



CME CF CRYPTOCURRENCY REFERENCE RATES

Methodology Guide

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Table of Contents

1	Version History.....	3
2	Overview.....	4
3	Definitions.....	5
4	Methodology and Rules.....	6
4.1	Methodology.....	6
4.1.1	Qualitative Description.....	6
4.1.2	Mathematical Representation.....	7
4.2	A Note on Properties.....	8
5	Contingency Calculation Rules.....	10
5.1	Delayed Data and Missing Data.....	10
5.2	Erroneous Data.....	10
5.3	Potentially Erroneous Data.....	11
5.4	Expert Judgement.....	11
5.5	Calculation Failure.....	11
6	Reference Rate Parameters.....	13
7	Reference Rate Specifications.....	14
8	Methodology Review and Changes to the Reference Rates.....	15

1 Version History

Version	Version Date	Changes to Previous
1	10 th November 2016	N/A
2	6 th March 2017	Added description of treatment of erroneous data.
3	14 th May 2018	Generalised methodology to support multiple reference rates.
3.1	24 th September 2018	Changed ETH_RR_USD ticker symbol to ETHUSD_RR
4	4 th January 2019	Parameterisation of Rule 5.3 for different Reference Rates
5	16 th July 2019	Rebrand to CF Benchmarks
6	11 th September 2019	Update legal text with BMR registration
7	10 th February 2020	Change potentially erroneous data parameter
8	20 th May 2020	Update copyright year
9		Addition of: <ul style="list-style-type: none">• Underlying Economic Reality in Section 2• Expert Judgement in Section 5• Methodology Review and Change Section 8

2 Overview

Responding to the need for enhanced pricing information on the rapidly growing cryptocurrency asset class, CME Group and CF Benchmarks have developed standardized cryptocurrency reference rates and real time indices.

Each reference rate and real time index represent transparent indicators with independent governance and oversight and build on our experience to accelerate the professionalization of cryptocurrency trading.

This document covers the CME CF Cryptocurrency Reference Rates. A summary of specifications is provided in Section 7.

Underlying Economic Reality

The CME CF Reference Rates are intended to measure the underlying economic reality of the exchange of the base asset for the quote asset and vice versa. This is accomplished by the use of transactional input data from Constituent Exchanges, the criteria for eligibility for which are available in the CME CF Constituent Exchange Criteria.

3 Definitions

API: Application programming interface.

Calculation Day: Any day for which a CME CF Cryptocurrency Reference Rate is published.

Constituent Exchange: A cryptocurrency trading venue approved by the CME CF Cryptocurrency Indices Oversight Committee to serve as pricing source for the calculation of a CME CF Cryptocurrency Reference Rate.¹

Relevant Pair: The cryptocurrency versus legal tender pair referenced by a CME CF Cryptocurrency Reference Rate, as defined in Section 6.

Relevant Transaction: Any cryptocurrency versus legal tender spot trade that occurs during the TWAP Period on a Constituent Exchange in the Relevant Pair that is reported through its API to the Calculation Agent.

Retrieval Time: One minute after the end of the TWAP Period on a given Calculation Day, as given by the server clock of the Calculation Agent.

TWAP Period: A period of time equal to the TWAP Period Length leading up to the Effective Time, as defined in Section 6.

¹ Constituent Exchanges and the criteria for inclusion are published on the Administrator's website <https://www.cfbenchmarks.com>.

4 Methodology and Rules

4.1 Methodology

4.1.1 Qualitative Description

CME CF Cryptocurrency Reference Rates are calculated based on the Relevant Transactions of all Constituent Exchanges. Calculation steps on any given Calculation Day are as follows:

1. All Relevant Transactions are added to a joint list, recording the trade price and size for each transaction.
2. The list is partitioned into a number of equally-sized time intervals, as specified in Section 6.
3. For each partition separately, the volume-weighted median trade price is calculated from the trade prices and sizes of all Relevant Transactions, i.e. across all Constituent Exchanges. A volume-weighted median differs from a standard median in that a weighting factor, in this case trade size, is factored into the calculation.
4. The CME CF Cryptocurrency Reference Rate is then given by the equally-weighted average of the volume-weighted medians of all partitions.

4.1.2 Mathematical Representation

The following table shows the symbols used in the mathematical representation of CME CF Cryptocurrency Reference Rates.

Symbol	Name	Description	Type
T	Effective time	The time as of which a CME CF Cryptocurrency Reference Rate is calculated	Parameter, see Section 6
τ	TWAP period length	The length of the time-period prior to the effective time during which transaction data is collected	Parameter, see Section 6
$\hat{\tau}$ with $\hat{\tau} \leq \tau$ and $\hat{\tau} \mid \tau$	Partition length	The length of the time periods into which the TWAP period length is partitioned	Parameter, see Section 6
K	Number of partitions	The number of partitions, given by $K = \tau / \hat{\tau}$	Output
k with $k \in (1, \dots, K)$	Partition	The k th partition	Output
X_k for $k \in (1, \dots, K)$	TWAP period trades	The price-ordered collection of price / size trade pairs observed in the Relevant Pair on all Constituent Exchanges in the k th partition, i.e. between times $T - \tau + (k - 1)$ and $T - \tau + k$	Input
I_k	TWAP period trades count	The number of trades in the k th partition	Output
$x_{k,i}$ with $x_{k,i} = (p_{k,i}, s_{k,i})$ and $x_{k,i} \in X_k$	TWAP period trade	The i th price / size trade pair of the k th partition	Input
$p_{k,i}$	TWAP period trade price	The price of the i th price/size trade pair of the k th partition	Input
$s_{k,i}$	TWAP period trade size	The size of the i th price/size trade pair of the k th partition	Input
WM_k	Weighted median	The weighted median trade price of the k th partition	Output

$CCRR_T$	CCRR	The CME CF Cryptocurrency Reference Rate at time T	Output
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For each partition k , the volume-weighted median trade prices WM_k across all Relevant Transactions is calculated as:

$WM_k = p_{k,j} \text{ where } j \text{ satisfies } \sum_{i=1}^{j-1} s_{k,i} < \frac{1}{2} \sum_{i=1}^{I_k} s_{k,i} \text{ and } \sum_{i=j+1}^{I_k} s_{k,i} \leq \frac{1}{2} \sum_{i=1}^{I_k} s_{k,i}$ $\text{If } s_{k,1} \geq \frac{1}{2} \sum_{i=1}^{I_k} s_{k,i} \text{ then } WM_k = p_{k,1}$ $\text{If } \sum_{i=j+1}^{I_k} s_{k,i} = \frac{1}{2} \sum_{i=1}^{I_k} s_{k,i}, \text{ then } WM_k = \frac{p_{k,j} + p_{k,j+1}}{2}$	Eq. 1
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The CME CF Cryptocurrency Reference Rate as of the effective time T , $CCRR_T$, is then given by:

$CCRR_T = \frac{1}{K} \sum_{k=1}^K WM_k$	Eq. 2
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4.2 A Note on Properties

The calculation methodology immunizes CME CF Cryptocurrency Reference Rates to a high degree against price anomalies, while being replicable through spot trading on Constituent Exchanges. This is achieved through the following design choices:

Partitions

CME CF Cryptocurrency Reference Rates are calculated as the equally-weighted average of the intermediate calculation steps for the K partitions. A single large trade or cluster of trades occurring in any one partition will therefore only have a limited effect on CME CF Cryptocurrency Reference Rates.

Weighting of Partitions

Partitions are equally-weighted (as opposed to volume-weighted) to facilitate replication of CME CF Cryptocurrency Reference Rates through trading on Constituent Exchanges. Assuming K partitions, a trader aiming to transact Y units of the relevant cryptocurrency at the CME CF Cryptocurrency Reference Rates can do so with little tracking error by transacting Y/K units of the cryptocurrency during each partition.

Medians

Spot prices have historically varied considerably across trading venues, in particular during times of high volatility. The use of medians to calculate the weighted median

trade price for each partition (as opposed to averages) greatly reduces CME CF Cryptocurrency Reference Rates' susceptibility to price extremes on one or more Constituent Exchanges.

Volume-Weighting of Medians

Trading is driven to some extent by automated algorithms that may execute a high number of small trades. The use of volume-weighted medians to calculate the weighted median trade price for each partition (as opposed to simple medians) assures that CME CF Cryptocurrency Reference Rates appropriately reflect large trades and that whether an order is executed in parts or in full has no effect on calculation results.

5 Contingency Calculation Rules

5.1 Delayed Data and Missing Data

Delayed data and missing data are treated according to the following rules:

1. Any Relevant Transaction for a given Calculation Day that for any reason cannot be retrieved by the Calculation Agent from a Constituent Exchange's API by the Retrieval Time is disregarded in the calculation of the CME CF Cryptocurrency Reference Rate for that Calculation Day.
2. If no Relevant Transaction occurs on a Constituent Exchange on a given Calculation Day or one or more Relevant Transactions occur but for any reason cannot be retrieved by the Calculation Agent, the Constituent Exchange is disregarded in the calculation of the CME CF Cryptocurrency Reference Rate for that Calculation Day.
3. If, for any of the K partitions of the TWAP Period, no Relevant Transaction occurs on any Constituent Exchange or one or more Relevant Transactions occur but for any reason cannot be retrieved by the Calculation Agent, the partition remains empty and will be disregarded in the calculation of the CME CF Cryptocurrency Reference Rate for that Calculation Day. The denominator in Eq. 2 will then be decremented by the number of empty partitions.
4. If no Relevant Transaction occurs on any Constituent Exchange on a given Calculation Day or one or more Relevant Transactions occur but for any reason no Relevant Transaction can be retrieved from any Constituent Exchange by the Calculation Agent, a CME CF Cryptocurrency Reference Rate calculation failure occurs for that Calculation Day (see Section 5.5).

5.2 Erroneous Data

All Relevant Transactions retrieved by the Calculation Agent for a given Calculation Day are subject to an automated screening for erroneous data according to the following rules:

1. If a Relevant Transaction shows a non-numeric or non-positive trade price or trade size, it is flagged as erroneous.
2. If a Relevant Transaction is reported in a format that deviates from the expected format such that it cannot be parsed, it is flagged as erroneous.

Relevant Transactions flagged as erroneous for a given Calculation Day are disregarded in the calculation of the CME CF Cryptocurrency Reference Rate for that Calculation Day.

If all Relevant Transactions of all Constituent Exchanges are flagged as erroneous for a given Calculation Day, a CME CF Cryptocurrency Reference Rate calculation failure occurs for that Calculation Day (see Section 5.5).

5.3 Potentially Erroneous Data

All Relevant Transactions retrieved by the Calculation Agent for a given Calculation Day are subject to an automated screening for potentially erroneous data according to the following rules:

1. For each Constituent Exchange individually, the volume-weighted median trade price across all Relevant Transactions of that Constituent Exchange is calculated.
2. For each Constituent Exchange, the absolute percentage deviation of the volume-weighted median trade price, as calculated in the previous step, from the median of the volume-weighted median trade prices of all Constituent Exchanges is calculated.
3. If for any Constituent Exchange the absolute percentage deviation, as calculated in the previous step, exceeds the Potentially Erroneous Data Parameter for the respective Reference Rate represented in Reference Rate Parameters (see section 6) then all Relevant Transactions of that Constituent Exchange for the affected Reference Rate are flagged as potentially erroneous.

Relevant Transactions flagged as potentially erroneous for a given Calculation Day are disregarded in the calculation of the CME CF Cryptocurrency Reference Rate for that Calculation Day. The occurrence of any such flag is reported to the Oversight Committee.

If all Relevant Transactions of all Constituent Exchanges are flagged as potentially erroneous for a given Calculation Day, a CME CF Cryptocurrency Reference Rate calculation failure occurs for that Calculation Day (see Section 5.5).

5.4 Expert Judgement

The Administrator does not utilise expert judgment in the day to day calculation of the Reference Rates. In extraordinary circumstances Expert Judgement may be exercised by the Administrator in accordance with its codified policies and processes which are available upon request.

5.5 Calculation Failure

If a CME CF Cryptocurrency Reference Rate cannot be calculated for a given Calculation Day, for instance because:

- no Relevant Transaction occurs on any Constituent Exchange on that Calculation Day, or
- one or more Relevant Transactions occur but for any reason cannot be retrieved by the Calculation Agent, or
- all Relevant Transactions retrieved by the Calculation Agent are flagged as erroneous or potentially erroneous (see Section 5.2); or
- any other reason or circumstance that prevents the orderly calculation of a CME CF Cryptocurrency Reference Rate,

then the CME CF Cryptocurrency Reference Rate for that Calculation Day is given by the CME CF Cryptocurrency Reference Rate published on the previous Calculation Day. The occurrence of any CME CF Cryptocurrency Reference Rate calculation failure is reported to the Oversight Committee.

6 Reference Rate Parameters

The following table summarizes the parameters for the currently supported CME CF Cryptocurrency Reference Rates:

	CME CF Bitcoin Reference Rate	CME CF Ether-Dollar Reference Rate
Ticker Symbol	BRR	ETHUSD_RR
Relevant Pair	Bitcoin vs. U.S. Dollars	Ether vs. U.S. Dollars
Effective Time (T)	4:00 p.m. London time	4:00 p.m. London time
TWAP Period Length (τ)	60 minutes	60 minutes
TWAP Period	3:00pm to 4:00 pm London time	
Partition Length ($\hat{\tau}$)	5 minutes	5 minutes
Number of Partitions (K)	12	12
Potentially Erroneous Data	10%	10%

7 Reference Rate Specifications

	CME CF Bitcoin Reference Rate	CME CF Ether-Dollar Reference Rate
Ticker Symbol	BRR	ETHUSD_RR
Relevant Pair	Bitcoin vs. U.S. Dollars	Ether vs. U.S. Dollars
Administrator	CF Benchmarks Ltd	
Calculation Agent	CF Benchmarks Ltd	
Description	U.S. Dollar price of one bitcoin as of 4:00 p.m. London time	U.S. Dollar price of one ether as of 4:00 p.m. London time
Calculation Methodology	Aggregation of trade executions occurring on Constituent Exchanges between during the TWAP period.	
Dissemination Time	Once per day, every day of the year including weekends and holidays, between 4:00 p.m. and 4:30 p.m. London time	
Dissemination Precision	0.01 U.S. Dollars	0.01 U.S. Dollars

8 Methodology Review and Changes

This methodology is subject to internal review by the Administrator and the CME CF Oversight Committee at least annually.

Any changes to this methodology are overseen by the CME CF Oversight Committee, and In accordance with EU BMR Article 13.

All *material* changes to the methodology shall only be implemented after a consultation process with users and relevant stakeholders that shall be conducted according to the Administrator's policies and overseen by the CME CF Oversight Committee.

Should the Administrator deem it necessary to cease providing any of the Reference Rates it shall only do so after a consultation process with users and relevant stakeholders that shall be conducted according to the Administrator's policies and overseen by the CME CF Oversight Committee

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