



COINMETRICS

**TRUSTED EXCHANGE
FRAMEWORK 2.2**

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INTRODUCTION

Centralized exchanges are a vital part of the crypto ecosystem, serving as the primary interface to the blockchain for a significant percentage of market participants. Yet, exchanges vary widely in quality across several use-cases, whether as custodial platforms, as data sources, or as entities for executing programmatic actions.

The Coin Metrics' Trusted Exchange Framework thus aims to quantitatively assess exchanges to promote transparency, innovation, and trust for the industry and its users. The common usage patterns for an exchange are translated to criteria that define the fundamental properties of exchange trustworthiness: transparency, resilience & security, data quality, regulatory compliance, and API quality. The criteria sources public information about an exchange such as incident history, financial statements, and license disclosure as well as market activity that can be derived from exchange data.

During the course of our research, we conducted a comprehensive literature review to identify prior techniques in evaluating exchanges, including the extensive research in detecting wash trading, fake volume, and fraud. Several of these techniques are included in our framework. We also made use of Coin Metrics' unique experience of maintaining our market data collection system for over 40 exchanges over the past five years, which involves extensive interaction with exchanges' APIs and regular evaluations of data quality issues and interruptions in service. Our framework contributes to the literature by utilizing a primarily quantitative approach in calculating exchange features (keeping subjective determinations to a minimum) and presenting the most complete collection of all facets of exchange trustworthiness to date.

Coin Metrics utilizes the output from our Trusted Exchange Framework to select high-quality constituent exchanges in our prices, indexes, and metrics.

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RELEASE NOTES

2.2 (April 2024)

- **Data Quality:** For Benford's Law, Trade Sizes, and Trade Permutations, we've tightened the requirements to pass and changed how we're weighing volume for computing errors. For price discovery and price anomalies, we allow partial credit for exchanges that fall within the middle-tail of the distribution.
- **Resilience & Security:** Added Bug Bounties
- **Transparency:** Recalibrated our scoring slightly to allow for a higher score if an exchange has multiple methods demonstrating proof of reserve/liability (eg. Public Address balances and 3rd Party Audit). Increased the value of Publicly Disclosed Financials which clearly report digital asset holdings and liabilities to a government regulatory entity.
- **Regulatory:** Added VASP license and FATF graylist flags. Adjusted for how regulatory agency quality is factored based on the World Bank's methodology^[7] for regulatory quality by jurisdiction.
- **API Quality:** Recalibrated how API outages are factored to reduce false positives and follow a more logarithmic scale.

2.1 (October 2023)

In response to feedback to the first iteration of the Trusted Exchange Framework V2, several improvements were made to create a simpler and easier to interpret framework. Below is a quick summary of what's new.

- Numeric scores have been translated into a letter grading scale for convenience. See Grading Scale.
- The Regulatory score was revamped to be significantly more reflective of how crypto exchanges are regulated globally. Exchanges are no longer penalized for not operating under the US if they serve their international customers in a manner that is deemed acceptable to regulators in reputable jurisdictions. The new score is more focused on the regulatory compliance framework rather than general compliance (security standards, which are now moved to Resilience & Security)
- Transparency and Resilience were broken out into their own separate scores to make for more mutually exhaustive groupings.
- Infrastructure now refers to API Quality. New criteria such as rate limit assessments were added.

Conclusion

Although the notion of a "Trusted Exchange" is a bit of a misnomer and highly dependent on the context, the framework serves as a rough approximation of how to holistically evaluate exchanges based on the most important qualities it must have. As noted in the past, we highly encourage users to think closely about what

context they may evaluate exchanges on, and apply that context with the evaluation criteria within the Framework in mind. Treat this framework more like a model; “All models are wrong, but some are useful”.

Please note our [FAQ](#) for common questions regarding our framework.

2.0 (March 2023)

The [original framework](#) was primarily focused on quantifying the amount of fake volume per exchange. New techniques have since been developed that directly measure the footprints of fake volume using a wider variety of market data from the exchange. Additionally, the new framework expands beyond quantifying fake volume and into providing a more holistic assessment of an exchange’s trustworthiness.

OVERALL RANKINGS

EXCHANGE	DATA QUALITY (SPOT)	TRANSPARENCY	RESILIENCE & SECURITY	REGULATORY COMPLIANCE	API QUALITY	GRADE
Coinbase	A	B+	B	A	A-	A
Bitstamp	A	B+	A	A	B-	A
Binance	A	A	C	A	C	A
Crypto.com	A	B-	B+	A	B+	A-
Kraken	A	A-	A-	A	C-	A-
Gate.io	A	B+	B	B	C	B+
Bybit	A	B+	A	A-	D	B+
Gemini	A	C+	B+	A	C	B+
KuCoin	A	A	C+	C-	C	B+
OKX	A	B+	C	A	C-	B+
CME	N/A	A	A-	A	C-	B+
Bitfinex	A	C-	A-	B-	C	B
Bullish	A	D	A	A-	C	B
HTX	B	B+	B-	A-	D	B
LMAX	A	D	C+	A-	C-	B-
Itbit	A	D	A-	A-	D	B-
Deribit	C-	B+	B	A-	B-	B-
Bithumb	N/A	B+	C+	C	B-	C+
Mexc	B-	B+	B	C-	D	C+
BitMEX	N/A	B+	A	C-	D	C+
Upbit	C-	B+	C	A	D	C
Binance US	C	D	C+	C	B+	C
Bitflyer	C	D	C+	A	C-	C
CEX.io	C-	D	C+	A-	C	C-
LBank	C	D	C+	B	D	C-
Bitbank	N/A	D	A-	A	D	C-
HitBTC	C	D	D	D	B-	D
Bibox	D	D	C+	C-	C-	D
Poloniex	D	D	D	D	C-	D

*Exchanges without sufficient data were not penalized for their data quality scores. They are however disqualified for being included in the trusted volume metric.

Grading Scale

We translated the numeric scores into a letter grading scale for convenience. The table below illustrates how to interpret the resulting scores.

GRADE	INTERPRETATION
A- to A	These exchanges excel in most or all of the factors assessed. Exchanges in this tier often have the highest quality data and efficient markets relative to its peers.
B- to B+	These exchanges are generally of good quality across most of the factors assessed. Minor penalties in Data Quality, Regulatory Compliance, Transparency, and/or Resilience & Security keep exchanges in this tier from being in the A tier.
C- to C+	These exchanges are generally middle-of-the-road across most of the factors assessed. Some exchanges in this tier may have organic trading activity, but suffer from incomplete compliance and/or past minor security incident(s), and vice versa.
D	These exchanges score poorly across most of the factors assessed. Exchanges in this tier tend to not be compliant in major jurisdictions, have suffered major security incidents, and/or contain significant amounts of inorganic market activity.

Weights

Each category is scored across numerous subcategories (see next section) and normalized each to a max score of 1. These categories were then computed with a weighted average to create an overall score. The categories are weighted using the following values:

EXCHANGE TYPE	DATA QUALITY (SPOT)	TRANSPARENCY	RESILIENCE & SECURITY	REGULATORY COMPLIANCE	API QUALITY	TOTAL
Spot	30%	15%	15%	30%	10%	100%
Futures-Only*	0%	21.4%	21.4%	42.9%	14.3%	100%

**Futures-Only weights were derived by omitting spot data quality and proportionally distributing weights across the remaining categories. Exchanges with an N/A for Data Quality (Spot) are applied with the Futures-Only weighting.*

Note that the “true” value of the weights are relative to the context of how an exchange is being used. A custody-focused use-case looking to avert risk may downweight Data Quality and API Quality in favor of Transparency, Resilience & Security, and Regulatory Compliance. In contrast, a data-provider that relies on exchange APIs but does not hold assets in custody in exchanges may want to weigh these categories in the opposite direction. We publish the scores for each category so that users with unique use cases can make their own assessment if needed.

Each category is explained in depth in the next section along with a description of each feature used to evaluate exchange trustworthiness.

CATEGORIES

The Trusted Exchange Framework categorizes the major categories of exchange trustworthiness as: Data Quality, Regulatory Compliance, Transparency, Resilience & Security, and Technical Infrastructure / API Quality. These categories are broadly defined below.

Data Quality (Spot)

The Data Quality score assesses the confidence that an exchange's reported data is accurate. Exchanges are the primary source for market data metrics such as price and volume, yet exchange-reported data has historically been fabricated. Crypto exchanges are known to create "fake" or non-economic volume to attract users to its platform.

Estimates vary on how much of the reported volume is fake. Bitwise estimated in 2019 that 95% of volume reported by exchanges are fake by observing anomalous trade patterns.^[2] Forbes estimated in 2022 that about 51% of bitcoin trading volume is fake by weighting likelihood of fake volume given regulatory and web usage patterns.^[3] However, fake volume boiled down to a percent value is misleading because it depends on which exchanges are included in the calculation, the reported volume of each exchange, and the proportionality of volume that is fake. For example, if a well-behaved crypto exchange accurately reports \$100M of volume in one day and an ill-behaved crypto exchange reports \$1.9B of mostly fake volume in one day, then ~95% of the volume between those two exchanges is fake.

Fake volume is not evenly distributed across crypto exchanges. The variance in our data quality test results is strong evidence of this. Thus, we want to only include trustworthy exchanges and exclude exchanges whose volumes are shown to be mostly inorganic when calculating metrics such as total trading volume.

This category utilizes several techniques that have been used to identify fake volume on an exchange: the distribution of leading digits and fitting against Benford's Law, quantifying cross-correlation of volume across markets, examining the distribution of buy/sell flag permutations on trade sequences, examining the distribution of trade sizes, an analysis of lead/lag of asset prices to determine where price discovery occurs, and an analysis of pricing anomalies.

Trusted Volume

A score of **B** or above on the Data Quality category qualifies an exchange to be a part of our “trusted volume” universe, an important designation that is used to select high-quality constituent exchanges for the calculation of Coin Metrics’ prices, indexes, metrics, and other data products. An exchange with this designation is determined to have *most* of its trading volumes to be organic.

Calculation Methodology

Data Sampling

All data was sourced from Coin Metrics Market Data Feed. Due to large amounts of transaction data that can accrue over time, it’s unfeasible to apply all of these techniques across all transactions and markets for a long period of time. These techniques were instead applied on a synthetic 24 hour dataset randomly sampled across the most liquid markets across several time windows bounded by a time period of interest (e.g. Q3 2023-Q1 2024) to minimize sampling bias.

Scoring

Each feature is scored by how well an exchange’s observed market data is distributed relative to a known ideal or expected value or distribution. Using a representative sample of market data for each exchange, a goodness-of-fit score is calculated against the expected distribution for a given feature. These scores are weighted by market volume and averaged to compute a composite score for each feature and exchange. For each feature, statistical tests are applied to rank exchanges relative to its peers. An exchange that deviates too far from the expected behavior for a given feature fails the test and is thus penalized.

Note that this score represents an estimated “confidence level” (not in the traditional statistical sense) of how likely most of an exchange’s volume is representative of organic and informed market activity. An exchange that fails one test signals a moderate amount of confidence about the exchange’s data quality, but does not rule out the possibility that most of the exchange’s volume is organic due to the likelihood of false positives. An exchange that fails multiple tests signals a general lack of confidence in data quality. Similarly, an exchange with a perfect score signals a general confidence for data quality but does not imply that their data is 100% accurate. Thus, the score is not meant to be interpreted as a strict probability or proportion of data that is legitimate.

Subcategories

Leading Digit Distributions (Benford's Law)

An assessment of how well an exchange's trade patterns follow a natural order of leading digits where leading digits tend to be small, also known as Benford's Law. Benford's Law has been used to detect fraud in financial (such as trade amounts in traditional markets) and non-financial applications (such as elections) where the distributions of quantities of leading digits do not follow Benford's Law. If an exchange's trade value patterns violate this pattern, it's an indicator of (but not definitive proof) of manipulated behavior.^[4] See Figure 1.

Volume Correlations

An assessment of how correlated an exchange's volume is relative to its peers. Well-behaved exchanges tend to behave similarly to each other, and on average have a higher correlation of relative changes in volume across time. More precisely, we expect volume to increase and decrease at the same time across exchanges in response to material releases of new information. Inversely, less-behaved exchanges are different in different ways, and thus exhibit lower correlation across the rest of the exchanges. Exchanges that manipulate their reported trading volume via artificial processes such as wash trading exhibit volume profiles that differ from their legitimate peers.^[1]

Trade Permutations

An assessment of the legitimacy of the distribution of trade buy/sell flags of an exchange. Exchanges that have historically fabricated volume are known to show an even distribution of buy/sell flags when examining trade sequences, likely due to wash trading, non-economic trading activity, or other trading activity generated from an artificial process. Legitimate market activity tends to heavily skew towards several consecutive buy or sell trades due to the presence of informed traders that are willing to cross the spread and take liquidity in response to material new information.^[5] See Figure 2.

Trade Sizes

A measure of how trade sizes are distributed on an exchange. Organic trading activity tends to result in a distribution which is linear when the natural log transformation is applied to both trade counts and trade sizes. This can be ascribed to the presence of retail and institutional market participants as well as the effect of liquidity constraints on order sizing. In contrast, inorganic trading activity generated from artificial processes can exhibit a different distribution with large numbers of trades executed with unusual trade sizes. The degree to which the distribution of trade sizes on an exchange follows or deviates from this distribution can be measured using the R^2 fit of a trend line with the distribution in log-log scale. See Figure 3.

Price Discovery

A measure of the lead/lag of asset prices on an exchange relative to a benchmark price. Exchanges that are centers of price discovery tend to lead price movement by an observable amount of time. This is measured using the Hayashi-Yoshida Estimator, allowing for a ranking of exchanges based on their lead/lag dynamics.^[6] Exchanges found to lead other exchanges represent exchanges where price discovery occurs and thus score more favorably for this criteria.

In our implementation, we use a 24-hour sample of trades collected from each considered market and aggregate these trades onto a 10th-second time grid using volume-weighted-average price. The result is a series of prices, at 10th-second granularity, for each considered market. The Hayashi-Yoshida Estimator is calculated using these series and a reference market's time series. The time by which each market leads or lags the reference market is then identified, allowing exchanges to be ranked by their relative role in leading asset prices. See Figure 4.

Pricing Anomalies

Frequency that an anomaly in price among an exchange's most liquid asset pairs is found relative to other exchanges that offer the same asset pairs. An anomaly defined as having a price beyond 2 standard deviations across a common set of markets.

Transparency

The Transparency score is an assessment of the quality of publicly disclosed information from an exchange. This is valued using the following heuristic:

- Quality of Proof-of-Reserves (PoR) is assessed based on Nic Carter’s PoR rubric. ^[1]
- Publicly disclosed financial information is graded relative to the PoR rubric.
- If an exchange has both PoR and publicly disclosed financial information, their Transparency score is the highest of the two.
- Exchanges may be exempt from PoR if it is not relevant to their operations, i.e. if they do not custody crypto and settle their contracts in cash.
- Wallet disclosures, “proof” of assets but no credible proof of liabilities, ownership or oversight give partial credit.

In contrast to the Regulatory Compliance category described in further detail below, the Transparency criteria here focuses on the *self-regulating* processes that an exchange offers. Criteria in this category includes the quality of an exchange’s proof of reserves (where applicable), public disclosure of finances, and the public disclosure of an exchange’s addresses.

Subcategories

Proof of Reserves Quality

This criteria evaluates the quality of an exchange’s proof of reserves attestation. A selection of major exchanges have begun publishing proof of reserves attestations, yet a closer examination of these disclosures reveal that the attestations published are of varying quality. Quality is assessed on the basis of cryptographic verification of just assets or both assets and liabilities, the breadth of assets covered in the proof of reserves attestation, the frequency of the proof, user verification of liabilities, and the presence of a third party audit. These features are individually converted to a binary flag and then summed to create a score between 0 and 6, with 6 indicating a proof of reserves attestation with the strongest assurances. Our methodology is informed by Nic Carter’s prior research on proof of reserves and updated based on ^[1].

Publicly Disclosed Financials

An indicator for whether an exchange has disclosed their finances to the public. Exchanges that do not publish Proof of Reserves can get partial credit for disclosing their assets and liabilities.

Wallet Disclosures

An indicator for whether an exchange has disclosed their wallets or if they can be traced on-chain. This criteria can be thought of as a small fraction of fulfilling a complete Proof of Reserves, as this does not include proof of liabilities, a third party audit, frequent updates, or cryptographic proof of ownership.

Resilience & Security

Resilience & Security refers to how well an exchange protects its users. This criteria assesses exchanges for enacting proactive compliance measures such as complying to security standards (SOC2 Type II or ISO/IEC 27001) and penalizes exchanges for historical major market incidents (extensive pausing of withdrawals due to market conditions) and security incidents (hacks, data breaches). Incidents are weighted by recency and value lost.

Subcategories

SOC 2 Type 2 or ISO/IEC 27001

A binary flag for whether an exchange has demonstrated the ability to meet standardized security compliance procedures, such as SOC 2 or ISO/IEC 27001. Developed by the American Institute of CPAs (AICPA), SOC 2 defines criteria for managing customer data based on five “trust service principles”—security, availability, processing integrity, confidentiality and privacy. ISO/IEC 27001 is an international standard to manage information security.

Offers Insurance

A binary flag for whether an exchange offers cash or crypto insurance on customer deposits.

Offers a Bug Bounty

A binary flag for whether an exchange offers a reward for uncovering security vulnerabilities.

Security Incident History

A score for whether an exchange has suffered a major security incident, defined as a breach in the exchange that leads to the exposure of private consumer data or loss of customer funds. Major security incidents were identified by searching major news publications focused on coverage of cryptocurrencies. A score is calculated that is a function of the recency of the incident and the amount of lost value in U.S. dollars, where exchanges that have experienced a more severe loss of funds are penalized more but where any penalty decays gradually over time.

Market Incident History

A binary flag for “market incidents”, defined as whether an exchange has paused withdrawals for reasons beyond regular site maintenance or known exogenous events (such as the Ethereum Merge). An exchange can pause withdrawals due to a loss in banking relationships or in response to a serious security incident that compromises the security of their wallets.

Regulatory Compliance

The Regulatory Compliance score is an assessment on an exchange's ability to meet regulatory requirements via its existing licenses. This score focuses on whether an exchange is regulated in the jurisdiction where they do business and the *relative quality of its jurisdiction's regulators*, which accounts for the country of domicile/headquarters, registration with a regulatory body or bodies, and any additional voluntary compliance procedures.

Subcategories

Relative Quality of Regulatory Environment Agency

A score for the relative quality of the regulatory environment that an exchange is registered in. If an exchange is not registered to a regulatory agency in its jurisdiction, it receives a partial score based on the regulatory quality of the country where the exchange is domiciled in. Regulatory quality is assessed using the World Bank's methodology^[7] which captures the perception of a government's ability to implement sound regulations.

Virtual Asset Service Provider (VASP) License

A binary flag for whether an exchange has a VASP license.

On Financial Action Task Force (FATF) Graylist

A binary flag for whether an exchange's headquarters is in the FATF graylist. If true, a small penalty is received.

KYC/AML

A binary flag for whether an exchange enforces Know-Your-Customer/Anti-Money-Laundering (KYC/AML) policies in order to use the exchange. An exchange is determined to enforce KYC/AML policies if enforcement is applied upon user account creation. If an exchange allows users limited abilities to deposit, withdraw, or engage in trading before verifying the user's identity, the binary flag is set to 0.

Offers Fiat Currencies

A binary flag for whether an exchange offers fiat currencies specifically for developed markets.

API Quality (Formerly Infrastructure)

The API Quality score is an assessment of an exchange's quality to be used as a programmable entity. The quality of technical infrastructure informs the ease-of-use of being able to execute actions programmatically, such as for reading data or executing trades, using an exchange's API. Quality is assessed based on quantitative and qualitative factors that the Coin Metrics team has identified from building data feeds from each exchange on this list.

Criteria in this category include the availability of an exchange's historical data and whether the exchange offers features that are critical for users who wish to collect market data or trade programmatically: a streaming API interface, a FIX API interface, a status page, trade buy/sell indicators, unique trade identifier, trade execution time, and sequential integer trade IDs. The selection of these features are informed by Coin Metrics' experience in developing and maintaining our market data collection system.

Subcategories

Historical Data

A binary flag for indicating whether an exchange allows users to query historical trades data. Exchanges differ in the amount of historical trades that are served via their API. Some exchanges only allow a user to query a fixed amount of trades, such as the past 1,000 trades that occurred on a market, or a fixed time window, such as the previous 24 hours of trades. The most transparent exchanges offer the full history of trades starting from the inception of the exchange. Exchanges that limit the ability to query historical data receive a 0 while exchanges that offer full history receive a 1.

FIX API

A binary flag indicating whether an exchange offers a FIX API interface.

Status Page

A binary flag indicating whether an exchange has a status page.

Buy/Sell Indicator

A binary flag indicating whether an exchange serves trades data with a buy/sell flag.

Unique Trade Identifier

A binary flag indicating whether an exchange's API provides a unique trade identifier.

Sequential Integer Trade ID

A binary flag indicating whether an exchange's API returns a trade ID that is ordered sequentially by time. Exchanges that offer a sequential integer trade ID allow for market participants to independently verify that they have the complete set of trades from an exchange by looking for any gaps in trade IDs.

Rate Limiting

An indicator for how well an exchange API's rate limits are commensurate to actual usage. Penalties are incurred if an exchange has no rate limits or if an exchange's rate limits are overly prohibitive. The proportion between the exchange API's rate limits and actual usage is based on empirical observations from extracting real-time data.

Outages

A metric for the duration of API outages that the exchange has experienced. Exchanges are penalized based on how long outages occur.

CHANGELOG

DATE	NOTES
April 30, 2024	Trusted Exchange Framework V2.2 released.
March 6, 2024	Added a new rule to remove a failed exchanges ahead of an the next official TEF release 3 months after trading ceases
October 31, 2023	Trusted Exchange Framework V2.1 released. Revamped Transparency, Resilience & Security, Regulatory scores; add grading scale, add rate limiting score
March 1, 2023	Trusted Exchange Framework V2.0 released

APPENDIX

Figure 1. Benford's Law Fits by Exchange

Organic market activity tends to follow specific properties from Benford's Law – leading digits tend to be low and most frequent, and the frequencies decrease as the leading digit increases. Markets that deviate from this behavior fail this test. The figures below illustrate the difference between a well-behaved market (binance-btc-usdt-spot) and a market that would violate this law (bibox-btc-usdt-spot). The x-axis represents the leading digits while the y-axis represents the frequency of the leading digits.

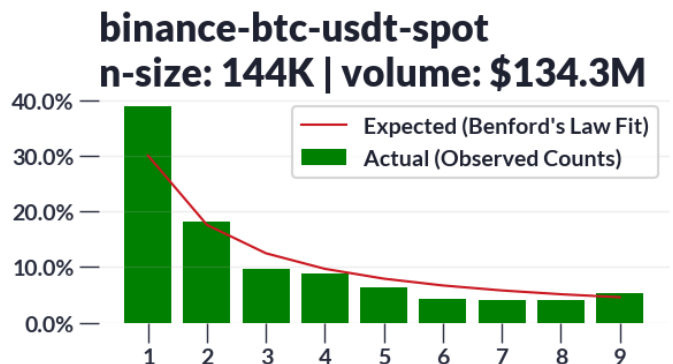
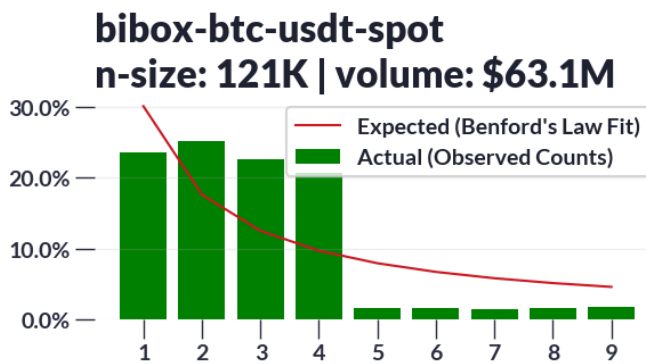


Figure 2. Trade Permutations by market-pair by exchange

The majority of well-behaved crypto markets follow trade permutation patterns with several consecutive buy or sell orders. Conversely, markets that often exhibit heavy wash trading will have a uniform distribution for their trade permutations. Below we illustrate the difference between a well-behaved market (coinbase-btc-usdt) and a market which has trade permutation patterns that are usually indicative of heavy wash trading (mexc-btc-usdc).

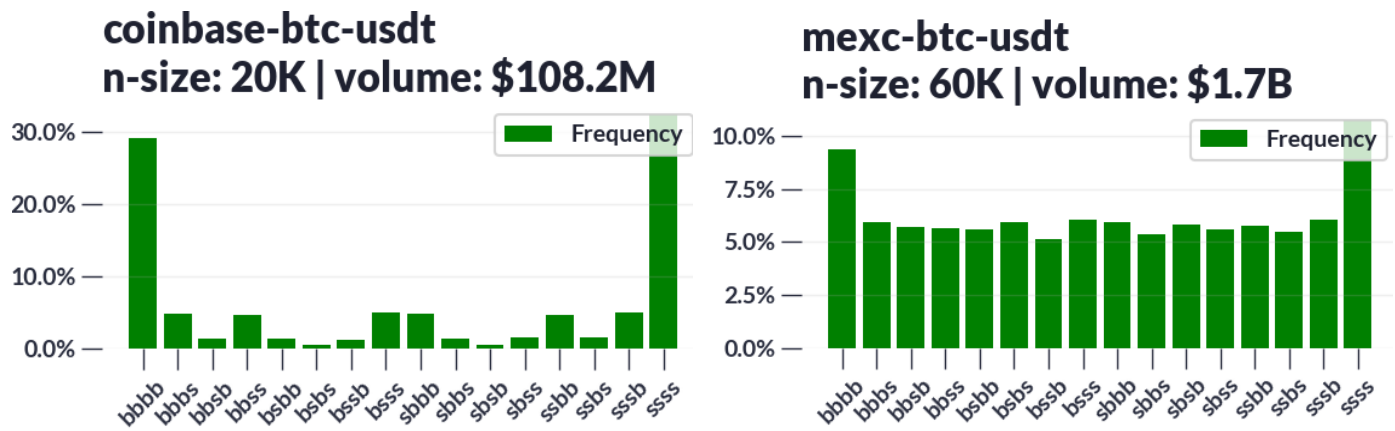


Figure 3. Trade Size Distributions

Organic trading activity tends to cause trade sizes to follow a linear distribution on doubly-logarithmic scale. Markets with significant levels of inorganic or spurious trades deviate from this distribution significantly, as can be measured by the R^2 fit of a trend line in this scale. For illustrative purposes, we plotted the raw trade size histogram between a well-behaved market (coinbase-btc-usd) and a market that does not fit this distribution (cex.io-btc-usd).

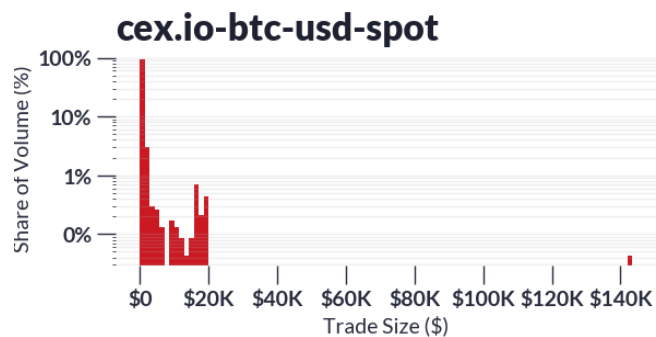
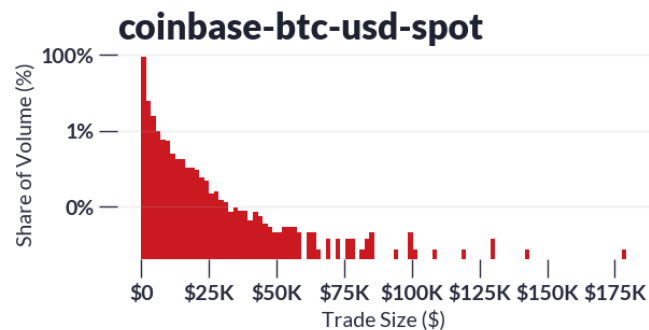
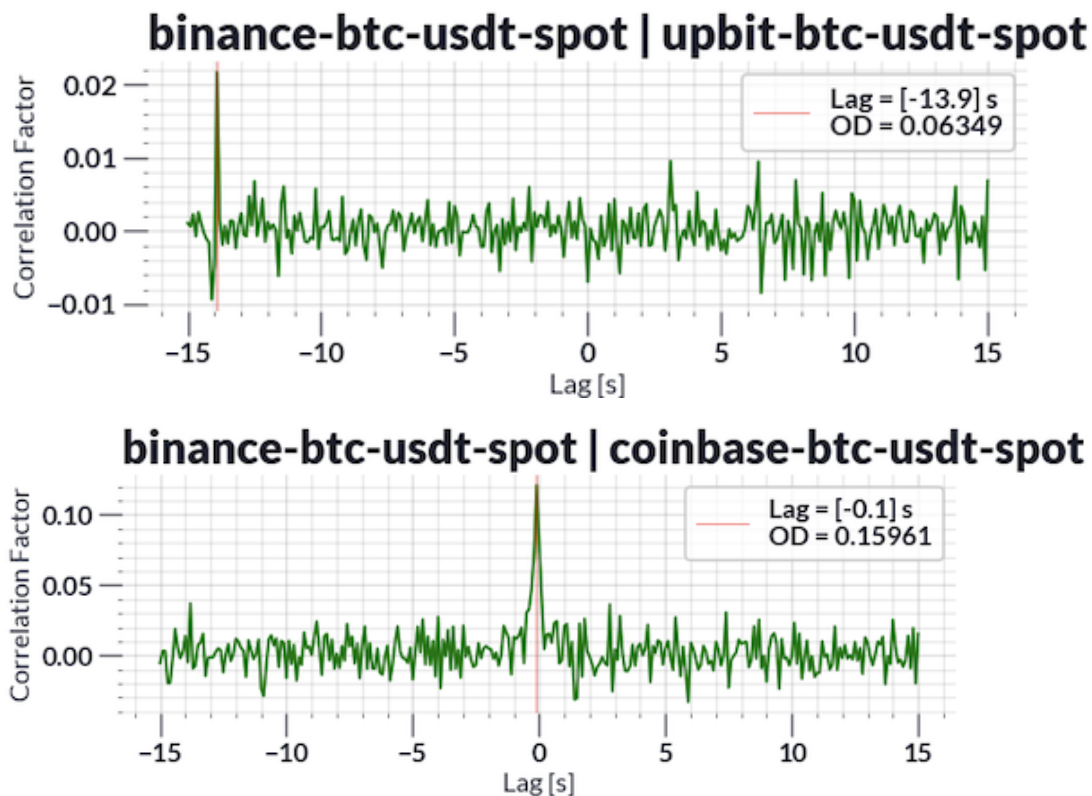


Figure 4. Price Discovery

Lag curves are a crucial component of the Hayashi-Yoshida methodology used to quantify Price Discovery. In this method, returns of an asset on one market are shifted forwards and backwards in time relative to the returns of the same asset on a reference market. Estimating the correlation between these returns, as a function of time displacement, allows for analysts to observe how much a given market should be lagged for its prices to most strongly correlate with the adjacent reference market.

Consider the lag curves for the example BTC-USDT markets below, taking Binance as a reference exchange. Prices between Coinbase and Binance correlate at -0.1s, meaning that the two markets are in sync within 0.1s. This is not so for Upbit, where the maximum correlation occurs at -13.9s. This means that Upbit's BTC-USDT market lags Binance by -13.9s. By measuring these lag times for multiple base assets, the aggregate lead/lag dynamics between exchanges can be quantified.

Hayashi-Yoshida Lag Curves for Example Markets



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