RULEBOOK

kaiko.com

Kaiko Digital Assets Rates

Kaiko
smart data

CONTENT

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INTRODUCTION

The following document covers the methodology of the Kaiko Digital Asset Rates. Designed to bring greater transparency to pricing, these are solely based on executed trades from centralised exchanges. Each rate is calculated on a real-time basis and with pre-defined daily fixings.

Calculation and dissemination: All rates are calculated real-time every 5 seconds, as well as daily fixings at 4 pm in three different time zones:

- Europe - London time
- Asia - Singapore time
- North America - New York time

The list of all rates can be at https://www.kaiko.com/pages/rates.

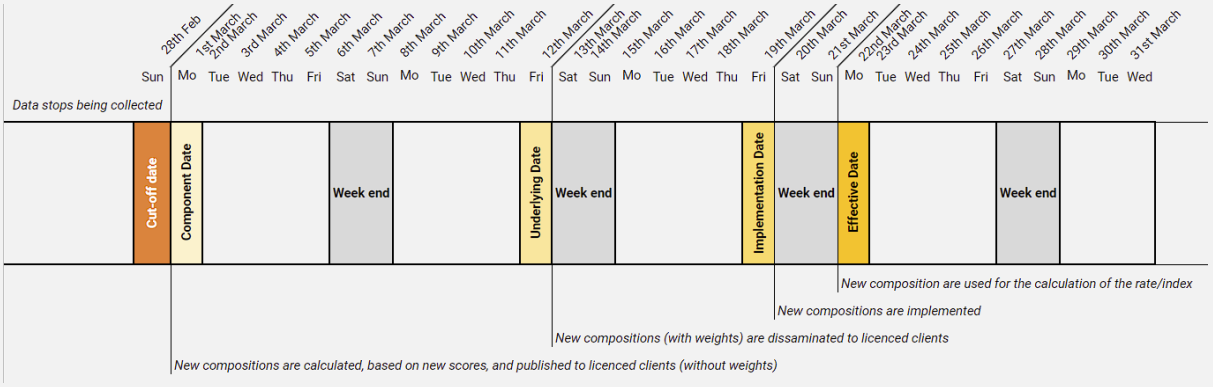
REVIEW CALENDAR

Scheduled Review and Rebalancing

Rebalancing is a time related process that allows the rates to follow the most relevant price data feeds and comply with initial vetting, liquidity or optimization requirements which will be developed further in the following description of the Exchange Selection Model. All families of Kaiko Rates will follow the same quarterly rebalancing calendar (March, June, September and December) with cut off and effective dates structuring the data collection and processing periods followed by publication periods.

Event	Date	Description	Example with June 2022 rebalancing
Cut-off	Last day of the month preceding the rebalancing	Data collection for composition determination stops on that day.*	*31st of May, 2022*
Underlying data	Second Friday of the rebalancing month	The new exchange composition with corresponding weights is available.	*10th of June, 2022*
Effective	Monday after the third Friday of the rebalancing month	The new exchange composition becomes effective in the calculation of the rates.	*20th of June, 2022*

**For instance, if a 3-month Average Daily Traded Volume must be calculated, the covered period will start 3 months before the cut-off date and end on the cut-off date (included).*



Extraordinary Review

On the basis of its qualified and expert judgement, Kaiko reserves the right to exclude or replace an exchange selected during the Scheduled Review. Such extraordinary event would happen if an exchange has been found to experience an exclusion action such as:

- Fraud
- Market manipulation
- Significant loss of volume or liquidity

In such cases, the Kaiko Index Steering Committee will publish its findings and exclude the exchange from the rates calculation 3 days after the initial public communication.

METHODOLOGY

Before any rate can be computed, each eligible exchange is screened for both quantitative and qualitative aspects. Said screenings compose a key element to ensure the reliability and authenticity of each and every rate.

Data Source

The daily price levels are based on the historical tick-by-tick trade data provided by Kaiko.

Kaiko has been operating since 2014 and is the leading cryptocurrency market data provider for institutional investors and enterprises. It empowers market participants with accurate, transparent, and reliable financial data to be leveraged for a range of market activities. Its mission is to be the foundation of the new digital finance economy by serving as a single source for market information. Said mission is premised on the idea that high-quality data drives market efficiency and greater transparency throughout the industry.

Kaiko covers more than a hundred cryptocurrency exchanges and 10,000 pairs globally. It operates an institutional grade technical stack with storage and collection run on redundant, geographically dispersed servers. Kaiko's unbiased data is currently used for trading, research, valuation and/or display purposes, with major market participants.

Exchange Selection Model

Markets in crypto assets are by nature highly fragmented, with hundreds or even thousands of exchanges spread over different geographical areas, each with their own regulatory framework. Each crypto asset trading platform works as an independent dark pool, and as such, official statistics and research data are rarely publicly available.

As a global digital asset market data provider, Kaiko covers more than a hundred cryptocurrency exchanges. However, not all exchanges are offering the same level of standards in terms of legal and compliance, infrastructure security, liquidity, data quality or even technology. The model leverages specific parameters of Kaiko Exchange Ranking to make sure only high quality data are incorporated in the computation of each rate.

For the purpose of the Price Rates computation, only centralised spot exchanges absent from any sanction lists are considered.

1. Asset-agnostic Vetting

Asset-agnostic vetting is built on Kaiko Exchange Ranking parameters. In the case of Kaiko Price Rates, there is no vetting applied to the list of eligible exchanges for each period of the rate history. The only requirement for exchanges is the absence from any sanction lists. The aim of Kaiko Price Rates is to create a family of rates with a broad coverage that would be representative of the liquidity on the market without any other requirements. All exchanges fulfilling all criteria mentioned constitute the Kaiko Vetted Exchanges List (KVEL).

2. Asset-specific Vetting

Liquidity

The 3-months volume history of the relevant pair is extracted and, for each month, an average daily trading volume as a percent of the total average trading volume from the curated list is computed. The monthly averages values are in turn averaged, and all exchanges whose average liquidity is strictly below 1% are not considered as relevant in terms of liquidity and thus are excluded from the KVEL.

Additional Liquidity Layer

When the list of exchanges following the liquidity and market quality assessment is above 10 exchanges, we apply a limitation layer that selects only the 10 most liquid

exchanges in terms of contribution to the global volume for a specific asset during the relevant period.

3. Further Optimization

Individual Exchange Analysis

From the curated list of exchanges, further optimization is computed based on the number of zero-volume buckets of the relevant pair in each fixing window during the period. A zero-volume bucket is defined as a timestamp for which no trades in the relevant pair are observed during the rolling window considered. Thus, the aim behind this step is to individually analyse exchanges and classify them based on the number of zero-volume buckets compared to the level of liquidity. This optimization step completes the following combination analysis when deciding between two similar combinations in terms of minimum coverage or liquidity.

Combinations Analysis And Ranking

This step is dedicated to extracting the final combination of minimum 1 and up to 5 exchanges generating the best liquidity (i.e., minimum number of zero-volume buckets and average liquidity per interval). These combinations are ranked according to those parameters. From this step, the list of exchanges which will be considered in the calculation of the price rate is finalised.

Publication Events

Each rate is composed of two types of publication events: real-time and fixing publications.

1. Real-Time Publications

Real-time rates are defined by publication events occurring at a granularity higher than a minute. In the specific case of Price Rates we apply the following parameters that were calibrated according to minimum liquidity coverage and market price representativity:

- Publication interval: 5s frequency
- Standardised calculation window sizes tested: 15s, 20s, 30s, 60s, 120s, 300s
- Selected calculation window: 300s (fixed)

2. Fixing Publications

Fixing publications are defined as recurring events occurring with a granularity lower than a minute. We assume those fixing events to occur on a daily basis with three different timings corresponding to 3 time zone fixings (US, EMEA, APAC):

- Europe: Paris time (GMT+2)
- Asia: Singapore time (GMT+8)
- North America: New York time (GMT-4)

Daily fixings for Kaiko Price Rates are calculated with the following parameters calibrated with a minimum liquidity coverage and market representativity:

- Publication interval: daily for the 3 fixings
- Standardised calculation window sizes tested: 300s, 600s, 900s, 1200s, 1800s, 3600s
- Selected calculation window: 3600s (fixed)

Rates Calculation

The aggregation methodology consists of splitting the calculation period considered into equal size partitions and, for each of them, extracting the most representative trade whose price will be used for the final rate calculation.

All trades in the relevant pair for the relevant exchange are pooled together and grouped into relevant time partitions. For each partition, the most representative trade is defined as the volume median one.

1. Step-by-step Methodology

- At fixing time, collect all executed trades in the calculation window (before the fixing) on all selected exchanges.
- Merge all the executed trades from the different exchanges in the same dataset sorted by prices in ascending order.
- Create K partitions of S_{part} size from the calculation window (eg. 1h calc. window with 20 partitions of 3 min).
- Each partition is then subject to a Volume Weighted Median (outlier resistant by nature). A detailed description of this aggregation method is provided below.
- A time weight is associated with each partition's volume-weighted median (more weights to the last partitions which are the most recent).
- Aggregation of those weighted prices (eg. 20 prices aggregated on 1h calc. window) to obtain the reference price for this publication event.

2. Inputs

Symbol	Name	Description
t	Event	The timestamp at which the fixing price (FP) is calculated.
S_{wind}	Calculation Window Size	Size of the calculation period for which trades are collected and aggregated.
S_{part}	Partition Size	Size of each partition in the calculation window.
K	Number of Partitions	The number of partitions is an integer calculated as S_{wind}/S_{part}.
k	Partition Number	k_{th} partition.

I_k	Partition Trade Distribution	List of trades included in partition k and ordered by ascending price.
p_i^k	Partition Trade Price	i^{th} trade price in the k_{th} partition (price-ordered distribution).
v_i^k	Partition Trade Volume	i^{th} trade volume in the k_{th} partition (price-ordered distribution).
VWM_k	Volume-Weighted Median	Volume-weighted median of the k_{th} partition.
FP_t	Fixing Price	Fixing price (FP) at time t.

3. Volume Weighted Median

The volume-weighted median (VWM_k) is calculated as the price (p_j^k) of the j^{th} trade where the j^{th} trade is the trade that lies at 50% of the cumulative volume for the partition k. VWM_k is calculated for each partition in S_{wind}:

$$VWM_k = p_j^k \text{ where } j \text{ satisfies } \sum_{i=0}^{j-1} v_i^k < \frac{\sum_{i=1}^{I_k} v_i^k}{2} \text{ and } \sum_{i=j+1}^{I_k} v_i^k \leq \frac{\sum_{i=1}^{I_k} v_i^k}{2}$$

$$\text{If } \exists\ j : v_j^k > \frac{\sum_{i=1}^{I_k} v_i^k}{2} \text{ then } VWM_k = p_j^k$$

$$\text{If } \exists\ j : \sum_{i=j+1}^{I_k} v_i^k = \frac{\sum_{i=1}^{I_k} v_i^k}{2} \text{ then } VWM_k = \frac{p_j^k + p_{j+1}^k}{2}$$

4. Fixing Price

The Fixing Price (FP) is calculated as a time weighted average price (TWAP) of all the VWM_k of all the K partitions. We implement a sensitivity calibration method on partitions to increase the weight of the most recent prices included in the calculation window.

First, we apply a specific weighting function in order to obtain weights which are inversely proportional to time t. It gives:

$$w_k = \frac{1}{n} \sum_{j=0}^{I_k} 1_{j \leq k}$$

The weights are then normalised:

$$\overline{w_k} = \frac{w_k}{\sum_j w_j}$$

Thus, the fixing price is equal to:

$$FP_T = \sum_{k=1}^{K} (VWM_k \times \overline{w_k})$$

5. Partitioning Scheme

Each price rate uses 10 partitions of 30 seconds for real-time publications and 10 partitions of 360s for daily fixings.

6. Data Rounding

All rates are calculated with all available decimals but published with two decimals.

7. Blockchain Forks

In the event of a fork of the blockchain, the ticker used on each Constituent Exchange may be adjusted in order to represent the relevant instrument.

8. Data Gaps

Missing Data

At the time of the calculation (t), some relevant transactions may be missing for an array of reasons. If no relevant transactions are recorded on the relevant partition, the corresponding partition is excluded from the calculation and weights are adjusted accordingly.

Delayed Data

If for any reason Kaiko was unable to retrieve relevant transactions at the Calculation Time, the corresponding partition is excluded from the calculation.

Spurious Data

If for any reason any transactions were identified as potentially suspect within a partition, the most representative trade may be adjusted to disregard the spurious data.