



CF SPOT RATES

Methodology Guide

Version: 2.0

Version Date: August 15th 2018

Table of Contents

| | | |
|-------|------------------------------------|----|
| 1 | Version History..... | 3 |
| 2 | Overview..... | 4 |
| 3 | Definitions..... | 5 |
| 4 | Methodology and Rules..... | 6 |
| 4.1 | Methodology..... | 6 |
| 4.1.1 | Qualitative Description..... | 6 |
| 4.1.2 | Mathematical Representation..... | 7 |
| 4.2 | A Note on Properties..... | 9 |
| 5 | Contingency Calculation Rules..... | 11 |
| 5.1 | Delayed Data..... | 11 |
| 5.2 | Erroneous Data..... | 11 |
| 5.2.1 | Erroneous Books..... | 11 |
| 5.2.2 | Erroneous Prices..... | 11 |
| 5.3 | Potentially Erroneous Data..... | 12 |
| 5.4 | Calculation Failure..... | 12 |
| 6 | Spot Rate Parameters..... | 13 |
| 7 | Spot Rate Specifications..... | 14 |

1 Version History

| Version | Version Date | Changes to Previous |
|---------|------------------------------|--|
| 1.0 | June 20 th 2018 | N/A |
| 2.0 | August 15 th 2018 | Addition of Parameters & Specifications for CF Bitcoin Cash Dollar Spot Rate |

2 Overview & Aims

The CF Spot Rates have been specifically designed to serve as a transparent and representative indicator of the instantaneous price of a digital asset for the purposes of calculating margining requirements for orderly futures trading. No further applications of the CF Spot Rates have been taken into consideration in its design.

This document covers the methodology for calculating the CF Spot Rates. A summary of specifications is provided in Section 7.

3 Definitions

API: Application programming interface.

Calculation Time: Any time as of which a CF Spot Rate is published.

Constituent Exchange: A cryptocurrency trading venue approved by CF management to serve as pricing source for the calculation of a CF Spot Rate

Relevant Pair: The cryptocurrency versus cryptocurrency or legal tender pair referenced by a CF Spot Rate, as defined in Section 0.

Relevant Order Book: The universe of the currently unmatched limit orders to buy or sell a unit of cryptocurrency versus cryptocurrency or legal tender on a Constituent Exchange in the Relevant Pair that is reported through its API to the Calculation Agent.

Retrieval Time: The time, as given by the server clock of the Calculation Agent, as of which the Relevant Order Book of a Constituent Exchange is requested by the Calculation Agent through the API of the Constituent Exchange.

4 Methodology and Rules

4.1 Methodology

4.1.1 Qualitative Description

The CF Spot Rates are calculated in real time based on the Relevant Order Books of all Constituent Exchanges. An order book is a list of buy and sell orders with associated limit prices and sizes that have not yet been matched due to lack of supply or demand to trade at that price. It therefore informs about the price at which a trader can buy or sell a certain amount of cryptocurrency as of now. In line with existing cryptocurrency market practises, the price/sizes tuples of buy orders ("bids") descend by price and the price/size tuples of sell orders ("asks") ascend by price.

Calculation steps are as follows:

1. At the Effective Time, the Relevant Order Book of each Constituent Exchange is added to a joint list of order books.
2. The joint list of order books is aggregated into one consolidated order book. If the size of a bid or ask order exceeds the order size cap, it enters the consolidated order book with a size equal to the order size cap.
3. The cumulative bid price-volume curve, ask price-volume curve, mid price-volume curve and mid spread-volume curve are calculated from the consolidated order book at a granularity equal to the spacing parameter.
 - a. The bid price-volume curve maps transaction volume to the marginal price per cryptocurrency unit a seller is required to accept in order to sell this volume to the consolidated order book.
 - b. The ask price-volume curve maps a transaction volume to the marginal price per cryptocurrency unit a buyer is required to pay in order to purchase this volume from the consolidated order book.
 - c. The mid price-volume curve represents the average of the bid price-volume curve and the ask price-volume curve.
 - d. The mid spread-volume curve represents the percentage deviation of the ask price-volume curve from the mid price-volume curve.
4. The utilized depth is calculated as the maximum cumulative volume for which the mid spread-volume curve does not exceed a certain percentage deviation from the mid price. If this volume is less than one, utilized depth is set to one.

5. The mid price-volume curve is weighted by the normalized probability density of the exponential distribution up to the utilized depth.
6. The CF Spot Rate is then given by the sum of the weighted mid price-volume curve obtained in the previous step.

4.1.2 Mathematical Representation

The following table shows the symbols used in the mathematical representation of CF Spot Rates.

| Symbol | Name | Description | Type |
|--|--------------------|---|--------------------------|
| T | Effective time | The time at which a CF Spot Rate is calculated | Parameter, see Section 0 |
| C | Order size cap | The size above which any excess size of a bid or ask order is discarded | Parameter, see Section 0 |
| D | Deviation from mid | The maximum percentage deviation of a limit order from the mid price-volume curve, until which that limit order is used for the calculation of a CF Spot Rate | Parameter, see Section 0 |
| λ | Lambda | A parameter that determines the shape of the probability density function of the exponential distribution | Parameter, see Section 0 |
| s | Spacing | The spacing granularity of a price-volume curve | Parameter, see Section 0 |
| v | Volume | The independent variable of a price-volume curve | Internal variable |
| A_T | Ask orders | The ask orders of the consolidated order book as of the effective time, ordered ascending by price | Input |
| $a_{T,i}$ with $a_{T,i} = (ap_{T,i}, as_{T,i})$, $a_{T,i} \in A_T$, $as_{T,i} = \min\{as_{T,i}, C\}$ | Ask order | The i th price/size ask order pair of the consolidated order book | Input |
| B_T | Bid orders | The bid orders of the consolidated order book as of | Input |

| | | | |
|---|----------------------|---|--------|
| | | the effective time, ordered descending by price | |
| $b_{T,i}$ with $b_{T,i} = (bp_{T,i}, bs_{T,i})$, $b_{T,i} \in B, bs_{T,i} = \min\{bs_{T,i}, C\}$ | Bid order | The i th price/size bid order pair of the consolidated order book | Input |
| NF | Normalization factor | A parameter chosen such that $\frac{1}{NF} \sum_{v=1}^{\bar{v}_T} \lambda e^{-\lambda v} = 1$ | Output |
| $CCRTI_T$ | CCRTI | The CF Spot Rate at time T | Output |

Using the above notation, we define the ask price-volume curve, $askPV_T$, the bid price-volume curve, $bidPV_T$, the mid price-volume curve, $midPV_T$, and the mid spread-volume curve, $midSV_T$, in each case as of the effective time T , as:

| | |
|--|--------|
| $ask\widehat{PV}_T(v) = ap_{T,j+1}$ where $\sum_{i=1}^j as_{T,i} < v$ and $\sum_{i=1}^{j+1} as_{T,i} \geq v$ | Eq. 3a |
| $bid\widehat{PV}_T(v) = bp_{T,j+1}$ where $\sum_{i=1}^j bs_{T,i} < v$ and $\sum_{i=1}^{j+1} bs_{T,i} \geq v$ | Eq. 3b |
| $askPV_T(v) = ask\widehat{PV}_T\left(s \left\lfloor \frac{v}{s} \right\rfloor\right)$ | Eq. 3c |
| $bidPV_T(v) = bid\widehat{PV}_T\left(s \left\lfloor \frac{v}{s} \right\rfloor\right)$ | Eq. 3d |
| $midPV_T(v) = \frac{askPV_T(v) + bidPV_T(v)}{2}$ | Eq. 3e |
| $midSV_T(v) = \frac{askPV_T(v)}{midPV_T(v)} - 1$ | Eq. 3f |

The utilized depth, \bar{v}_T , is calculated as:

| | |
|---|-------|
| $\bar{v}_T = \max(v_i \text{ where } midSV_T(v_i) \leq D \text{ and } midSV_T(v_{i+1}) > D, 1)$ | Eq. 4 |
|---|-------|

The CF Spot Rate as of the effective time T , $CCRTI_T$, is then given by:

$$CCRTI_T = \sum_{v=1}^{\bar{v}_T} midPV_T(v) \frac{1}{NF} \lambda e^{-\lambda v}$$

Eq. 5

4.2 A Note on Properties

The CF Spot Rates reflect the instantaneous supply and demand of a given cryptocurrency and result in a robust, yet highly timely indication of the current price. This is achieved through the following design choices:

Order Book Data

CF Spot Rates are calculated from order book data, as opposed to, for instance, trade data. Order book data is composed of unmatched limit orders to buy or sell cryptocurrency. It informs about the price at which a trader can buy or sell cryptocurrency now or in the future and is therefore forward-looking by nature. Further, absent retrieval constraints, order book data is always up to date. This is in contrast to trade data, which is produced in stochastic intervals only and informs about the price at which the cryptocurrency has traded in the past.

Mid Price Volume Curve

The mid price volume curve represents the average of the marginal price at which a certain amount of cryptocurrency can be sold and bought. By averaging across the mid price volume curve, CF Spot Rates Indices represent a blend of such (hypothetical) transactions at various transaction sizes.

Utilized Depth

CF Spot Rates are calculated from the section of the mid price volume curve for which ask limit orders at a certain depth diverge by no more than a certain percentage from the mid price at that depth. It therefore reflects a significant portion of the top of the consolidated order book (as opposed to, for instance, the best bid and ask prices only) but discards limit orders that are less likely to be matched. This makes it a meaningful representation of true liquidity and robust to local changes in order books.

Note that utilized depth will always include any crossing section of the consolidated order book, as well as the non-crossing section with limit orders up to a certain percentage away from the crossing point. If zero size resides in both these sections, utilized depth is set to one. The CF Spot Rate is then effectively equal to the mid price of the consolidated order book.

Exponential Weighting

The mid price-volume curve is weighted by the normalized probability density of the exponential distribution. The exponential distribution and its first derivative are monotonically decreasing, resulting in a higher emphasis on the initial section of the

mid price-volume curve, i.e. bid and ask prices that are closest to the global best bid and ask price.

Markov Process and Martingale

Indices are frequently based on historical data, such as recent trade prices or volumes. This can result in certain predictability, for instance due to the expectation that stale prices will be updated or that a price will drop out of a weighting window.

By relying solely on order book data, CF Spot Rates are both a Markov process and a martingale. A Markov process is a stochastic process with a probability distribution that depends only on the current information set, not on historical information sets. The martingale property implies that the best prediction of the next CF Spot Rate value is its current value:

$$E(CCRTI_{t+1} | CCRTI_1, CCRTI_2, \dots, CCRTI_t) = CCRTI_t$$

This makes CF Spot Rates fit for its primary application of facilitating orderly futures trading.

5 Contingency Calculation Rules

5.1 Delayed Data

Delayed data is treated according to the following rules:

1. If the Retrieval Time of the Relevant Order Book of a Constituent Exchange is at least 30 seconds older than the Calculation Time, the Constituent Exchange is disregarded in the calculation of the CF Spot Rate for that Calculation Time.

If the Retrieval Times of the Relevant Order Books of all Constituent Exchanges are each at least 30 seconds older than the Calculation Time, a CF Spot Rate calculation failure occurs for that Calculation Time (see Section 5.4).

5.2 Erroneous Data

5.2.1 Erroneous Books

All Relevant Order Books are subject to an automated screening for erroneous data according to the following rules:

1. If the format of a Relevant Order Book deviates from the expected format such that it cannot be parsed, it is flagged as erroneous.
2. If the Relevant Order Book contains no bid orders or no ask orders, it is flagged as erroneous.
3. If the Relevant Order Book crosses, it is flagged as erroneous.

Relevant Order Books flagged as erroneous for a given Calculation Time are disregarded in the calculation of the CF Spot Rate for that Calculation Time.

If the Relevant Order Books of all Constituent Exchanges are flagged as erroneous for a given Calculation Time, a CF Spot Rate calculation failure occurs for that Calculation Time (see Section 5.4).

5.2.2 Erroneous Prices

All Relevant Order Books are subject to an automated filtering process according to the following rule.

1. If a Relevant Order Book contains any entries with a non-numeric or non-positive limit price or size then any such entries are flagged as erroneous.

All entries in a Relevant Order Book which are flagged as erroneous for a given Calculation Time are disregarded in the calculation of the CF Spot Rate for that Calculation Time.

5.3 Potentially Erroneous Data

All Relevant Order Books are subject to an automated screening for potentially erroneous data according to the following rules:

1. For each Constituent Exchange individually, the current mid price is calculated as the average of the highest bid price and the lowest ask price of the Relevant Order Book.
2. For each Constituent Exchange, the absolute percentage deviation of the mid price, as calculated in the previous step, from the median of the mid prices of all Constituent Exchanges is calculated.
3. If for any Constituent Exchange the absolute percentage deviation, as calculated in the previous step, exceeds 25%, the Relevant Order Book of that Constituent Exchange is flagged as potentially erroneous.

Relevant Order Books flagged as potentially erroneous for a given Calculation Time are disregarded in the calculation of the CF Spot Rate for that Calculation Time. The occurrence of any such flag is reported to the Oversight Committee.

If the Relevant Order Books of all Constituent Exchanges are flagged as potentially erroneous for a given Calculation Time, a CF Spot rate Calculation Failure occurs for that Calculation Time (see Section 5.4).

5.4 Calculation Failure

If a CF Spot Rate cannot be calculated for a given Calculation Time, for instance because:

- the Retrieval Times of the Relevant Order Books of all Constituent Exchanges are each at least 30 seconds older than the Calculation Time, or
- all Relevant Order Books are flagged as erroneous or potentially erroneous (see Section 5.2); or
- any other reason or circumstance that prevents the orderly calculation of a CF Spot Rate,

then the CF Spot Rate for that Calculation Time is not published. The occurrence of any CF Spot Rate calculation failure is reported to CF management and persistent failure will lead to a review of the methodology.

6 Spot Rate Parameters

The following table summarizes the parameters for the currently supported CF Spot Rates:

| | CF Litecoin Dollar Spot Rate | CF XRP Dollar Spot Rate | CF XRP Bitcoin Spot Rate | CF BitcoinCash Dollar Spot Rate |
|--|---|--------------------------------|---------------------------------|--|
| Ticker Symbol | IN_LTCUSD | IN_XRPUSD | IN_XRPXBT | IN_BCHUSD |
| Relevant Pair | Litecoin vs. U.S. Dollars | XRP vs. U.S. Dollars | XRP vs. Bitcoin | BitcoinCash vs U.S. Dollars |
| Effective Time (T) | Approximately every second of each day for the entire year including weekends and holidays. | | | |
| Constituent Exchanges | Bitstamp Kraken | Bitstamp Kraken | Bitfinex Bitstamp Kraken | Bitstamp Kraken |
| Order Size Cap (C) | 1,000 | 100,000 | 100,000 | 100 |
| Spacing (s) | 50 | 10,000 | 10,000 | 10 |
| Deviation from Mid (D) | 0.01% | 0.01% | 0.01% | 0.01% |
| Lambda (λ) | $\frac{1}{0.3\bar{v}_T}$ | $\frac{1}{0.3\bar{v}_T}$ | $\frac{1}{0.3\bar{v}_T}$ | $\frac{1}{0.3\bar{v}_T}$ |

7 Spot Rate Specifications

The following table summarizes the specifications for the currently supported CF Spot Rates:

| | CF Litecoin Dollar Spot Rate | CF XRP Dollar Spot Rate | CF XRP Bitcoin Spot Rate | CF BitcoinCash Dollar Spot Rate |
|--------------------------------|---|---|--|---|
| Ticker Symbol | IN_LTCUSD | IN_XRPUSD | IN_XRPXBT | IN_BCHUSD |
| Administrator | Crypto Facilities Ltd | | | |
| Calculation Agent | Crypto Facilities Ltd | | | |
| Description | Instantaneous U.S. Dollar price of one Litecoin | Instantaneous U.S. Dollar price of one XRP | Instantaneous Bitcoin price of one XRP | Instantaneous Dollar price of one BitcoinCash |
| Calculation Methodology | Real time aggregation of order book data of Constituent Exchanges | Approximately every second of each day for the entire year including weekends and holidays. | | |
| Dissemination Time | Approximately every second of every day | | | |
| Dissemination Precision | 0.01 U.S. Dollars | 0.00001 U.S. Dollars | 0.00000001 Bitcoin | 0.01 U.S. Dollars |

Contact Information

Crypto Facilities Ltd

| Address | Contact |
|---|--|
| Crypto Facilities Ltd 4 th Floor 25 Copthall Avenue London EC2R 7BP United Kingdom | Web: https://www.cryptofacilities.com/indices Phone: +44 20 7655 6085 Email: contact@cryptofacilities.com |

Notice and Disclaimer

© 2016 - 2018 Crypto Facilities Ltd. All rights reserved. Patent Pending.

No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other non-commercial uses permitted by copyright law. For permission requests, write to the publisher, addressed "Attention: Permissions Coordinator," at the address below.

Crypto Facilities Ltd is authorised and regulated by the Financial Conduct Authority (FRN 757895). Crypto Facilities Ltd is registered in England with registered number 9172128 and registered office at 25 Cophthall Avenue, London EC2R 7BP, United Kingdom.

This document and all of the information contained in it, including without limitation all methods, processes, concepts, text, data, graphs, charts (collectively, the "Information") is the property of Crypto Facilities Ltd or its licensors, direct or indirect suppliers or any third party involved in making or compiling any Information (collectively, with Crypto Facilities Ltd, the "Information Providers") and is provided for informational purposes only. The Information may not be reproduced or disseminated in whole or in part without prior written consent from Crypto Facilities Ltd.

The Information may not be used to create derivative works or to verify or correct other data or information without prior written consent from Crypto Facilities Ltd. For example (but without limitation), the Information may not be used to create indices, databases, risk models, analytics, software, or in connection with the issuing, offering, sponsoring, managing or marketing of any securities, portfolios, financial products or other investment vehicles utilizing or based on, linked to, tracking or otherwise derived from the Information or any other Crypto Facilities Ltd data, information, products or services.

The user of the Information assumes the entire risk of any use it may make or permit to be made of the Information. NONE OF THE INFORMATION PROVIDERS MAKES ANY EXPRESS OR IMPLIED WARRANTIES OR REPRESENTATIONS WITH RESPECT TO THE INFORMATION (OR THE RESULTS TO BE OBTAINED BY THE USE THEREOF), AND TO THE MAXIMUM EXTENT PERMITTED BY APPLICABLE LAW, EACH INFORMATION PROVIDER EXPRESSLY DISCLAIMS ALL IMPLIED WARRANTIES (INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF ORIGINALITY, ACCURACY, TIMELINESS, NON-INFRINGEMENT, COMPLETENESS, MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE) WITH RESPECT TO ANY OF THE INFORMATION.

Without limiting any of the foregoing and to the maximum extent permitted by applicable law, in no event shall any Information Provider have any liability regarding any of the Information for any direct, indirect, special, punitive, consequential (including lost profits) or any other damages even if notified of the possibility of such damages. The foregoing shall not exclude or limit any liability that may not by applicable law be excluded or limited, including without limitation (as applicable), any liability for death or personal injury to the extent that such injury results from the negligence or wilful default of itself, its servants, agents or sub-contractors.

Information containing any historical information, data or analysis should not be taken as an indication or guarantee of any future performance, analysis, forecast or prediction. Past performance does not guarantee future results.

None of the Information constitutes an offer to sell (or a solicitation of an offer to buy), any security, financial product or other investment vehicle or any trading strategy.

None of Crypto Facilities Ltd's products or services recommends, endorses, approves or otherwise expresses any opinion regarding any issuer, securities, financial products or instruments or trading strategies and none of Crypto Facilities Ltd's products or services is intended to constitute investment advice or a recommendation to make (or refrain from making) any kind of investment decision and may not be relied on as such.

The Information has not been submitted to, nor received approval from, the United Kingdom Financial Conduct Authority, the United States Securities and Exchange Commission or any other regulatory body. Any use of or access to products, services or information of Crypto Facilities Ltd requires a license from Crypto Facilities Ltd. Crypto Facilities is a registered trademark of Crypto Facilities Ltd.