Announcement of a Digital Asset Event	<p>Divisor Impact: Divisor-impacting information is corrected and reposted.</p> <p>No Divisor Impact: Late information, that does not impact the index divisor are applied at the earliest opportunity when S&amp;P DJI becomes aware of the event.</p> <p>Hard Forks are applied on the correct event date. If announced on the same day (either that this is taking place or that a previously announced event is being postponed or cancelled), the hard fork is applied on the correct event date and files are not reposted. Same day events are included in the current day files, so previous day files are not reposted. If these events are announced after the event date, then the Index Committee will review for potential impact and announce intended action accordingly.</p>
Incorrect Calculation or Data Entry Error	Incorrect calculations or data entry mistakes caused by S&P DJI are corrected and impacted indices are recalculated.

Clients are notified of index recalculations and files being reposted.

**Index Methodology Event.** The Index Committee shall determine whether or not to recalculate an index in the event an error is discovered by S&P DJI that was caused by the incorrect application of an index methodology and results in the incorrect composition and/or weighting of index constituents. The committee has final discretion but generally considers the following guidelines:

In the event the Index Committee discovers a constituent that does not meet index eligibility and selection criteria for a given index as documented in the index's methodology, and was therefore incorrectly added or retained in an index, or the constituent weightings in the index were incorrectly assigned, the Index Committee may decide to amend the constituents or weighting of the index in line with the index methodology proactively (as opposed to retroactively) on a future date, providing reasonable advance notice from the announcement date to the effective date. The Index Committee will generally not alter the index composition and/or weightings of constituents retroactively except in accordance with the following guidelines:

- The addition of a constituent that does not meet the index objective as defined in the index methodology (e.g., adding a digital asset that is deemed a privacy enhanced coin).
- The changes made differ from those that were announced by S&P DJI in advance of the effective date (e.g., pro-forma files).
- The change would result in greater than de minimis performance impact and is consistent with index usage.

If an incorrect application of the methodology for determining index composition or weighting is discovered after the action has been announced by S&P DJI, but prior to the effective date of the action, S&P DJI reserves the right to rescind the action and restate it using corrected data.

In the event S&P DJI chooses to recalculate an index, it shall do so within a reasonable timeframe following the detection and review of the issue. If it is determined that an index will be recalculated, the following steps will be taken upon completion of the recalculation:

All impacted files are regenerated and reposted.

All clients (i.e., S&P DJI-licensed entities) are notified of the recalculation and alerted when files have been successfully reposted.

S&P DJI calculates real-time (intraday) values for some of its indices. In the event there is an error with a real-time calculation or a restatement of end-of-day values for one of these indices, S&P DJI will not recalculate intraday values for the impacted time period.

Any decisions that differ from the stated rules will be reviewed by the Index Committee and announced accordingly.

# Index Governance

## Index Committee

An S&P Dow Jones Indices Index Committee maintains the indices. Most committees are comprised of full-time professional members of S&P Dow Jones Indices' staff, except for some co-branded indices, which may include committee members from external companies or exchanges. Please refer to individual index methodology documents for information on index committees with external index committee members. At each meeting, the Index Committee may review pending coin events that may affect index constituents, statistics comparing the composition of the indices to the market, digital assets that are being considered as candidates for addition to an index, and any significant market events. In addition, the Index Committee may revise index policy covering rules for selecting digital assets, number of coins associated with the index, or other matters.

Questions of interpretation or possible exceptions to rules are considered by the Index Committee responsible for the indices in question.

S&P DJI considers information about changes to its indices and related matters to be potentially market moving and material. Therefore, all Index Committee discussions are confidential.

S&P DJI's Index Committees reserve the right to make exceptions in the treatment if the need arises. In any scenario where the treatment differs from the general rules stated in this document, clients will receive notice, whenever reasonably possible.

## Quality Assurance

S&P DJI maintains quality assurance processes and procedures for the calculation and maintenance of its indices that include a regularly scheduled meeting to review incidents or errors, if any, that occurred during the previous week and identify causes, determine repetitive issues and evaluate whether any long-term changes are necessary (e.g., a change in process). Incidents and errors are tracked through S&P DJI's internal system and significant matters are escalated, requiring, at times, an ad hoc meeting of the same group.

## Internal Reviews of Methodology

**Annual Review Process.** In addition to its daily governance of indices and maintenance of index methodologies, at least once within any 12-month period, the Index Committee reviews each index methodology to ensure the indices continue to achieve the stated objectives, and that the data and methodology remain effective. The annual review process includes the gathering of information on the appropriateness, representativeness, and effectiveness of the index methodology from colleagues responsible for commercializing the indices. In the case that an index methodology is reviewed off cycle from the annual review, the Index Committee reserves the right to cancel the annual review if the requested review covers all the relevant issues.

**Communication with Stakeholders and Consultations.** S&P DJI communicates and consults with stakeholders through various channels using press releases, index announcements, emails and the distribution of data files. In addition, S&P DJI has a designated client service team available to respond to inquiries.

When a material change to an index methodology is considered, S&P DJI publishes a consultation inviting comments from external parties. A material change alters the index objective or changes the methodology in a way that affects the likelihood that the index will achieve its objective. Examples of



methodology changes that could impact the index objective include altering rules determining the index universe, the selection of its constituents, or the weighting of its constituents. Consultations are posted on the Web site at [www.spglobal.com/spdji/](http://www.spglobal.com/spdji/), and feedback is accepted only during the posted timeframe. Under normal circumstances, the consultation period is open for a minimum of 30 days from publication. In instances where a material change is deemed to be time sensitive, S&P DJI may determine that a shorter consultation period is required. Time sensitive changes are those that may require consideration or implementation within a shorter timeframe, and where the full consultation time period is not possible.

Prior to the Index Committee's final review, S&P DJI will consider the issues and may request clarifications from respondents as part of that review. All feedback from consultations is reviewed and considered before a final decision is made by the Index Committee. Any changes to an index methodology resulting from a consultation are announced on our web site.

Substantive changes to methodology documents not resulting from consultations will also be announced. S&P DJI will generally not issue an announcement for minor edits to methodology documents that it deems not substantive, such as clarifications and format edits that are not related to any kind of methodological change.

Occasionally, S&P DJI may hold client meetings, conference calls, or Advisory Panels.

**Complaints Procedure.** For any inquiry, comment, or complaint regarding the indices governed by this methodology, a Client Services Form can be found at <http://us.spindices.com/feedback/client-services>.

## **Expert Judgment**

S&P Dow Jones Indices' Index Committees may exercise Expert Judgment when the situation calls for the interpretation of data in calculating and maintaining an S&P DJI Index. S&P DJI maintains internal records of the use of Expert Judgment and the rationale for any such use. Expert Judgment specifically and exclusively refers to S&P DJI's exercise of discretion with respect to its use of data in determining an index in the following context: Expert Judgment includes extrapolating data from prior or related transactions, adjusting data for factors that might influence the quality of data such as market events or impairment of a buyer or seller's credit quality, or weighing firm bids or offers greater than a particular concluded transaction. Other areas of discretion, such as methodology changes, are not, for the purposes of this document, considered Expert Judgment.

## **Discretion**

S&P Dow Jones Indices' Index Committees reserve the right to make exceptions when applying the methodology if the need arises. In any scenario where the treatment differs from the general rules stated in this document or supplemental documents, clients will receive notice, whenever reasonably possible.

The Index Committee may apply discretion to make decisions that differ from the index methodology in certain circumstances that include the following: to avoid unnecessary turnover, excessive index changes or adjustments, and possible market disruption; to enhance/allow for index replicability; when strict application of the index rules results in inconsistency with the index objective.

The Index Committee reserves the right in its sole discretion to cease or suspend publication of an index and/or remove a digital asset that becomes subject to a legal, regulatory or practical concern (e.g., because the digital asset may be an unregistered security, allegations of trading manipulation, it potentially implicates US or other economic sanctions, inclusion of privacy features that may pose anti-money laundering concerns, the asset is subject to a hacking event) or due to potential market disruption.

## **Other**

Please note that users of S&P DJI's indices are solely responsible for ensuring such users' compliance with all applicable law (including, without limitation, sanctions laws and any other rules, regulations, or prohibitions) in connection with such use (including, without limitation, trading, investment, or other use).

# Index Policy

## Announcements

All index constituents are evaluated daily for data needed to calculate index levels and returns. All events affecting the daily index calculation are typically announced in advance via the Index Corporate Events report (.SDE), delivered daily to all clients. Any unusual treatment of a digital asset event or short notice of an event may be communicated via email to clients.

Announcements of additions and deletions for headline digital assets indices are generally made shortly after the S&P-determined end of day.

## Pro-forma Files

In addition to the corporate events file (.SDE), S&P DJI provides constituent pro-forma files for many indices at the time of rebalancing. The pro-forma file is typically provided daily in advance of the rebalancing date and contains all constituents and their corresponding weights and index shares effective for the upcoming rebalancing. Since index coins are assigned based on prices prior to the rebalancing, the actual weight of each index coin at the rebalancing will differ from these weights due to market movements.

Please visit [www.spglobal.com/spdji](http://www.spglobal.com/spdji) for a complete schedule of rebalancing timelines and pro-forma delivery times.

## Calculation Schedule

The indices calculate on all business days. If there is a market disruption, or with the data provider, the indices calculate based on the last available price.

A complete index holiday schedule for the year is available at [www.spglobal.com/spdji/](http://www.spglobal.com/spdji/).

## Special Index Variations

S&P DJI may calculate separate versions of S&P- or Dow Jones-branded indices which may be tailored in a variety of ways such as the exclusion of certain constituents or sectors, different rebalancing schedules, weighting schemes, currencies of calculation, or tax rates. In such cases, the index follows the methodology of the parent index except where otherwise noted.

## Child Indices

S&P DJI calculates and maintains a number of sub-indices ("Child Index" or "Child Indices") derived from a larger or broader index ("Parent Index" or "Parent Indices"). A Child Index provides a further breakdown of individual constituents within a Parent Index based on a specific attribute, such as a specific sector, country, or geographic region. The actual composition of each Child Index is a subset of the respective Parent Index, with the weights of the Child Index constituents relative to their weights in the Parent Index. Therefore, a change to a Parent Index's composition causes a simultaneous change to the composition of the relevant Child Index.

A Child Index can be viewed as a building block of the Parent Index, which helps users better understand the overall performance of the Parent Index. In certain cases, Child Indices range from broad, well diversified benchmarks to very narrow, concentrated baskets. S&P DJI may choose to publish these Child Indices for a variety of purposes including performance attribution.

Child Indices are eligible to be calculated and published each trading day in end-of-day files provided the current composition of the Parent Index includes the specific attribute. For example, if a particular digital asset type is not represented in the Parent Index on trading day (t), then no Child Index for that type is calculated and published by S&P DJI on trading day (t). However, if that type is represented within the Parent Index following a future rebalancing or reconstitution, S&P DJI will calculate and publish the applicable Child Index in end-of-day files.

As the constituents of a Parent Index change over time, there may be periods where an eligible Child Index is active or inactive, and is thereby added to or removed from end-of-day files. If a Child Index is added on trading day (t), the Child Index level is set to a predefined value (e.g., 100.00 or 1000.00) on trading day (t-1), and subsequently appears in end-of-day files on trading day (t). If a Child Index is removed, the relevant Child Index no longer appears in the end-of-day files but remains eligible for inclusion in the future. The calculation and publication of Child Indices is an automated process, dependent on whether the applicable attribute appears in the Parent Index; accordingly, S&P DJI does not provide advance notice on the addition to or removal of Child Indices from end-of-day files.

Measuring the performance of an index requires a continuous and uninterrupted time series. Each reactivation instance of a Child Index signifies a new time series, and any historical data prior to that reactivation date should be treated as a separate time series.

### **Calculations and Pricing Disruptions**

Depending on the index methodology, S&P DJI utilizes prices provided by external providers for end-of-day index calculations. In situations where this data, based on expert judgement, is incomplete or incorrect, S&P DJI will correct or amend this data.

Please refer to the *Recalculation Policy* section of this document.

In extreme circumstances, S&P DJI may decide to delay index adjustments or not publish an index.

### **Index Terminations**

S&P DJI may determine that an index should be discontinued. Reasons for an index termination can include:

- Fewer than the required number of digital assets are available for inclusion in an index
- An index duplicates another S&P DJI index
- Data required for an index is no longer available or no longer reliable
- Market conditions, regulations, or potential index constituents have changed, rendering the index unlikely to achieve its stated objective
- Declining investor use or interest

All proposals to discontinue an index are assessed to determine any potential impact on the market. S&P DJI may, at its discretion, consult with market participants regarding an index termination.

If the data on a discontinued index is provided to clients at the time of termination, S&P DJI may suggest possible appropriate alternative S&P DJI indices. Index terminations will be announced in advance, and vendors will be notified. Index levels and related data on a discontinued index are retained by S&P DJI.

If financial product issuers or investment managers choose to use an S&P DJI index, regardless of index family, as the basis of an index-linked financial product or an investment fund, they should consider the potential need to terminate or modify the terms of a financial product resulting from the termination of the calculation of the index.

Indices discontinued due to a lack of digital assets available may resume calculation if sufficient digital assets become eligible in the future.

# Index Mathematics

The following sections outline the general index calculations for the S&P Digital Asset Indices. The calculations presented here are principally as equations, which have largely been excluded from the individual index methodologies. Additionally, examples or tables of results are provided to help demonstrate the calculations.

# Different Varieties of Indices

S&P Dow Jones Indices' 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.

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

- Market Capitalization Weighted Indices:
  - Market-capitalization indices – where constituent weights are determined by market capitalization.
- Non-Market Capitalization Indices:
  - Equal weighted indices – where each constituent is weighted equally in the index.
  - Strategy Indices - where each constituent is weighted following a strategy that is different from market capitalization or equally weighted.

# Effective Coin Supply

To calculate S&P Digital Market Indices, two different concepts are introduced: **Coin Supply** and **Effective Coin Supply** (the number of coins used in index calculations).

Coin Supply ( $CS_{i,t}$ ), for digital asset  $i$  at time  $t$ , is the total number of coins created since inception. Coin Supply varies in real time, due to factors such as the mining process built in to the respective blockchain.

Since Coin Supply varies in real time, the total market value of a given digital asset also varies in real time. To calculate a market capitalization weighted index, the concept of Effective Coin Supply ( $ECS_{i,t}$ ) is introduced. Effective Coin Supply is determined every rebalancing reference date and set equal to Coin Supply at that point in time.

$$ECS_{i,t} = CS_{i,t}$$

In periods between rebalance reference dates the Effective Coin Supply does not change.

Rebalancing reference dates are the last calendar days of February, May, August, and November. Coin Supply is evaluated as of the S&P-determined end of that day to determine Effective Coin Supply.

On each index calculation day, the market capitalization (MC) represented in the index is then:

$$MC_{i,t} = ECS_{i,t} * P_{i,t}$$

where:

$P_{i,t}$  denotes the price of the digital asset  $i$  at time  $t$

# Index Divisor

The purpose of the index divisor is to maintain the continuity of an index level independently of non-price events that might change the composition of the underlying constituents.

At each point in time  $t$  an index has two values associated with it, the Market Value of the underlying constituents and the Index Level. The market value of the underlying constituents is calculated as:

$$MV_t = \sum_{i \in IS_t} IC_{i,t} * P_{i,t}$$

where

$IS_t$  = the set of constituents of the index

$IC_{i,t}$  = the nominal number of coins associated to the index for the constituent  $i$  at time  $t$

$P_{i,t}$  = denotes the price of the constituent  $i$  at time  $t$

The market value of an index can change for two reasons, in addition to a change in price of the underlying constituents. The reasons are:

- A change in the index constituents. Adding or dropping digital assets. This change could be due to an index reconstitution or to external factors as discontinuation of digital assets, airdrops, etc.
- A change in the nominal number of coins IC. This could be due to a reweight or reconstitution of the index or to a change in effective coin supply (ECS).

Within the divisor methodology the Index Level at time  $t$  is determined by:

$$Index\ Level_t = \frac{MV_t}{Divisor_t}$$

Where the divisor is calculated as follows:

At index base date ( $t = 0$ ), the divisor is initially fixed using the market value of the initial constituents and the base index level:

$$Divisor_0 = \frac{MV_0}{Index\ Level_0}$$

Subsequently, the divisor at any time  $t$  is equal to the divisor at time  $t-1$  unless there is a non-price event that modifies the market value of the index. Such events trigger a divisor adjustment, determined as follows:

$$Divisor_a = \frac{Divisor_b * MV_a}{MV_b}$$

The subscripts  $b$  and  $a$  indicate before and after accounting for the event, respectively, not necessarily of a different date or time. The calculation is as:

$$Index\ Level_a = \frac{MV_a}{Divisor_a} = \frac{MV_a}{\frac{Divisor_b * MV_a}{MV_b}} = \frac{MV_b}{Divisor_b} = Index\ Level_b$$

The index level depends on the following factors:

1. Index Level at  $t=0$ ,
2. Index Divisor (and its history),
3. Price of each digital asset (and its history),
4. Index Set of Constituents,
5. Index Coins per index constituent.

Items 4) and 5) constitute the index constituents. Therefore, to fix the index constituents at time  $t$ , it is necessary to fix the set of constituents  $IS_t$  and the nominal number of coins  $IC_{i,t}$  per constituent  $i$ .

The selection of index constituents is defined in each specific index methodology. The index number of coins  $IC_{i,t}$  determines the relative weight of each constituent in the index as follows:

$$w_{i,t} = \frac{IC_{i,t} * P_{i,t}}{MV_t}.$$

Index Coins are calculated on rebalancing reference dates or reconstitution reference dates following a schedule determined in the Index Methodology. Index Coins can also change for other events depending on the index type, for example a change in the investable weight factor in Market Capitalization-Weighted Indices.

Index coins will always satisfy the following:

$$IC_{i,t} = \frac{w_{i,t} * MV_t}{P_{i,t}}.$$

However, the  $IC_{i,t}$  is also part of the formula that determines  $MV_t$ . For this reason and to standardize the treatment of different weighting schemes we will decompose the  $IC_{i,t}$  into the effective coin supply and an adjustment weight factor called  $AWF_{i,t}$ ,

$$IC_{i,t} = AWF_{i,t} * ECS_{i,t}$$

As demonstrated in the following section, the adjustment weight factor,  $AWF_{i,t}$  can be understood as the under/overweight ratio relative to a market capitalization weighted index.



# Market Capitalization Weighted Indices

For market capitalization weighted indices, for each constituent  $i$  of the index number of coins  $IC_{i,t}$  is calculated by:

$$IC_{i,t} = ECS_{i,t}$$

Therefore,

$$AWF_{i,t} = 1$$

And

$$w_{i,t} = \frac{ECS_{i,t} * P_{i,t}}{MV_t} = \frac{MC_{i,t}}{MV_t}$$

For each constituent  $i$ .

# Strategy Weighted Indices

A strategy weighted index is calculated by:

$$IC_{i,t} = \frac{w_{i,t} * MVMC_t}{P_{i,t}}$$

where:

$MVMC_t$  = the market value of an index with the same constituent and market capitalization weighted.

That is:

$$MVMC_t = \sum_{i \in IS_t} ECS_{i,t} * P_{i,t}$$

In this type of index, the  $AWF_{i,t}$  is determined by:

$$AWF_{i,t} = \frac{w_{i,t} * MVMC_t}{ECS_{i,t} * P_{i,t}} = \frac{w_{i,t}}{wmc_{i,t}}$$

where:

$wmc_{i,t}$  = the weight of the constituent  $i$  in an index with the same constituent set but market capitalization weighted.

Therefore, the  $AWF_{i,t}$  can be interpreted as an under/overweight ratio relative to a market capitalization weighted index.

# Equal Weighted Indices

To calculate an equal weighted index with  $n$  constituents, for each constituent  $i$  the assigned weight to each constituent will be  $1/n$ .

$$IC_{i,t} = \frac{w_{i,t} * MVMC_t}{P_{i,t}} = \frac{1/n * MVMC_t}{P_{i,t}}$$

Therefore:

$$AWF_{i,t} = \frac{1/n * MVMC_t}{ECS_{i,t} * P_{i,t}} = \frac{1/n}{wmc_{i,t}}$$

## Negative/Zero Index Levels

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 Levels

Index levels calculate using the prices available at the specific S&P-determined “End of Day” for each S&P Digital Asset Index.

*For more information on an index’s specific End-of-Day calculation time, please refer to the index methodology.*

# 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.com/spdji](http://www.spglobal.com/spdji).

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

$$\text{Risk Control Index Return}_t = K_{rb} * \left( \frac{\text{Underlying Index}_t}{\text{Underlying Index}_{rb}} - 1 \right) + (1 - K_{rb}) * \left[ \prod_{i=rb+1}^t (1 + \text{InterestRate}_{i-1} * D_{i-1,i} / 360) - 1 \right] \quad (1)$$

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

$$\text{RiskControlIndexValue}_t = (\text{RiskControlIndexValue}_{rb}) * (1 + \text{RiskControlIndex Return}_t) \quad (2)$$

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

$$\text{Risk Control Index Value}_t = \text{Risk Control Index Value}_{rb} * \left[ 1 + \left[ K_{rb} * \left( \frac{\text{Underlying Index}_t}{\text{Underlying Index}_{rb}} - 1 \right) + (1 - K_{rb}) * \left[ \prod_{i=rb+1}^t (1 + \text{InterestRate}_{i-1} * D_{i-1,i} / 360) - 1 \right] \right] \right] \quad (3)$$

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

*Risk Control ER Index Value<sub>t</sub>* =

*RiskControl ER Index Value<sub>rb</sub>* \*

$$\left[ 1 + \left[ K_{rb} * \left( \frac{\text{UnderlyingIndex}_t}{\text{UnderlyingIndex}_{t-1}} - 1 \right) - K_{rb} * \left[ \prod_{i=rb+1}^t \left( 1 + \text{InterestRate}_{t-1} * \frac{D_{i-1,i}}{360} \right) - 1 \right] \right] \right]$$

where:

*UnderlyingIndex<sub>t</sub>* = The level of the underlying index on day *t*

*UnderlyingIndex<sub>rb</sub>* = The level of the underlying index as of the previous rebalancing date

*rb* = The last index rebalancing date<sup>1</sup>

*K<sub>rb</sub>* = The leverage factor set at the last rebalancing date, calculated as:

*Min(Max K, Target Volatility/Realized Volatility<sub>rb-d</sub>)*

*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<sub>rb</sub>*)

*Target Volatility* = The target level of volatility set for the index

*Realized Volatility<sub>rb-d</sub>* = 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<sub>i-1</sub>* = The interest rate set for the index<sup>2</sup>

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

$$\text{Risk Control Index Value}_{rb} * \left[ 1 + \left[ K_{rb} * \left( \frac{\text{Underlying Index}_t}{\text{Underlying Index}_{rb}} - 1 \right) + (1 - K_{rb}) * \left[ \prod_{i=rb+1}^t (1 + \text{InterestRate}_{i-1}) - 1 \right] \right] \right]$$

where:

$$\text{InterestRate}_{i-1} = (D_{i-1,t} * IR3M_{i-1} - (IR3M_{i-1} - IR3M_{i-2} - D_{i-1,t} * (IR3M_{i-1} - IR2M_{i-1}) * (\frac{1}{30})) * 90) / 360$$

where:

*D<sub>i-1, t</sub>* = The number of calendar days between day *i-1* and day *t*

*IR3M<sub>i-1</sub>* = Three-month interest rate on day *i-1*

*IR2M<sub>i-1</sub>* = Two-month interest rate on day *i-1*<sup>3</sup>

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<sub>rb</sub>* is calculated as follows:

<sup>1</sup> The inception date of each risk control index is considered the first rebalancing date of that index.

<sup>2</sup> 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.

<sup>3</sup> 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<sub>i-1</sub>* = One-month interest rate on day *i-1*.

$$K_{rb} = K_{rb-1} * \left( \frac{\text{Underlying Index}_{rb}}{\text{Underlying Index}_{rb-1}} \right) / \left( \frac{\text{RiskControlIndexValue}_{rb}}{\text{RiskControlIndexValue}_{rb-1}} \right)$$

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,  $K_b$  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:

$$K_t = \text{Min}(\text{Max } K, \text{Target Volatility/Realized Volatility}_{t-d})$$

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:

$$thK_t = \text{Min}(\text{Max } K, \frac{\text{Target Volatility}}{\text{Realized Volatility}_{t-d}})$$

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:

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

Then

$t$  is a rebalancing day, and

$$K_t = thK_t$$

Else

$t$  is not a rebalancing day

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

where:

$\theta$  = Minimum 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.

# Glossary

**ACTOR:** In the blockchain industry, any entity that is capable of participating in an action or a network.

**AIRDROP:** A distribution of a cryptocurrency token or coin, usually for free, to numerous wallet addresses. Airdrops are primarily implemented as a way of gaining attention and new followers, resulting in a larger user-base and a wider disbursement of coins. Airdrops aim to take advantage of network effect by engaging existing holders of a particular blockchain-based currency, such as Bitcoin or Ethereum in their currency or project.

**BLOCK:** A single section of discrete data. Blocks typically comprise a list of transactions or actions to be performed when processing the data in the block.

**BLOCKCHAIN:** A method of storing data in discrete sections (blocks) that are linked together. Blockchains specify criteria for what data can be stored in a block and reject invalid data. The submission of blocks to a decentralized blockchain is governed by its consensus mechanism.

**BLOCKCHAIN 1.0:** The generation of blockchain technology that focused on performing simple token transactions. Blockchain 1.0 chains have limited scope and ability but served to prove the fundamental technologies of blockchains and show that a market existed for those technologies. *Example:* Bitcoin was the first of the Blockchain 1.0 generation.

**BLOCKCHAIN 2.0:** The generation of blockchain technology that enabled smart contracts and generalized processing on chain. Blockchain 2.0 chains are typically built on Turing-complete programming languages and provide expanded capabilities beyond simple peer-to-peer (P2P) value exchange. *Example:* Ethereum was the first of the Blockchain 2.0 generation.

**BLOCKCHAIN 3.0:** The generation of blockchain technology that focuses on scalability and interoperability. This generation of blockchain typically enables the use of smart contracts. *Example:* Blockchain 3.0 chains are currently in early development with no front-runners as of yet. Two promising Blockchain 3.0 projects are SkyCoin and EOSIO.

**COIN SUPPLY:** The total number of coins mined since the inception of the coin. This number varies in real time, for example due to the mining process built in to update of the associated blockchain. Since the coin supply varies in real time, it is not fit to be used in the calculation of returns of coin or digital asset baskets.

**CONSENSUS:** In the blockchain industry, the process by which distinct sections of a network determine a single truth. Blockchain networks use consensus algorithms to establish agreement regarding which blocks are to be added to the chain and which nodes are valid.

**CRYPTOCURRENCY:** A Cryptocurrency is a digital asset designed to work as a medium of exchange that uses cryptography to secure its transactions, to control the creation of additional units, and to verify the transfer of assets.

**DECENTRALIZATION:** The movement of data, actions, and other interests away from a single actor in favor of distribution amongst all actors. In a decentralized system, no actor or group of actors can control the system without the consent of the rest of the actors.

**EFFECTIVE COIN SUPPLY:** The number of coins used in index calculations (as defined in *Effective Coin Supply* above)



**FORK:** In the blockchain industry, a unique network created using the same protocol or consensus as a previously existing network. (Forks can contain the original network's state or instantiate their own state.) Forks happen naturally when a blockchain network is not at 100% consensus and resolve when the network reaches consensus. Forks can also be forced by refusing to adhere to the consensus of the network.

**FORK, HARD:** A fork that is permanently incompatible with the original network. Hard forks typically change transaction data structures, consensus algorithms, or add/remove blocks that would not have otherwise been included. In effect, participants taking part in transactions on the old Blockchain must upgrade to the new one in order to continue validating transactions in the new Blockchain. However, participants that do not upgrade may continue to support and validate transactions on the old Blockchain protocol separately. The result: a Blockchain splits into two. *Examples:* Bitcoin Cash is a hard fork of Bitcoin, and Ethereum Classic is a hard fork of Ethereum.

**FORK, SOFT:** A fork that is compatible with the data on the original chain. Blocks created on the original chain after a soft fork would be valid on the forked chain; however, the reverse does not have to be true. *Example:* A protocol upgrade allows transactions to include an additional memo field where no field previously existed. These transactions would not have been valid on the previous version of the chain. However, transactions without that field are still valid formats in either version. When Ethereum upgraded to the Byzantium version, it was affected through a soft fork.

**GAS:** Refers to the fee, or pricing value, required to successfully conduct a transaction or execute a contract on the Ethereum blockchain platform. Priced in small fractions of the cryptocurrency ether, commonly referred to as gwei or sometimes nanoeth, the gas is used to allocate resources of the ethereum virtual machine (EVM) so that decentralized applications such as smart contracts can self-execute in a secured fashion. The exact price of the gas is determined by the network's miners, who can decline to process a transaction if the gas price does not meet their threshold. The concept of gas was introduced to keep a distinct value that solely indicates the consumption toward computational expenses on the Ethereum network. Having a separate unit allows maintaining a distinction between the actual valuation of the cryptocurrency, and the computational cost.

**GAS PRICE:** The number of tokens that will be charged as a fee for each unit of gas consumed by a smart contract's function. Gas prices allow a network to dynamically respond to changes in bandwidth demand based on market forces.

**MAINNET:** The largest blockchain network a specific protocol runs, or the most valuable chain as decided by the community. Mainnets are typically where real value is derived and represent the truest intent of the core developers.

**MINER:** A miner is an actor in a blockchain network that has the ability to create and submit new blocks to the chain. Which miner is allowed to produce a specific block may be predetermined, or miners may simultaneously compete to add the next block to the chain.

**NETWORK:** A set of actors collectively interconnected for a common purpose.

**NODE:** A participant in a blockchain network that is connected to peers and is capable of validating and propagating new blocks.

**NODE, FULL:** A node that has the complete state of the blockchain available.

**OPCODE:** A machine-level instruction for a processor. Opcodes are extremely basic commands, such as addition, multiplication, and bit shifting. Higher-level programs are compiled from human-readable instructions into opcodes before being sent to the processor.

**PRIVACY COIN:** A privacy coin is a cryptocurrency that hides data about its users. At a minimum, privacy coins hide identifies. They also often hide the amount of cryptocurrency traded and held in wallets. Zcash, Dash, and Monero are three examples.

**PROOF-OF-WORK (POW):** A consensus mechanism in which actors race to solve a computationally difficult problem in order to win the ability to produce the next block in a blockchain. Generally, the process involves a degree of randomness that makes it impossible to find a solution based upon previous inputs; the only information obtained from a solution is that the particular solution is valid. Multiple solutions may be valid for solving the problem, although the odds of finding two unique solutions is incredibly small.

While finding the solution to these problems requires significant processing time, proving that a solution is correct is trivial in nature. Whoever solves the problem in the context of a specific block's data is allowed to submit that block to the blockchain. The network must then start the race over with the updated data. Proof-of-Work's security is rooted in the computational difficulty of the algorithm. Because it is an essentially random process to find a solution, the probability of solving the problem is related to the actor's processing speed and the acceptance criteria for the solution (the difficulty). Stricter acceptance criteria reduce the speed at which the network finds a solution, and varying the acceptance criteria can allow a network to control the solution rate.

*Example:* If a network is producing solved proofs every 10 seconds at 100 attempts per second, and it wants to reduce the time to five seconds, the acceptance criteria can be changed to allow twice as many possible solutions, or the network can double its processing speed. Let's say there are 10 good actors with machines running 10 attempts per second, making the total network rate 100 attempts per second.

For a bad actor to replace a previous solution with his or her own, he or she would need to have enough machines to make an additional 100 attempts per second. To take over all production of blocks requires only half of that though; the bad actor only needs to solve the problem faster on average than the rest of the network. Because this threshold is  $\frac{1}{2}$  of the total network processing rate, the system is considered byzantine fault tolerant.

**PROOF-OF-STAKE (POS):** A consensus mechanism in which the ability to produce a block is proportional to the amount of the blockchain's native cryptocurrency an actor holds. The more cryptocurrency the actor holds, the more likely it becomes that he or she will be assigned as a block producer.

**SMART CONTRACT:** Code that is executable within the environment of a virtual machine. Blockchains use smart contracts in the context of the chain's state to extend the functionality of the chain and provide trustless program execution. Smart contracts in blockchains are particularly useful because their outputs are deterministic, meaning anyone who processes a function in a smart contract will get the same output as anyone else performing the same function.

**STAKING:** Participation in a proof-of-stake (PoS) system to put your tokens in to serve as a validator to the blockchain and receive rewards.

**TOKEN:** In the blockchain industry, tokens are the generalized base unit of a cryptocurrency. A token is the lowest unit possible; it cannot be divided further.

**WHITEPAPER:** A document prepared by a project team to explain its vision, use, design, technical information of an asset, and a roadmap for how it plans to grow and succeed.

# S&P Dow Jones Indices' Contact Information

## Contact Information

For questions regarding an index, please contact: [index\\_services@spglobal.com](mailto:index_services@spglobal.com).

# Appendix

## Digital Assets Inherent Risks

### PRICE VOLATILITY

Digital assets have historically experienced significant intraday and long-term price swings.

### SPOT MARKETS

The spot markets through which cryptocurrencies trade are new and largely unregulated. Furthermore, many spot markets and over-the-counter market venues, do not provide the public with significant information regarding their ownership structure, management teams, corporate practices, or oversight of customer trading. As a result, the marketplace may lose confidence in, or may experience problems relating to, these venues. Spot markets may impose daily, weekly, monthly, or customer-specific transaction or withdrawal limits or suspend withdrawals entirely, rendering the exchange of bitcoin for fiat currency difficult or impossible. Participation in spot markets requires users to take on credit risk by transferring bitcoin from a personal account to a third party's account.

### MARKET ADOPTION

It is possible that digital assets generally or any digital asset in particular will never be broadly adopted by either the retail or commercial marketplace, in which case, one or more digital assets may lose most, if not all, of its value.

### GOVERNMENT REGULATION

The regulatory framework of digital assets remains unclear and application of existing regulations and/or future restrictions by international, federal, and state authorities may have a significant impact on the value of digital assets.

### SECURITY

There have been significant incidents of digital asset theft and digital assets remain a potential target for hackers. Digital assets that are lost or stolen cannot be replaced, as transactions are irrevocable.

### OTHER

Digital assets are susceptible to error and can be affected by forks, discontinuation, and/or suspension in trading.

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