

# Pricing and Valuation Services

NAV & index calculations require a unique set of asset reference prices for any financial product that includes crypto assets as a component. Kaiko has designed an auditable valuation endpoint that allows customers to build their own single-asset and multi-asset price feeds, with back testing capabilities over historical data. This new endpoint provides a composite index along with reference prices for each constituent asset, aggregated across a defined selection of exchanges.

## Methodology

The asset reference price  $P_i$ , expressed in fiat currency (CCY), is evaluated across a set of constituent exchanges  $E$  as a Volume Weighted Average Price (VWAP) over symmetric time windows around a set of fixing time  $T$ . For each fixing time, the composite price  $P_{Comp}$  is a linear function over a weighted basket of assets  $I = \{i, w_i\}$  and reference prices  $P_{ref} = \{i, P_{ref,i}\}$ . Weights are associated with a fixed amount of fiat currency units  $Q_f = 100$  to calculate absolute weights from initial reference prices. From this conversion, asset contributions  $C_i$  are computed and summed to derive the composite price  $P_{Comp}$  calculated at time  $T_{calc}$ .

Since crypto-currency markets are open 24h a day, seven days a week, a symmetric time window starting at  $T - \Delta T$  and ending at  $T + \Delta T$  is required in order to obtain a significant sample size of transactions over an extended period around the synthetic price-fixing. Also, the weighting function  $W = \{w_i, i \in I, \sum_i(w_i) = 1\}$  is the same across exchanges. The formula relies on the following intermediary variables:

Symbol	Name	Description
$p_{ei}$	<b>VWAP</b>	VWAP on exchange $e$ of asset $i$ in CCY (direct exchange rate) over the time interval $t \in [T - \Delta T, T + \Delta T]$ .
$v_{ei}$	<b>Volume</b>	Total volume traded on exchange $e$ of asset $i$ over the time interval $t \in [T - \Delta T, T + \Delta T]$ .

The composite price  $P_{Comp}$  is then by definition:

$$P_{Comp} = \sum_{i \in I} w_{abs,i} \times \left( \sum_{e \in E} \rho_{ei} v_{ei} / \sum_{e \in E} v_{ei} \right)$$

## Outlier Management

For various technical reasons, some data points may be misleading and should be excluded from the price distribution over the time window. To enable this, the endpoint gives the user the possibility to define the level of outliers that will remain included in the computation. The outlier management layer is implemented at the exchange and time window level. Thus, the reference price  $P_k$  corresponds to the calculation done over “ $k$ ” percent of the price distribution centered around the median price.

## Implementation

### Input

Parameter	Value	Description
<b>start time</b>	<i>Date</i>	first fixing for the calculation
<b>end time</b>	<i>Date</i>	last fixing for the calculation
<b>interval</b>	<i>Seconds, minutes, hours,...</i>	frequency in time unit after the first fixing.
<b>semi length window</b>	<i>Seconds, minutes, hours,...</i>	semi-length of the aggregation window.
<b>quote</b>	<i>ccy</i>	the fiat pricing currency
<b>bases</b>	$\{i\}$	list of bases components
<b>weights</b>	$\{w_i\}$	weights of listed pairs
<b>exchanges</b>	$\{e\}$	list of constituent exchanges
<b>percentages</b>	$\{k\}$	list of percentages for outlier management
<b>sources</b>	<i>Boolean</i>	Parameter to access price details at exchange level

## Computation & Constraints

Considering the volume of data points processed for the computation of each data point, some parameter constraints have been implemented in order to optimize computation time:

- Number of base assets must be less or equal to 5
- Number of percentiles must be less or equal to 5
- Weights and bases must have the same length
- Weights must sum up to 1
- Interval must be greater than twice the semi length window
- Time difference between start date and end date must not exceed 7 days. For longer periods, performance can be tracked by linking periods with an overlap on the last and first fixing. The percent change can then be used as a proxy to retrieve composite price according to last price fixing levels.

## Output

The output of the calculation consists of the corresponding fixing date, percentages with their associated composite price ( $P_{Comp}$ ), reference price per asset ( $P_{ref,i}$ ) with their respective weight ( $w_i$ ) and contribution in the composite ( $C_i$ ). The endpoint also offers enough granularity to retrieve the underlying reference prices and volumes used in the calculation at the exchange level  $\{(p_e, v_e), e \in E\}$  by using the parameter sources (true/false).

Datetime	%	$P_{Comp}$	Pair	$C_i$	$P_{ref,i}$	$w_i$
2021-06-14 01:00:00 UTC	0.7	100.27	aave-usd	25.14	266.59	0.25
			btc-usd	25.14	35990.91	0.25
			comp-usd	15.09	279.17	0.15
			mkr-usd	19.88	2683.5	0.2
			sushi-usd	15.01	7.82	0.15
	1	100.38	aave-usd	25.16	266.61	0.25
			btc-usd	25.17	36000.95	0.25
			comp-usd	15.11	279.50	0.15
			mkr-usd	19.88	2683.5	0.2
			sushi-usd	15.06	7.84	0.15

For each fixing time, the output includes the timestamp corresponding to the effective calculation time.

## Delivery

The reference price endpoint is available via CSV files, REST API and Stream. Note: via Stream, an additional parameter is required for the frequency of publication. The reference price endpoint is available over historical data only via CSV, and with 7 days of history through API.

## Appendix

### Blockchain Forks

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

### Data Gaps

#### Missing Data

At the time of the calculation ( $T_{calc}$ ), some relevant transactions may be missing for any an array of reasons:

1. If no relevant transactions are recorded on the Constituent Exchange, the corresponding Constituent Exchange is assigned an Exchange Volume of zero and thereby excluded from the calculation.
2. If Kaiko was unable to retrieve any relevant transactions from the Constituent Exchange because of some failure, unavailability, or planned maintenance of the Constituent Exchange. In this case, the corresponding relevant transactions are excluded from the calculation.
3. If Kaiko was unable to retrieve any relevant transactions from the Constituent Exchange because of some failure, unavailability of Kaiko's services. In this case, the corresponding transactions are excluded from the calculation.

4. If the upload procedure of the output data to the CSV file failed for any reason. In this case, the Exchange Rate may be calculated at a later time.

#### **Delayed Data**

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

#### **Spurious Data**

If for any reason any transactions were identified as potentially suspect, the corresponding Constituent Exchange Price and Exchange Volume may be adjusted to disregard the spurious data.

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