



CM Reference Rates Methodology

Version 1.1

Last Revised: May 30, 2019

0 Change Log	2
1 Introduction	3
2 Description	3
3 Coverage Universe	3
4 Data and Calculation Methodology	7
4.1 Data Sources	7
4.2 Market Selection Framework	7
4.3 Data Inputs	8
4.3.1 Bitcoin (BTC) and Ethereum (ETH)	8
4.3.2 Other Cryptocurrencies Excluding Stablecoins	8
4.3.3 Stablecoins	9
4.4 Calculation Algorithm	9
4.5 Data Contingency Rules	12
4.6 Data Exclusion Rules	13
5 Reference Rate Revisions	13
6 Administration	13
7 Internal Oversight	14
8 Conflicts of Interest	14
9 Material Changes or Termination	14
10 Internal Controls	15
11 Complaints	15
12 Internal Audit	15
13 Record Retention	15
14 Compliance	16

0 Change Log

Release	Date	Changes
Version 1.0	May 13, 2019	Finalized Reference Rate Methodology
Version 1.1	May 30, 2019	<p>Update to the second Data Contingency Rule: instead of using the price of the last observable transaction of the selected market before the start of the first time interval, use the next available time interval's volume-weighted median price.</p> <p>Update to the third Data Contingency Rule: instead of applying to any 1-minute time interval, only apply to any of the non-first or non-last 1-minute time intervals.</p> <p>Update to the fourth Data Contingency Rule: instead of using the last published rate, use the last hourly reference rate in which there were trades during that hour's Observation Window.</p>

1 Introduction

Coin Metrics produces the CM Reference Rates (the “Reference Rates”), a collection of daily reference rates quoted in U.S. dollars for a set of cryptocurrencies. The Reference Rates are designed to serve as a transparent and independent pricing source that promotes the functioning of efficient markets, reduces information asymmetries among market participants, facilitates trading in standardized contracts, and accelerates the adoption of cryptocurrencies as an asset class with the highest standards. The Reference Rates are calculated using a robust and resilient methodology that is resistant to manipulation and adheres to international best practices for financial benchmarks, including the International Organization of Securities Commissions’ (IOSCO) Principles for Financial Benchmarks. The Coin Metrics Oversight Committee (the “Oversight Committee”) and an independent governance structure protect the integrity of the Reference Rates and ensure the Reference Rates serve as a source of transparent and independent pricing.

2 Description

The Reference Rates are currently produced for a midnight UTC Fixing Time¹, They and represent the reference rate of one unit of the cryptocurrency quoted in U.S. dollars. The Reference Rates are published within 60 minutes after the Fixing Time (the “Publication Time”)

3 Coverage Universe

Coin Metrics produces reference rates for the following cryptocurrencies:

Name	Ticker
Bitcoin	btc
Ethereum	eth
Tether	usdt
Litecoin	ltc
Ripple	xrp
EOS	eos
Bitcoin Cash	bch
Dash	dash
ZCash	zec
Stellar	xlm
Monero	xmr

¹ Fixing Times for various daily closes (New York, London, Tokyo) are expected to be added soon.

Qtum	qtum
Ethereum Classic	etc
TRON	trx
Binance Coin	bnb
NEO	neo
Bitcoin Cash SV	bsv
USD Coin	usdc
Cardano	ada
TrueUSD	tusd
OmiseGO	omg
Paxos Standard Token	pax
0x	zrx
Basic Attention Token	bat
Bitcoin Gold	btg
Augur	rep
NEM	xem
VeChain	vet
Zilliqa	zil
BitTorrent Token	btt
IOTA	miota
Status	snt
Ontology	ont
Waves	waves
ICON	icx
Dai	dai
Aeternity	ae
Enjin Coin	enj
Dogecoin	doge
Golem	gnt
Huobi Token	ht
BitShares	bts

IOST	iost
ELF	elf
Kyber Network	knc
Verge	xvg
ChainLink	link
Lisk	lsk
Tezos	xtz
Decentraland	mana
Crypto.com	mco
Mithril	mith
Steem	steem
Loopring	lrc
Storj	storj
Loom Network	loom
Polymath	poly
Bitcoin Diamond	bcd
Bytom	btm
Waltonchain	wtc
Theta Token	theta
Power Ledger	powr
Siacoin	sc
Stratis	strat
Nano	nano
Decred	dcr
Civic	cvc
Komodo	kmd
Nebulas	nas
WAX	wax
Bancor	bnt
DigiByte	dgb
Odyssey	ocn

FunFair	fun
HyperCash	hc_hypercash
Maker	mkr
Ardor	ardr
QASH	qash
TenX	pay
Metal	mtl_metal
iExec RLC	rlc
Raiden Network Token	rdn
Project Pai	pai
Gas	gas
Dent	dent
PIVX	pivx
Bytecoin	bcn
Arcblock	abt
Aion	aion
Eidoo	edo
GXChain	gxs
Enigma	eng
Groestlcoin	grs
Populous	ppt
Ripio Credit Network	rcn_ripiocreditnetwork
ZCoin	xzc
CyberMiles	cmt
Gemini Dollar	gusd
Matrix AI Network	man
Ethos	ethos
Cosmos	atom
Grin	grin

4 Data and Calculation Methodology

4.1 Data Sources

The input data source for the Reference Rates are markets traded on cryptocurrency exchanges that are approved to serve as pricing sources by the Oversight Committee. The Oversight Committee evaluates markets using a Market Selection Framework that assesses markets along a wide set of criteria to determine if the data source reflects trading activity in a transparent and representative manner. The Oversight Committee evaluates new markets for inclusion as a selected data source and evaluates already selected markets using the Market Selection Framework on a quarterly basis or as market conditions warrant. Markets that are approved by the Oversight Committee are added to a list of selected markets (the “Selected Markets”). A separate list of Selected Markets is maintained for each of the Reference Rates in the coverage universe.

A candidate market can be nominated for inclusion and an already selected market can be nominated for exclusion by any member of the public or member of the Oversight Committee. Public nominations for inclusion or exclusion of a market can be submitted in writing to support@coinmetrics.io. The Oversight Committee may convene to apply the Market Selection Framework to evaluate the inclusion or exclusion of a market between regularly-scheduled quarterly meetings if market conditions or circumstances warrant. Coin Metrics publishes a current list of Selected Markets for each of the Reference Rates, updates on inclusions or exclusions of exchanges, and the rationale for making any change.

4.2 Market Selection Framework

The Market Selection Framework consists of a fully-systematized process for evaluating markets to serve as input pricing sources for the calculation of the Reference Rates. It produces a unique set of candidate selected markets for each asset in the coverage universe that are then subsequently reviewed by the Oversight Committee. The market selection framework evaluates markets based on the following criteria:

1. **Technology:** An assessment of whether the technology infrastructure of the market's exchange provides sufficient availability and reliability for input data collection. Evaluates whether the exchange offers a REST API, Websocket feed, or FIX API suitable for data collection. Evaluates the performance of the API in terms of reliability and latency.
2. **Legal and Compliance:** An assessment of whether the market's exchange complies with laws and regulations. Evaluates the exchange's legal risk exposure, and whether it adheres to regulatory best practices. Evaluates whether the exchange has publicly-disclosed trading policies, uses market surveillance technology, and complies with national regulatory organizations, and enforces KYC and AML requirements. Evaluates whether the exchange has functioning fiat and cryptocurrency withdrawals processed within a normal timeframe. Evaluates whether a data sharing license can be executed with the exchange.
3. **Business Model:** An assessment of the market's exchange with respect to its business model, including its fee structure and asset listing standards.
4. **Data Availability:** An assessment of the available data the market's exchange offers for the given cryptocurrency, including the number of markets where the given cryptocurrency is the base

currency, whether the markets are quoted in fiat currencies or other cryptocurrencies, and the type of markets offered.

5. Price: An assessment of the quality of the market's price data, including testing for the occurrence of price outliers and impactful price deviations from other markets, and implementing tests that determine whether the exchange's markets function as active markets in the underlying cryptocurrency and are anchored by observable transactions entered into at arm's length between buyers and sellers.
6. Volume: An assessment of the quality of the market's volume data, including testing for manipulated volume figures, and implementing tests that determine whether the exchange's markets function as active markets in the underlying cryptocurrency and are anchored by observable transactions entered into at arm's length between buyers and sellers. The size of the exchange's markets are also considered.
7. Order Book: An assessment of the quality of the market's order book data, including tests for manipulated orders, and implementing tests that determine whether the market function as active markets in the underlying cryptocurrency and are anchored by observable transactions entered into at arm's length between buyers and sellers. The liquidity of the market is also considered.

4.3 Data Inputs

The data inputs for the calculation of the Reference Rates are observable transactions in an active market where the given cryptocurrency is traded. The pool of candidate markets that are evaluated by the Market Selection Framework are determined by a hierarchy of data inputs that varies depending on the given cryptocurrency. Coin Metrics publishes a list of current data inputs for each of the Reference Rates, changes to the data inputs, and the rationale for making any change.

4.3.1 Bitcoin (BTC) and Ethereum (ETH)

The pool of candidate markets that are evaluated for the calculation of the Reference Rates for Bitcoin (BTC) and Ethereum (ETH) are determined using the following data hierarchy:

1. The primary data input is observable transactions in an active market where the given cryptocurrency is the base currency and the quote currency is U.S. dollars.
2. Markets where the given cryptocurrency is the base currency and the quote currency is not U.S. dollars are not considered, including markets quoted in other fiat currencies or markets quoted in stablecoins.

4.3.2 Other Cryptocurrencies Excluding Stablecoins

The pool of candidate markets that are evaluated for the calculation of the Reference Rates for other cryptocurrencies, excluding Bitcoin (BTC), Ethereum (ETH), and stablecoins are determined using the following data hierarchy:

1. The primary data input is observable transactions in an active market where the given cryptocurrency is the base currency and the quote currency is U.S. dollars.
2. If the above data inputs do not exist or the Oversight Committee makes a determination that the above data inputs are insufficient to calculate the reference rate, the universe of data inputs will expand to include observable transactions in an active market where the given cryptocurrency is the base currency and quote currency is BTC.

3. If the above data inputs do not exist or the Oversight Committee makes a determination that the above data inputs are insufficient to calculate the reference rate, the universe of data inputs will expand to include observable transactions in an active market where the given cryptocurrency is the base currency and quote currency is ETH.

4.3.3 Stablecoins

The pool of candidate markets that are evaluated for the calculation of the Reference Rates for stablecoins are determined using the following data hierarchy:

1. The primary data input is observable transactions in an active market where the given stablecoin is the base currency and the quote currency is U.S. dollars.
2. If the above data inputs do not exist or the Oversight Committee makes a determination that the above data inputs are insufficient to calculate the reference rate, the universe of data inputs will expand to include observable transactions in an active market where Bitcoin (BTC) is the base currency and quote currency is the given stablecoin.
3. If the above data inputs do not exist or the Oversight Committee makes a determination that the above data inputs are insufficient to calculate the reference rate, the universe of data inputs will expand to include observable transactions in an active market where Ethereum (ETH) is the base currency and quote currency is the given stablecoin.

The data hierarchy for stablecoins differs from other cryptocurrencies because market convention sets stablecoins as the quote currency for the majority of active markets. The following cryptocurrencies in the coverage universe are considered to be stablecoins:

Name	Ticker
Tether	usdt
USD Coin	usdc
TrueUSD	tusd
Paxos Standard Token	pax
Dai	dai
Gemini Dollar	gusd

4.4 Calculation Algorithm

The calculation algorithm of the Reference Rates is described below.

1. All observable transactions from selected markets are combined and partitioned into time intervals, with each time interval spanning a period of 1 minute. The first 1-minute time interval begins 60 minutes before the Fixing Time and the last 1-minute time interval begins at the Fixing Time and ends 1 minute after the Fixing Time. In total, the calculation period spans a period of 61 minutes (the "Observation Window"). A total of 61 1-minute time intervals are created.
2. The price of each observable transaction for one unit of the given cryptocurrency is converted to U.S. dollars if necessary using the Reference Rates calculated for Bitcoin (BTC) or Ethereum (ETH).
3. The volume-weighted median price (VWMP) of each time interval is calculated. The volume-weighted median rate is calculated by ordering the transactions from lowest to highest

price, taking the cumulative sum of volumes of these transactions, and identifying the price associated with the trades at the 50th percentile of dollar volume.

4. The time-weighted average price (TWAP) of the 61 time intervals is calculated using a custom weight function. The weight function assigns a weight of 0 to the first time interval, subsequent time intervals are assigned a weight that increases linearly, and the last two time intervals are assigned a weight of 0.05 such that the sum of all weights equals 1. The weight function assigns more weight to time slices that are closer to the Fixing Time. The resulting figure is the published reference rate.

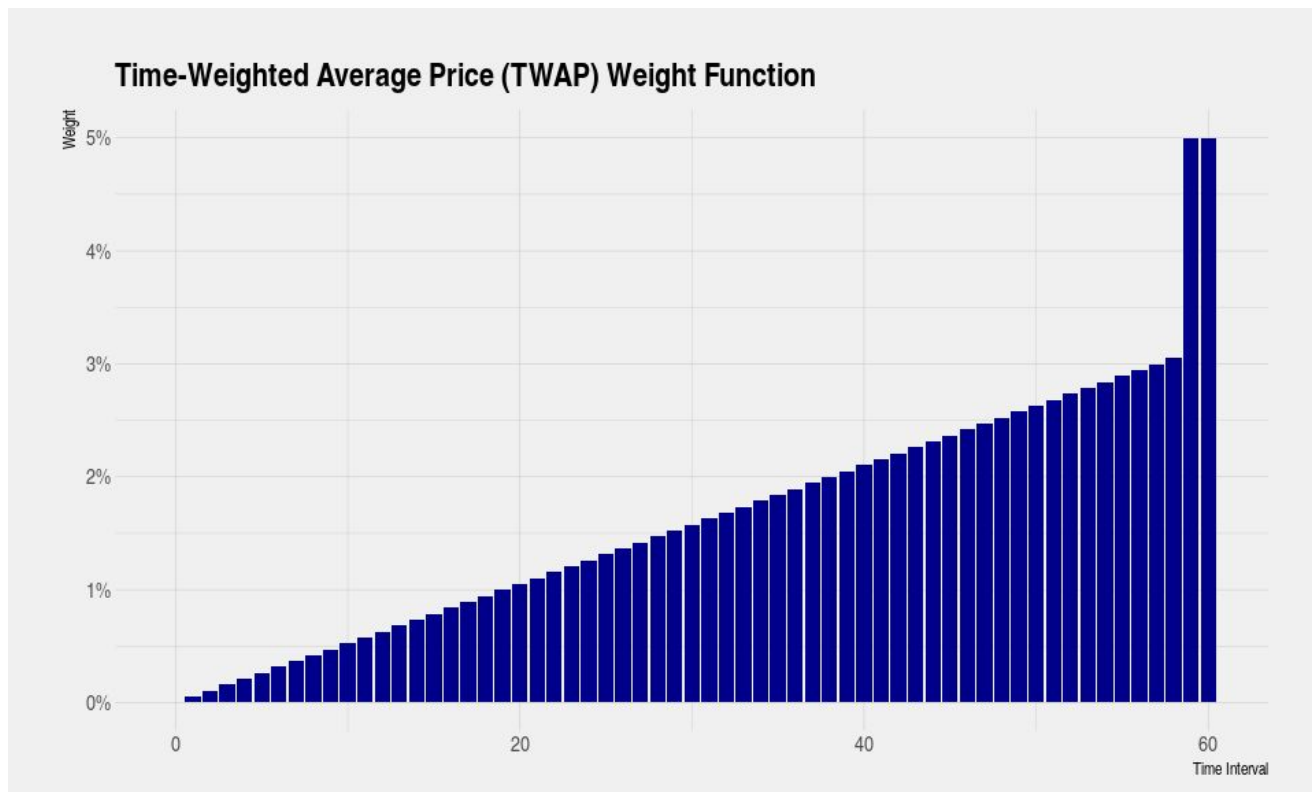
The weights of each time interval are included below:

Time Interval	Weight
0	0.000000
1	0.000526
2	0.001052
3	0.001578
4	0.002104
5	0.002630
6	0.003156
7	0.003682
8	0.004208
9	0.004734
10	0.005260
11	0.005786
12	0.006312
13	0.006838
14	0.007364
15	0.007890
16	0.008416
17	0.008942
18	0.009468
19	0.009994
20	0.010520
21	0.011046
22	0.011572
23	0.012098
24	0.012624
25	0.013150

26	0.013676
27	0.014202
28	0.014728
29	0.015254
30	0.015780
31	0.016306
32	0.016832
33	0.017358
34	0.017884
35	0.018410
36	0.018936
37	0.019462
38	0.019988
39	0.020514
40	0.021040
41	0.021566
42	0.022092
43	0.022618
44	0.023144
45	0.023670
46	0.024196
47	0.024722
48	0.025248
49	0.025774
50	0.026300
51	0.026826
52	0.027352
53	0.027878
54	0.028404
55	0.028930
56	0.029456
57	0.029982
58	0.030508
59	0.050000

60	0.050000
----	----------

A chart of the weights is included below:



4.5 Data Contingency Rules

The following contingency rules are followed to address situations where data is delayed, missing, or unavailable due to periods of illiquidity, extraordinary market circumstances, or outside factors beyond the control of Coin Metrics.

1. If observable transactions from a selected market are unable to be collected due to technical problems specific to the selected market's exchange during the calculation of a reference rate, the observable transactions from the selected market are not included in the calculation of the specific instance of the given reference rate.
2. If no observable transactions from selected markets occur during the first 1-minute time interval, the following next available time interval's volume-weighted median price is used as the volume-weighted median price for first 1-minute time interval. This contingency rule is applied recursively if necessary
3. If no observable transactions from selected markets occur during any of the non-first or non-last 1-minute time intervals, the following next available time interval's volume-weighted median price is used as the volume-weighted median price for the empty 1-minute time interval. This contingency rule is applied recursively if necessary.

4. If no observable transactions from selected markets occur during the last 1-minute time interval, the previous available time interval's volume-weighted median price is used as the volume-weighted median price for the last 1-minute time interval. This contingency rule is applied recursively if necessary.
5. If no observable transactions from selected markets exist during the calculation period for a reference rate, the reference rate will be determined to equal the last hourly reference rate in which there were trades during that hour's Observation Window.

4.6 Data Exclusion Rules

All observable transactions from selected markets are evaluated using a systematic data quality control process. If potential errors or anomalies in the data are detected, the exercise of expert judgment will be applied to determine if the potentially erroneous data is included in the calculation of the reference rate. The exercise of expert judgment in this circumstance is used to determine if the potentially erroneous data reflects observable transactions that are entered into at arm's length between buyers and sellers and constitute an active market in the underlying cryptocurrency, whether the observable transactions in question are formed by the competitive forces of supply and demand, and whether the observable transactions in question are a credible indicator of executable prices in the underlying cryptocurrency. An investigation into the causes of the potential error, including whether any price deviations are specific to the exchange itself, is conducted. Any exercise of expert judgment is subject to dual approval by staff members, and is logged and reported to the Oversight Committee which periodically reviews the application of expert judgment to ensure consistency.

5 Reference Rate Revisions

If errors are discovered in observable transactions used to calculate the reference rate or in the calculation process subsequent to the publication of the reference rate, a revised reference rate may be published within 8 hours of the Publication Time. Revisions will only be effected within 8 hours of the Publication Time and only if the change in the rate exceeds 1 percent of the original reference rate. A footnote will be published to indicate the revision of any reference rate.

6 Administration

Coin Metrics serves as the administrator for the Reference Rates and has primary responsibility for all aspects of the Reference Rates determination process, including the development, definition, determination, dissemination, operation, and governance of the Reference Rates. All aspects of the production of the Reference Rates are carried out by Coin Metrics, and Coin Metrics does not rely on any third parties for the determination of the Reference Rates.

Coin Metrics ensures that transparency regarding significant decisions and associated rationale are published and made available to external stakeholders. Data contingency and data exclusion rules are in place to handle certain extraordinary circumstances and external factors beyond the control of Coin Metrics. The Oversight Committee reviews and provides challenge on the Reference Rates production process.

7 Internal Oversight

The Oversight Committee provides independent oversight over the production of the Reference Rates. The Oversight Committee's responsibilities include regular reviews of the Reference Rate production process, the Reference Rate definition and calculation methodology, the selection of data sources and data inputs, any uses of expert judgment or non-standard procedures, conflicts of interest, material changes to or termination of the Reference Rates, reviewing the results of external and internal audits, and any complaints or questions regarding the Reference Rates from external stakeholders. Additional information regarding the responsibilities and membership of the Oversight Committee can be found in the Coin Metrics Operating Committee Charter document.

8 Conflicts of Interest

Coin Metrics enforces policies and procedures relating to conflicts of interest in connection with the production of the Reference Rates. The conflicts of interest policy addresses the identification, disclosure, management, and mitigation of conflicts of interest. These policies and procedures are periodically reviewed by the Oversight Committee. Coin Metrics is committed to disclosing any material conflicts of interest to external stakeholders and to regulatory authorities.

9 Material Changes or Termination

Coin Metrics may initiate material changes to or terminate a reference rate due to certain extraordinary market circumstances or external factors. These circumstances or external factors include, but are not limited to:

1. The reference rate no longer serves, and could not be modified to serve, as a transparent and independent pricing source for the underlying cryptocurrency
2. The market liquidity in the underlying cryptocurrency declines to an extent that the input data sources no longer function as active markets
3. The underlying cryptocurrency experiences a contentious hard fork in which both forks survive

In such circumstances, Coin Metrics will review the Reference Rates to ensure the Reference Rates are properly reflecting their underlying cryptocurrencies, and if necessary, make changes to the methodology or definition of the Reference Rates to properly account for changing market structure, circumstances, and conventions in the underlying cryptocurrency. Any such change or termination will be reviewed and approved by the Oversight Committee. Any approved change or termination will be publicly disclosed to external stakeholders with a detailed explanation of the rationale. In a manner appropriate to the circumstances, Coin Metrics will develop a plan to notify, solicit comments from, and consult with external stakeholders before implementing any material change or termination. Any change or termination will include a timeline explaining the timing of changes or termination and include steps to mitigate any negative effects on external stakeholders.

10 Internal Controls

Coin Metrics has implemented internal controls to protect the integrity of the Reference Rates. These controls cover the selection of input data sources, the collection of data from input data sources, and maintaining the integrity of collected data. Staff involved with the production of the Reference Rates have been trained in the proper usage of the data and maintain proper segregation of responsibilities. Any exercise of expert judgment or non-standard procedures is subject to dual approval by staff members, and is logged and reported to the Oversight Committee which periodically reviews any incidents. In addition, Coin Metrics maintains a whistleblowing mechanism to facilitate the reporting of any potential misconduct.

11 Complaints

Complaints about the calculation methodology of the Reference Rates or the value of a published reference rate should be submitted in writing to support@coinmetrics.io. Coin Metrics will investigate any complaints and respond to the complainant in a fair and timely manner. Any investigation of the complaint will adhere to the following procedures:

1. The personnel receiving and investigating the complaint will be independent of any personnel who may have been involved in the subject of the complaint.
2. All records and documents submitted by the complainant and related to the investigation into the complaint will be retained for a period of at least five years and submitted to the Oversight Committee for review.
3. Any complaint that results in a change in the determination of the Reference Rates, its calculation methodology, or its policies will be publicly disclosed that explain the action taken.

12 Internal Audit

The Oversight Committee appoints an independent internal auditor to review the Reference Rates's adherence to its stated methodology, compliance with policies, and adherence to the IOSCO's Principles of Financial Benchmarks. The frequency of the independent internal audit is once annually.

13 Record Retention

Coin Metrics retains records, for at least five years, on the following items:

1. All market data that is collected and used in the calculation of the Reference Rates
2. Any use of expert judgment in the calculation of the Reference Rates
3. Any use of non-standard procedures in the calculation of the Reference Rates
4. The identities of staff responsible for the calculation of the Reference Rates
5. Any responses, questions, or complaints received in connection with the calculation of the Reference Rates

14 Compliance

Coin Metrics maintains records and has processes in place to comply with requests for information from regulatory authorities. Coin Metrics commits to full cooperation with any regulatory authority in carrying out their regulatory or supervisory duties.