CM Real-Time Reference Rates Methodology

Version 0.2 (Beta 2.1)

Last Revised: February 6, 2020

0 Change Log

Release	Date	Changes
Version 0.2 (Beta 2.1)	February 6, 2020	**Periodic Market Selection Updates:** The markets for a number of assets were updated as part of the periodic review. **Coverage Universe Update:** The following assets were removed box, cosm, fsn, medx, pst, and ttc_ttcprotocol. New assets were created to account for the transition between Sai (sai) and Dai (dai).
Version 0.1 (Beta 2)	December 9, 2019	**Modified Calculation Algorithm** to include inverse variance weighting to lessen the occurence of outlier rates. **Expanded Coverage Universe:** Added the following assets: algo, beam.
Version 0 (Beta)	August 30, 2019	Finalized Real-Time Reference Rate Methodology v0 for Beta release.

1 Introduction

Coin Metrics produces the CM Real-Time Reference Rates (the “Real-Time Reference Rates”), a real-time price quoted in U.S. dollars for a set of cryptocurrencies. The Real-Time Reference Rates is 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 Real-Time Reference Rates is 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 Real-Time Reference Rates and ensure the Real-Time Reference Rates serves as a source of transparent and independent pricing.

2 Description

The Real-Time Reference Rates are calculated once every second and represents the real-time price of one unit of the cryptocurrency quoted in U.S. dollars.

3 Coverage Universe

Cryptocurrencies included in the CM Real-Time Reference Rate coverage universe are listed in Appendix A.

4 Data and Calculation Methodology

4.1 Data Sources

The input data source for the Real-Time 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 Real-Time 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 Real-Time 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 Real-Time 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 Real-Time 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 Real-Time 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 Real-Time 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 is described below.

1. Calculate the volume denominated in units of the cryptocurrency from observable transactions that occurred over the trailing 60 minutes for each of the selected markets. Calculate the volume weight for each of the selected markets by dividing the volume figure for each of the selected markets by the total volume across all selected markets. This figure is referred to as the volume weight.

2. Convert the trade price of all observable transactions over the trailing 60 minutes for each of the selected markets to U.S. dollars if necessary using the Real-Time Reference Rate calculated for Bitcoin (BTC) or Ethereum (ETH). Calculate the inverse variance of the trade price converted to U.S. dollars for each of the selected markets using the population mean in the calculation of variance, where the population mean is defined as the mean price of all trades from selected markets over the trailing 60 minutes.If a selected market has an infinite or undefined inverse price variance, the inverse price variance for that market is set to zero. Calculate the inverse price variance weight for each of the selected markets by dividing the inverse price variance by the total inverse price variance across all selected markets. This figure is referred to as the inverse price variance weight.

3. Calculate the final weight for each of the selected markets by taking a mean of the volume weight and the inverse price variance weight.

4. Extract the most recent observable transaction from each of the selected markets. Convert the trade price of the most recent observable transaction to U.S. dollars if necessary using the Real-Time Reference Rate calculated for Bitcoin (BTC) or Ethereum (ETH).

5. Calculate the weighted median price of the most recent observable transactions, where the price is calculated in step 4 and the final weight is calculated in step 3. The weighted median price is calculated by ordering the transactions from lowest to highest price, and identifying the price associated with the trades at the 50th percentile of final weight. The resulting figure is the calculated Real-Time Reference Rate.

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 the Real-Time Reference Rates, the observable transactions from the selected market are not included in the calculation of the specific instance of the given index.

2. If no observable transactions from selected markets exist during the trailing 60 minutes, the value of the Real-Time Reference Rate will be determined to equal the value calculated during the previous second.

4.6 Data Exclusion Rules

The calculation of the Real-Time Reference Rates does not rely on any data exclusion rules.

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

7 Internal Oversight

The Oversight Committee provides independent oversight over the production of the Real-Time Reference Rates. The Oversight Committee's responsibilities include regular reviews of the Real-Time Reference Rates production process, the Real-Time Reference Rates definition and calculation methodology, the selection of data sources and data inputs, any uses of non-standard procedures, conflicts of interest, material changes to or termination of the Real-Time 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 Real-Time 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 the Real-Time Reference Rates due to certain extraordinary market circumstances or external factors. These circumstances or external factors include, but are not limited to:

1. The Real-Time Reference Rates 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 the 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 Real-Time Reference Rates to ensure the Real-Time Reference Rates are properly reflecting their underlying cryptocurrencies, and if necessary, make changes to the methodology or definition of the Real-Time 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 Real-Time 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 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 Real-Time Reference Rates or the value of a published Real-Time Reference Rates 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 Real-Time 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 Real-Time 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 Real-Time Reference Rates

2. Any use of expert judgment in the calculation of the Real-Time Reference Rates

3. Any use of non-standard procedures in the calculation of the Real-Time Reference Rates

4. The identities of staff responsible for the calculation of the Real-Time Reference Rates

5. Any responses, questions, or complaints received in connection with the calculation of the Real-Time 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.

Appendix A: Coverage Universe

Coin Metrics produces the Real-Time Reference Rates for the following cryptocurrencies:

#	name	ticker
1	**Bitcoin**	btc
2	**Bitcoin Cash**	bch
3	**Litecoin**	ltc
4	**XRP**	xrp
5	**Ethereum**	eth
6	**Ethereum Classic**	etc
7	**ZCash**	zec
8	**Monero**	xmr
9	**Dash**	dash
10	**IOTA**	miota
11	**EOS**	eos
12	**OmiseGO**	omg
13	**NEO**	neo
14	**Metaverse ETP**	etp
15	**Qtum**	qtum
16	**Eidoo**	edo
17	**Bitcoin Gold**	btg
18	**QASH**	qash
19	**YOYOW**	yoyow
20	**Golem**	gnt
21	**Status**	snt
22	**Basic Attention Token**	bat
23	**Decentraland**	mana
24	**FunFair**	fun
25	**0x**	zrx
26	**Time New Bank**	tnb
27	**POA Network**	poa
28	**TRON**	trx

29	**iExec RLC**	rlc
30	**SingularDTV**	sngls
31	**Augur**	rep
32	**ELF**	elf
33	**IOST**	iost
34	**Aion**	aion
35	**Request Network**	req
36	**Raiden Network Token**	rdn
37	**Loopring**	lrc
38	**WAX**	waxp
39	**Sai**	sai
40	**SingularityNET**	agi
41	**BnkToTheFuture**	bft
42	**Mithril**	mith
43	**Storj**	storj
44	**Stellar**	xlm
45	**Verge**	xvg
46	**Lympo**	lym
47	**Maker**	mkr
48	**VeChain**	vet
49	**Kyber Network**	knc
50	**UTRUST**	utk
51	**Ripio Credit Network**	rcn_ripiocreditnetwork
52	**Polymath**	poly
53	**Nucleus Vision**	ncash
54	**Cindicator**	cnd
55	**Cortex**	ctxc
56	**Project Pai**	pai
57	**DATA**	dta
58	**WePower**	wpr
59	**Zilliqa**	zil
60	**Bancor**	bnt
61	**Matrix AI Network**	man

62	**MonaCoin**	mona
63	**NEM**	xem
64	**Binance Coin**	bnb
65	**Gas**	gas
66	**Tether**	usdt
67	**OAX**	oax
68	**district0x**	dnt
69	**Crypto.com**	mco
70	**Waltonchain**	wtc
71	**Stratis**	strat
72	**Ethos**	ethos
73	**ChainLink**	link
74	**Moeda Loyalty Points**	mda
75	**Metal**	mtl_metal
76	**Enigma**	eng
77	**AirSwap**	ast
78	**Everex**	evx
79	**Viberate**	vib
80	**Power Ledger**	powr
81	**Ark**	ark
82	**Enjin Coin**	enj
83	**Komodo**	kmd
84	**Nuls**	nuls
85	**Ambrosus**	amb
86	**BlockMason Credit Protocol**	bcpt
87	**Aeron**	arn
88	**Blox**	cdt
89	**GXChain**	gxs
90	**Quantstamp**	qsp
91	**BitShares**	bts
92	**ZCoin**	xzc
93	**Lisk**	lsk
94	**Tierion**	tnt
95	**Etherparty**	fuel

96	**Bitcoin Diamond**	bcd
97	**DigixDAO**	dgd
98	**AdEx**	adx
99	**Cardano**	ada
100	**Populous**	ppt
101	**CyberMiles**	cmt
102	**ETHLend**	lend
103	**Waves**	waves
104	**Gifto**	gto
105	**ICON**	icx
106	**PIVX**	pivx
107	**OST**	ost
108	**NavCoin**	nav
109	**Lunyr**	lun
110	**AppCoins**	appc
111	**ChatCoin**	chat
112	**Civic**	cvc
113	**Steem**	steem
114	**Nano**	nano
115	**Viacoin**	via
116	**Bluzelle**	blz
117	**Aeternity**	ae
118	**Ontology**	ont
119	**Storm**	storm
120	**Wanchain**	wan
121	**Syscoin**	sys
122	**Ardor**	ardr
123	**Groestlcoin**	grs
124	**Holo**	hot_holo
125	**Loom Network**	loom
126	**Bytecoin**	bcn
127	**TrueUSD**	tusd
128	**Horizen**	zen
129	**Theta Token**	theta

130	**IoTeX**	iotx
131	**QuarkChain**	qkc
132	**Selfkey**	key
133	**Pundi X**	npxs
134	**Mainframe**	mft
135	**Siacoin**	sc
136	**Nebulas**	nas
137	**Dent**	dent
138	**Dock**	dock
139	**Gnosis**	gno
140	**Dogecoin**	doge
141	**Bytom**	btm
142	**BitKan**	kan
143	**Arcblock**	abt
144	**Decred**	dcr
145	**DigiByte**	dgb
146	**IoT Chain**	itc
147	**Libra Credit**	lba
148	**TenX**	pay
149	**Republic Protocol**	ren
150	**Nxt**	nxt
151	**Odyssey**	ocn
152	**Huobi Token**	ht
153	**Elastos**	ela
154	**WaykiChain**	wicc
155	**SIRIN LABS Token**	srn
156	**DeepBrain Chain**	dbc
157	**Propy**	pro
158	**Bibox Token**	bix
159	**HyperCash**	hc_hypercash
160	**MaidSafeCoin**	maid
161	**Tezos**	xtz
162	**Ignis**	ignis
163	**Crowd Machine**	cmct

164	**Nexo**	nexo
165	**PumaPay**	pma
166	**Penta**	pnt
167	**IHT Real Estate Protocol**	iht
168	**UNUS SED LEO**	leo
169	**Factom**	fct
170	**Vertcoin**	vtc
171	**Game.com**	gtc_gamecom
172	**Ravencoin**	rvn
173	**ReddCoin**	rdd
174	**Numeraire**	nmr
175	**Content Neutrality Network**	cnn
176	**Dragonchain**	drgn
177	**USD Coin**	usdc
178	**Paxos Standard Token**	pax
179	**Gemini Dollar**	gusd
180	**GoChain**	go
181	**Red Pulse Phoenix**	phx
182	**Electroneum**	etn
183	**Bitcoin Cash SV**	bsv
184	**Grin**	grin
185	**Lambda**	lamb
186	**BitTorrent Token**	btt
187	**Beam**	beam
188	**Ontology Gas**	ong_ontologygas
189	**Ankr Network**	ankr
190	**Metadium**	meta
191	**Quant**	qnt
192	**SOLVE**	solve
193	**Crypto.com Chain**	cro
194	**Cosmos**	atom
195	**Orbs**	orbs
196	**Theta Fuel**	tfuel
197	**Celer Network**	celr

198	**Fantom**	ftm
199	**Algorand**	algo
200	**Dai**	dai