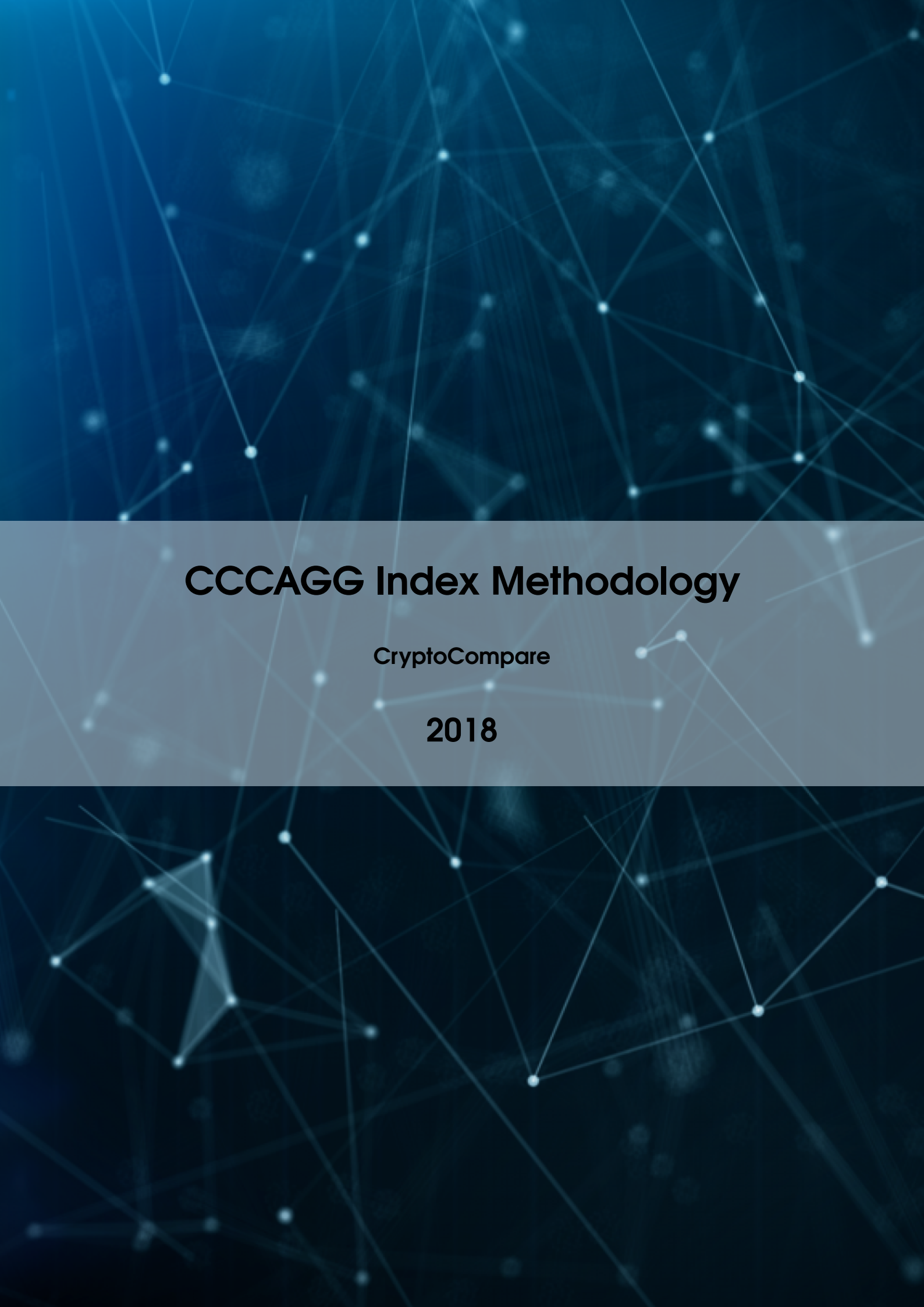

# CCCAGG Index Methodology

CryptoCompare

2018

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Published by CryptoCompare

CRYPTOCOMPARE.COM

*26 February 2018*

# Contents

# 1. Version History

| Version | Date | Reviewed by | Details |
|---|---|---|---|
| 1 | 2017-07-01 | Vlad Cealicu | Initial version |
| 2 | 2017-11-20 | Quynh Tran-Thanh | Added review process description |
| 3 | 2018-02-26 | Quynh Tran-Thanh, Konrad Strachan | Outlier methodology |

# 2. Summary

## 2.1 Introduction

The Crypto Coin Comparison Aggregated Index ("CCCAGG") refers to the real-time index calculation methodology, the purpose of which is to show the best price estimation for crypto traders and investors to value their portfolio at any time. It aggregates transaction data of over 70 exchanges, using 24 hour volume weighted average. The CCCAGG is calculated for each crypto coin in each currency it is trading in (example: CCCAGG BTC-USD).

Crypto coins such as Bitcoin, Ethereum, Monero, etc. are traded at various markets against multiple currencies including fiat currencies (USD, JPY, GBP, etc) and other cryptos. Depending on the market type (exchange or OTC), liquidity level, trading volume, transaction fees, and many other factors, a coin can be traded at different prices across different markets, and therefore making it difficult to know the value of a coin at a certain time.

Unlike traditional stock exchanges, crypto exchanges are facing the following problems that make pricing even more challenging:

- DDOS attack, causing an interruption of trading
- Hacking of user accounts
- Lack of standards and naming convention for symbols
- Unstable technological and legal environment (causing changes in fee structure, blocking of funds withdrawal, etc).

## 2.2 Use and attribution



## 2.3 Description

| | |
|---|---|
| Name | CCCAGG |
| Calculation agent | Crypto Coin Comparison Ltd. |
| Dissemination | Real-time |
| Day close | 12 am GMT |
| Methodology | 24 hour volume weighted average with time adjustment |

# 3. Data collection

## 3.1 Data source

Transactional data (historical trades) is collected from each exchange via public REST API polled every 2 seconds or websocket endpoints. All collected data will be standardized internally, stored and backed up in servers.

Exchanges and markets are added on an ongoing basis based on research or user request. 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, CCCAGG approach of using transactional data enables auditability and replicability.

## 3.2 Data format

The collected data consist of:

- Trade id
- Timestamp (UNIX)
- Price
- Amount
- Position (buy/sell)

## 3.3 Failure of data retrieval

On the event of failure to retrieve data from an exchange (due to service outage on the exchange), per design of the CCCAGG indices, the last price of the respective exchange will expire over time (its weighting will decrease to close to zero). As long as the currency pair is trading on other exchanges, the CCCAGG calculation is uninterrupted.

# 4. Methodology

## 4.1 Input data

CCCAGG is calculated every time a new transaction gets executed. The following input data is needed from each transaction:

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

## 4.2 Constituent exchanges

Crypto Coin Comparison Ltd. has integrated with a list of exchanges, but only a subset of them count towards the calculation of CCCAGG.

The rule of thumb is to include as many exchanges as possible after a testing period. Exclusion happens in the following cases:

- Volatile prices compared to market average (OTC markets excluded)
- Exchange suspends trading activity
- Verified user or social media reports of fake data reporting
- Malfunctioning API (on the exchange side)

Each case for exclusion is discussed by the Review Committee on an ad-hoc basis but at least once every calendar month.An excluded exchange can be re-included if the Review Committee finds that the problem causing the market disturbance has been solved. Changes in constituent exchanges are communicated via API newsletter and direct communication channels with clients.

## 4.3 Index calculation

### 4.3.1 Volume weighted average

CCCAGG uses 24 hour volume weighted average to calculate prices. 24 hour volumes are calculated solely based on transactional data. This way CCCAGG is giving the most liquid market prices more importance, and price impact of illiquid (and therefore more volatile) markets are negligible.

### 4.3.2 Time adjustment

Next to volume weighting, a time penalty factor is also added, to ensure that exchanges that suspend trading has an expiring price impact. An example of a case where this methodology showed its advantage was the Bitfinex hack in 2016.

Bitfinex had one of the highest trading volumes in Bitcoin, therefore had a significant weight in most price indices. Therefore, when trading was suddenly suspended on Bitfinex, causing a crash on all other markets, most indices still showed the a Bitcoin price close to the last price on Bitfinex, although markets have already moved on.

CCCAGG takes last trade time into account, therefore the last Bitfinex price expired with time and the index could move with the market.

### 4.3.3 Aggregation over trading currency

CCCAGG only takes direct trading pairs into consideration for calculation. For example CCCAGG BTC-USD only accepts trades from exchanges trading BTC-USD directly, therefore no conversion needed for the aggregated index calculation.

The reason for this methodology is that a coin can trade on multiple currency markets with a significant price difference (premium or discount), therefore aggregating across all markets will result in an average price that is not useful for a trader or investor who holds a crypto position in a certain currency and will most likely trade in that currency.

### 4.3.4 Mathematical representation

For simplicity, we define the CCCAGG Price Index for a pre-speficied currency pair ABC_XYZ, all notations below refer to this pair.

| Variable | Explanation |
|---|---|
| $i, j$ | Exchange |
| $t, s$ | Unix timestamp in seconds |
| $P_t^i$ | Price at exchange i and time t |
| $P_t^*$ | CCCAGG Index price i and time t |
| $W_t^i$ | Index weight of exchange i at time t |
| $V_t^i$ | 24 hour volume of exchange i at time t |
| $x$ | Excluded from pricing, $x = \{0, 1\}$ |
| $\gamma_t^i$ | Liquidity penalty factor of exchange i at time t |
| $h_t$ | Last hour timestamp at time t |
| $\tau_t^i$ | Time since last trade in minutes on exchange i at time t |
| $\delta_t^i$ | Price deviation of trade on exchange i at time t |
| $A$ | Price deviation threshold |

At any time $t$ the Index price for a currency pair is the weighted average of prices on all exchanges.

$$P_t^* = \sum_i P_t^i W_t^i \tag{4.1}$$

A weight belonging to an exchange is the ratio of the 24 hour trading volume of a currency pair to the total volume of the pair on all exchanges.

$$W_t^i = \frac{V_t^i 1_{\{x=0\}} \gamma_t^i}{\sum_k V_t^k 1_{\{x=0\}} \gamma_t^k} \tag{4.2}$$

The 24 hour volume of an exchange at a certain time is defined as the sum of trading volume of the last 24 full hours.

$$V_t^i = \sum_{s=h_t-86400}^{h_t} V_s^i \tag{4.3}$$

The exchange volume is adjusted with the liquidity penalty factor, that decreases with the

increasing time since the last trade.

$$\gamma_t^j = \begin{cases} 1 & \text{if } \tau_t^i \leq 5 \\ 0.8 & \text{if } 5 < \tau_t^i \leq 10 \\ 0.6 & \text{if } 10 < \tau_t^i \leq 15 \\ 0.4 & \text{if } 15 < \tau_t^i \leq 20 \\ 0.2 & \text{if } 20 < \tau_t^i \leq 25 \\ 0.001 & \text{otherwise} \end{cases}$$

### 4.3.5 Outlier Detection

Apart from a manual setup of an exchange exclusion or inclusion, an outlier detection mechanism is in place to exclude certain trades.

An outlier is considered to be a significant deviation on a specific exchange relative to the previous tick average on the all previous exchanges (including exchange in question). Handling this data is important as outlier data can have a sizable impact when calculating our CCCAGG value.

There are a number of potential situations where this can occur - for example:

- low liquidity instruments or exchanges
- erroneous data from exchange
- incorrect mappings between instruments

The following outlier handling logic is implemented:

1. For one or two exchanges - no exclusion logic is applied. Everything is considered an inlier and included.
2. For three or more exchanges the following logic applies.
   (a) Any trade that deviates by more than a certain threshold from the previously calculated index price (either up or down) causes the exchange to be labelled as an outlier and excluded.
   (b) Excluded exchanges are automatically re-included in the Index if the Index average price moves to a point where the exchange price is no longer considered to be an outlier
   (c) Excluded exchanges result in exclusion of price weighting as well as volume
   (d) There can be a price change when an exchange is excluded due to recalculation of price with the smaller number of exchanges and different volume levels
   (e) Existing price decay and 24 hour window for inclusion in calculation are unimpacted by this additional logic.

The deviation is calculated for each new trade in the following way:

$$\delta_t^j = \begin{cases} \frac{1}{P_{t-1}^* - P_t^i} - 1 & \text{if } P_t^i < P_{t-1}^* \\ \frac{P_t^i}{P_{t-1}^*} - 1 & \text{if } P_t^i \geq P_{t-1}^* \end{cases}$$

If $\delta_t^j$ exceeds a threshold, a trade is deemed an outlier. The threshold is currently set to $A = 3$. For exchange $j$:

$$x_t^j = \begin{cases} 0 & \text{if } \delta_t^j < A \\ 1 & \text{if } \delta_t^j \geq A \end{cases}$$

This means trades exceeding 400% or drop below 25% of the previous CCCAGG Index price will be deemed an outlier.

An edge case can exist where a split in the market occurs between two distinct groups of exchanges. If Group 1 exchanges trade at a significant price different to be included as outliers, only price and volume information from Group 2 will be included.

In this situation, if the number of exchanges in Group 1 (ourliers) exceeds the number of exchanges in Group 2 (inliers), an inlier/outlier flip occurs with the previous included exchanges in Group 2 becoming excluded and the previously excluded Group 1 exchanges becoming included.

When an exchange is re-included - only current and future pricing data will reflect the re-inclusion. No back-filling or recalculation occurs for previously reported pricing in the Index.

## 4.4 Auditability and replicability

CCCAGG 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 CCCAGG indices.

# 5. Review

## 5.1 Model review

The methodology is reviewed at least every quarter by the Review Committee. As of date the Review Committee consists of:

- Vlad Cealicu, CTO
- Konrad Strachan, Senior developer
- Quynh Tran-Thanh, Quant developer

## 5.2 Exchange review

Exchange exclusion is reviewed by the Review Committee at least once every calendar month or on an ad-hoc basis, when market or technical events require. Market or technical events can be

- Suspended trading
- False data provision
- Service outage

## 5.3 Change communication

If the Review Committee requires changes in the methodology or exchange exclusion, CCCAGG consumers will be notified via the API newsletter or will direct client communication channels.

# 6. Dissemination

CCCAGG indices are disseminated via REST API and Websocket API. Read the API documentation at https://www.cryptocompare.com/api.

# 7. Disclaimer



Crypto Coin Comparison Ltd is a registered company in England with a register number 08846965 and address 1 Duchess Street, W1W6AN, London, United Kingdom.