CADLI Methodology

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Contents

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1 Version History

Version	Date	Details
1	27-Nov-2023	Initial version
2	11-Dec-2023	Added subsubsection 5.3.3.

2 Introduction

2.1 Index Description

CCData's Adaptive Diversified Liquidity Index ("CADLI") for a given cryptocurrency refers to the real-time index calculation methodology, the purpose of which is to provide a representative market average estimation that can be used for price discovery. CADLI is one of CCData's proprietary index calculation methodologies for digital assets, based on 24-hour volume-weighted average calculation, time-penalty factor, and outlier methodology. It aggregates transaction data for a single cryptocurrency over different Markets on approximately 300 Exchanges and returns a unified USD price for more than 3,600 cryptocurrencies. CADLI prices can also be converted and returned in other currencies different to USD (see subsection 5.4).

2.2 Index Properties

Calculation agent	CC Data Limited
Dissemination	Real-time and historical
Day close	12:00 am UTC
Methodology	24-hour volume-weighted average with time penalty and outlier adjustment
Calculation days	Every day of the week including business holidays
Markets	All cryptocurrencies

3 Definitions

24 Hour Volume means, with respect to a Market and a point in time, the sum of the volume traded on the Market over the last 23 calendar hours and the cumulative volume of the current calendar hour, in units of the base cryptocurrency.

API stands for Application Programming Interface.

CADLI means, with respect to a cryptocurrency, the CCData Adaptive Diversified Liquidity Index.

CADLI Converted Price means the CADLI index converted to other quote currencies different than USD Dollars (see subsection 5.4).

Calculation Date means any day for which a CADLI is published.

Conversion Pair means with respect to the Market, the CADLI index used as the exchange rate to convert the final index price to US Dollars.

Dynamic Index means the version of CADLI that is subject to retrospective backfilling in the event of a failure to retrieve exchange data in a timely manner.

Exchange means an exchange that trades cryptocurrencies and is part of our constituent exchange universe.

Market means every combination of Exchange and Pair where the cryptocurrency is trading at. For example, for the cryptocurrency Bitcoin, Binance BTC-USDT, Coinbase BTC-USD and Coinbase BTC-USDT are 3 separate markets.

Pair means a pair of:

- cryptocurrencies, or
- a cryptocurrency and a fiat currency

Outlier Detection Factor means a factor used for penalising a price deemed to be an outlier in the CADLI calculation and is determined in accordance with Equation 3.

Static Index means the immutable version of CADLI, which does not account for missed trades.

Time Penalty Factor means a factor used for penalising outdated prices in the CADLI calculation and is determined in accordance with Equation 7.

UTC stands for Coordinated Universal Time.

4 Data Collection

4.1 Data Source

Transactional data (historical trades) is collected from each Exchange via public REST API polled every 1-120 seconds (depending on the Market's liquidity) and WebSocket endpoints. All collected data will be standardized internally, stored and backed up in servers.

Exchanges that do not meet the technical requirements (available API for transactional data) cannot be added to the data collection. Unlike many data providers, who use snapshot data, CADLI approach of using transactional data enables auditability and replicability.

4.2 Data Format

The collected data consists of:

- Trade ID: string or numerical
- Timestamp: Unix timestamp in seconds
- Price: numerical
- Amount: numerical
- Position: buy/sell

4.3 Data Validation

Each trade is validated for the following:

- Each field has the correct data format
- Price and amount is positive
- Timestamp is not in the future
- Trades are not duplicated

4.4 Failure of Data Retrieval

In the event of a failure to retrieve data from a Market (due to service outage of the Exchange API service), per design of the CADLI, the last price of the respective Market will expire over time (its weighting will decrease to zero). As long as the cryptocurrency is trading on other Markets, the CADLI calculation is uninterrupted.

If the missed data is recoverable, CCData makes its best effort to retrospectively backfill the data for historical accuracy. This might result in recalculation of certain CADLI prices, therefore CCData publishes two sets of indices: the Static Index, which is immutable, and the Dynamic Index, which can be adjusted

retrospectively. The default index price retrieved from the CCData API is the Dynamic Index. The real-time index dissemination is also the Dynamic Index.

5 Index Calculation Methodology

5.1 Input Data

CADLI is calculated using as an input the last transaction received from each Market per second. A new CADLI value is broadcasted for every constituent Market transaction, which can result in multiple updates per second. The following input data is needed from each transaction:

- Trade price
- Trade amount
- Trade timestamp
- Market where the transaction was executed

5.2 Constituent Exchanges and Markets

CADLI is calculated using every Market where the cryptocurrency is traded. Every time a new Market is listed it will be automatically added to the calculation, subject to the availability of the CADLI Conversion Pair. If the CADLI Conversion Pair is not available or stale [1] the Market will not be included in the CADLI calculation.

For Stablecoins the eligible Market universe is reduced to only direct USD and USDT Markets. This is because, Stable coins are primarily used as CADLI Conversion Pairs, and CCData aims to avoid introducing any additional premiums or discounts to the prices associated with the conversion process.

Additionally, CCData reserves the right to remove any Markets at its own discretion if they impact CADLI's price inaccurately.

5.3 Index Calculation

5.3.1 Mathematical Representation

We use the notation $|\cdot|$ to represent size of sets. What follows is the calculation of each relevant variable.

For a pre-specified cryptocurrency, the CALDI is a volume-weighted average (last trade) price calculated as follows:

$$P_t = \sum_{e \in E_t} w_t^m \cdot p_t^m \cdot FX_t^q \tag{1}$$

Where:

[1] A CADLI Conversion Pair is considered stale if it has not traded in the last 24 hours.

t denotes a point in time, where the integer value represents seconds in unix timestamps [2]

P_t is the CADLI price at time t

m denotes a Market in set M_t

q denotes Market m quote's currency

M_t is the set of all Markets used in the calculation of CADLI at time t

w_t^m is the weight assigned to Market m at time t and is calculated in accordance with Equation 2

p_t^m is, with respect to Market m and time t, the price of the last trade to contribute to CADLI

FX_t^q is, with respect to the quote currency q, the FX Conversion value at time t for the relevant q-USD Pair calculated as follows:

- FX_t^q corresponds to the CADLI Conversion Pair when q is a cryptocurrency, calculated in accordance with Equation 1;
- FX_t^q corresponds to the FX rate taken from openexchangerates[3] when q is a fiat currency;

The weight of Market m at time t is calculated as follows:

$$w_t^m = \frac{\mathbb{1}_t^m \cdot V_t^m \cdot \gamma_t^m}{\sum_{x \in M_t} \mathbb{1}_t^x \cdot V_t^x \cdot \gamma_t^x} \tag{2}$$

Where:

x denotes a Market (including Exchange m) in set M_t

$\mathbb{1}_t^m$ is, with respect to Market m and time t, the Outlier Detection Factor determined in accordance with Equation 3

V_t^m is, with respect to Market m and time t, the 24 Hour Volume calculated in accordance with Equation 5

γ_t^m is, with respect to Market m and time t, the Time Penalty Factor determined in accordance with Equation 7

The Outlier Detection Factor, with respect to Market m and time t, is determined as follows:

$$\mathbb{1}_t^m = \begin{cases} 0 & \text{if } |M_t| > 2 \text{ and } (p_t^m > A \cdot P_{l_t} \text{ or } A \cdot p_t^m < P_{l_t}) \\ 1 & \text{otherwise} \end{cases} \tag{3}$$

[2] Therefore 0 represents 00:00:00 on January 1st, 1970 UTC.

[3] `https://openexchangerates.org/`

Where:

M_t and p_t^m are as defined above

A is a constant that denotes the price deviation threshold; it is currently set to:

$$A = \begin{cases} 1.05 & \text{if } |M_t| \geq 15, \\ 1.10 & \text{if } 10 \leq |M_t| < 15, \\ 1.15 & \text{otherwise} \end{cases} \tag{4}$$

l_t is, with respect to t, the time of the last trade from any Exchange to contribute to CADLI [4]

P_{l_t} is the CADLI price at time l_t

The 24 Hour Volume, as defined in this document, with respect to Market m and time t, is calculated as follows:

$$V_t^m = \sum_{h_t \leq s < t} v_s^m \tag{5}$$

Where:

h_t is, with respect to time t, the timestamp of the last calendar hour in UTC in the previous 24-hour period determined as follows:

$$h_t = t - (23 \cdot 3600 + c) \tag{6}$$

Where:

c is the number of seconds past in the current hour

s denotes a point in time between h_t (inclusive) and t (exclusive) for which there was a trade on Market m

v_s^m is the quantity traded on Market m at time s [5]

The Time Penalty Factor, with respect to Market m and time t, is determined as follows:

$$\gamma_t^m = \begin{cases} \gamma_{\min} & \text{if } \tau_t^m < \tau_{\min}, \\ \gamma_{\max} & \text{if } \tau_t^m \geq \tau_{\max}, \\ \gamma_{\min} + \frac{(\gamma_{\max} - \gamma_{\min})}{(\tau_{\max} - \tau_{\min})} \cdot (\tau_t^m - \tau_{\min}) & \text{otherwise} \end{cases} \tag{7}$$

[4] This would be the last time that the CADLI was calculated.

[5] Note we do not include the volumes of trades deemed to be outliers.

Where:

$\gamma_{\min}$ is the minimum penalty factor, which is currently set to 1

$\gamma_{\max}$ is the maximum penalty factor, which is currently set to 0.001

$\tau_{\min}$ is the number of seconds at which the minimum penalty factor applies, which is currently set to 60 (1 minute)

$\tau_{\max}$ is the number of seconds after which the maximum penalty factor applies, which is currently set to 1,500 (25 minutes)

τ_t^m is, with respect to Market m and time t, the length of time in seconds since the last trade on Market m calculated as follows:

$$\tau_t^m = t - l_t^e \tag{8}$$

Where:

l_t^m is, with respect to Market m and time t, the time of the last trade on such Market m to contribute to CADLI

5.3.2 Outlier Detection

Along with the real-time outlier detection dictated by $\mathbb{1}_t^e$ in Equation 3, CCData will manually remove trades that are deemed outliers for other reasons, such as exchange errors.

5.3.3 New additions

When adding a new cryptocurrency to CADLI's universe the initial CADLI value is calculated in accordance to Equation 1.

If none of the cryptocurrency Markets has traded in the last 24 hours and all $w_t^m = 0$, the most recent Market price traded is assigned as CADLI's initial value for that cryptocurrency.

5.4 CADLI Converted Price

In accordance with Equation 1, CADLI is calculated using all Markets for a specific cryptocurrency and converting them into USD. However, CADLI can also be converted to other quote currencies. For example, the user can query BTC-GBP and the CCData API will return CADLI BTC-USD converted into GBP, determined as follows:

$$PC_t = P_t \cdot FX_t^{USD-q} \tag{9}$$

Where:

PC_t is the CADLI Converted Price a time t

P_t is the CADLI price at time t

FX_t^{USD-q} is, with respect to the quote currency q, the FX Conversion value at time t for the relevant USD-q Pair calculated as follows:

- FX_t^{USD-q} corresponds to the inverse of the CADLI Conversion Pair when q is a cryptocurrency, calculated in accordance with Equation 1;
- FX_t^{USD-q} corresponds to the FX rate taken from openexchangerates[6] when q is a fiat currency;

The historical quote volumes associated with CADLI Converted Prices on CCData API are estimated by multiplying the CADLI base currency volume by the average price of the period (instead of using the last price at time t).

$$VC_i^q = V_i \cdot PA_i^q \tag{10}$$

Where:

i denotes the period (i.e. day, month).

q denotes the conversion quote currency

VC_i^q denotes the CADLI Converted Prices traded volume measured in units of the conversion quote currency for period i

V_i denotes the traded volume associated with the CADLI cryptocurrency price measured in units of the cryptocurrency for period i

PA_i^q denotes the average price cryptocurrency-quote for period i, calculated as the average CADLI price of the period divided by the quote-USD average price of the period:

$$PA_i^q = \frac{PA_i}{PA_i^{q-USD}} = \frac{V_i^{USD}/V_i}{V_i^{q-USD}/V_i^q} \tag{11}$$

Where:

PA_i denotes the cryptocurrency average USD price for period i

PA_i^{q-USD} denotes the quote-USD average price for period i

V_i^{USD} denotes the CADLI traded volume measured in USD

V_i denotes the traded volume associated with the CADLI cryptocurrency price measured in units of the cryptocurrency for period i

[6] `https://openexchangerates.org/`

V_i^{q-USD} denotes the traded volume associated with the CADLI quote price measured in USD for period i

V_i^q denotes the traded volume associated with the CADLI quote price measured in units of the quote currency i

5.5 Auditability and Replicability

CADLI is auditable and replicable since its calculation is based on transaction data retrieved from Exchanges via public API. Anyone who has access to this data can recreate the CADLI.

5.6 Discretion Regarding the Use of Input Data

Pursuant to Art. 12 No.1. (b) of the BMR, CCData has established the following rules identifying how and when discretion may be exercised in the administration of CADLI.

In cases where input data is or appears to be qualitatively inferior or different sources provide different data, or a situation is not covered by this index methodology document, CCData may use or change the data at its own discretion according to the following discretion policy after a plausibility check. This may include:

- Liquidity and size data
- Event information
- Classifications and other secondary data

Any changes to input data that CCData intends to apply because of missing data, different data from different sources, or other information concluding the inappropriateness or incorrectness of data must be subject to reasonable discretion. The decision on any change must be required, appropriate, commensurable, and in line with the respective index scope and objective and must reasonably consider in a balance weight the interest of users, investors in related products and the integrity of the market.

The Technical Committee ensures consistency in the use of discretion in its judgement and decision. Employees involved in the Technical Committee must have shown the respective experience and skills. Significant decisions are subject to sign-off by a supervisor. In case of material changes to data, the relevant situation will be analysed in detail, described and presented to the Oversight Function and discussed and reviewed with the Oversight Function.

The broad range of possible data quality problems does not allow to define specific steps for each possible instance. CCData will always weigh the different interests of CADLI users, the integrity of the market and other involved parties, and determine the least disadvantageous measure that equally considers the relevant interests best.

In order to avoid individual decisions on the use of data in similar cases for the future, an update of the index rules can be taken into consideration, if applicable. Other possible mitigation measures may include the change of input data sources or providers and/or own data research where possible and reasonable.

Records are kept about material judgement or discretion and will include the reasoning for said judgement or discretion.

6 Dissemination

CADLI is disseminated via REST API and Websocket API. The relevant API endpoint can be found here: `https://developers.cryptocompare.com/documentation/data-api/index_cc`.

7 Disclaimer

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