Coin Metrics Prices Methodology

Version 1.1

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Contents

1   Introduction

Coin Metrics publishes a collection of prices for a set of cryptocurrencies and fiat currencies consisting of the Coin Metrics Reference Rates ("CM Reference Rates") and the Coin Metrics Principal Market Prices ("CM Principal Market Prices"), which are collectively referred to as the Coin Metrics Prices ("CM Prices"). This document describes the data inputs, calculation methodologies, and data exclusion rules for the CM Prices.

The CM Reference Rates are published once a day, once an hour, once a minute, once a second, and once every 200 milliseconds and utilize volume-weighted median, time-weighted average, and inverse price variance-weighted median techniques. Common use cases for the CM Reference Rates include research, backtesting, calculating net asset value for investment funds, calculating closing prices for indexes or financial benchmarks, serving as a data source for on-chain price oracles, risk management, indicative intraday values for investment funds and financial benchmarks, and settling financial derivatives.

The CM Principal Market Prices are published once a day, once an hour, once a minute, and once a second and adhere to the guidelines regarding fair value measurement issued by the International Financial Reporting Standards and the Association of International Certified Professional Accountants, specifically standards IFRS 13 and FASB ASC 820. The Principal Market Prices identify a principal market for each asset and utilize the most recent price from this market. Common use cases are for fair value measurement, preparing financial statements, and calculating closing prices for indexes or financial benchmarks.

The CM Prices are designed to serve as a set of transparent and independent pricing sources that promote the functioning of efficient markets, reduce information asymmetries among market participants, facilitate trading in standardized contracts, and accelerate the adoption of cryptocurrencies as an asset class with the highest standards. The CM Prices are calculated using robust and resilient methodologies that are resistant to manipulation and adhere 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 CM Prices and ensure the CM Prices serve as a source of transparent and independent pricing.

2   Other Documents

The CM Prices are collectively governed by policies described in Coin Metrics Prices Policies which describes the administration, oversight, conflicts of interest, material changes and terminations, recalculations, internal controls, complaints, record retention, and compliance policies.

The CM Prices are supervised by the Coin Metrics Oversight Committee Charter which defines the responsibilities of the Oversight Committee.

3 Data Inputs

The Oversight Committee evaluates markets traded on digital asset exchanges as potential input data sources for the CM Prices using a Market Selection Framework. The framework consists of a fully-systematized process for evaluating markets along a wide set of criteria to determine if the data source reflects trading activity in a transparent and representative manner. In this framework, a market refers to a specific traded asset pair on a specific exchange. Only spot markets are considered. It produces a unique set of candidate selected markets for each asset in the coverage universe.

The Oversight Committee evaluates new markets for inclusion as a selected market and assesses already selected markets using the Market Selection Framework on a quarterly basis and during interim periods if market conditions warrant. Such market conditions include, but are not limited to, material changes in an exchange's solvency risk, material changes in the degree of free capital flows in and out of an exchange, the presence of long-lasting price differences from other exchanges, and during times of market stress.

Markets that are approved by the Oversight Committee are added to a list of constituent markets (the "Constituent Markets"). A separate list of Constituent Markets is maintained for each of the assets in the coverage universe.

A candidate market can be nominated for inclusion and an existing constituent 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 Constituent Markets for each asset in the coverage universe, as well as updates on inclusions or exclusions of constituent markets, and the rationale for making any change.

The data inputs for the calculation of the CM Prices are observable transactions in a constituent where the given asset is traded.

3.1 Feature Descriptions

The Market Selection Framework consists of 45 features, 36 of which are in active use. Features represent individual measurable properties that provide an indication of the suitability for a market to serve as an input data source, which are combined to form a market rating.

Some of the features described in this section are indicator variables that encode qualitative information about a market or exchange. These indicator variables can require a degree of subjectivity in determining whether a market or exchange meets a certain criteria. In such cases, the indicator variable is set to true only if an unambiguous source is found that provides sufficient information to make an evaluation. In the absence of such a source, the indicator variable is set to false.

3.1.1 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 or websocket feed for data collection. Evaluates the performance of the API in terms of reliability.

1. **has_rest_api**: An indicator variable for the existence of a REST API.

2. **has_websocket_feed**: An indicator variable for the existence of a websocket feed.

3. **has_fix_gateway**: An indicator variable for the existence of a FIX gateway.

4. **has_historical_trade_data**: An indicator variable for whether the exchange offers historical trade data via its API.

5. **has_real_time_trade_data**: An indicator variable for whether the exchange offers real-time trade data via its API.

6. **has_real_time_order_book_data**: An indicator variable for whether the exchange offers real-time order book data via its API.

7. **api_downtime_incidents**: A feature that represents the stability of an API.

3.1.2 Legal and Compliance

An assessment of selected indicator variables relating to compliance and risk for each exchange. These indicator variables include whether the exchange has publicly-disclosed trading policies, uses market surveillance technology, obtains regulatory licenses, has fiat and crypto insurance, requires customers to verify their identity before opening an account as part of its KYC and AML process, and whether the exchange has functioning fiat and cryptocurrency withdrawals processed within a normal timeframe.

1. **has_trading_policy**: An indicator variable for whether the exchange has a trading policy to promote fair and transparent markets. The trading policy should explicitly address manipulative trading policies like front-running, wash trading, spoofing, layering, churning, and quote stuffing.

2. **has_market_surveillance**: An indicator variable for whether the exchange uses market surveillance technology to detect market manipulation practices, including front-running, wash trading, spoofing, layering, churning, and quote stuffing.

3. **has_regulatory_oversight**: An indicator variable for whether the exchange obtains licenses from national or regional regulatory organizations.

4. **has_fiat_insurance**: An indicator variable for whether the exchange maintains commercial insurance or is covered under government-provided insurance to insure against losses of customer funds denominated in fiat currencies.

5. **has_crypto_insurance**: An indicator variable for whether the exchange maintains commercial insurance to insure against losses of customer funds denominated in digital assets.

6. **has_kycaml**: An indicator variable for whether the exchange requires identity verification before being able to open an account as part of its KYC and AML process. For the purposes of this indicator variable, an exchange which requires identity verification only if a customer wishes to deposit or withdraw fiat or if a customer wishes to withdraw digital assets is determined to not have sufficient controls. An exchange must require customers to verify their identity when opening an account as part of its KYC and AML process.

7. **has_free_capital_flows**: An indicator variable for whether the exchange has had a history of free capital flows over the last quarter, including functioning fiat and digital asset deposits and withdrawals that are processed within a normal timeframe.

3.1.3 Business Model

An assessment of the market's exchange with respect to its business model, including its fee structure and asset listing standards.

1. **has_fiat_markets**: An indicator variable that indicates whether the exchange has markets where the quote currency is a fiat currency.

2. **has_fees**: An indicator variable that indicates whether the exchange charges trading fees as a percentage of the trade size. Exchanges that charge zero fees or charge fees indirectly through a transaction mining model are determined to not charge fees.

3. **has_listing_standards**: An indicator variable that indicates whether the exchange has publicly disclosed a framework for deciding which assets to list.

4. **has_usa_hq**: An indicator variable for whether the company's headquarters are domiciled in the United States.

3.1.4 Data Availability

An assessment of the available data the market's exchange offers for the given digital asset, including the amount of historical data available for a market and the quoted currency of the market.

1. **market_days_history**: The number of days of historical data for the market.

2. **market_quote_modifier**: An optional modifier to give greater weight to a certain quote currency. Currently all quote currencies have equal weight.

3.1.5 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 digital asset and are anchored by observable transactions entered into at arm's length between buyers and sellers.

In this section, prices are compared to the global median price. The global median price is defined as the median price of all markets in which the digital asset is the base currency from the following list of exchanges: `["Coinbase", "Poloniex", "Bittrex", "Gemini", "Kraken", "Binance", "Bitstamp", "itBit"]`. This list of exchanges was selected by first calculating the market ratings for each market but without the price-related features below. The median market rating was then calculated for each exchange and the top 8 exchanges were selected.

1. **market_open_mape_all**: The mean absolute percentage error of the market's daily open price compared to the global median's daily open price over the last 90 days.

2. **market_close_mape_all**: The mean absolute percentage error of the market's daily close price compared to the global median's daily close price over the last 90 days.

3. **market_low_mape_all**: The mean absolute percentage error of the market's daily low price compared to the global median's daily low price over the last 90 days.

4. **`market_high_mape_all`**: The mean absolute percentage error of the market's daily high price compared to the global median's daily high price over the last 90 days.

5. **`market_open_mape_trimmed`**: The mean absolute percentage error of the market's daily open price trimmed to exclude the bottom and top 5th percentiles compared to the global median's daily open price over the last 90 days.

6. **`market_close_mape_trimmed`**: The mean absolute percentage error of the market's daily close price trimmed to exclude the bottom and top 5th percentiles compared to the global median's daily close price over the last 90 days.

7. **`market_low_mape_trimmed`**: The mean absolute percentage error of the market's daily low price trimmed to exclude the bottom and top 5th percentiles compared to the global median's daily low price over the last 90 days.

8. **`market_high_mape_trimmed`**: The mean absolute percentage error of the market's daily high price trimmed to exclude the bottom and top 5th percentiles compared to the global median's daily high price over the last 90 days.

3.1.6 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 digital asset and are anchored by observable transactions entered into at arm's length between buyers and sellers. The size of the exchange's markets is also considered.

1. **`market_volume_usd`**: The total volume of the market over the past 90 days in U.S. dollars.

2. **`market_volume_dispersion`**: The coefficient of variation of the market's daily volume in U.S. dollars over the past 90 days.

3. **`market_volume_price_corr_raw`**: The correlation of the market's daily return to detrended daily volume where volume is quoted in raw units over the past 90 days.

4. **`market_volume_price_corr_usd`**: The correlation of the market's daily return to detrended daily volume where volume is quoted in U.S. dollars over the past 90 days.

5. **`alexa_rank`**: The global rank of the exchange's website as reported by Alexa.

6. **alexa_page_views_per_million**: The average page views per million visitors of the exchange's website over the past month as reported by Alexa.

7. **alexa_reach_per_million**: The average reach per million visitors of the exchange's website over the past month as reported by Alexa.

8. **alexa_pvpmvu**: The total U.S. dollar volume of the exchange over the past month divided by the page views per million visitors as reported by Alexa.

9. **alexa_rpmvu**: The total U.S. dollar volume of the exchange over the past month divided by the reach per million visitors as reported by Alexa.

10. **similarweb_global_rank**: The global rank of the exchange's website as reported by SimilarWeb.

11. **similarweb_visit_monthly**: The number of monthly visits as reported by SimilarWeb.

12. **similarweb_vmvu**: The total U.S. dollar volume of the exchange over the past month divided by the monthly visits as reported by SimilarWeb.

3.1.7 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 functions as an active market in the underlying digital asset and are anchored by observable transactions entered into at arm's length between buyers and sellers. The liquidity of the market is also considered.

1. **order_book_depth**: The total volume of bids and offers on the order book within 1 percent of the mid price of the exchange's largest traded market where the given asset is the base currency reported in U.S. dollars.

2. **slippage**: The amount of slippage in percent terms if an immediate market sell order of $50,000 U.S. dollars is executed of the exchange's largest traded market where the given asset is the base currency.

3. **spread**: The median of the spread calculated as the difference between the best bid minus the best ask divided by the mid-price over the past 30 days.

4. **order_book_depth_residual**: A regression model is fit by regressing volume on order book depth for the largest traded market for a collection of exchanges. Given an order book depth, an estimated volume is calculated and a residual is calculated as `actual_volume - estimated_volume`.

5. **slippage_residual**: A regression model is fit by regressing volume on slippage for the largest traded market for a collection of exchanges. Given a slippage, an estimated volume is calculated and a residual is calculated as `actual_volume - estimated_volume`.

3.2 Feature Normalization

All features are normalized to between 0 and 1, with a number closer to 1 meaning that the feature contributes positively to the likelihood that the market will be selected. The qualitative features are all indicator variables that take values 0 or 1. For quantitative features, a separate empirical cumulative distribution function is calculated for all the markets for each asset. The quantitative feature is normalized by converting the value to its equivalent value on the empirical cumulative distribution function.

3.3 Rating Algorithm

In order for a market to be eligible to receive a rating, the following three indicator variables for the market must be true: `has_rest_api`, `has_real_time_trade_data`, `has_real_time_order_book_data`. These indicator variables are required to be true because the ability to collect real-time trade data and real-time order book data via an API is necessary in order for the market to serve as an input data source.

The rating algorithm uses a weighted sum using a custom weighting function of the normalized features:

Feature	Weight
has_websocket_feed	1
has_fix_gateway	1
has_historical_trade_data	1
has_trading_policy	1
has_market_surveillance	1
has_regulatory_oversight	1
has_kycaml	1
has_fiat_insurance	1
has_crypto_insurance	1
has_free_capital_flows	3
has_fiat_market	1
has_fees	1
has_listing_standards	1
has_usa_hq	3
market_days_history	1
market_quote_modifier	1

Feature	Weight
market_open_mape_all	1
market_close_mape_all	1
market_low_mape_all	1
market_high_mape_all	1
market_open_mape_trimmed	1
market_close_mape_trimmed	1
market_low_mape_trimmed	1
market_high_mape_trimmed	1
market_volume_usd	3
market_volume_dispersion	1
market_volume_price_corr_raw	1
market_volume_price_corr_usd	1
alexa_rank	2
alexa_page_views_per_million	1
alexa_reach_per_million	1
alexa_pvpmvu	1
alexa_rpmvu	1
similarweb_global_rank	2
similarweb_visit_monthly	1
similarweb_vmvu	1

3.4   Selection Algorithm

Markets with a rating higher than 22.5 are selected. For each asset in the coverage universe, markets that are in the top 4 by rank are also selected, regardless of the market's rating. Any market with volume, measured in U.S. dollars over the past 90 days, of less than 5 percent of the volume of the selected market with the largest volume is excluded.

3.5   Candidate Markets

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 asset.

3.5.1   Bitcoin (BTC) and Ethereum (ETH)

The pool of candidate markets that are evaluated for the calculation of the CM Prices 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.

3.5.2 Other Cryptocurrencies Excluding Stablecoins

The pool of candidate markets that are evaluated for the calculation of the CM Prices for 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 are insufficient to calculate the price, 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 Bitcoin (BTC).

3. If the above data inputs do not exist or are insufficient to calculate the price, 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 Ethereum (ETH).

4. If the above data inputs do not exist or are insufficient to calculate the price, 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 USD Coin (USDC).

5. If the above data inputs do not exist or are insufficient to calculate the price, 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 Tether (USDT).

3.5.3 Stablecoins

The pool of candidate markets that are evaluated for the calculation of the CM Prices 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 are insufficient to calculate the price, 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 are insufficient to calculate the price, 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.

4. If the above data inputs do not exist or are insufficient to calculate the price, the universe of data inputs will expand to include observable transactions in an active market where the given stablecoin is the base currency and quote currency is USD Coin (USDC).

5. If the above data inputs do not exist or are insufficient to calculate the price, the universe of data inputs will expand to include observable transactions in an active market where the given stablecoin is the base currency and quote currency is Tether (USDT).

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 assets in the coverage universe are considered to be stablecoins:

Name	Ticker
Tether	usdt
TrueUSD	tusd
USD Coin	usdc
Paxos Standard	pax
Gemini Dollar	gusd
Binance USD	busd
Dai	dai
BIDR	bidr
sUSD	susd
TerraUSD	ust
Pax Dollar	usdp
USDD	usdd
Euro Coin	euroc
Staked Ether Lido	steth
poundtoken	gbpt
Terra 2.0	luna2

3.5.4 Fiat Currencies

The pool of candidate markets that are evaluated for the calculation of the CM Prices for fiat currencies are determined using the following data hierarchy:

1. The primary data input is observable transactions in an active market where the given fiat currency is the base currency and the quote currency is U.S. dollars.

2. If the above data inputs do not exist or are insufficient to calculate the price, 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 fiat currency.

3. If the above data inputs do not exist or are insufficient to calculate the price, 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 fiat currency.

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

Name	Ticker
Euro	eur
British Pound	gbp
Japanese Yen	jpy
Canadian Dollar	cad
Korean won	krw
Russian Ruble	rub
Ukrainian Hryvnia	uah
Turkish Lira	try
Australian Dollar	aud
Brazilian Real	brl
Swiss Franc	chf
Hong Kong Dollar	hkd
Singapore Dollar	sgd

4 Reference Rates Calculation Methodology

The CM Reference Rates represent the reference rate of one unit of the asset quoted in U.S. dollars or other currency. The CM Reference Rates supports

multiple frequencies. The daily and hourly frequencies utilize one calculation methodology and the minute, second, and 200 millisecond frequencies ("real-time frequencies") utilize a separate calculation methodology. The daily and hourly frequencies are calculated at the end of every hour and day, respectively, (the "Calculation Time") and are published within 5 minutes (the "Publication Time"). The real-time frequencies are published in real-time with no delay.
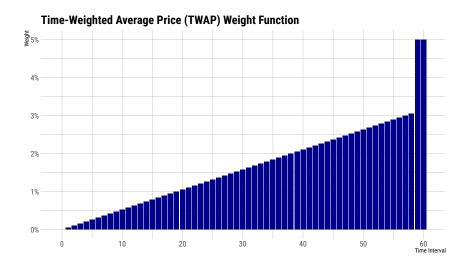
4.1 Coverage Universe

The set of assets included in the CM Reference Rates coverage universe are included in Appendix A.

4.2 Calculation Algorithm for Daily and Hourly Frequencies

The calculation algorithm of the CM Reference Rates for daily and hourly frequencies is described below.

1. All observable transactions from Constituent Markets are combined and partitioned into time intervals, with each time interval spanning a period of one minute. The first one-minute time interval begins 60 minutes before the Calculation Time and the last one-minute time interval begins at the Calculation and ends one minute after the Calculation Time. In total, the calculation period spans a period of 61 minutes (the "Observation Window"). A total of 61 one-minute time intervals are created.

2. The price of each observable transaction for one unit of the given asset is converted to U.S. dollars if necessary using the Reference Rates calculated for Bitcoin (BTC), Ethereum (ETH), USD Coin (USDC), or Tether (USDT).

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 volume measured in native units.

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 percent 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 5 percent such that the sum of all weights equals 100 percent. The weight function assigns more weight to time slices that are closer to the Calculation Time. The resulting figure is the published reference rate.

A chart of the weights is included below and the exact weights for each time interval are listed in Appendix B:

Time-Weighted Average Price (TWAP) Weight Function

4.3 Data Contingency Rules for Daily and Hourly Frequencies

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 constituent market are unable to be collected due to technical problems specific to the constituent market's exchange during the calculation of a reference rate, the observable transactions from the constituent market are not included in the calculation of the specific instance of the given reference rate.

2. If no observable transactions from constituent markets occur during the first one-minute time interval, the next one-minute time interval's volume-weighted median price is used as the volume-weighted median price. This contingency rule is applied recursively if necessary.

3. If no observable transactions from constituent markets occur during any one-minute time intervals, excluding the first and last one-minute time intervals in the Calculation Window, the next one-minute time interval's volume-weighted median price is used as the volume-weighted median price. This contingency rule is applied recursively if necessary.

4. If no observable transactions from constituent markets occur during the last one-minute time interval, the previous time interval's volume-weighted median price is used as the volume-weighted median price. This contingency rule is applied recursively if necessary.

5. If no observable transactions from constituent markets exist during the Calculation Period for a reference rate, the reference rate will be determined to equal the previous hourly reference rate in which there were trades during that hour's Observation Window.

4.4 Calculation Algorithm for Real-Time Frequencies

The calculation algorithm of the CM Reference Rates for the real-time frequencies is described below.

1. Calculate the volume denominated in units of the given asset from observable transactions that occurred over the trailing 60 minutes for each of the Constituent Markets. Calculate the volume weight for each of the Constituent Markets by dividing the volume figure for each of the Constituent Markets by the total volume across all Constituent Markets. The resulting 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 Constituent Markets to U.S. dollars if necessary using the Real-Time Reference Rate calculated for Bitcoin (BTC), Ethereum (ETH), USD Coin (USDC), or Tether (USDT). Calculate the inverse variance of the trade price converted to U.S. dollars for each of the Constituent Markets using the population mean in the calculation of variance, where the population mean is defined as the mean price of all trades from Constituent Markets over the trailing 60 minutes. If a Constituent Market has an infinite or undefined inverse price variance, the inverse price variance for that Constituent Market is set to zero. Calculate the inverse price variance weight for each of the Constituent Markets by dividing the inverse price variance by the total inverse price variance across all Constituent Markets. The resulting figure is referred to as the inverse price variance weight.

3. Calculate the final weight for each of the Constituent 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 Constituent Markets. Convert the trade price of the most recent observable transactions to U.S. dollars if necessary using the Reference Rate calculated for Bitcoin (BTC), Ethereum (ETH), USD Coin (USDC), or Tether (USDT).

5. Calculate the weighted median price of the most recent observable transactions using the prices calculated in step 4 and the final weights 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 published reference rate for the given asset.

4.5 Data Contingency Rules for Real-Time Frequencies

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 constituent market are unable to be collected due to technical problems specific to the constituent market's exchange during the calculation of a real-time reference rate, the observable transactions from the constituent market are not included in the calculation of the specific instance of the given real-time reference rate.

2. If no observable transactions from constituent 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.

5 Principal Market Prices Calculation Methodology

The Principal Market Prices are published once per second, every day of the year, and represent the price of one unit of the asset quoted in U.S. dollars.

5.1 Fair Market Valuation Background

The Principal Market Prices were developed taking into account the requirements of IFRS 13 and FASB ASC 820 accounting guidelines defining what a Principal Market is and how it should be selected. These guidelines also allow for additional controls to verify the market is active and trades are orderly.

As Coin Metrics already provides the CM Reference Rates methodology to price cryptocurrencies which we believe to be robust and stable, it is worth briefly describing the philosophy behind producing the Principal Market Prices to supplement the reference rates. The first and most significant criteria is that certain regulatory agencies require a methodology consistent with the aforementioned

accounting principles. These principles clearly describe the preferred "fair market value" calculation as one which identifies a Principal Market by trade volume and tracks executed trades in that market.

Beyond external requirements, the benefits for a Principal Market Prices methodology are that it is clearly defined and auditable. The price is always taken from a single market, which tends to remain constant, and can easily be traced and verified for a given time stamp. We minimize computations being done on the price, which reduces the likelihood of unforeseen behavior. Additionally, the trades are always taken from the exchange where the most of the activity occurs, which is a characteristic users are interested in.

Like all things in life, this comes with some trade offs. Our CM Reference Rates look for a central tendency among several markets. In some cases this can avoid volatility and the presence of outliers if the Principal Market Prices deviate from the global average, but it also means that the final price may be taken from comparatively insignificant market where the price is between the prices of markets of larger volume. With these trade-offs in mind, our methodology seeks to err on the side of trusting the largest market by volume of trades and only excludes a market in extreme situations.

We also attempt to avoid numerical comparisons of the price between markets in the methodology, in order to minimize the possibility that a price anomaly in another market could affect the calculation. Our CM Reference Rates by contrast choose to combine multiple markets to identify a more stable price representative of the global environment.

5.2 Coverage Universe

The set of assets included in the Principal Market Prices coverage universe are included in Appendix A.

5.3 Calculation Algorithm

The calculation algorithm of the Principal Market Prices is described below.

1. Consider the list of Constituent Markets selected by the Market Selection Framework.

2. Identify any inactive markets, and exclude all trades associated with the inactive market. A market is considered inactive if it meets the following conditions: (1) The last trade was more than 1-minute ago and the last trade was either: longer than 10 minutes from the calculation time or longer than 100 * [mean trade interval], (2) The mean trade interval is defined as the the average of all intervals between sequential trades in the window 0 to 60 minutes before the calculation time. For example, if

trades occur at timestamps `[00:02, 00:12, 00:37, 01:15]`, the mean trade interval will be `mean([10 seconds, 25 seconds, 38 seconds]) = 23.3 seconds`.

3. If there are no active markets, then the Principal Market Price will forward-fill the last non-null value available.

4. Check if any trades in the markets are not considered orderly (IFRS 13.B37-B38). Exclude any non-orderly trades from the calculation. This is accomplished by examining the window 60 to 120 minutes before the calculation time to calculate a reference standard deviation of prices in each market separately. If there are insufficient trades to calculate a standard deviation, then all trades are considered orderly (i.e. no trades are dropped if there is sparse data).

5. We then partition the calculation window 0 to 60 minutes before the calculation time into 60 one-minute time intervals and calculate how far each trade is from the mean price of trades from that market in the one-minute time interval the trade resides in.

6. Finally, we exclude trades that occur more than three reference standard deviations from the mean price of trades within a particular one-minute time interval. We require at least five trades occur in a particular one-minute time interval in order to exclude trades. The two parameters (3 reference deviations and 5 trades) may be adjusted in the future.

7. Identify the active market with the largest volume of orderly trades in the calculation window 0 to 60 minutes before the calculation time. This will serve as the Principal Market (IFRS 13.16, FASB ASC 820-35-5).

8. Use the most recent orderly trade from the Principal Market and publish its price as the Principal Market Price.

6 Data Exclusion Rules

All observable transactions from constituent 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 price. 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 asset, 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 asset.

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.

7   Appendix A

The following table lists the current coverage universe:

Name	Ticker
Bitcoin	btc
Bitcoin Cash	bch
Litecoin	ltc
Euro	eur
XRP	xrp
Ethereum	eth
Ethereum Classic	etc
British Pound	gbp
Zcash	zec
Monero	xmr
Dash	dash
Japanese Yen	jpy
IOTA	miota
EOS	eos
OMG Network	omg
Neo	neo
Metaverse ETP	etp
Qtum	qtum
Aventus	avt
Bitcoin Gold	btg
Streamr	data
QASH	qash
Status	snt
Basic Attention Token	bat
Decentraland	mana
FUNToken	fun
0x	zrx
Time New Bank	tnb
TRON	trx
iExec RLC	rlc
Augur	rep
aelf	elf

Name	Ticker
IOST	iost
Request	req
Loopring	lrc
WAX	waxp
Aragon	ant
Mithril	mith
Storj	storj
Stellar	xlm
Verge	xvg
Lympo	lym
Maker	mkr
VeChain	vet
Kyber Network Crystal	knc
Utrust	utk
Ripio Credit Network	rcn_ripiocreditnetwork
Polymath	poly
Fusion	fsn
Nitro Network	ncash
Cortex	ctxc
DATA	dta
Zilliqa	zil
Bancor	bnt
MonaCoin	mona
NEM	xem
BNB	bnb
Gas	gas
Tether	usdt
OAX	oax
district0x	dnt
Waltonchain	wtc
Chainlink	link
Moeda Loyalty Points	mda
Metal DAO	mtl_metal
AirSwap	ast
Viberate	vib
Powerledger	powr
Ark	ark
Enjin Coin	enj
Komodo	kmd
NULS	nuls
AirDAO	amb
Quantstamp	qsp
BitShares	bts
Lisk	lsk

Name	Ticker
Bitcoin Diamond	bcd
Ambire AdEx	adx
Cardano	ada
Waves	waves
ICON	icx
PIVX	pivx
OST	ost
Civic	cvc
Steem	steem
Nano (New)	nano
Bluzelle	blz
Aeternity	ae
Ontology	ont
Wanchain	wan
Syscoin	sys
Ardor	ardr
Holo	hot_holo
Loom Network	loom
Bytecoin	bcn
TrueUSD	tusd
Horizen	zen
Theta Network	theta
IoTeX	iotx
QuarkChain	qkc
SelfKey	key
Siacoin	sc
Nebulas	nas
Dent	dent
Dock	dock
Gnosis	gno
Canadian Dollar	cad
Enzyme	mln
Dogecoin	doge
Bytom	btm
BitKan	kan
Arcblock	abt
Auto	auto
CyberVein	cvt
Decred	dcr
DigiByte	dgb
Cred	lba
Measurable Data Token	mdt
TenX	pay
Revain	rev

Name	Ticker
Ren	ren
SwftCoin	swftc
Nxt	nxt
VITE	vite
Odyssey	ocn
Huobi Token	ht
Elastos	ela
WaykiChain	wicc
SIRIN LABS Token	srn
DeepBrain Chain	dbc
Propy	pro
Bibox Token	bix
HyperCash	hc_hypercash
MaidSafeCoin	maid
Amp	amp
Chrono.tech	time
Pluton	plu
Tezos	xtz
Stacks	stx
Ignis	ignis
Atletico De Madrid Fan Token	atm
PolySwarm	nct
Kin	kin
IndiGG	indi
SwissBorg	chsb
OriginTrail	trac
Nexo	nexo
Telcoin	tel
Berry	berry
Crypterium	crpt
IHT Real Estate Protocol	iht
VeThor Token	vtho
DxChain Token	dx
CEEK VR	ceek
Oxygen	oxy
UNUS SED LEO	leo
Vertcoin	vtc
Game.com	gtc_gamecom
MediBloc	med
Creditcoin	ctc
NKN	nkn
Uquid Coin	uqc
Korean won	krw
IQ	iq

Name	Ticker
Ravencoin	rvn
LBRY Credits	lbc
ReddCoin	rdd
Numeraire	nmr
Russian Ruble	rub
Ukrainian Hryvnia	uah
Turkish Lira	try
Aurora Chain	aoa
Australian Dollar	aud
Brazilian Real	brl
Swiss Franc	chf
Ethernity	ern
Hong Kong Dollar	hkd
Singapore Dollar	sgd
OpenDAO	sos
Dragonchain	drgn
Kleros	pnk
USD Coin	usdc
KuCoin Token	kcs
Paxos Standard	pax
Gemini Dollar	gusd
Constellation	dag
Nimiq	nim
GoChain	go
Electroneum	etn
Bitcoin SV	bsv
Artificial Liquid Intelligence	ali
MXC	mxc
TomoChain	tomo
Livepeer	lpt
RSK Infrastructure Framework	rif
v.systems	vsys
Grin	grin
Seele	seele
Lambda	lamb
Dora Factory	dora
Beam	beam
Unibright	ubt
FTX Token	ftt
Kryll	krl
Fetch.ai	fet
Ontology Gas	ong_ontologygas
Ankr	ankr
Haven Protocol	xhv

Name	Ticker
Quant	qnt
SOLVE	solve
Aergo	aergo
Circuits of Value	coval
Cronos	cro
Cosmos	atom
Orbs	orbs
Theta Fuel	tfuel
BORA	bora
Function X	fx
IRISnet	iris
Celer Network	celr
ABBC Coin	abbc
Verasity	vra
Wrapped Bitcoin	wbtc
Polygon	matic
Litentry	lit
Fantom	ftm
Algorand	algo
Dusk Network	dusk
XYO	xyo
Ocean Protocol	ocean
Celsius	cel
Synthetix	snx
ThunderCore	tt
MovieBloc	mbl
Reserve Rights	rsr
STP	stpt
Harmony	one_harmony
ARPA	arpa
Phoenix	phb
WINkLink	win_wink
Binance USD	busd
Dai	dai
Tether Gold	xaut
PAX Gold	paxg
OKB	okb
Hedera	hbar
Nervos Network	ckb
Solar	sxp
Terra Classic	luna
Chiliz	chz
Orchid	oxt
LCX	lcx

Name	Ticker
Nahmii	nii
WazirX	wrx
Band Protocol	band
Kusama	ksm
Hive	hive
Energi	nrg
GateToken	gt
Kava	kava
MX TOKEN	mx
Arweave	ar
Compound	comp
Keep Network	keep
Origin Protocol	ogn
Render Token	rndr
Cocos-BCX	cocos
DREP	drep
LTO Network	lto
COTI	coti
Solana	sol
Cartesi	ctsi
Chromia	chr
StormX	stmx
BIDR	bidr
Polkadot	dot
Celo	celo
Filecoin	fil
sUSD	susd
Travala.com	ava
Wirex Token	wxt
Syntropy	noia
Akropolis	akro
Ampleforth	ampl
SENSO	senso
DigitalBits	xdb
Sylo	sylo
KardiaChain	kai
Energy Web Token	ewt
yearn.finance	yfi
UMA	uma
Avalanche	avax
BOSagora	boa
JUST	jst
Bifrost	bfc
DEAPcoin	dep

Name	Ticker
DIA	dia
ForTube	for
Green Satoshi Token	gst
Helium	hnt
IDEX	idex
Kadena	kda
Klaytn	klay
mStable Governance Token: Meta (MTA)	mta
NEST Protocol	nest
MANTRA	om
Orion Protocol	orn
Prom	prom
PARSIQ	prq
Rocket Pool	rpl
Reserve	rsv
THORChain	rune
ShareToken	shr
Serum	srm
SUKU	suku
tBTC	tbtc
Tellor	trb
BiLira	tryb
Curve DAO Token	crv
Velas	vlx
Wrapped NXM	wnxm
DFI.Money	yfii
Balancer	bal
SushiSwap	sushi
Swerve	swrv
Cream Finance	cream
Sun Token	sun
MultiversX	egld
Uniswap	uni
Alchemy Pay	ach
Aleph.im	aleph
Bella Protocol	bel
Frontier	front
Klever	klv
TrustSwap	swap
Toncoin	ton
TerraUSD	ust
Handshake	hns
Ultra	uos
BakeryToken	bake

Name	Ticker
Aavegotchi	ghst
Rarible	rari
Velo	velo
Aave	aave
PancakeSwap	cake
DODO	dodo
Harvest Finance	farm
Polkastarter	pols
Secret	scrt
Venus	xvs
Core	core
Dego Finance	dego
Ergo	erg
MATH	math
NEAR Protocol	near
DeFiChain	dfi
Audius	audio
Axie Infinity	axs
Conflux	cfx
Shentu	ctk
Celo Dollar	cusd
Injective	inj
Keep3rV1	kp3r
Oasys	oas
Smooth Love Potion	slp
StaFi	fis
Flamingo	flm
Oasis Network	rose
TrueFi	tru
Unifi Protocol DAO	unfi
Golem	glm
Hegic	hegic
API3	api3
Badger DAO	badger
Firo	firo
MobileCoin	mob
Synapse	syn
Virtua	tvk
The Graph	grt
1inch	1inch
Alpha Venture DAO	alpha
OctoFi	octo
saffron.finance	sfi
Perpetual Protocol	perp

Name	Ticker
AS Roma Fan Token	asr
BarnBridge	bond
CUDOS	cudos
DeXe	dexe
Bonfida	fida
Frax	frax
Frax Share	fxs
Juventus Fan Token	juv
Linear	lina
Mdex	mdx
Mirror Protocol	mir
OG Fan Token	og
Marlin	pond
Paris Saint-Germain Fan Token	psg
REVV	revv
Rook	rook
Trust Wallet Token	twt
ZKSpace	zks
Flow	flow
Stratis	strax
Reef	reef
Bitcoin Standard Hashrate Token	btcst
The Sandbox	sand
SafePal	sfp
SKALE	skl
Phala Network	pha
WOO Network	woo
Raydium	ray
AC Milan Fan Token	acm
Akash Network	akt
Alchemix	alcx
DAO Maker	dao
DerivaDAO	ddx
Dypius	dyp
Inverse Finance	inv
MAPS	maps
Mask Network	mask
NFTX	nftx
Prosper	pros
BENQI	qi
Radicle	rad
Rally	rly
SuperVerse	super
Tornado Cash	torn

Name	Ticker
AIOZ Network	aioz
Alpaca Finance	alpaca
Anchor Protocol	anc
Boson Protocol	boson
Convergence	conv
Fei USD	fei
Fire Protocol	fire
Flux	flux
Franklin	fly
Galxe	gal
Illuvium	ilv
JasmyCoin	jasmy
Polkacity	polc
Rai Reflex Index	rai
Strike	strk
Alien Worlds	tlm
Tribe	tribe
Symbol	xym
Internet Computer	icp
Shiba Inu	shib
FC Barcelona Fan Token	bar
SpookySwap	boo
Somnium Space Cubes	cube
Dogelon Mars	elon
Ampleforth Governance Token	forth
Gitcoin	gtc
Hot Cross	hotcross
Kishu Inu	kishu
Liquity	lqty
Media Network	media
APENFT	nft
QuickSwap	quick
Songbird	sgb
Step Finance	step
Telos	tlos
Persistence	xprt
Liquity USD	lusd
Lido DAO	ldo
Baby Doge Coin	babydoge
BitDAO	bit
Coin98	c98
Celo Euro	ceur
Centrifuge	cfg
Tranchess	chess

Name	Ticker
CLV	clv
Covalent	cqt
Convex Finance	cvx
Dvision Network	dvi
Gala	gala
Goldfinch	gfi
Metahero	hero
Karura	kar
Lithium	lith
MOBOX	mbox
Moonriver	movr
PlayDapp	pla
Qredo	qrdo
RadioCaca	raca
SuperRare	rare
Saitama	saitama
Shiden Network	sdn
Seedify.fund	sfund
SOMESING	ssx
StarLink	starl
Wrapped NCG	wncg
XCAD Network	xcad
eCash	xec
Yield Guild Games	ygg
Pax Dollar	usdp
My Neighbor Alice	alice
ASD	asd
XDC Network	xdc
Mina	mina
Adventure Gold	agld
Star Atlas DAO	polis
dYdX	dydx
Spell Token	spell
Angle	angle
Ariva	arv
Assemble Protocol	asm
AstroSwap	astro
Star Atlas	atlas
Beta Finance	beta
BinaryX	bnx
Braintrust	btrst
Manchester City Fan Token	city
Clearpool	cpool
DOSE	dose

Name	Ticker
FLOKI	floki
Gods Unchained	gods
Highstreet	high
JOE	joe
S.S. Lazio Fan Token	lazio
Moss Carbon Credit	mco2
Marinade Staked SOL	msol
Olympus	ohm
Orca	orca
PackagePortal	port
Ribbon Finance	rbn
Samoyedcoin	samo
Saber	sbr
ssv.network	ssv
Strips Finance	strp
Tokemak	toke
VEMP	vemp
Wrapped Centrifuge	wcfg
Mines of Dalarnia	dar
Ethereum Name Service	ens
GM Wagmi	gm
GYEN	gyen
Immutable	imx
KOK	kok
Magic Internet Money	mim
FC Porto Fan Token	porto
ParaSwap	psp
Aurora	aurora
Binance Beacon ETH	beth
Boba Network	boba
Everscale	ever
Merit Circle	mc
Maple	mpl
Numbers Protocol	num
ONSTON	onston
ConstitutionDAO	people
Santos FC Fan Token	santos
Symbiosis	sis
BitTorrent (new)	bttc
Vulcan Forged PYR	pyr
Tether EURt	eurt
Casper	cspr
Automata Network	ata
ApeCoin	ape

Name	Ticker
LooksRare	looks
Moonbeam	glmr
Tulip Protocol	tulip
Osmosis	osmo
STEPN	gmt
Biconomy	bico
Alpine F1 Team Fan Token	alpine
Astar	astr
Biswap	bsw
PowerPool	cvp
Gari Network	gari
Index Cooperative	index
Multichain	multi
Optimism	op
REI Network	rei
SHPING	shping
Stargate Finance	stg
Voxies	voxel
Zebec Protocol	zbc
Acala Token	aca
Bounce Token	auction
Eden	eden
Ellipsis	epx
Shapeshift FOX Token	fox
Geojam Token	jam_geojam
League of Kingdoms Arena	loka
MetisDAO	metis
Ooki Protocol	ooki
Pundi X	pundix
Threshold	t
Voyager Token	vgx
USDD	usdd
Chia	xch
Euro Coin	euroc
Beefy Finance	bifi_beef
Staked Ether Lido	steth
poundtoken	gbpt
Terra 2.0	luna2
Nano	xno
Onyxcoin	xcn
NYM	nym
Efinity Token	efi
WEMIX	wemix
Step App	fitfi

Name	Ticker
Sweat Economy	sweat
FirmaChain	fct2
Tokenlon Network Token	lon
pSTAKE Finance	pstake
Vesper	vsp
GuildFi	gf
LeverFi	lever
Euler	eul
GensoKishi Metaverse	mv
EthereumPoW	ethw
Crabada	cra
Reflexer Ungovernance Token	flx
JUNO	juno
Altered State Token	asto
BreederDAO	breed
Saddle	sdl
Arsenal Fan Token	afc
Aptos	apt
Axelar	axl
Bitcicoin	bitci
Cult DAO	cult
Forta	fort
GMX	gmx
Hashflow	hft
Metaplex	mplx
Polymesh	polyx
SIDUS	sidus
Agoric	bld
Avocado DAO Token	avg
ECOx	ecox
Evmos	evmos
PathDAO	path
Stader	sd
Tribal Token	tribl
Bonk	bonk
Hooked Protocol	hook
Dogechain	dc
Flare	flr
Hifi Finance	hifi
Access Protocol	acs
Blur	blur
DeFi Kingdoms	jewel
Dopex	dpx
MAGIC	magic

Name	Ticker
Arbitrum	arb

8 Appendix B

The following table lists the weights applied to each one-minute time interval described in Section 5.4 Calculation Algorithm.

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

Time Interval	Weight
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

9 Change Log

1. **Version 1.1 on August 15, 2023**: The coverage universe is expanded to include the following assets: ali, dep, hotcross, tlos, cfg, lith, sfund, dose, num, sis, jam_geojam, mv, mplx, sidus, acs, blur, arb, snm, fuel, tct, edu, bob, mnt, ron, cos, perl, troy, vidt, wom, brz, fio, mtr, mtrg, solo, spa, xpr, df, burger, nbs, hard, cover, vai, ez, ousd, iag, mngo, wing, aury, gofx, ice, pendle, xrd, id, mbs, umee, tko, uft, radar, mnde, xen, vinu, volt, prmx, myth, bone, brise, gft, gns, prime, rdnt, agix, xeta, igu, kcal, movez, rss3, grail, strm, lai, pepe, aidoge, astra, canto, cetus, cgpt, kas, ladys, mong, squad, sui, tenet, tomi, turbo, turbos, wojak, combo_combo, mav, rlb, tapt, hades, smr, vela, bgb, quick_new, arkm, wld, neon, sei. The following assets are terminated

from the coverage universe: `nu`, `usdk`, `chat`, `cmt`, `mof`, `inx`, `qlc`, `renbtc`, `dta`, `hkd`, `cocos`, `rsv`, `xhv`, `nrg`, `aoa`, `seele`, `ohm`, `tnb`, `path`, `ncash`, `hades`.

2. **Version 1.0 on March 16, 2023**: Initial publication of Coin Metrics Pricing Methodology. Previous versions of this document were contained in our Market Selection Framework, Hourly Reference Rates Methodology, Real-Time Reference Rates Methodology, and Principal Mark Price Methodology. Those four documents are now consolidated into the Coin Metrics Pricing Methodology. The coverage universe is expanded to include the following assets: `bonk`, `cusd`, `cra`, `jewel`, `apt`, `asto`, `aurora`, `avg`, `axl`, `bld`, `breed`, `ceur`, `cpool`, `ecox`, `evmos`, `flx`, `fly`, `fort`, `gf`, `index`, `indi`, `inx`, `multi`, `path`, `rpl`, `rsv`, `sd`, `sdl`, `tbtc`, `tribl`, `gmx`, `bifi_beef`, `dpx`, `boo`, `beth`, `magic`, `juno`, `port`, `phb`, `kishu`, `lever`, `flr`, `hft`, `porto`, `polyx`, `lazio`, `atm`, `acm`, `xcad`, `ssv`, `pros`, `rei`, `qlc`, `dego`, `vite`, `firo`, `iq`, `bar`, `og`, `hifi`, `asr`, `dyp`, `time`, `sylo`, `polc`, `bitci`, `fct2`, `onston`, `vsp`, `afc`, `bsw`, `epx`, `xno`, `dexe`, `core`, `vemp`, `cult`, `saitama`, `ever`, `babydoge`, `dc`, `kar`, `fsn`, `hero`, `oas`, `hook`, `cocos`. The following assets are terminated from the coverage universe: `mft`, `hpt`, `hxro`, `usdn`, `aion`.

3. **Coin Metrics Real-Time Reference Rates Methodology Version 0.15 on February 9, 2023**: Added a 200 milliseconds publication frequency.

4. **Coin Metrics Hourly Reference Rates Methodology Version 2.13 and Coin Metrics Real-Time Reference Rates Methodology Version 0.14 on September 21, 2022**: The coverage universe is expanded to include the following assets: `loka`, `mc`, `polis`, `sgb`, `steth`, `frax`, `rai`, `lusd`, `dfi`, `gbpt`, `ooki`, `fis`, `nest`, `drep`, `math`, `aleph`, `media`, `luna2`, `t`, `ethw`, `bttc`, `vra`, `swftc`, `raca`, `pyr`, `mbox`, `sweat`, `fitfi`, `qrdo`, `wemix`, `zbc`, `psg`, `voxel`, `chess`, `prq`, `gari`, `nym`, `arv`, `cudos`, `efi`, `for`, `juv`, `cvp`, `mbl`, `auto`, `eden`, `xcn`, `kai`, `velo`, `akt`, `berry`, `klv`, `kok`, `senso`, `floki`, `sdn`, `alpine`, `step`, `eurt`, `bfc`, `toke`, `shping`, `oxy`, `ssx`, `lit`, `conv`. The publication of reference rates is terminated for the following assets: `ramp`, `grs`, `ppt`, `nav`, `itc`, `qc`, `meta`, `cope`, `zb`. Minor changes to internal audit section.

5. **Coin Metrics Hourly Reference Rates Methodology Version 2.12 and Coin Metrics Real-Time Reference Rates Methodology Version 0.13 on July 1, 2022**: The coverage universe is expanded to include the following assets: `fei`, `op`, `usdd`, `xch`, `gmt`, `bico`, `ctk`, `flm`, `sfp`, `starl`, `glmr`, `tulip`, `astro`, `sfi`, `gst`, `mob`, `bit`, `vgx`, `auction`, `pundix`, `stg`, `ata`, `bel`, `dar`, `gal`, `astr`, `cqt`, `cspr`, `metis`, `boba`, `twt`, `aca`, `dao`, `xprt`, `cube`. The publication of reference rates is terminated for the following assets: `gxs`, `dgtx`, `wluna`, `dgd`, `foam`, `csp`, `cnn`, `bft`.

6. **Market Selection Framework Version 1.0.2 on February 15, 2022**: The selection algorithm was modified so that any market with volume,

measured in U.S. dollars over the past 90 days, of less than 5 percent of the volume of the selected market with the largest volume is excluded.

7. **Coin Metrics Hourly Reference Rates Methodology Version 2.11 and Coin Metrics Real-Time Reference Rates Methodology Version 0.12 on February 15, 2022**: The coverage universe is expanded to include the following assets: `xec`, `kda`, `mina`, `xdc`, `elon`, `flux`, `movr`, `ceek`, `win_wink`, `dvi`, `dusk`, `asd`, `gala`, `spell`, `ens`, `tru`, `alcx`, `clv`, `imx`, `agld`, `jasmy`, `farm`, `alice`, `chr`, `dydx`, `tlm`, `mdt`, `gtc`, `sun`, `c98`, `people`, `lina`, `rndr`, `ach`, `super`, `mask`, `quick`, `arpa`, `qi`, `idex`, `rad`, `bond`, `mir`, `joe`, `gods`, `front`, `pla`, `orn`, `ramp`, `rgt`, `fida`, `forth`, `tribe`, `wluna`, `coval`, `rbn`, `lcx`, `asm`, `ddx`, `suku`, `krl`, `rari`, `mco2`, `gyen`, `btrst`, `api3`, `rly`, `wcfg`, `musd`, `ilv`, `atlas`, `usdp`, `joe`, `ldo`, `cvx`, `fxs`, `kp3r`, `alpaca`, `bnx`, `boson`, `dora`, `ghst`, `nft`, `ohm`, `om`, `pond`, `rare`, `revv`, `stpt`, `torn`, `tvk`, `wncg`, `xym`, `ygg`. The publication of reference rates is terminated for the following assets: `hedg`, `eurs`, `bzrx`, `poa`, `wpr`, `dmg`, `cdt`, `phx`, `appc`, `btt`, `idrt`, `rdn`, `via`, `evx`. The section "Data Inputs", subsections "Other Cryptocurrencies Excluding Stablecoins" and "Stablecoins", was modified to consider markets quoted in USD Coin or Tether to serve as constituent markets. The constituent markets for all assets in the coverage universe are updated. The constituent markets for all assets in the coverage universe are updated.

8. **Coin Metrics Hourly Reference Rates Methodology Version 2.10 and Coin Metrics Real-Time Reference Rates Methodology Version 0.11 on September 28, 2021**: The coverage universe is expanded to include the following assets: `amp`, `axs`, `shib`, `audio`, `bake`, `med`, `dag`, `slp`, `xdb`. The publication of reference rates is terminated for the following assets: `agi` ,`btmx`, `dgx`, `ethos`, `mco`, `sngls`, `cpay`, `eng`, `lun`, `pnt`. The constituent markets for all assets in the coverage universe are updated.

9. **Coin Metrics Hourly Reference Rates Methodology Version 2.9 and Coin Metrics Real-Time Reference Rates Methodology Version 0.10 on May 27, 2021**: The coverage universe is expanded to include the following assets: `icp`, `cope`, `maps`, `btcst`, `ctsi`, `erg`, `woo`, `prom`, `strax`, `usdn`, `cfx`, `mdx`, `nkn`, `sand`, `fx`, `pha`. The publication of reference rates is terminated for the following assets: `tnt`, `npxs`, `zar`. The constituent markets for all assets in the coverage universe are updated.

10. **Coin Metrics Hourly Reference Rates Methodology Version 2.8 and Coin Metrics Real-Time Reference Rates Methodology Version 0.9 on April 25, 2021**: The methodology was modified to add fiat currencies to the coverage universe. The coverage universe is expanded to include the following assets: `eur`, `krw`, `gbp`, `jpy`, `aud`, `try`, `brl`, `rub`, `sgd`, `bidr`, `ngn`, `cad`, `chf`, `zar`, `idrt`, `hkd`, `uah`, `qc`, `klay`, `cake`, `btmx`, `flow`, `zks`, `stmx`, `skl`, `reef`, `dodo`, `coti`, `bora`, `cream`, `ray`, `tryb`, `rook`. The publication of reference rates is terminated for the following assets: `xzc`, `bcpt`, `yamv2`, `xns`, `tmtg`, `kp3r`.

11. **Coin Metrics Hourly Reference Rates Methodology Version 2.7 and Coin Metrics Real-Time Reference Rates Methodology Version 0.8 on February 23, 2021**: The coverage universe is expanded to include the following assets: `1inch`, `alpha`, `octo`, `perp`, `scrt`, `grt`, `keep`, `xvs`, `nu`, `tel`, `badger`.

12. **Coin Metrics Hourly Reference Rates Methodology Version 2.6 and Coin Metrics Real-Time Reference Rates Methodology Version 0.7 on January 26, 2021**: The coverage universe is expanded to include the following assets: `susd`, `pols`, `ust`, `lto`, `swap`, `nim`, `lbc`, `mta`, `kp3r`, `glm`, `near`, `noia`, `rose`, `inj`. The publication of reference rates is terminated for the following assets: `gnt`, `fxc`, `bht`, `cmct`, `strat`, `loki`. The constituent markets for all assets in the coverage universe are updated.

13. **Coin Metrics Hourly Reference Rates Methodology Version 2.5 and Coin Metrics Real-Time Reference Rates Methodology Version 0.6 on November 5, 2020**: The coverage universe is expanded to include the following assets: `akro`, `ampl`, `ar`, `bal`, `bzrx`, `celo`, `comp`, `crv`, `csp`, `dmg`, `dot`, `foam`, `kin`, `oxt`, `rune`, `sol`, `srm`, `vtho`, `wbtc`, `wnxm`, `xhv`, `xyo`, `yamv2`, `yfi`, `yfii`, `uma`, `ewt`, `rev`, `rsr`, `avax`, `tmtg`, `jst`, `hnt`, `trac`, `vlx`, `mxc`, `fet`, `aoa`, `iris`, `pnk`, `mln`, `shr`, `uqc`, `one_harmony`, `trb`, `ogn`, `ava`, `loki`, `hxro`, `wxt`, `cpay`, `fil`, `uni`, `swrv`, `sushi`, `aave`, `egld`, `hns`, `dia`, `boa`, `uos`, `ctc`, `renbtc`. The publication of reference rates is terminated for the following assets: `arn`, `pma`, `erd`, `man`, `iq`, `lend`. The Market Selection Framework was amended such that extremely low volume markets are less likely to be selected as a constituent market if higher volume markets of similar quality are available. The constituent markets for all assets in the coverage universe are updated.

14. **Market Selection Framework Version 1.0.1 on November 5, 2020**: The selection algorithm was modified so that any market with volume, measured in U.S. dollars over the past 90 days, of less than 1 percent of the volume of the selected market with the largest volume is excluded.

15. **Coin Metrics Hourly Reference Rates Methodology Version 2.4 on July 29, 2020 and Coin Metrics Real-Time Reference Rates Methodology Version 0.5 on July 29, 2020**: The coverage universe is expanded to include the following assets: `wrx`, `band`, `ksm`, `usdk`, `snx`, `stx`, `fxc`, `kcs`, `hive`, `nrg`, `cel`, `ubt`, `chsb`, `crpt`, `bht`, `cvt`, `data`, `eurs`, `xns`, `gt`, `dgtx`, `kava`, `tt`, `sxp`, `mx`, `ocean`, `erd`, `lpt`. The publication of reference rates is terminated for the following assets: `storm`, `gto`. A revision policy was amended. The constituent markets for all assets in the coverage universe are updated.

16. **Coin Metrics Hourly Reference Rates Methodology Version 2.3 on February 27, 2020 and Coin Metrics Real-Time Reference Rates Methodology Version 0.4 on February 27, 2020**: The coverage universe is expanded to include the following assets: `xaut`, `paxg`,

husd, dgx, busd, ftt, hedg, okb, zb, hbar, ckb, mof, vsys, cennz, luna, chz, seele, dx, matic, abbc, rif, tomo, hpt, and ant.

17. **Coin Metrics Hourly Reference Rates Methodology Version 2.2 on February 6, 2020 and Coin Metrics Real-Time Reference Rates Methodology Version 0.3 on February 6, 2020**: The constituent markets for all assets in the coverage universe are updated. The coverage universe is adjusted to remove the following assets: box, cosm, fsn, medx, pst, and ttc_protocol. The coverage universe was expanded to include Dai and the previous asset with this name was renamed to Sai to appropriately reflect MakerDAO's transition from Single-Collateral Dai (Sai) to Multi-Collateral Dai (Dai).

18. **Coin Metrics Hourly Reference Rates Methodology Version 2.1 on December 9, 2019 and Coin Metrics Real-Time Reference Rates Methodology Version 0.2 on December 9, 2019**: The coverage universe is expanded to include the following assets: algo and beam. Updated calculation methodology to include price inverse variance weighting to reduce the impact of outliers.

19. **Coin Metrics Real-Time Reference Rates Methodology Version 0.1 on August 30, 2019**: Initial publication of Real-Time Reference Rates Methodology.

20. **Coin Metrics Hourly Reference Rates Methodology Version 2.0 on July 8, 2019**: Increased publication times from once daily at midnight UTC to once hourly. Changed human oversight from once daily at midnight UTC to once daily at 16:00 New York time.

21. **Coin Metrics Hourly Reference Rates Methodology Version 1.2 on June 13, 2019**: The coverage universe is expanded to include the following assets: gno, hot_holo, maid, nuls, qkc, rdd, rvn, zen, and mona.

22. **Coin Metrics Hourly Reference Rates Methodology Version 1.1 on May 30, 2019**: Updated data contingency rules. If no observable transactions from constituent markets occur during a one-minute time interval, the next one-minute time interval's volume-weighted median price is used instead of the previous. This contingency rule is applied recursively.

23. **Coin Metrics Hourly Reference Rates Methodology Version 1.0 on May 13, 2019**: Initial publication of Reference Rates Methodology.

24. **Market Selection Framework Version 1.0.0 on May 13, 2019**: Initial publication of Market Selection Framework.