COINMETRICS

TRUSTED EXCHANGE FRAMEWORK 2.0

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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 and resilience, data quality, compliance, and tech infrastructure. 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 evaluation 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.

WHAT'S NEW IN V2

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.

Scores

The overall rankings are shown below

EXCHANGE	DATA QUALITY	TRANSPARENCY & RESILIENCE	SECURITY AND REGULATORY COMPLIANCE	INFRASTRUCTURE	OVERALL SCORE
coinbase	1.00	0.80	1.00	1.00	0.94
binance.us	1.00	0.60	0.83	0.86	0.82
kraken	1.00	1.00	0.50	0.57	0.80
gemini	1.00	0.40	1.00	0.71	0.79
bitstamp	1.00	0.60	0.67	0.71	0.75
bitmex	n/a	0.80	0.67	0.71	0.73
bitfinex	1.00	0.60	0.50	0.71	0.70
binance	1.00	0.40	0.67	0.71	0.69
lmax	1.00	0.60	0.50	0.57	0.68
cex.io	0.50	0.60	0.67	1.00	0.65
bittrex	0.83	0.60	0.67	0.57	0.68
crypto.com	0.83	0.40	0.83	0.57	0.67

OKX	1.00	0.60	0.33	0.57	0.63
gate.io	0.83	0.80	0.33	0.43	0.62
kucoin	1.00	0.60	0.33	0.43	0.61
huobi	1.00	0.60	0.17	0.71	0.61
bitthumb	n/a	0.80	0.50	0.43	0.61
itbit	0.33	0.60	0.83	0.57	0.59
bybit	1.00	0.60	0.33	0.29	0.59
cme	n/a	0.60	0.50	0.71	0.58
bibox	0.67	0.60	0.33	0.57	0.54
bitflyer	0.50	0.60	0.50	0.57	0.54
deribit	n/a	0.60	0.33	0.86	0.54
hitbtc	0.67	0.60	0.17	0.86	0.53
therocktrading	0.33	0.60	0.50	0.57	0.49
poloniex	0.67	0.60	0.17	0.71	0.51
bitbank	n/a	0.60	0.33	0.43	0.46
upbit	0.33	0.60	0.33	0.43	0.42
mexc	0.33	0.60	0.33	0.29	0.40
lbank	0.67	0.60	0.00	0.43	0.42
localbitcoins	0.00	0.60	0.17	0.29	0.36
zb.com	0.50	0.20	0.17	0.43	0.31

**Exchanges without sufficient spot market data were rated n/a for data quality and were not penalized for their data quality scores. They are however disqualified for being included in the trusted volume metric.*

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:

CATEGORY	WEIGHT
Transparency and Resilience	0.29
Security and Regulatory Compliance	0.29
Data Quality	0.29
Technical Infrastructure	0.13

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 Technical Infrastructure in favor of Transparency and Resilience and 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: Transparency and Resilience, Security and Regulation, Data Quality, and Technical Infrastructure. These categories are broadly defined below.

Transparency and Resilience

The Transparency and Resilience score is an assessment on an exchange's historical and inferred ability to prove it can meet customer obligations. Transparency is defined as the ability for the community to validate and audit an exchange using public information. Although a true real-time assessment of an exchange's solvency is not completely provable with current methods, we can approximate solvency by using evidence that is known to signal solvency.

In contrast to the Security and Regulatory category described in further detail below, the Transparency and Resilience 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, historical hacks and security incidence (weighted by recency and value lost), incidents of paused withdrawals, exchange age, and the public disclosure of an exchange's addresses.

Subcategories

Proof of Reserves Quality

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. This criteria evaluates the quality of an exchange's proof of reserves attestation. 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.[1]

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.

Paused Withdrawals

A binary flag for 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.

Exchange Age

A score based on the relative age of an exchange with its peers. Older exchanges are awarded a higher score.

Security and Regulatory

The Security and Regulatory score is an assessment on an exchange's ability to meet regulatory and security obligations via its existing licenses. In contrast to the *Transparency and Resilience* category, criteria here focuses on trust-based, third party regulatory processes that an exchange has undergone, often via licensure. Criteria in this category includes System and Organization Controls (SOC) compliance, its strictness in enforcing Know Your Customer (KYC) and anti-money laundering (AML) regulations, the existence of an insurance fund, license to operate in the US, and whether the exchange offers trading in fiat currencies.

Subcategories

Security Certifications - SOC 1 & 2

A binary flag for whether an exchange is SOC compliant. The SOC certification consists of a suite of reports assessing an organization's internal controls produced during an audit by an independent third party. The SOC 1 report evaluates internal control over financial reporting. The SOC 2 report evaluates controls on five trust service principles: security, availability, confidentiality, processing integrity, and privacy. Each certification is counted separately.

Financial Regulations - KYC/AML

A binary flag for whether an exchange enforces 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.

Financial Regulations - Offers Insurance

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

Licensed to Operate in the US

A binary flag for whether an exchange is permitted to be used in the United States, defined by whitelisting IP addresses originating from the US.

Offers Fiat Currencies

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

Data Quality

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]

This category utilizes several techniques that have been used to suss out fake volume: 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 0.8 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.

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. Q4 2022) 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.

All exchange features are normalized and weighted to sum to a total score out of 1 for interpretability. Note that this score represents an estimated "confidence level" (not in the traditional statistical sense) of how likely an exchange's volume is representative of organic and informed market activity. 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 in log-log scale, a behavior observed on many exchanges. 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 4.

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 5.

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.

Technical Infrastructure

The Technical Infrastructure 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 quantitative 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.

Streaming API

A binary flag indicating whether an exchange offers a streaming API interface, such as an API that utilizes the websocket protocol.

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.

Trade Execution Time

A binary flag indicating whether an exchange's API provides a trade execution time.

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.

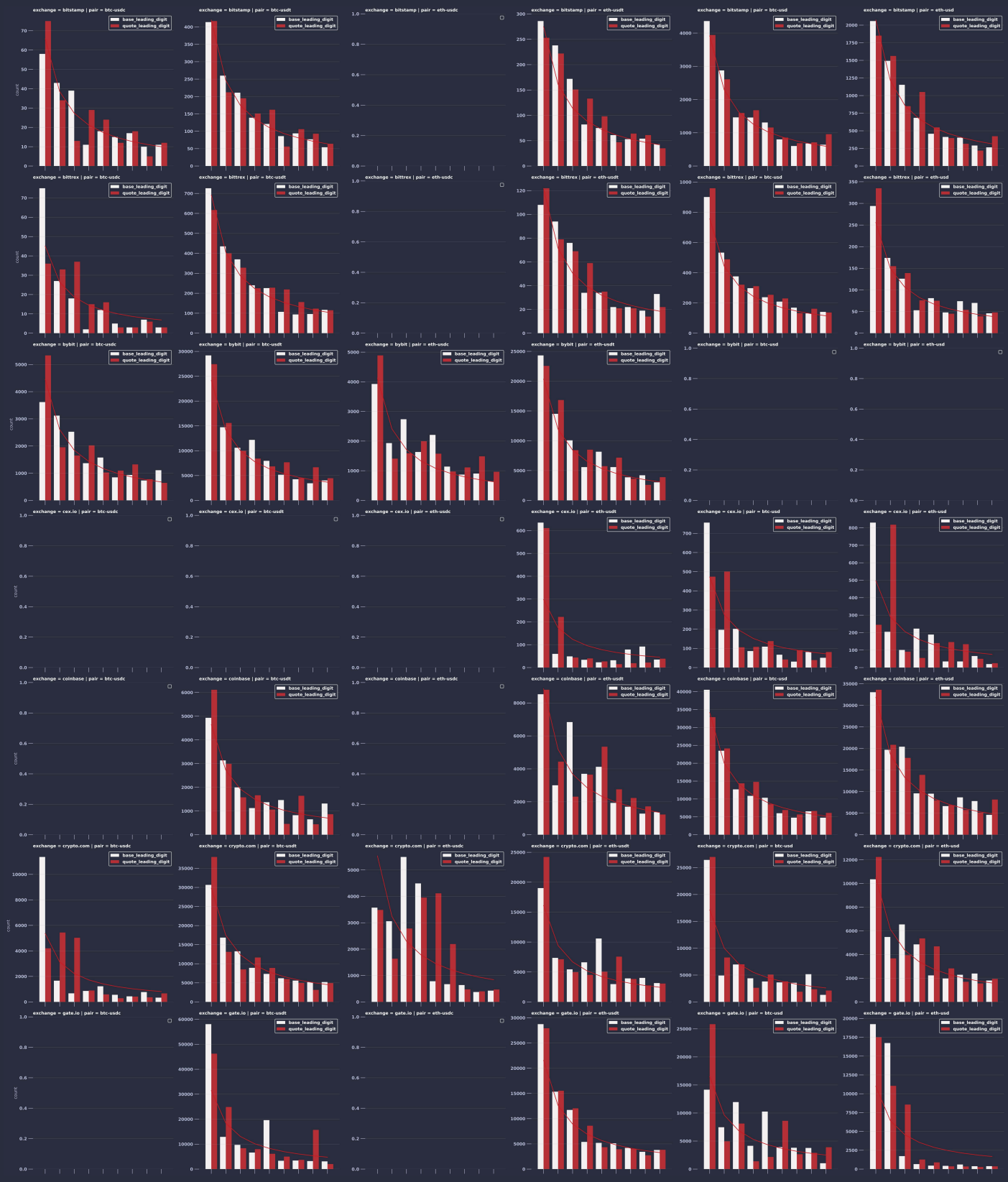
CHANGELOG

DATE	NOTES
March 1, 2023	Trusted Exchange 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. Examples that would fail this test include Crypto.com's ETH-USDT market and Lbank's BTC-USDT market.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quote_leading_digit
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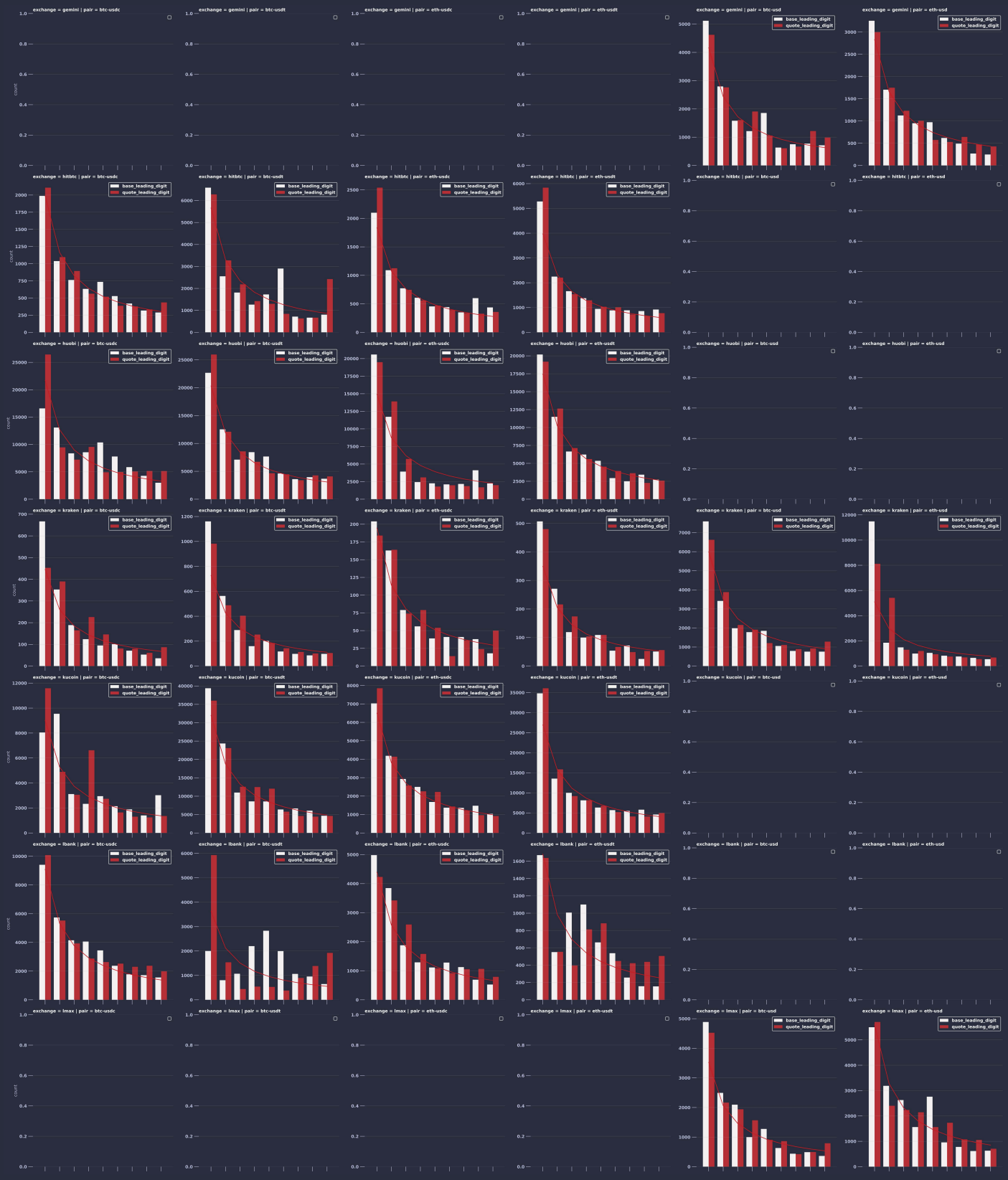
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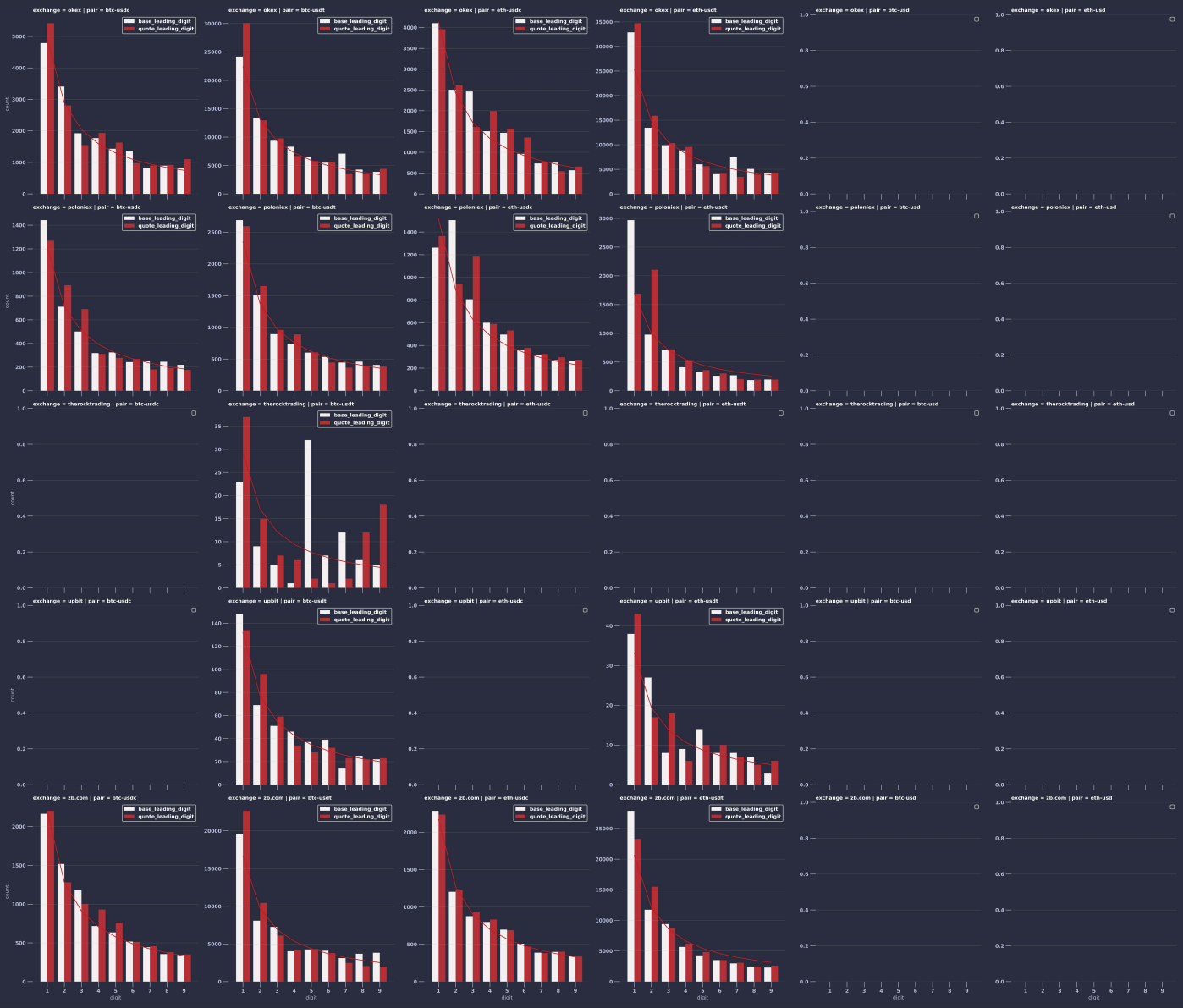
quote_leading_digit
count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exchange = zb.com | pair = eth-usdc
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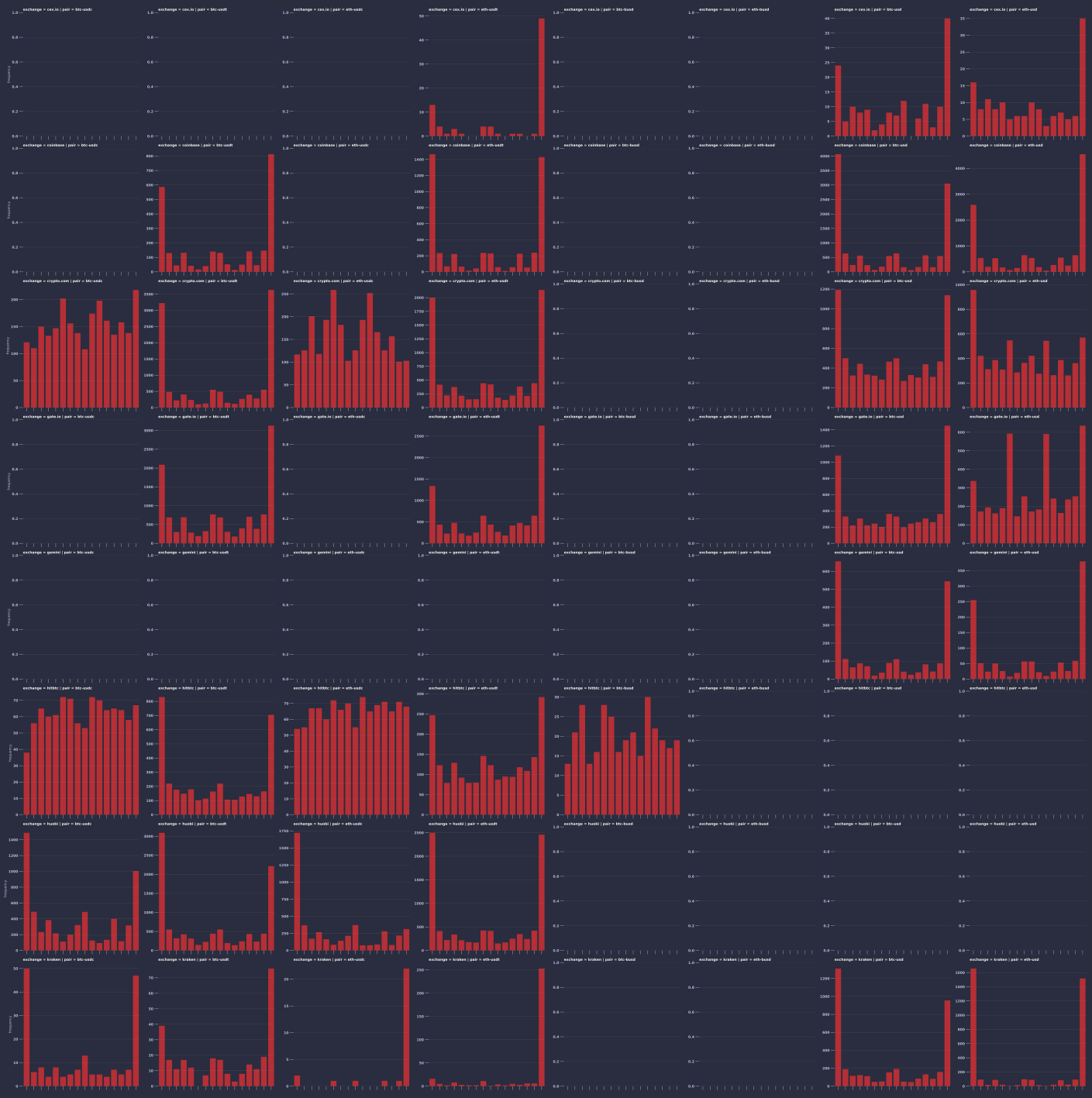
exchange = zb.com | pair = btc-usd
exchange = zb.com | pair = eth-usd
base_leading_digit
quote_leading_digit
count
digit

Figure 2. Trade Permutations by market-pair by exchange

Organic market activity tends to cluster consecutive buys or sells together. Conversely, trade permutations that resemble a random distribution are indicative of uninformed market participants and non-economic activity.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exchange = lnxx | pair = btc-usd
exchange = lnxx | pair = eth-usd
exchange = okex | pair = btc-usdc
exchange = okex | pair = btc-usdt
exchange = okex | pair = eth-usdc
exchange = okex | pair = eth-usdt
exchange = okex | pair = btc-busd
exchange = okex | pair = eth-busd
exchange = okex | pair = btc-usd
exchange = okex | pair = eth-usd
exchange = poloniex | pair = btc-usdc
exchange = poloniex | pair = btc-usdt
exchange = poloniex | pair = eth-usdc
exchange = poloniex | pair = eth-usdt
exchange = poloniex | pair = btc-busd
exchange = poloniex | pair = eth-busd
exchange = poloniex | pair = btc-usd
exchange = poloniex | pair = eth-usd
exchange = therocktrading | pair = btc-usdc
exchange = therocktrading | pair = btc-usdt
exchange = therocktrading | pair = eth-usdc
exchange = therocktrading | pair = eth-usdt
exchange = therocktrading | pair = btc-busd
exchange = therocktrading | pair = eth-busd
exchange = therocktrading | pair = btc-usd
exchange = therocktrading | pair = eth-usd
exchange = upbit | pair = btc-usdc
exchange = upbit | pair = btc-usdt
exchange = upbit | pair = eth-usdc
exchange = upbit | pair = eth-usdt
exchange = upbit | pair = btc-busd
exchange = upbit | pair = eth-busd
exchange = upbit | pair = btc-usd
exchange = upbit | pair = eth-usd
exchange = zb.com | pair = btc-usdc
exchange = zb.com | pair = btc-usdt
exchange = zb.com | pair = eth-usdc
exchange = zb.com | pair = eth-usdt
exchange = zb.com | pair = btc-busd
exchange = zb.com | pair = eth-busd
exchange = zb.com | pair = btc-usd
exchange = zb.com | pair = eth-usd
frequency
pattern

Figure 3. Trade Data Checks

Quantifying the goodness-of-fit between the trades data and the expected Benford's Law distribution and trade permutations, higher quality exchanges tend to score well on Benford's Law and deviate far from an even distribution of trade permutations. The chart below shows that generally, higher quality exchanges tend to cluster in the lower right quadrant, while lesser quality exchanges deviate from that cluster.

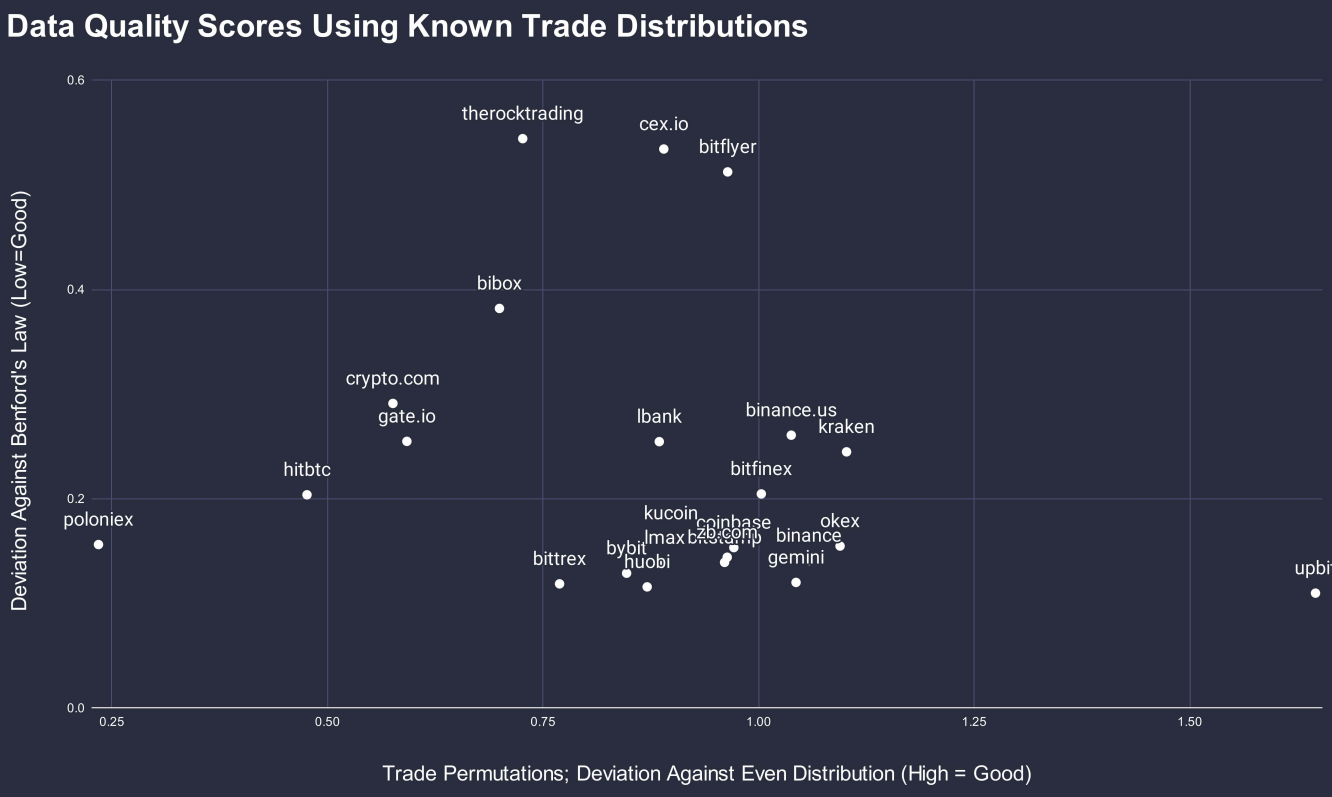
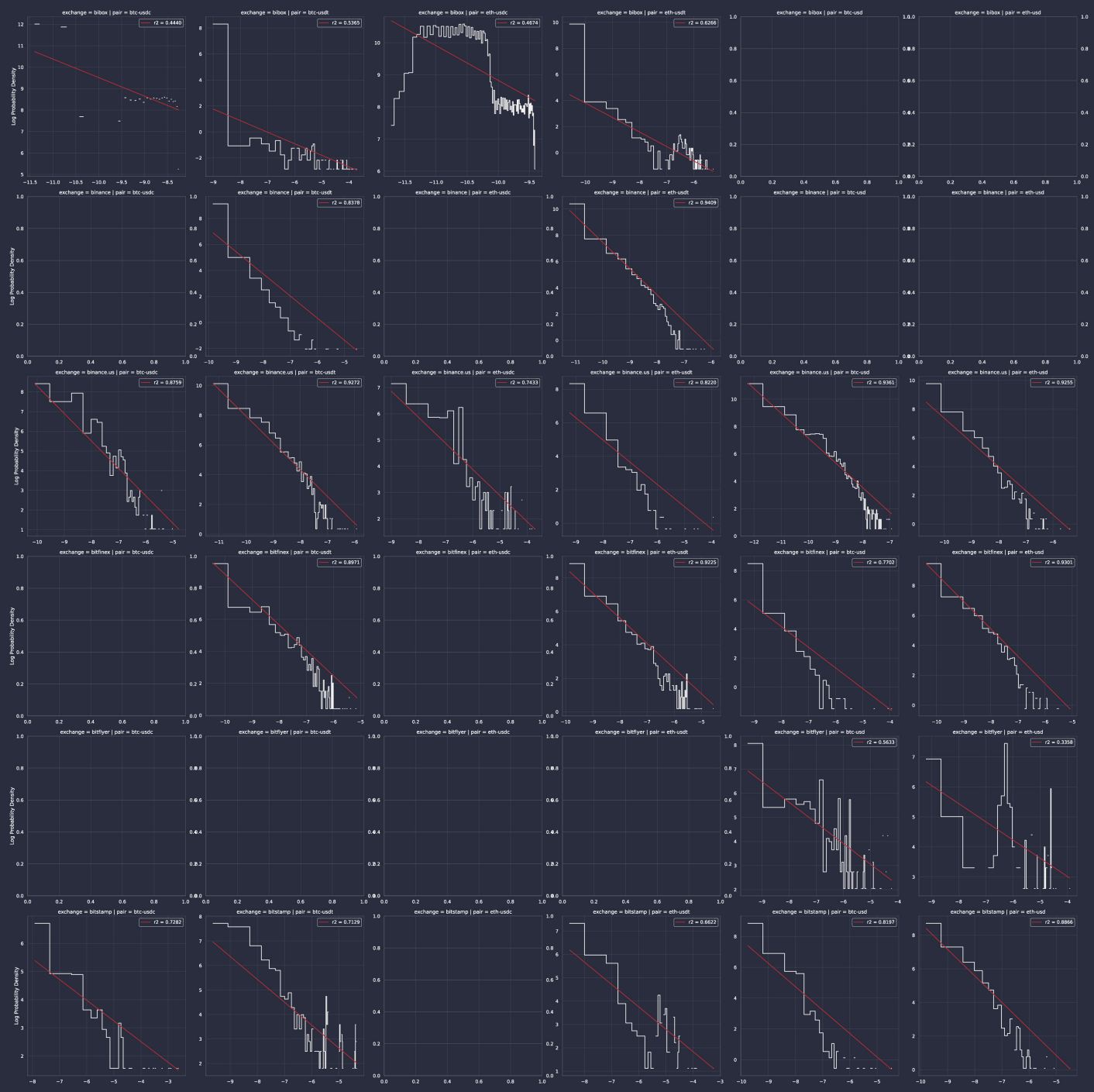
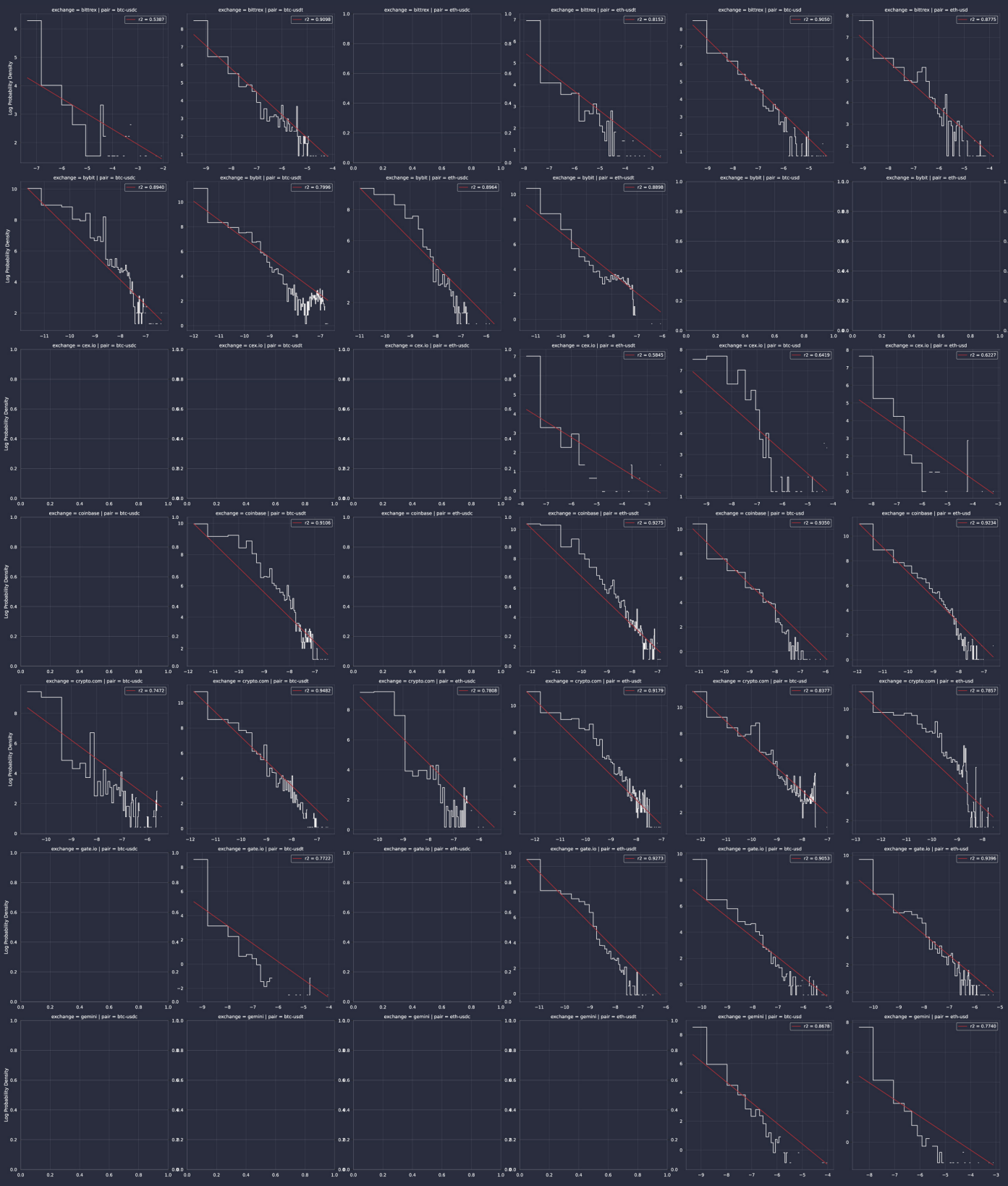
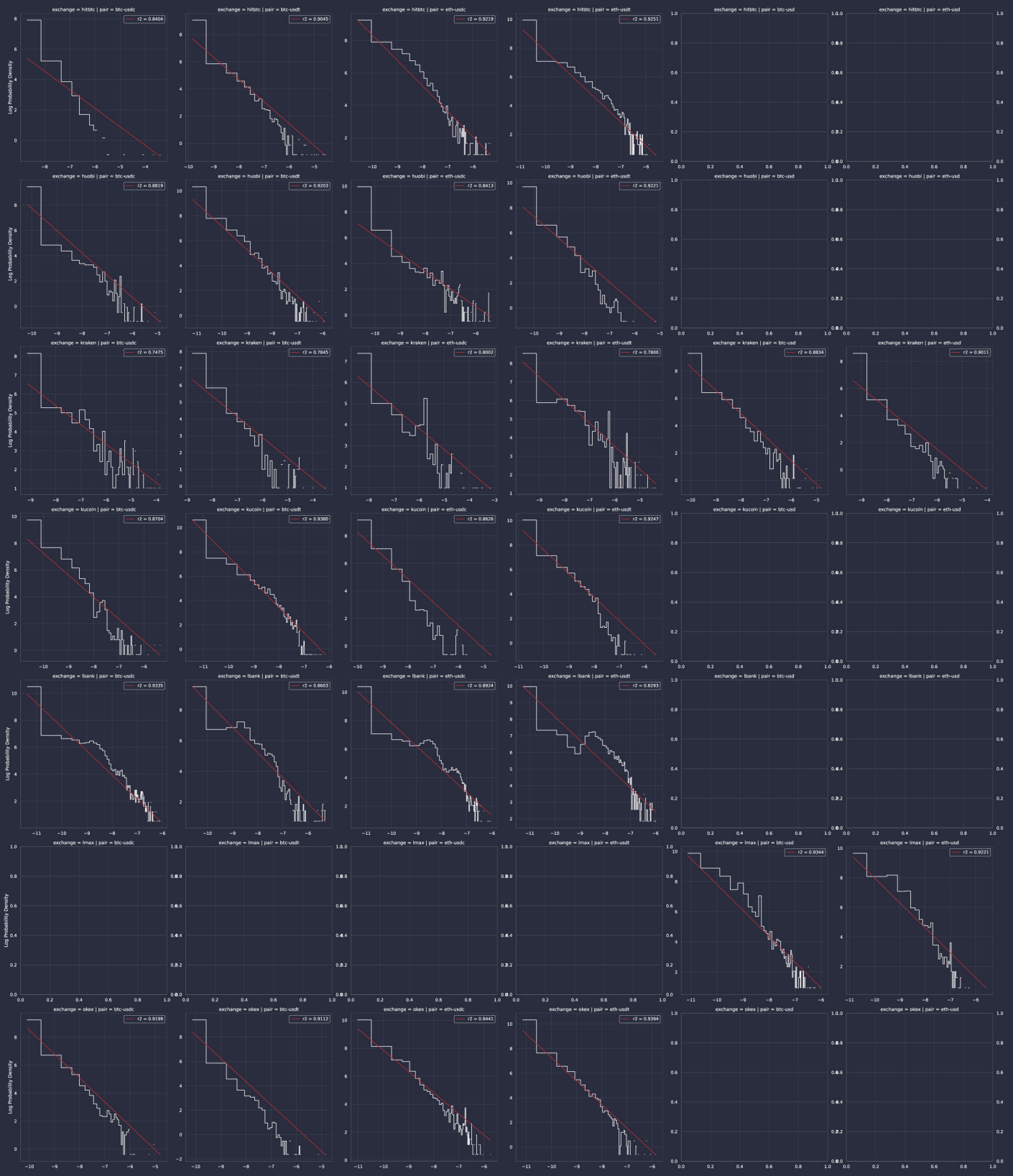


Figure 4. Trade Size Distributions

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.




exchange = bittrex | pair = btc-usdc
r2 = 0.5387
exchange = bittrex | pair = btc-usdt
r2 = 0.9098
exchange = bittrex | pair = eth-usdc
exchange = bittrex | pair = eth-usdt
r2 = 0.8152
exchange = bittrex | pair = btc-usd
r2 = 0.9050
exchange = bittrex | pair = eth-usd
r2 = 0.8775
exchange = bybit | pair = btc-usdc
r2 = 0.8940
exchange = bybit | pair = btc-usdt
r2 = 0.7996
exchange = bybit | pair = eth-usdc
r2 = 0.8964
exchange = bybit | pair = eth-usdt
r2 = 0.8898
exchange = bybit | pair = btc-usd
exchange = bybit | pair = eth-usd
exchange = cex.io | pair = btc-usdc
exchange = cex.io | pair = btc-usdt
exchange = cex.io | pair = eth-usdc
exchange = cex.io | pair = eth-usdt
r2 = 0.5845
exchange = cex.io | pair = btc-usd
r2 = 0.6419
exchange = cex.io | pair = eth-usd
r2 = 0.6227
exchange = coinbase | pair = btc-usdc
exchange = coinbase | pair = btc-usdt
r2 = 0.9106
exchange = coinbase | pair = eth-usdc
exchange = coinbase | pair = eth-usdt
r2 = 0.9275
exchange = coinbase | pair = btc-usd
r2 = 0.9350
exchange = coinbase | pair = eth-usd
r2 = 0.9234
exchange = crypto.com | pair = btc-usdc
r2 = 0.7472
exchange = crypto.com | pair = btc-usdt
r2 = 0.9482
exchange = crypto.com | pair = eth-usdc
r2 = 0.7808
exchange = crypto.com | pair = eth-usdt
r2 = 0.9179
exchange = crypto.com | pair = btc-usd
r2 = 0.8377
exchange = crypto.com | pair = eth-usd
r2 = 0.7857
exchange = gate.io | pair = btc-usdc
exchange = gate.io | pair = btc-usdt
r2 = 0.7722
exchange = gate.io | pair = eth-usdc
exchange = gate.io | pair = eth-usdt
r2 = 0.9273
exchange = gate.io | pair = btc-usd
r2 = 0.9053
exchange = gate.io | pair = eth-usd
r2 = 0.9396
exchange = gemini | pair = btc-usdc
exchange = gemini | pair = btc-usdt
exchange = gemini | pair = eth-usdc
exchange = gemini | pair = eth-usdt
exchange = gemini | pair = btc-usd
r2 = 0.8678
exchange = gemini | pair = eth-usd
r2 = 0.7740
Log Probability Density


exchange = hitbtc | pair = btc-usdc
r2 = 0.8404
exchange = hitbtc | pair = btc-usdt
r2 = 0.9045
exchange = hitbtc | pair = eth-usdc
r2 = 0.9219
exchange = hitbtc | pair = eth-usdt
r2 = 0.9251
exchange = hitbtc | pair = btc-usd
exchange = hitbtc | pair = eth-usd
exchange = huobi | pair = btc-usdc
r2 = 0.8819
exchange = huobi | pair = btc-usdt
r2 = 0.9203
exchange = huobi | pair = eth-usdc
r2 = 0.8413
exchange = huobi | pair = eth-usdt
r2 = 0.9221
exchange = huobi | pair = btc-usd
exchange = huobi | pair = eth-usd
exchange = kraken | pair = btc-usdc
r2 = 0.7475
exchange = kraken | pair = btc-usdt
r2 = 0.7845
exchange = kraken | pair = eth-usdc
r2 = 0.8002
exchange = kraken | pair = eth-usdt
r2 = 0.7800
exchange = kraken | pair = btc-usd
r2 = 0.8834
exchange = kraken | pair = eth-usd
r2 = 0.9011
exchange = kucoin | pair = btc-usdc
r2 = 0.8704
exchange = kucoin | pair = btc-usdt
r2 = 0.9380
exchange = kucoin | pair = eth-usdc
r2 = 0.8626
exchange = kucoin | pair = eth-usdt
r2 = 0.9247
exchange = kucoin | pair = btc-usd
exchange = kucoin | pair = eth-usd
exchange = lbank | pair = btc-usdc
r2 = 0.9335
exchange = lbank | pair = btc-usdt
r2 = 0.8603
exchange = lbank | pair = eth-usdc
r2 = 0.8924
exchange = lbank | pair = eth-usdt
r2 = 0.8293
exchange = lbank | pair = btc-usd
exchange = lbank | pair = eth-usd
exchange = lmax | pair = btc-usdc
exchange = lmax | pair = btc-usdt
exchange = lmax | pair = eth-usdc
exchange = lmax | pair = eth-usdt
exchange = lmax | pair = btc-usd
r2 = 0.9344
exchange = lmax | pair = eth-usd
r2 = 0.9221
exchange = okex | pair = btc-usdc
r2 = 0.9199
exchange = okex | pair = btc-usdt
r2 = 0.9112
exchange = okex | pair = eth-usdc
r2 = 0.9441
exchange = okex | pair = eth-usdt
r2 = 0.9394
exchange = okex | pair = btc-usd
exchange = okex | pair = eth-usd
Log Probability Density

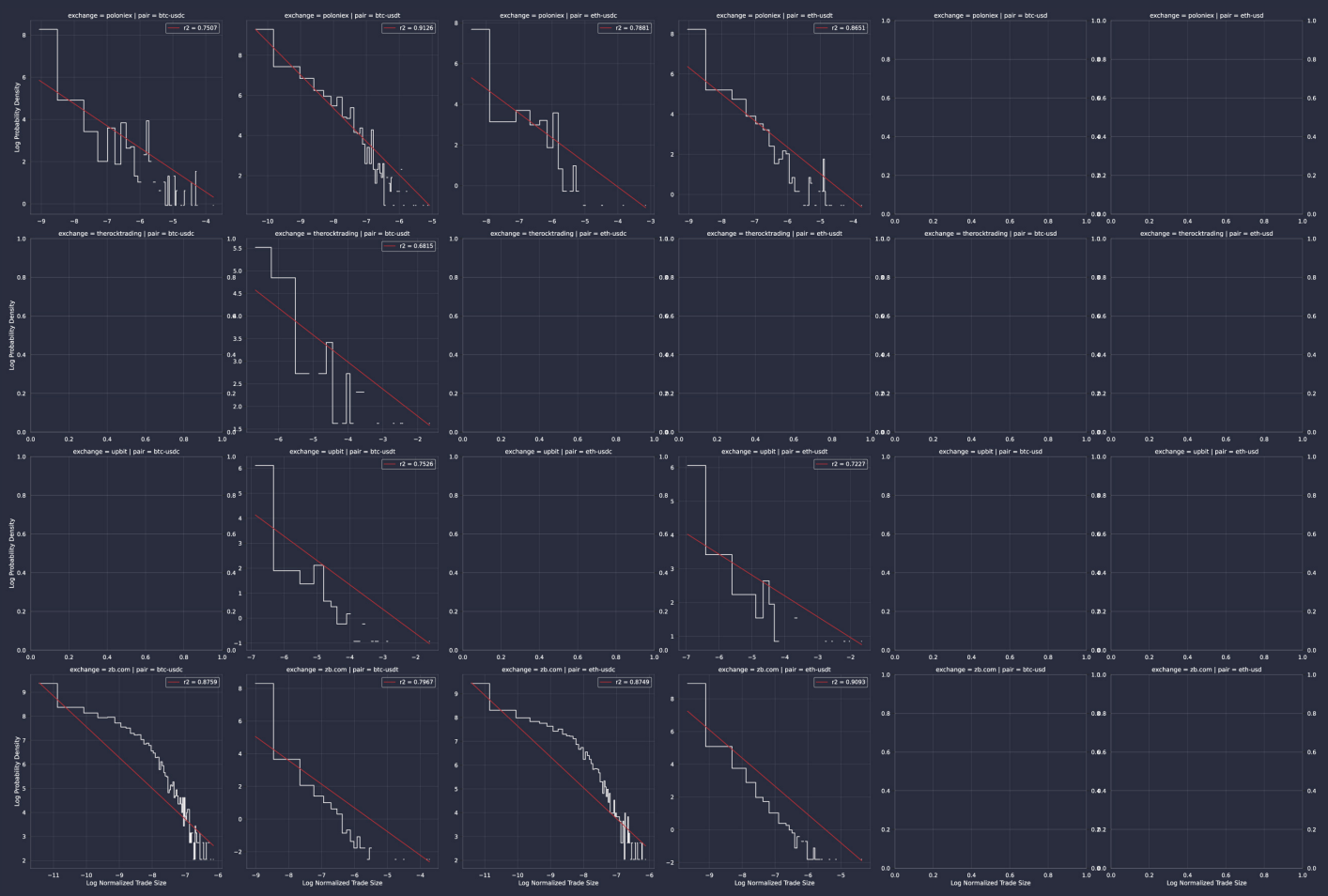


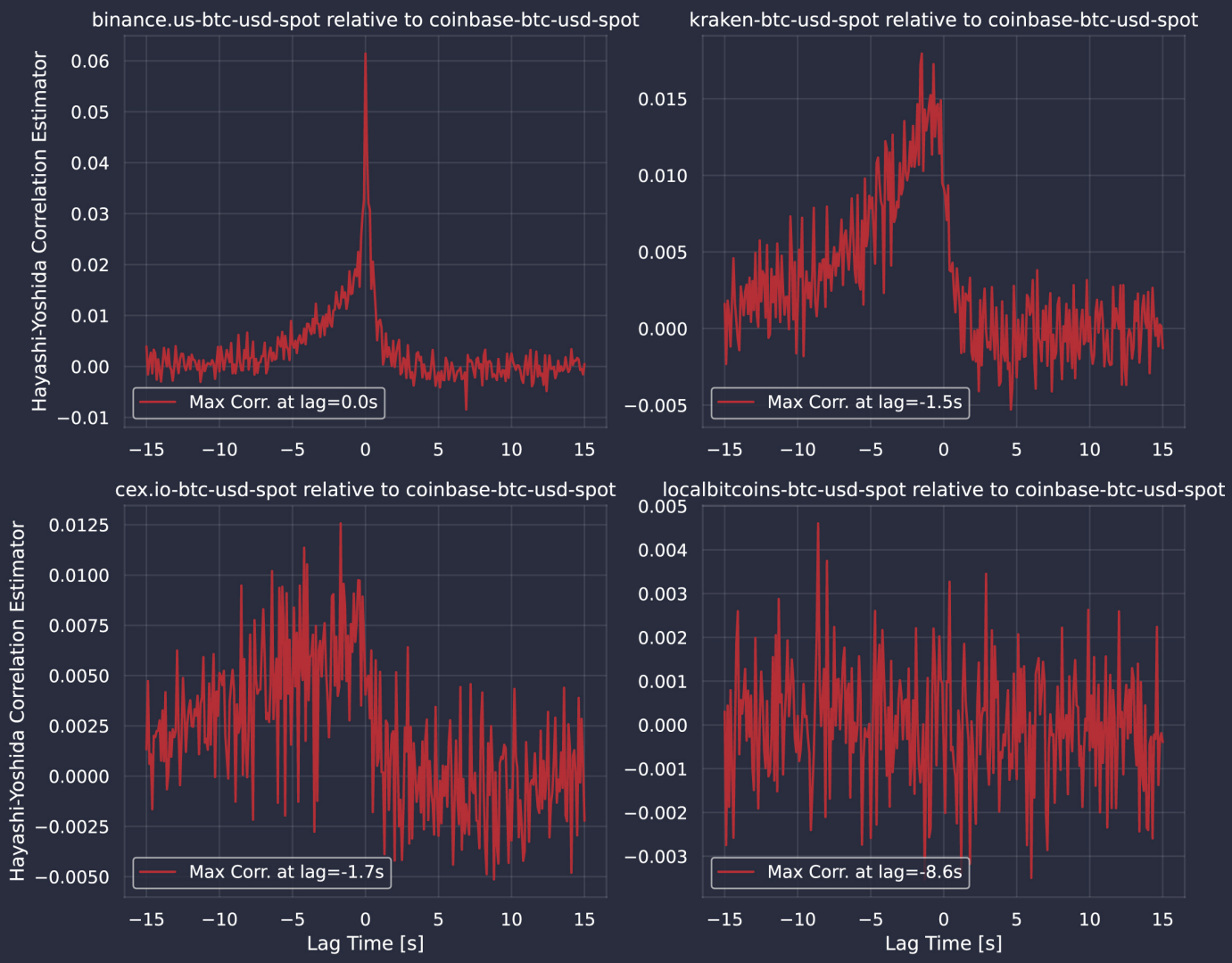
Figure 5. Price Discovery

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 four example BTC-USD markets below, taking Coinbase as a reference exchange. Prices on Binance.us are most correlated at a lag of 0.0s, meaning that the two markets are perfectly in sync. This is not so for Kraken, where the maximum correlation occurs at -1.5s. This means that Kraken's BTC-USD market lags Coinbase by 1.5s. By measuring these lag times for multiple base assets, the aggregate lead/lag dynamics between exchanges can be quantified.

It is important to note that there are edge cases, such as LocalBitcoins in the example below. When the lag curve exhibits no strong peak, there is no meaningful lag time to be identified. In these cases, the noisy market is omitted from the calculation.

Hayashi-Yoshida Lag Curves for Example Markets



WORKS CITED

1. Carter, Nic. “The Status of Proof of Reserve as of Year End 2022.” Medium, 29 December 2022, https://medium.com/@nic__carter/the-status-of-proof-of-reserve-as-of-year-end-2022-48120159377c. Accessed 30 January 2023.

2. Bitwise Asset Management. “Economic and Non-Economic Trading In Bitcoin: Exploring the Real Spot Market For The World's First Digital Commodity.” SEC.gov, 24 May 2019, https://www.sec.gov/comments/sr-nysearca-2019-01/srnysearca201901-5574233-185408.pdf. Accessed 27 January 2023.

3. “More Than Half of All Bitcoin Trades Are Fake.” Forbes, 10 August 2022, https://www.forbes.com/sites/javierpaz/2022/08/26/more-than-half-of-all-bitcoin-trades-are-fake/?sh=28d5007d6681. Accessed 30 January 2023.

4. Cong, Lin William, et al. “Crypto Wash Trading.” https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3530220.

5. Digital Asset Research. “Clean Prices: A Required Step for Crypto to Mature.” Medium, 25 October 2019, https://medium.com/digitalassetresearch/clean-prices-a-required-step-for-crypto-to-mature-bbb4156b76d8. Accessed 30 January 2023.

6. Robertson, Kevin, and Jiani Zhang. “Suitable Price Discovery Measurement of Bitcoin Spot and Futures Markets.” 12 January 2022, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4012165.

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