Reference Rates Methodology

Version 2.3

Last Revised: February 27, 2020

Contents

1 Change Log

1. **Version 2.3 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`.

2. **Version 2.2 on February 6, 2020**: The selected 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).

3. **Version 2.1 on December 9, 2019**: The coverage universe is expanded to include the following assets: `algo` and `beam`.

4. **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.

5. **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`.

6. **Version 1.1 on May 30, 2019**: Updated data contingency rules. If no observable transactions from selected 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.

7. **Version 1.0 on May 13, 2019**: Initial publication of Reference Rates Methodology.

2 Introduction

Coin Metrics produces the Coin Metrics Reference Rates (the "Reference Rates"), a collection of reference rates quoted in U.S. dollars, published once per hour, 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.

3 Description

The Reference Rates are published hourly, every day of the year, and represent the reference rate of one unit of the cryptocurrency quoted in U.S. dollars. The Reference Rates are calculated at the end of every hour (the "Calculation Time") and are published within 60 minutes (the "Publication Time").

4 Coverage Universe

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

5 Data and Calculation Methodology

5.1 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 constituent markets and evaluates existing constituent 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 constituent markets (the "Constituent Markets"). A separate list of Constituent Markets is maintained for each of the Reference Rates 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 cryptocurrency in

the Reference Rates coverage universe, updates on inclusions or exclusions of constituent markets, and the rationale for making any change.

5.2 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 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 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.

5.3 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.

5.3.1 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.

5.3.2 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.

5.3.3 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
Sai	sai
Tether	usdt
TrueUSD	tusd
USD Coin	usdc
Paxos Standard	pax
Gemini Dollar	gusd

Name	Ticker
Dai	dai
HUSD	husd
Binance USD	busd

5.4 Calculation Algorithm

The calculation algorithm of the Reference Rates is described below.

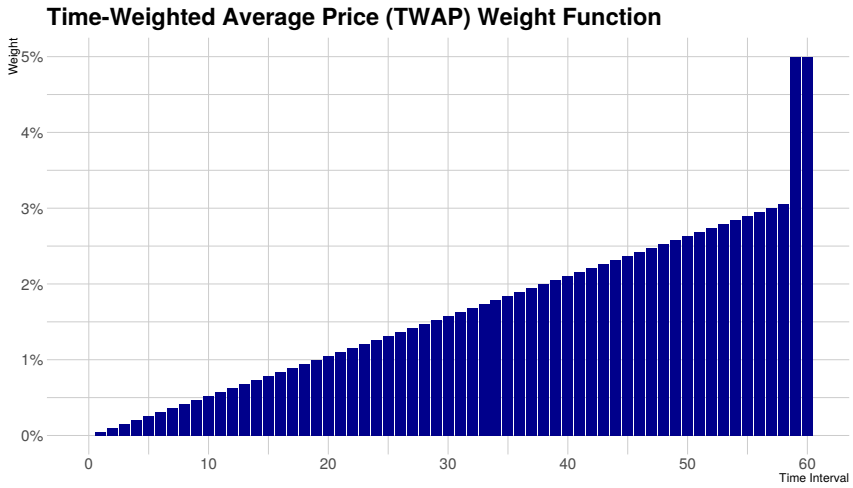
1. All observable transactions from Constituent Markets are combined and partitioned into time intervals, with each time interval spanning a period of one minute. The first one-minute time interval begins 60 minutes before the Calculation Time and the last one-minute time interval begins at the Calculation 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 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 U.S. 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 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:



5.5 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 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.

5.6 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 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.

6 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.

7 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.

8 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.

9 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.

10 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 industry 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.

11 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.

12 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 and will explain the action taken.

13 Internal Audit

The Oversight Committee appoints an independent internal auditor to review the Reference Rates' 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.

14 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

15 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.

16 Appendix A

The following table lists the current coverage universe:

Name	Ticker
Bitcoin	btc
Ethereum	eth
XRP	xrp
Bitcoin Cash	bch
Bitcoin SV	bsv
Tether	usdt
Litecoin	ltc
EOS	eos
Binance Coin	bnb
Tezos	xtz
Cardano	ada
Monero	xmr
Stellar	xlm
TRON	trx
ChainLink	link
Ethereum Classic	etc
Huobi Token	ht
UNUS SED LEO	leo
Dash	dash
NEO	neo
Crypto.com Chain	cro
Cosmos	atom
HedgeTrade	hedg
IOTA	miota
Maker	mkr
ZCash	zec
Ontology	ont
NEM	xem
USD Coin	usdc
VeChain	vet
Basic Attention Token	bat
OKB	okb
Dogecoin	doge
FTX Token	ftt
Qtum	qtum
Algorand	algo
Decred	dcr
Paxos Standard	pax
ICON	icx
Lisk	lsk
Bitcoin Gold	btg
0x	zrx
Ravencoin	rvn
TrueUSD	tusd

Name	Ticker
ZB Token	zb
OmiseGO	omg
Augur	rep
Waves	waves
Bitcoin Diamond	bcd
Dai	dai
Hedera Hashgraph	hbar
Theta Token	theta
MonaCoin	mona
Nano	nano
Holo	hot_holo
DxChain Token	dx
Kyber Network	knc
Bytecoin	bcn
Siacoin	sc
Nexo	nexo
Horizen	zen
DigixDAO	dgd
Enjin Coin	enj
BitTorrent	btt
MCO Token	mco
Nervos Network	ckb
Molecular Future	mof
Bytom	btm
v.systems	vsys
DigiByte	dgb
BitShares	bts
HyperCash	hc_hypercash
Komodo	kmd
Steem	steem
IOST	iost
Terra	luna
Verge	xvg
Zilliqa	zil
ABBC Coin	abbc
Aeternity	ae
Seele	seele
Binance USD	busd
Golem	gnt
Zcoin	xzc
Status	snt
Chiliz	chz
WaykiChain	wicc
Ardor	ardr

Name	Ticker
aelf	elf
Aion	aion
Matic Network	matic
Ren	ren
iExec RLC	rlc
RIF Token	rif
Decentraland	mana
Quant	qnt
Pundi X	npxs
WAX	waxp
MaidSafeCoin	maid
Electroneum	etn
Power Ledger	powr
Aave	lend
Loopring	lrc
Stratis	strat
TomoChain	tomo
Project Pai	pai
Huobipool Token	hpt
Grin	grin
Elastos	ela
Beam	beam
Aragon	ant
Ripio Credit Network	rcn_ripiocreditnetwork
SOLVE	solve
GXChain	gxs
Orbs	orbs
Ark	ark
Waltonchain	wtc
IoTeX	iotx
Wanchain	wan
Nebulas	nas
ReddCoin	rdd
Cortex	ctxc
Populous	ppt
Ignis	ignis
Bancor	bnt
FunFair	fun
Storj	storj
Factom	fct
Sai	sai
Metaverse ETP	etp
NULS	nuls
Tierion	tnt

Name	Ticker
PIVX	pivx
Loom Network	loom
Gnosis	gno
Enigma	eng
Metal	mtl_metal
Numeraire	nmr
QASH	qash
Lambda	lamb
Gas	gas
Syscoin	sys
Civic	cvc
BitKan	kan
Vertcoin	vtc
Bibox Token	bix
Groestlcoin	grs
Dent	dent
Eidoo	edo
Dragonchain	drgn
Fantom	ftm
Nxt	nxt
Centrality	cennz
PAX Gold	paxg
GoChain	go
Arcblock	abt
Celer Network	celr
Moeda Loyalty Points	mda
IoT Chain	itc
SingularityNET	agi
Cindicator	cnd
Cred	lba
Theta Fuel	tfuel
Polymath	poly
Request	req
CyberMiles	cmt
Voyager Token	ethos
BnkToTheFuture	bft
Metadium	meta
Storm	storm
QuarkChain	qkc
Mainframe	mft
OST	ost
Ankr	ankr
AdEx	adx
TenX	pay

Name	Ticker
Quantstamp	qsp
NavCoin	nav
Raiden Network Token	rdn
Utrust	utk
Gifto	gto
Everex	evx
Digix Gold Token	dgx
Mithril	mith
YOYOW	yoyow
Time New Bank	tnb
Selfkey	key
WePower	wpr
SingularDTV	sngls
Matrix AI Network	man
Nucleus Vision	ncash
Propy	pro
Bluzelle	blz
Viacoin	via
Blox	cdt
Dock	dock
Gemini Dollar	gusd
OAX	oax
district0x	dnt
AppCoins	appc
Viberate	vib
Game.com	gtc_gamecom
POA	poa
PumaPay	pma
DATA	dta
DeepBrain Chain	dbc
SIRIN LABS Token	srn
AirSwap	ast
Odyssey	ocn
BlockMason Credit Protocol	bcpt
Etherparty	fuel
Red Pulse Phoenix	phx
Aeron	arn
Content Neutrality Network	cnn
Lympo	lym
Ambrosus	amb
Lunyr	lun
Penta	pnt
IHT Real Estate Protocol	iht
ChatCoin	chat

Name	Ticker
Crowd Machine	cmct
HUSD	husd
Ontology Gas	ong_ontologygas
Tether Gold	xaut

17 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

Time Interval	Weight
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