

Economic and Non-Economic Trading In Bitcoin: Exploring the Real Spot Market For The World's First Digital Commodity

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ABSTRACT

As a digital commodity, bitcoin's spot trading market should be among the most orderly and efficient in the world. After all, bitcoin is a globally fungible good with near-zero transportation and storage costs; in a vacuum, you would expect arbitrageurs to capitalize on any discrepancy in bitcoin pricing between exchanges instantly, subject only to exchange-and market-level constraints (deposit/withdrawal times, exchange fees, hedging costs, etc.).

Public perception, however, holds almost the opposite point of view, believing the bitcoin trading market to be uniquely disorderly and inefficient, with wildly variant pricing and strange volume patterns that belie belief.

This paper will show that public perception is wrong, anchored in a bygone era and built on a foundation of bad data and false assumptions.

Using a data-driven approach, this paper will show that the modern bitcoin spot market is both significantly smaller and significantly more efficient than commonly understood. It will show that effective arbitrage keeps prices on real bitcoin spot exchanges around the world in lockstep, with meaningful pricing discrepancies eliminated in a matter of seconds. It will further show that a series of developments since December 2017 have transformed the bitcoin market, and that the bitcoin market of today bears little relationship to the bitcoin market of the past.

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Introduction

Bitcoin is the first digital commodity. As such, it shares both similarities and differences with other commodity markets.

Like all commodities, bitcoin is globally fungible: a bitcoin is a bitcoin, anywhere in the world. Unlike other commodities, like gold, oil or wheat, bitcoin has no physical manifestation. You can't touch it, feel it or weigh it.

Bitcoin's digital nature conveys unique attributes. Unlike bulky commodities, bitcoin is almost instantly transportable, anywhere around the world, at a cost approaching zero. Moreover, you can store a limitless amount of bitcoin at a cost approaching zero; no grain silos, storage tanks or tanker ships needed.

Arbitrage is "the nearly simultaneous purchase and sale of securities or foreign exchange in different markets in order to profit from price discrepancies."¹ By this definition, bitcoin should be among the most arbitrage-able goods in the world. Subject to exchange-level constraints, such as fees, withdrawal issues or the perceived risk of default, you would expect bitcoin to trade at the same price across exchanges around the world, since it can be bought, transferred, and sold across exchanges with extremely limited frictions.

Public perception, however, holds nearly the opposite point-of-view, believing the bitcoin market to be uniquely *disorderly* and *inefficient*. This perception exists for good reason: Leading data aggregators show prices on different exchanges separated by hundreds of dollars and report trading volumes that stretch the bounds of credulity.

This paper will demonstrate that these perceptions are wrong, built on a foundation of bad data and anchored in a historical understanding of the bitcoin trading ecosystem that bears little relationship to the bitcoin market of today.

Specifically, this white paper will explore:

- **The Prevalence (And Irrelevance) Of Fake Data:** This paper will demonstrate that roughly 95% of reported trading volume in bitcoin is fake or non-economic in nature and show why fake volume does not influence price discovery in the real bitcoin spot market.
- **The Remarkable Efficiency Of the Real Bitcoin Spot Market:** This paper will show that the real spot market for bitcoin is significantly smaller, more regulated, and more efficient than commonly understood.

¹ Merriam-Webster online, as of May 13, 2019. <https://www.merriam-webster.com/dictionary/arbitrage>

- **The Creation Of The Modern Bitcoin Market:** This paper will show that a variety of factors—including the launch of regulated bitcoin futures, the development of an institutional short lending market in bitcoin, the entry of large algorithmic market makers into the bitcoin market, the arrival of (and requirement for) market surveillance at multiple bitcoin spot exchanges, and advances in the market for bitcoin custody and custodial insurance—combined to dramatically improve the efficiency of the bitcoin market since December 2017. The paper will further show that the bitcoin market of today bears little resemblance to the bitcoin market of the past, and that today’s market is approaching the asymptotic limit of efficiency.

This white paper builds upon the research that Bitwise Asset Management (“Bitwise”) presented to the U.S. Securities and Exchange Commission (the “Commission”) on March 17, 2019 (the “Bitwise Study”).² This paper is designed to stand on its own, reflecting *de novo* data gathered and analyzed after the publication of the Bitwise Study. Nonetheless, readers may want to familiarize themselves with the Bitwise Study to understand the context in which this paper appears. Of note, some of the analysis in this paper was developed in response to questions raised by both the Commission and the public since the publication of the original Bitwise Study, including:

- How and why do exchanges fake volume?
- Is there any real trading volume on exchanges with mostly fake volume?
- Do prices on exchanges with fake volume influence the price of bitcoin in the real spot market?
- Does arbitrage occur between the rapidly growing regulated bitcoin futures market and the established, lightly regulated bitcoin spot market?

The goal of this paper is to help the financial community coalesce around a common, data-driven understanding of the true nature of the bitcoin spot market, and to improve the quality of data, level of understanding, and degree of transparency that attends this rapidly growing marketplace.

² “Meeting with Bitwise Asset Management, Inc., NYSE Arca, Inc., and Vedder Price P.C,” U.S. Securities and Exchange Commission, Meeting on March 19, 2019, Regarding File No. SR-NYSEArca-2019-01. <https://www.sec.gov/comments/sr-nysearca-2019-01/srnysearca201901-5164833-183434.pdf>

I. The Current State Of Bitcoin Trading Data And The History Of Concerns Surrounding That Data

About Bitcoin

Bitcoin is a globally fungible digital commodity that is used by millions of individuals and institutions as a digital store of value.

The idea for bitcoin was first described in a white paper titled *Bitcoin: A Peer-to-Peer Electronic Cash System*³, which was published on a cryptography mailing list on October 31, 2008, by an individual or group of individuals using the pseudonym Satoshi Nakamoto. The white paper defined how a new software protocol would allow for peer-to-peer transactions of a valuable digital good (or “electronic cash”) without the need for a trusted third-party intermediary like a bank to process and verify those transactions.

Nakamoto went on to actually implement the protocol as well, and the first bitcoin (as well as the Bitcoin blockchain, which is the record of who owns what bitcoin) was created on January 3, 2009. Nine days later, the first bitcoin transaction in the world took place, when Nakamoto sent 10 bitcoin to Hal Finney, a cryptographic activist and well-known computer programmer.⁴

Since that time, the bitcoin ecosystem has matured significantly. Whereas the Bitcoin blockchain originally ran on a single computer, today it is the largest networked supercomputer in the world.⁵ More importantly from our perspective, the trading ecosystem surrounding bitcoin has changed radically.

The History of the Bitcoin Exchange Ecosystem

As the title of its underlying white paper suggests, bitcoin was envisioned as a peer-to-peer electronic form of cash. While it is possible for individuals to trade bitcoin directly with one another in a true peer-to-peer setting, it is both cumbersome and inefficient. Trading bitcoin safely requires a certain understanding of software functionality and custodial practices. Additionally, isolated peer-to-peer trading fractures liquidity and makes defining a fair price for any particular bitcoin transaction difficult.

³ “Bitcoin: A Peer-to-Peer Electronic Cash System,” Satoshi Nakamoto, October 31, 2008. <https://bitcoin.org/bitcoin.pdf>

⁴ “Hal Finney Received The First Bitcoin Transaction. Here’s How He Describes It,” Andrea Peterson, The Washington Post, January 3, 2014. <https://www.washingtonpost.com/news/the-switch/wp/2014/01/03/hal-finney-received-the-first-bitcoin-transaction-heres-how-he-describes-it>

⁵ “The Exahash Era: SHA-256 Mining a Significant Achievement,” Jamie Redman, Bitcoin.coin, May 28, 2018. <https://news.bitcoin.com/the-exahash-era-sha-256-mining-is-a-significant-achievement-in-computer-engineering>

It is unsurprising, therefore, that as more and more individuals became interested in bitcoin in the years that followed its creation, demand grew for electronic trading venues that would centralize liquidity and ease the hassle of trading.

The first truly significant bitcoin exchange was Mt. Gox. Mt. Gox was originally an online trading platform for *Magic: The Gathering Place* playing cards, but morphed into a bitcoin-focused exchange on July 18, 2010⁶, and quickly became the dominant trading platform for bitcoin worldwide. By 2013, it was handling more than 70% of the world's bitcoin trading volume.⁷ In 2013 and 2014, however, a series of hacks and unfortunate decisions resulted in Mt. Gox losing almost 750,000 of its clients' bitcoin, worth more than \$470 million at the time, leading to the company's bankruptcy.⁸

Market observers have expressed surprise over the Mt. Gox hack, wondering how an exchange could be so negligent as to lose \$470 million. But in evaluating things like Mt. Gox, and the early days of bitcoin as a whole, it is important to keep in mind the humble, grassroots origins of the bitcoin exchange marketplace. Just a few years prior to handling hundreds of millions of dollars in client assets, Mt. Gox was a place teenagers came to trade playing cards.

Similar humble origins attend many of the first-generation firms that formed the original pillars of the bitcoin ecosystem. The most popular data aggregator in the space, for instance, CoinMarketCap.com, is an online website created in 2013 as a part-time project, and was run out of the founder's apartment for a number of years.⁹ It is an impressive growth business, but it arose organically.

Similarly, the most popular media outlets in crypto today evolved not out of traditional media giants, but out of early crypto enthusiasts.

As bitcoin has appreciated in value, the ecosystem surrounding it has matured as well. Today, with bitcoin's market cap hovering above \$100 billion—up more than 1,000,000% in value since the time of Mt. Gox's launch as a bitcoin exchange—bitcoin has entered a more established, regulated, and institutional phase of its existence.

⁶ "A Brief History of Mt. Gox, The \$3 Billion Bitcoin Tragedy That Just Won't End," Matthew Beedham, The Next Web, March 19, 2019.
<https://thenextweb.com/hardfork/2019/03/14/a-brief-history-of-mt-gox-the-3b-bitcoin-tragedy-that-just-wont-end>

⁷ "Five Things About The Mt. Gox Crisis," Paul Vigna, The Wall Street Journal, February 25, 2014.
<https://blogs.wsj.com/briefly/2014/02/25/5-things-about-mt-goxs-crisis>

⁸ "The Inside Story of Mt. Gox, Bitcoin's \$460 Million Disaster," Robert McMillan, Wired, March 4, 2014.
<https://www.wired.com/2014/03/bitcoin-exchange>

⁹ Inception date and office information from "The Programmer at the Center of the \$100 Billion Bitcoin Storm," Paul Vigna, The Wall Street Journal, January 23, 2018.
<https://www.wsj.com/articles/the-programmer-at-the-center-of-a-100-billion-crypto-storm-1516708800>

The largest crypto exchanges today are sizeable enterprises. Coinbase, for example, the largest U.S.-domiciled spot bitcoin exchange, has raised more than \$500 million in venture capital¹⁰, boasts a valuation that exceeds \$8 billion¹¹, has hundreds of employees¹², and is regulated by both the U.S. Department of Treasury's Financial Crimes Enforcement Network (FinCEN) and the New York State Department of Financial Services.

Similarly, mainstream data aggregators like NASDAQ¹³, the Intercontinental Exchange¹⁴, Bloomberg¹⁵, and Thomson Reuters¹⁶ are all entering and/or exploring the space. And mainstream media, including and particularly The Wall Street Journal, Bloomberg, and Forbes, among others, now devote significant resources to crypto as well.

The unregulated, grassroots history of the bitcoin ecosystem are fading, but the footprints are still there. They provide important context for the analysis in this white paper, which argues that some of the most widely distributed data about the bitcoin trading market is radically incorrect.

The Current Reported Data On Bitcoin Trading Volume Is Surprising

CoinMarketCap is by far the most popular source of data on the crypto trading markets in the world. It is one of the 500 most popular websites in the world¹⁷, with somewhere between 50 and 100 million page views per month.¹⁸ It goes by its own acronym in the crypto community—CMC—and is widely seen as a significant participant in crypto's growth over the years. It earned this position by focusing on crypto before anyone cared and by building a robust data ingestion engine with a simple and clean user interface.

¹⁰ Crunchbase reports a total fundraising amount of \$525.3 million as of May 9, 2019.

¹¹ "Coinbase Valued At \$8 Billion In Latest Fundraising Round," Aparajita Saxena, Rishika Chatterjee and Saumyadeb Chakrabarty, Reuters, October 30, 2018. <https://www.reuters.com/article/us-crypto-currencies-coinbase/coinbase-valued-at-8-billion-in-latest-fundraisin-g-round-idUSKCN1N41UW>

¹² "Coinbase's New NYC Office to Hire 100 in Wall Street Crypto Push," Leigh Cuen, Coindesk, September 15, 2018. <https://www.coindesk.com/coinbase-crypto-jobs-hiring>

¹³ "Nasdaq Crypto Index Platform Launch A Giant Step For Adoption," Martin Young, News BTC, February 26, 2019. <https://www.newsbtc.com/2019/02/26/nasdaq-crypto-index-platform-launch-a-giant-step-for-adoption>

¹⁴ See, for example, the ICE Cryptocurrency Data Feed.

<https://www.theice.com/market-data/connectivity-and-feeds/consolidated-feed/coverage-list/cryptocurrencies>

¹⁵ "Bloomberg and Galaxy Digital Capital Management Launch Cryptocurrency Benchmark Index," Bloomberg Press Release, May 9, 2018.

https://www.bloomberg.com/company/announcements/bloomberg_galaxy_launch_cryptocurrency_index

¹⁶ "Thomson Reuters Launches Cryptocurrency Real Time Rates," Thomson Reuters Press Release, May 14, 2018.

<https://www.thomsonreuters.com/en/press-releases/2018/may/thomson-reuters-launches-cryptocurrency-real-time-rates.html>

¹⁷ Alexa.com on May 13, 2019: <https://www.alexa.com/siteinfo/coinmarketcap.com>

¹⁸ SimilarWeb on May 13, 2019: <http://similarweb.com/website/coinmarketcap.com>

Mainstream media often reaches to niche data providers in new markets as established data providers can be slow to adapt. That's been true historically in crypto, where CoinMarketCap is used by nearly all mainstream media outlets as the definitive source of truth about crypto prices, volumes, and trends. It has been cited 57 times by The New York Times, 105 times by The Wall Street Journal, 117 times by Barron's, and 445 times by Bloomberg.com, including 126 times in the past year alone.¹⁹

"OKEx was the world's fourth most active crypto exchange in the past 24 hours, according to coinmarketcap.com, with bitcoin accounting for roughly one-third of its trading volume..."

THE WALL STREET JOURNAL April 4, 2018

"According to data from the website coinmarketcap.com..."

The New York Times August 20, 2018

"Digital coins are collectively valued at \$140 billion, according to coinmarketcap.com..."

BARRON'S November 23, 2018

Figure 1: CoinMarketCap references in media

What does CoinMarketCap.com say about the bitcoin market?

For the month of April 2019, CoinMarketCap.com showed an approximate average daily value of \$10,983,637,037 in bitcoin trading volume.²⁰ At a single snapshot on April 30, 2019, prices on various exchanges (all of which contribute to CoinMarketCap's official bitcoin price) ranged from \$5,170 to \$5,837.²¹

These are startling statistics that are worth contextualizing.

\$11 billion is a lot of trading volume. Apple, the single most liquid stock in the world, trades about \$5.5 billion per day, despite having a market cap that is nearly 9X the size of bitcoin's (\$934 billion vs. \$107 billion).²² PayPal, a popular payments company with a market cap that is more similar in size to bitcoin (\$127 billion), trades about \$712 million per day, or 6.5% of bitcoin's reported volume.²³

The best comparison, however, may be to gold, since many consider both gold and bitcoin to be long-term stores of value. Gold's daily trading volume is about 3 times higher than bitcoin's reported volume, with turnover of \$36.9 billion on the London Bullion Market Association's over-the-counter gold market (the primary spot market). But gold's market cap is roughly 80 times larger than

¹⁹ Time-delimited site searches via Google.com, as of May 7, 2019.

²⁰ CoinMarketCap.com. Data from April 2019. Average daily volume (ADV) only includes spot exchange volume and pairs where BTC is the base asset. For example, BTC/USD, BTC/USDT, and BTC/EUR are included, among others. However, LTC/BTC, EOS/BTC, and ETH/BTC are not included. ADV is calculated for the month of April using snapshots of CoinMarketCap from the Internet Archive: <https://archive.org/web>

²¹ CoinMarketCap.com. Data from April 30, 2019. Snapshot of CoinMarketCap from the Internet Archive: <https://archive.org/web>

²² Yahoo Finance. Data as of May 9, 2019. <https://finance.yahoo.com/quote/AAPL>

²³ Yahoo Finance. Data as of May 9, 2019. <https://finance.yahoo.com/quote/PYPL>

bitcoin's, at nearly \$8.6 trillion, which puts the trading volume in perspective.²⁴ Framed differently, CoinMarketCap's data suggests that 12% of all bitcoin trades hands each day; the same statistic for gold is 0.43%.

The CoinMarketCap data gets even more surprising when you dig into any particular exchange. For instance, the largest reported exchange in April, Fcoin, with \$1.7 billion in daily trading volume²⁵, has a limited public profile. It has been mentioned just four times on Bloomberg (all of which are in the context of fake volume)²⁶, has just 4,781 followers on Twitter²⁷, and is the 56,539th largest website in the world, according to Amazon's Alexa.com.²⁸ By comparison, the largest exchange that the original Bitwise Study showed had real volume—the 15th ranked exchange, Binance—reported just \$218 million in daily trading volume²⁹ (less than 1/7th of Fcoin), but has been mentioned on Bloomberg 6,830 times³⁰, has 342k people following its CEO on Twitter³¹, and is ranked as the 971st largest website in the world by Alexa.com.³² This doesn't make sense.

As this white paper will demonstrate, the volume numbers reported by CoinMarketCap.com (and other data aggregators in the space) are surprising because they are wrong, wildly inflated by a combination of fake volume and wash trading that dramatically skews the public's view of the bitcoin market in a negative way.

²⁴ Total above ground gold, according to the World Gold Council's April 9, 2018, report, "How Much Gold Has Been Mined," was 190,040 tonnes. LBMA daily trading volume in 2018 was \$36.9 billion, according to Kitco's "Report: London OTC Market Nearly As Large As Comex," November 20, 2018. Gold prices from Kitco as of May 9, 2019.

²⁵ CoinMarketCap.com. Data from April 2019.

²⁶ Bloomberg on May 13, 2019: <https://www.bloomberg.com/search?query=Fcoin>

²⁷ Twitter on May 13, 2019: <https://twitter.com/fcoinofficial>

²⁸ Alexa.com on May 13, 2019: <https://www.alexa.com/siteinfo/fcoin.com>

²⁹ CoinMarketCap.com. Data from April 2019.

³⁰ Bloomberg on May 13, 2019: <https://www.bloomberg.com/search?query=Binance>

³¹ Twitter on May 13, 2019: https://twitter.com/cz_binance

³² Alexa.com on May 13, 2019: <https://www.alexa.com/siteinfo/binance.com>

1 FCoin	\$1,719,041,197	26 Bgogo	\$134,515,181
2 CoinBene	\$557,848,678	27 TOPBTC	\$133,447,932
3 Negocie Coins	\$503,317,756	28 55 Global Markets	\$132,556,830
4 BW	\$450,759,909	29 BITKER	\$130,703,932
5 OEX	\$444,519,175	30 Huobi Global	\$128,043,683
6 ZBG	\$439,590,046	31 HitBTC	\$127,010,643
7 BitForex	\$374,427,397	32 EXX	\$108,055,653
8 Coinall	\$322,829,377	33 Tidebit	\$89,126,854
9 DigiFinex	\$305,318,748	34 CoinEgg	\$87,594,293
10 IDAX	\$289,075,645	35 LATOKEN	\$80,050,275
11 Coineal	\$267,401,565	36 Bitfinex	\$78,164,783
12 OKEx	\$228,879,610	37 Coinbase Pro	\$73,225,467
13 BitMart	\$222,729,252	38 CHAOEX	\$72,904,356
14 BCEX	\$220,821,665	39 DOBI Exchange	\$72,029,034
15 Binance	\$217,602,085	40 DragonEX	\$61,844,711
16 OOOBTC	\$200,427,027	41 Kraken	\$61,267,275
17 Liquid	\$197,886,145	42 LocalTrade	\$59,997,489
18 Bit-Z	\$194,181,404	43 Bitstamp	\$58,635,892
19 Bibox	\$186,317,974	44 Allcoin	\$52,938,139
20 Fatbtc	\$185,384,801	45 Upbit	\$52,847,736
21 CoinTiger	\$180,586,710	46 IDCM	\$50,733,819
22 RightBTC	\$177,929,259	47 P2PB2B	\$50,371,603
23 LBank	\$171,451,606	48 TOKOK	\$41,769,566
24 Simex	\$145,368,029	49 Bitinka	\$41,355,760
25 ZB.COM	\$135,548,813	...	

Table 1: Reported average daily trading volume on CoinMarketCap.com for April³³

The History Of Concerns Around Data Reliability In The Bitcoin Spot Market

Concerns about fake volume and data quality in the bitcoin market are nearly as old as bitcoin itself. Recent academic studies, for instance, suggest that the Mt. Gox exchange itself was riddled by fake

³³ CoinMarketCap.com. Data from April 2019. Average daily volume (ADV) only includes spot exchange volume and pairs where BTC is the base asset.

volume in its early days, with the exchange likely engaging in wash trading to prop up reported volumes.³⁴

Contemporaneous public concern first emerged in the public record in 2013 when the People's Bank of China implemented a ban on banks working with bitcoin exchanges, sending a shockwave through the bitcoin ecosystem. As users tried to trade out of positions on leading Chinese exchanges, they found the exchanges couldn't actually support the kind of volumes they claimed to have. The first widely read article available online asserting fake volume followed, citing one bitcoin arbitrageur who claimed that "the real transaction volume [on Chinese exchanges] could be as low as one tenth of what the company purported to exchange."³⁵

Concerns around fake volume at Chinese exchanges continued through early 2017 when, in response to government pressure, Chinese exchanges ended policies that offered "zero-fee trading." Specifically, BTCC, Huobi, and OKCoin—the three largest bitcoin exchanges by reported volume at the time—jointly decided to implement a 0.2% fixed-rate fee on all buy and sell orders starting on January 24, 2017.³⁶ Reported bitcoin trading volume immediately collapsed, with volume on the three exchanges falling nearly 80% overnight, as shown in Figure 2.³⁷

³⁴ "Market Manipulation of Bitcoin: Evidence From Mining the Mt. Gox Transaction Network," Weili Chen, Jun Wu, Zibin Zheng, Chuan Chen and Yuren Zhou, Cornell University, paper accepted for publication at the 2019 IEEE International Conference on Computer Communications, January 19, 2019.

<https://arxiv.org/abs/1902.01941>

³⁵ "Chinese Bitcoin Exchange OKCoin Accused of Faking Trading Data," Eric Mu, CoinDesk, December 21, 2013. <https://www.coindesk.com/chinese-bitcoin-exchange-okcoin-accused-faking-trading-data>

³⁶ "China's Bitcoin Exchanges End No-Fee Trading In Market Shake-Up," Pete Rizzo, CoinDesk, January 23, 2017. <https://www.coindesk.com/chinas-big-three-bitcoin-exchanges-end-no-fee-policy>

³⁷ The "overnight" nature of this drop cannot be overstated: Fees were implemented at 00:00 UTC on January 24, and volumes on OKCoin—one of the three largest bitcoin exchanges—fell by 80% when comparing 23:00-24:00 UTC on January 23, 2017, with 00:00-1:00 UTC on January 24, 2017.

<https://www.coindesk.com/bitcoin-price-china-exchange-fees>

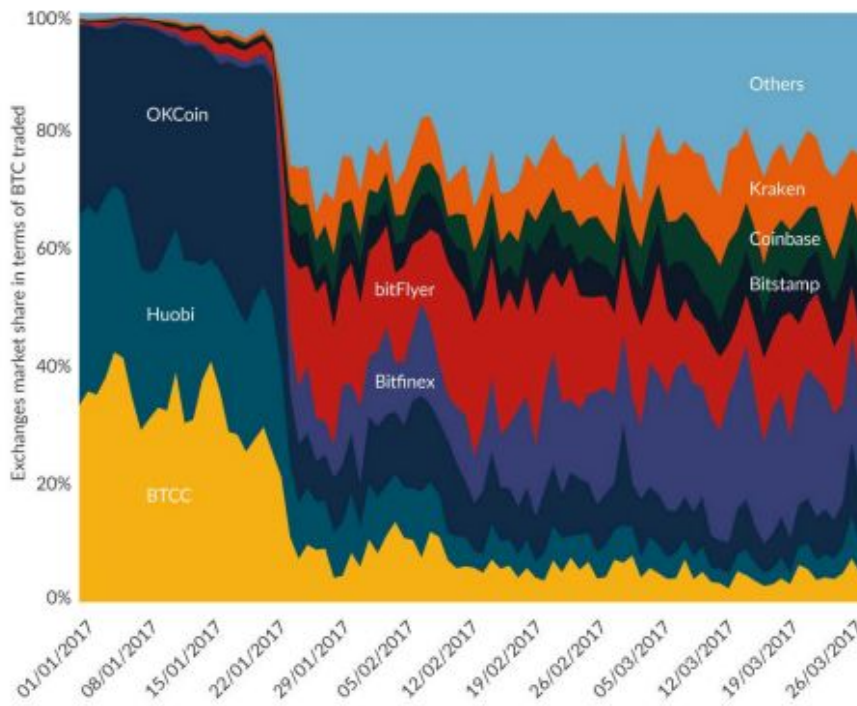


Figure 2: Bitcoin trading volume market share of major exchanges in 2017³⁸

While early concerns around fake volume focused on China, worries about other exchanges emerged over time. Today, a search for “fake volume” and “bitcoin” turns up 55,000 results on Google, “wash trading” and “bitcoin” turns up 111,000 results.³⁹

Numerous studies over the years have taken aim at the question of fake volume in the crypto market, and most have come to similar conclusions:

- The Blockchain Transparency Institute has been investigating fake volume in the crypto markets since 2018, and published its most recent report in April 2019. It found that 17 of the 25 largest exchanges on CoinMarketCap.com had more than 99% fake volume.⁴⁰

³⁸ “Global Cryptocurrency Benchmarking Study,” Garrick Hileman and Michel Rauchs, Cambridge Center for Alternative Finance, University of Cambridge, 2017. https://www.jbs.cam.ac.uk/fileadmin/user_upload/research/centres/alternative-finance/downloads/2017-global-cryptocurrency-benchmarking-study.pdf

³⁹ Google search results on May 9, 2019.

⁴⁰ “Market Surveillance Report–April 2019,” Blockchain Transparency Institute.

<https://www.bti.live/reports-april2019/> Note that this report covers all cryptoassets and not just bitcoin, and finds differing levels of fake volume on different cryptoasset pairs, even at the same exchange. Bitwise has only studied bitcoin trading pairs, and cannot speak to fake volume in other cryptoassets.

- TheTie, a crypto trading tool and data platform, published a report in March 2019 suggesting that as much as 87% of reported crypto trading volume was fake.⁴¹
- Crypto Integrity, a non-commercial project aimed at fraud detection and forensics in the crypto markets, published a report in March 2019 suggesting that 88% of crypto trading volume is inflated.⁴²
- CER, a crypto exchange data analytics firm, has conducted extensive research into fake volumes in the crypto market since the summer of 2018, and has found pervasive evidence that fake volume exists.⁴³
- Sylvain Ribes, a noted crypto investor, conducted a partial study of the ecosystem in March 2018 and found more than \$3 billion of fake volume.⁴⁴

While each researcher took a different approach, and while the specifics of their findings differ slightly, they all arrive at the same general conclusion: fake volume is endemic to the bitcoin and crypto markets, and accounts for the vast majority of reported volume in this space.

Why Does This Matter?

Bitwise Asset Management began examining questions around fake volume and data quality in the bitcoin market because the prevalence of fake data sows distrust and obscures the true nature of the bitcoin markets.

It makes little sense to argue that bitcoin is being used as a long-term store of value when its reported turnover is nearly 100X that of gold. Similarly, professional investors lose confidence in their basic understanding of the bitcoin market when they see that the single largest source of volume is at an exchange that they have never heard of and which has no real-world footprint.

But eliminating fake volume from industry statistics is only one half of the story, and the far less interesting half. As explored earlier in this paper, it's old news. The real story is about what's left after you remove the fake volume from the equation.

⁴¹ "New Report Warns 87 Percent of Cryptocurrency Exchange Volume Is Potentially Suspicious," William Suberg, March 19, 2019, CoinTelegraph.
<https://cointelegraph.com/news/new-report-warns-87-percent-of-cryptocurrency-exchange-volume-is-potentially-suspicious>

⁴² "Fake Volumes In Cryptocurrency Markets—February Report," Crypto Integrity, March 8, 2019.
<https://medium.com/crypto-integrity/fake-volumes-in-cryptocurrency-markets-february-report-fec9329f1f98>

⁴³ CER: <https://services.cer.live/exchange-analysis>

⁴⁴ "Chasing Fake Volume: A Crypto-Plague," Sylvain Ribes, March 10, 2018, Medium.
<https://medium.com/@sylvainartplayribes/chasing-fake-volume-a-crypto-plague-ea1a3c1e0b5e>

Bitwise is a specialist crypto asset manager that created the world's first cryptoasset index fund. We manage five private funds serving hundreds of accredited investors with millions in assets under management, investing solely in cryptoassets, including bitcoin. In running these funds, we regularly interact with the bitcoin trading market, buying and selling millions of dollars of bitcoin.

The bitcoin market we interact with bears little resemblance to the market that is represented in public data. The bitcoin market we interact with is incredibly organized and efficient, with extremely tight spreads and effective arbitrage that keeps prices in lockstep across exchanges across the U.S., Europe and Asia on a 24/7/365 basis. This efficient market, unfortunately, is obscured from public view by the foggy miasma of fake volume and bad data that clouds the bitcoin ecosystem.

Our goal in this white paper is to clear away that fog and reveal the true nature of the bitcoin market underneath.

II. Data Collection

A. Why Custom Data Collection Was Necessary

Analysts and researchers have long suspected fake volume was prevalent in bitcoin market data, and have used a variety of indirect and partial techniques in attempts to verify their suspicions. Unfortunately, none have been able to comprehensively and conclusively document the existence of fake volume in a manner strong enough to shock the system into correcting the problem.

It's not for lack of effort.

The inability to gather granular market data—trades and order book data—from a comprehensive set of bitcoin exchanges has made proving the existence of fake volume on exchanges in a comprehensive manner difficult.

Generally, exchanges that fake or exaggerate volumes do not want to share such granular data via their APIs.⁴⁵ In practice, they have shared the bare minimum amount of information—for example the price, ticker, and “candle” data (open price, high price, low price, close price, and volume)—required to be included in leading data aggregation sites. That makes sense; if your data is faked, you don't want to share it.

Like prior researchers, we faced the fundamental problem of trying to research a question for which data was actively not provided. Our solution was to tackle the problem head-on by building our own data collection system.

What we observed early on was that every exchange had a common denominator: A live trading view available on their website. This user interface had all the data we needed to collect—current orderbook and recent trades—even if the design, location, and format of this data on-screen was slightly different for each exchange.

To capture it, we built infrastructure to scalably read this information from the screens for over 80 exchanges continuously.

B. Custom Data Collection

1. Exchanges Covered

⁴⁵ Application Programming Interfaces, the most common way for entities to programmatically engage in large-scale data sharing with the public.

We created a global list of bitcoin exchanges for this study by taking the entire list of exchanges from top bitcoin trading pairs on CoinMarketCap.com⁴⁶ on December 5th, 2018, the first day we began comprehensively examining the bitcoin exchange marketplace for indications of fake volume. Table 2 outlines the exchanges covered.

1 ABCC	21 BITZ	41 COINTIGER	61 INDODAX	81 ZAIF
2 BCEX	22 BTCBOX	42 COSS	62 ITBIT	82 ZB
3 BGOGO	23 BTCMARKETS	43 CPDAX	63 KORBIT	83 ZBG
4 BIBOX	24 BW	44 CRYPTOLOGY	64 KRAKEN	
5 BIGONE	25 BXTHAILAND	45 DIGIFINEX	65 KRYPTONO	
6 BILAXY	26 CASHIEREST	46 DIGITALASSE	66 LATOKEN	
7 BINANCE	27 CEXIO	47 DRAGONEX	67 LBANK	
8 BITBANK	28 CHAOEX	48 EXMO	68 LIVECOIN	
9 BITFINEX	29 COINALL	49 EXTSTOCK	69 LUNO	
10 BITFLYER	30 COINBASE	50 EXX	70 OEX	
11 BITFOREX	31 COINBENE	51 FCOIN	71 OKEX	
12 BITHUMB	32 COINBIT	52 FIFTYFIVE	72 OOBTC	
13 BITKER	33 COINCHECK	53 GATEIO	73 P2PB2B	
14 BITLISH	34 COINDEAL	54 GEMINI	74 POLONIEX	
15 BITMART	35 COINEAL	55 GOPAX	75 RIGHTBTC	
16 BITMAX	36 COINEGG	56 HITBTC	76 SIMEX	
17 BITRUE	37 COINEX	57 HOTBIT	77 TIDEBIT	
18 BITSANE	38 COINSBANK	58 HUOBI	78 TOKOK	
19 BITSTAMP	39 COINSBIT	59 IDAX	79 TOPBTC	
20 BITTREX	40 COINSUPER	60 IDCM	80 UPBIT	

Table 2: Bitcoin exchanges covered

2. Trading Pairs Covered

We took into consideration all trading pairs where BTC was the base currency (e.g. BTC/USD rather than EOS/BTC) and where the quote currency was either a fiat currency (e.g. USD, EUR, JPY) or a stablecoin (e.g. USDT⁴⁷).

3. Methodology

⁴⁶ CoinMarketCap.com Bitcoin Markets: <https://coinmarketcap.com/currencies/bitcoin/#markets>

⁴⁷ USDT is the ticker symbol for Tether, the largest and most popular stablecoin on the market at the time this white paper was written.

We built individual screen scrapers for each exchange. We utilized a headless Chrome browser created by the Google Chrome team called Puppeteer⁴⁸ to navigate to the BTC trading pages of each exchange and scrape the orderbook and trade history from the browser screen. For example, take the BTC/USDT trading page of Binance in Figure 3.

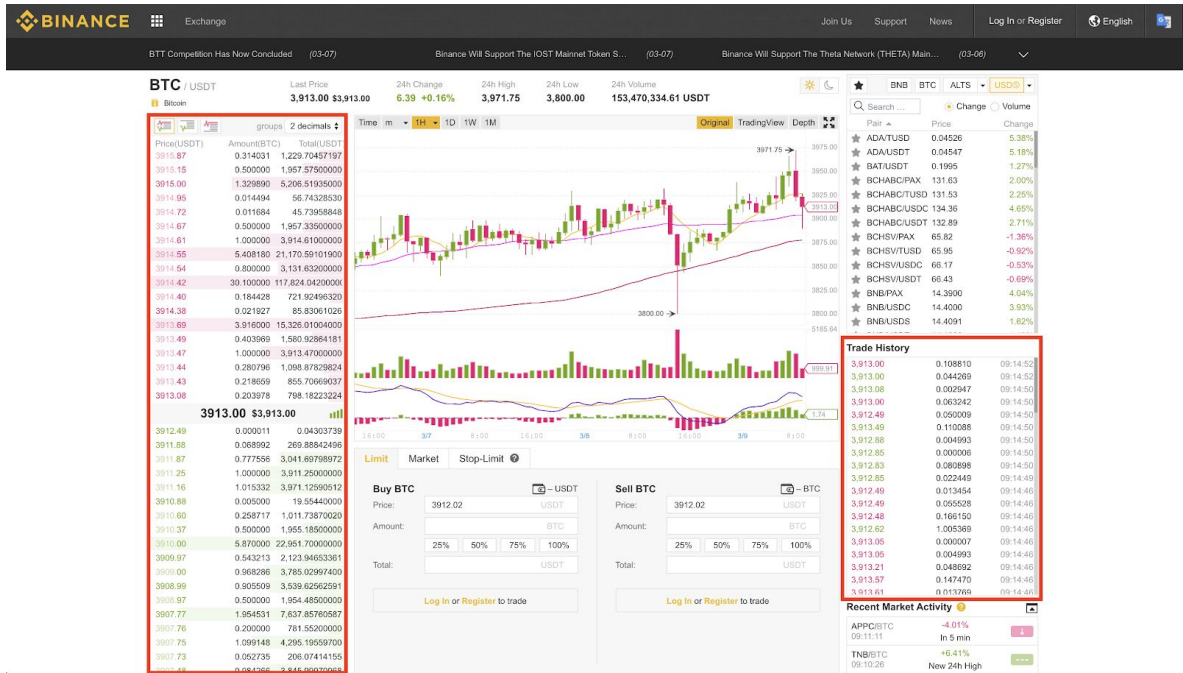


Figure 3: Binance BTC/USDT trading page⁴⁹

The current order book and recent trade history (highlighted with red boxes in the screenshot above) are visible on the screen and are updated in real-time. We scraped this data four times a second.

Every exchange had a different way of presenting this data in terms of UI location, color, and formatting, but the available data was ultimately the same.

4. Types Of Data Captured

For the ongoing trades, we collected price (in quote currency), trade size (in bitcoin), and the on-screen timestamp. For the order book entries, we collected bid/ask price (in quote currency), order amount (in bitcoin), and timestamp of the moment data was recorded.

5. System Architecture

⁴⁸ Puppeteer: <https://github.com/GoogleChrome/puppeteer>

⁴⁹ Screenshot captured from Binance: https://www.binance.com/en/trade/BTC_USDT

Figure 4 shows the deployment system architecture we designed to ensure redundancy and liveness of our data collection.

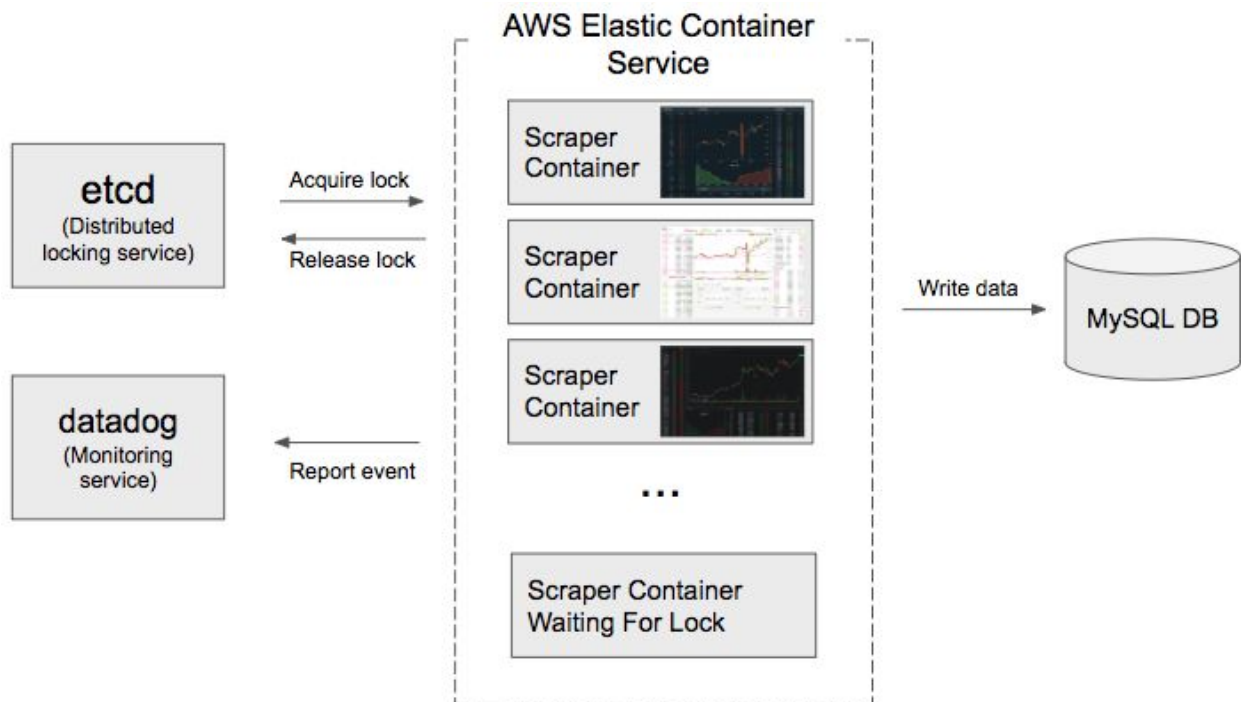


Figure 4: Scraper system architecture

We packaged scrapers into separate Docker⁵⁰ containers that could be easily created and removed on the AWS Elastic Container Service (ECS⁵¹). We used etcd⁵² as a distributed locking service that would hold a single lock for every BTC trading pair we needed to track and release them to scrapers as they spun up. This made sure that no two scrapers were collecting data for the same exchange trading pair at any given moment, and also that if ever a lock was released, either because the scraper process died or the browser was stuck for too long, a new scraper waiting for a new lock would acquire it to start anew. All scrapers wrote data to a MySQL⁵³ database and reported analytics, liveness, and failure events to Datadog⁵⁴, a third-party monitoring service.

C. Limitations Of Our Custom Data Collection Process

⁵⁰ Docker: <https://www.docker.com>

⁵¹ Amazon ECS: <https://aws.amazon.com/ecs>

⁵² etcd: <https://github.com/etcd-io/etcd>

⁵³ MySQL: <https://www.mysql.com>

⁵⁴ Datadog: <https://www.datadoghq.com>

Web scraping is inherently brittle. If the HTML structure of the web page we were scraping changed in any meaningful way, then our data collection for that exchange would break; given the 80+ exchanges in play, this was a common occurrence. For this reason we had monitoring in place to detect when certain scrapers stopped working. However, our engineering team was not always and instantly available to prepare a fix. That means there were and are gaps in the data, which we accounted for during the analytical phase of the project.

The second limitation of our data collection process was that new exchanges with astronomical trade volumes popped up every week on CoinMarketCap.com, so our list of exchanges became stale fairly quickly. Still, the main list is sufficiently consistent that the core analysis remains relevant.

D. Third-Party Data

We acquired historical bitcoin trade data from Kaiko⁵⁵ and Nomics⁵⁶ for parts of our analyses that required a continuous historical data set.

⁵⁵ Kaiko: <https://www.kaiko.com/pages/about-kaiko>

⁵⁶ Nomics: <https://p.nomics.com/about>

III. Economic and Non-Economic Trading In Bitcoin: Separating Real From Fake Volume In The Bitcoin Spot Market

Our goal in this research is to comprehensively demonstrate and identify those exchanges with a significant prevalence of fake volume in a repeatable, data-driven manner.

A. Definitions

For the purposes of this white paper, fake volume refers to any reported trading volume that does not reflect legitimate price discovery in the market. This includes:

- **Fraudulent Prints:** This is volume that is simply printed on the tape by an exchange, with no corresponding trading taking place.
- **Wash Trading:** Wash trading occurs when a single or affiliated trader executes trades with itself. We explore the various means by which exchanges engage in wash trading later in this document.

B. Data-Driven Techniques For Systematically Identifying Exchanges With Fake Volume

We used three primary tools to determine which exchanges were reporting systematically inflated volumes to leading data aggregators.

1. Time Period Of Visualized Data

When visualizing data to detect anomalous or artificial patterns, there's a natural question as to what the time period should be for the sample of data visualized. Too short and the natural patterns might not have enough time to develop. Too long and the anomalous patterns might appear less distinct, as exchanges attempting to fake volume may periodically change their algorithms and muddy the data. We've found that a full week is a good balance between the two concerns.

All of the graphs in this section are based on the full week of 4/28/19 - 5/5/19, Sunday to Saturday, the last week before we finalized this research. We chose the last week to be as current as possible; however, any single week sample would exhibit the same characteristics and lead to a similar conclusion.

2. Trade Size Histograms

Trade Size Histograms are a data visualization technique that allows you to see the percentage of trading volume on an exchange that occurs at particular trade sizes over a specified period.

For example, Figure 5 shows the Trade Size Histogram for Coinbase Pro for the week of 4/28/19 - 5/5/19.

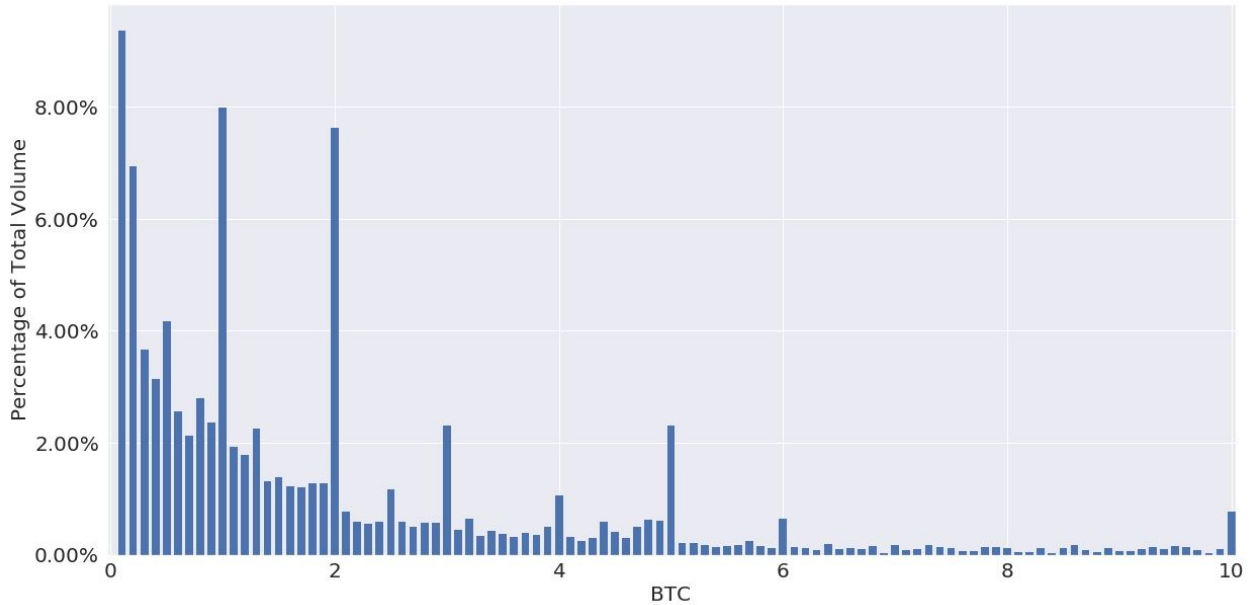


Figure 5: Trade Size Histogram for Coinbase Pro during 4/28/19 - 5/5/19⁵⁷

Each of the blue bars represent the percentage of trading that took place for a 0.1 BTC-sized bucket. For example, the first bar indicates that during the week of 4/28 - 5/5, about 9% of Coinbase Pro's BTC volume was traded in sizes between 0 to 0.1 BTC. The second bar indicates that about 7% of the volume was traded in sizes above 0.1 up to and including 0.2 BTC, and so on.⁵⁸

The general trend downwards means that more of the trade volume was composed of smaller trade sizes (e.g., within the 0 - 2 BTC range) than larger trade sizes (e.g., within the 8 - 10 BTC range). Spikes that don't follow the trend show that there was more trade volume in those particular trade size buckets than in neighboring trade size buckets. In the case of Coinbase Pro, the most noticeable spikes are generally each 10 bars apart. Specifically, there is significantly more trade volume in the trade size buckets of 0 - 0.1 BTC, 0.9 - 1.0 BTC, 1.9 - 2.0 BTC, 2.9 - 3.0 BTC, and so on, than there is in the trade size buckets that surround these whole numbers.

The last spike at the end of the graph also indicates there was a stronger preference to trade 9.9 - 10.0 BTC than any other trade size in the 6 - 10 BTC range. We decided to cut off the graph after

⁵⁷ Data collected by Bitwise

⁵⁸ Each bucket is inclusive of the largest tenth of a bitcoin. In other words, the first bucket runs from 0.00000001 BTC to 0.1 BTC, the second bucket runs from 0.10000001 BTC to 0.2 BTC, and so on. For ease of presentation, in the rest of the white paper, we use round numbers (e.g., 0.1-0.2 BTC); it should be assumed that these numbers really start at one satoshi (the smallest possible denomination of bitcoin, 0.00000001 BTC) over the lower number and run up to and inclusive of the larger number of bitcoin.

10.0 BTC, not because no trades larger than 10.0 BTC ever happen, but because the vast majority of trade volume occurs in the 0-10 BTC range and it is visually helpful to focus on this range.

With this understanding, let's see what a group of legitimate Trade Size Histograms looks like.

As a baseline, we'll use the six exchanges that have a BitLicense from the New York State Department of Financial Services.⁵⁹ The BitLicense was the first comprehensive set of rules governing the operation of businesses focused on the digital assets in the U.S., and is widely considered among the strictest set of digital asset regulations in the U.S. market.^{60 61} It includes general provisions around anti-money laundering activities, compliance structures, capital reserves, and more, as well as exchange-specific directives to detect, deter and report attempts at market manipulation and fraud.⁶² The rules are enforced through regular examinations. The BitLicense is useful for our purpose as it establishes a conservative set of exchanges that are not likely to have pervasive fake volume or wash trading.

The Trade Size Histograms of the six exchanges that hold a BitLicense are presented in Figure 6 in descending order of their average daily BTC trade volume. They all correspond to the same week as in Figure 5 (4/28/19 - 5/5/19).

⁵⁹ BitLicense: https://www.dfs.ny.gov/apps_and_licensing/virtual_currency_businesses

⁶⁰ "Bitcoin Rules Completed by New York Regulator," Michael J. de la Merced, The New York Times, June 3, 2015.
<https://www.nytimes.com/2015/06/04/business/dealbook/new-york-regulator-announces-final-rules-on-bitcoin.html>

⁶¹ "Blockchain and the City: New York State As A "Tough" Model Of Crypto Regulation," Kirill Bryanov, CoinTelegraph, February 21, 2019.

<https://cointelegraph.com/news/blockchain-and-the-city-new-york-state-as-a-tough-model-of-crypto-regulation>

⁶² "DFS TAKES ACTION TO DETER FRAUD AND MANIPULATION IN VIRTUAL CURRENCY MARKETS", New York State Department of Financial Services, February 7, 2018.

<https://www.dfs.ny.gov/about/press/pr1802071.htm>

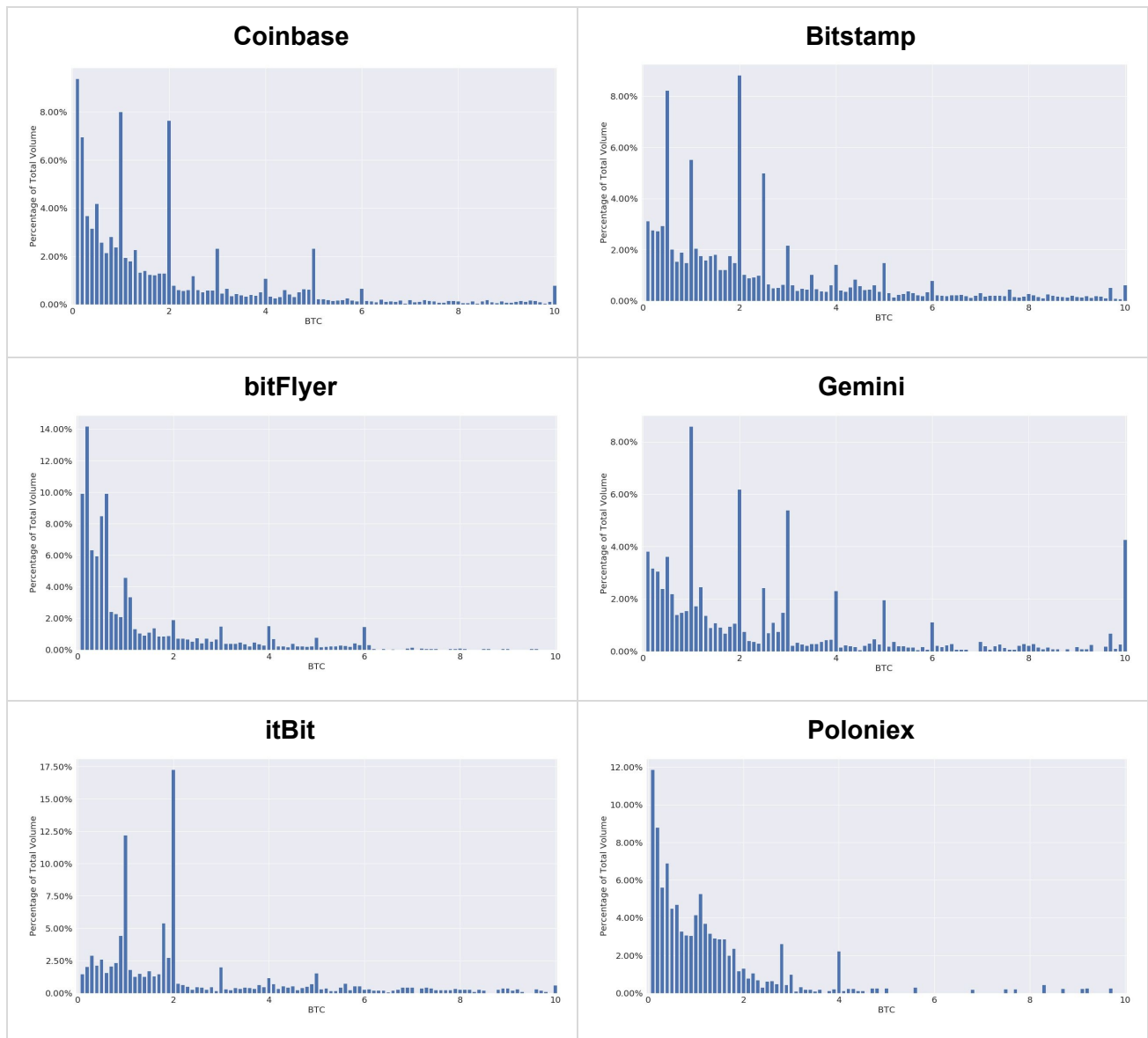


Figure 6: Trade Size Histograms for exchanges with BitLicenses during 4/28/19 - 5/5/19⁶³

Two general patterns are consistent. First, trade volume percentage (height of the bars) generally trends downwards as the trade sizes increase. Second, there are spikes that represent behavioral preferences around round numbers (e.g., 1 BTC, 2 BTC).

These two patterns—the exponential decay of trade count as trade size grows (counteracting the linear effect of a single trade counting for more when the trade size is larger) and the behavioral

⁶³ Data collected by Bitwise.

preference for round numbers for trade sizes—are well documented human behavior in existing traditional markets.⁶⁴

Now let's move our attention to exchanges outside of the reference set that show signs of fake volume and/or wash trading. They distinctly go against the trends found in the reference set.

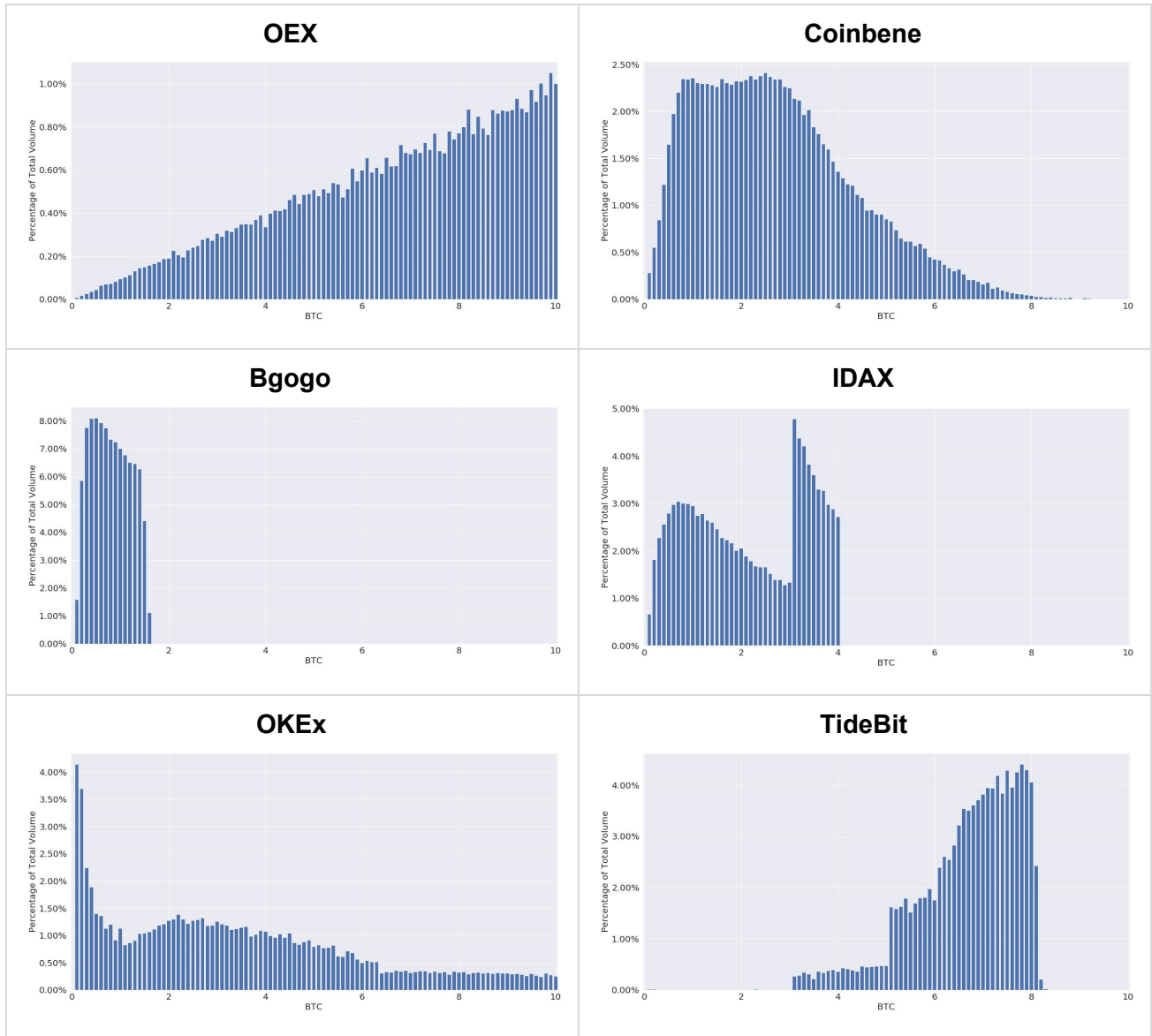


Figure 7: Trade Size Histograms for exchanges with fake volume during 4/28/19 - 5/5/19⁶⁵

⁶⁴ “Preferred numbers and the distribution of trade sizes and trading volumes in the Chinese stock market”, Guo-Hua Mu, Wei Chen, Janos Kertesz, and Wei-Xing Zhou, February 21, 2019. <https://arxiv.org/pdf/0812.1512.pdf>. Please note Figure 2 in Section 3, “Trade size distribution” of the paper referenced. Also note that the y-axis representing the trade count is logarithmic.

⁶⁵ Data collected by Bitwise.

These exchanges do not have the behavioral spikes that were observed in the reference set exchanges and documented in the historical literature. Also, the shape of the graphs defy the downward trend we established above. OEX has a linearly increasing volume percentage as trade size increases. Coinbene has a bell-shaped curve. Bgogo only has trades between 0 to 1.6 BTC. IDAX shows a mix between Coinbene's bell-like curve and Bgogo's sharp drop. OKEx has a large bump from 1 to 6 BTC and a fat long tail to follow. TideBit seems to exclusively have trades between 3 to 8 BTC.

There is no economic reason that the trade size distribution of these exchanges should defy the patterns and trends that are present in traditional markets and in the reference set of exchanges in such an idiosyncratic and artificial way. These are unnatural patterns. Importantly, this discrepancy cannot be attributed to low volumes: All six exchanges above report volumes that are greater (in many cases many times greater) than that of Coinbase Pro, the largest of the six exchanges with a BitLicense.⁶⁶

We believe that there is only one realistic explanation for these artificial patterns: That the exchanges are reporting artificial volume, either by fraudulently printing trades or by incentivizing others to trade for reasons other than a desire to buy or sell bitcoin at a given price. The full list of Trade Size Histograms for the 83 exchanges we examined can be found in Appendix I.

3. Volume Spike Alignment

As discussed earlier, bitcoin is a globally fungible commodity that can be transported anywhere almost instantly at a cost approaching zero. As such, while the bitcoin spot market is fractured across multiple exchanges operating in different locations around the world, all of those exchanges *should* respond to the same developments. An event that impacts the bitcoin market in New York should also impact the bitcoin market in London, Hong Kong, and so on.

To investigate if this is the case, and to consider the implications if it is, let's first examine the pattern of bitcoin trade volume on Coinbase Pro for the week of 4/28/19 - 5/5/19.

⁶⁶ April ADV calculated from CoinMarketCap.com.

OEX - \$444,519,175

CoinBene - \$557,848,678

Bgogo - \$134,515,181

IDAX - \$289,075,645

OKEx - \$228,879,610

TideBit - \$89,126,854

Coinbase Pro - \$73,225,467

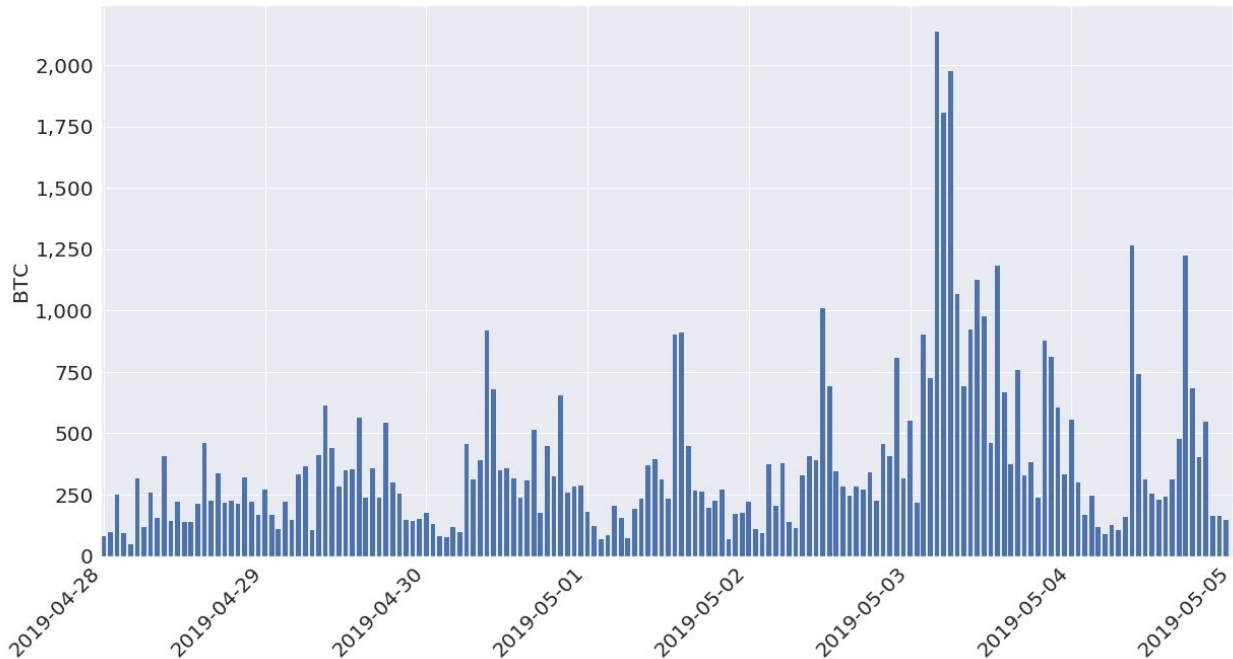


Figure 8: Hourly trade volume on Coinbase Pro during 4/28/19 - 5/5/19⁶⁷

Each bar in Figure 8 represents the amount of bitcoin traded in one hour on the exchange (denominated in bitcoin). The duration of the graph is an entire week. Bitcoin exchanges operate on a 24/7/365 basis, so there are no gaps in the x-axis.

A number of characteristics are worth noting.

First, the volume varies over the course of the day, with some hours having more volume than others. This peak-to-trough variance can be significant. It is fairly common for there to be as much as a 10X difference between the highest and lowest hourly volume in a given day.

Second, the pattern of volume does not repeat across days. Although some hours tend toward lower volume than others (for instance, volume typically dips during the overnight hours in U.S. time zones), this isn't always the case. On some days, those same hours have very large volumes. This likely occurs in response to developments in the bitcoin market, which do not hew to a fixed hourly schedule.

Finally, the chart shows several large volume spikes that dwarf the volume of neighboring hours and days. For example, for this particular week, trading volume spiked significantly higher on May 3rd from 4am-7am ET, with more than 2,000 bitcoin trading from 4am-5am ET alone. Just a day earlier, there was an hour when less than 100 bitcoin traded hands.

⁶⁷ Data collected by Bitwise.

With that framing, let's now compare the hourly volume charts for the six exchanges that have BitLicenses during the same time period (4/28/19 - 5/5/19).



Figure 9: Hourly trade volume on exchanges with BitLicenses during 4/28/19 - 5/5/19⁶⁸

The graphs are not identical, but they do show similar patterns. The most noticeable characteristic is the obvious alignment of volume spikes, including and particularly around the aforementioned May 3rd spike, when all of the exchanges saw significantly elevated volume during the same 3-hour period (4 - 7am ET).

⁶⁸ Data collected by Bitwise.

The alignment of volume spikes shows that this is a connected market.⁶⁹ Significant market events and sentiment changes seem to impact all of the exchanges simultaneously, whether through endemic activity and responses at each individual exchange, or because active arbitrage between exchanges ensures the sharing of pairwise volume when prices swing.

Now let's look at volume graphs of exchanges outside of our reference set that do not show signs of sharing the same market, but rather demonstrate volume patterns that are idiosyncratic and artificial. The graphs in Figure 10 are from the same week as our reference set (4/28/19 - 5/5/19).

⁶⁹ It is also worth noting again that this connected market is not limited to the U.S. geographically. Bitstamp and bitFlyer are prominent exchanges in Europe and Japan, respectively.

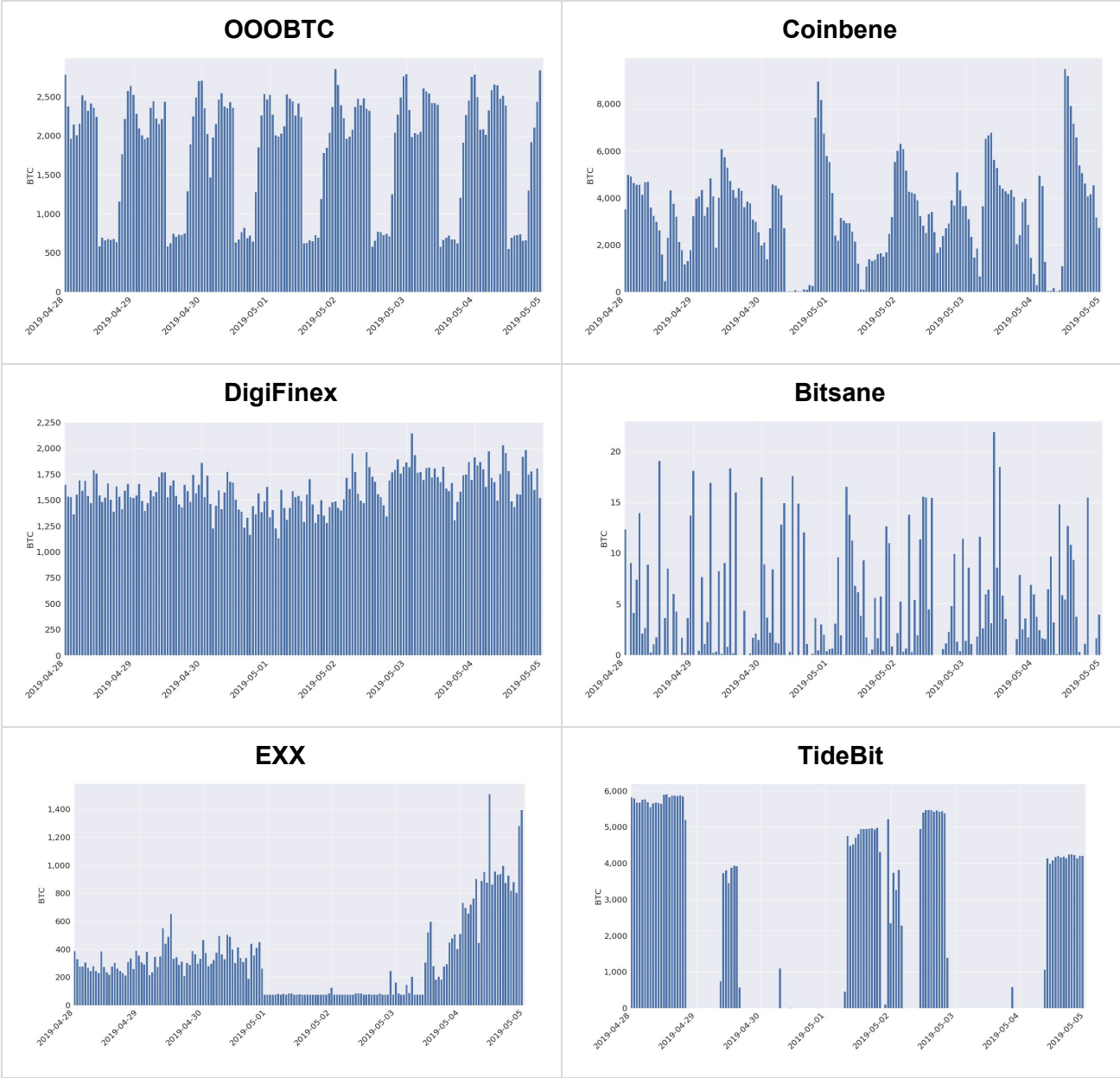


Figure 10: Hourly trade volume on exchanges with fake volume during 4/28/19 - 5/5/19⁷⁰

It is easy to see the abnormalities in the graphs above.

OOOBTC has exactly the same volume pattern every day; it looks like a tower. Coinbene shows random triangular contours of volume that have no resemblance to those of our reference set. DigiFinex reports a wall of consistent volume every hour of every day, irrespective of market conditions and time of day. Bitsane shows a sporadic oscillation between near-zero and peak hourly

⁷⁰ Data collected by Bitwise.

volumes. EXX has a two-and-a-half day period mid-week that is completely flat, with perfectly equivalent hour-by-hour volume. TideBit has entire days where there is zero volume compared to neighboring days; it shifts from a wall of peak volume to no volume for hours or days then back to peak volume for hours again. It is also worth noting that none of these exchanges have volume spikes that align with the May 3rd, 4 - 7am ET spike that was present in all exchanges in our reference set.

The idiosyncratic and highly unusual volume patterns coupled with the lack of volume spikes that align with exchanges we know reflect the real bitcoin market, strongly suggest that these exchanges are posting fake volume.

In this way, we can leverage Volume Spike Alignment analysis as another indicator in our determination of real or fake volume on any given exchange. The full list of volume graphs for the 83 exchanges we studied can be found in Appendix I.

4. Spread Patterning Analysis

The fact that the bitcoin market is driven by variable, real-world, and sometimes unpredictable phenomena is the key to understanding our third method for identifying fake volume, which we call Spread Patterning Analysis.

The graph in Figure 11 charts the spread between the highest price at which someone is willing to buy bitcoin on Coinbase Pro (the “bid”) and the lowest price at which someone is willing to sell bitcoin on Coinbase Pro (the “offer”), denominated in dollars, over the course of a week (4/28/19 - 5/5/19). We call it a “spread graph.”

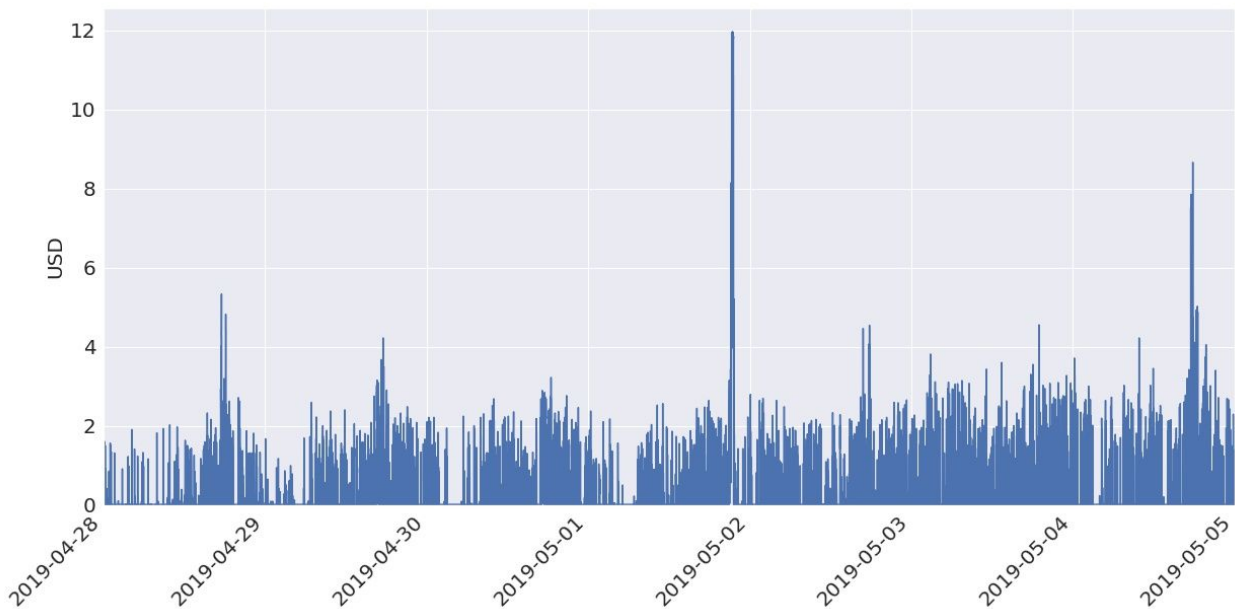


Figure 11: Bid/ask spread on Coinbase Pro during 4/28/19 - 5/5/19⁷¹

The minimum amount bitcoin's price can move on Coinbase Pro is \$0.01 (the "tick size"), so the smallest value possible for the bid/ask spread is \$0.01.

As you can see, the spread on Coinbase Pro varies over time, oscillating between \$0.01 and approximately \$3, with occasional higher spikes. On May 2, for instance, the spread momentarily reached \$12, although it returned to normal levels shortly thereafter. A number of factors drive this oscillation, including price volatility and trading volume.

Aside from its natural variability, another key characteristics to note about the spread is that it is generally quite low; in fact, although it's difficult to see, the median spread on Coinbase Pro during this time was \$0.01.

It's also important to note that the spread is anchored near zero. This reflects a healthy market, where multiple market makers are competing to drive the spread as low as possible, only widening their quotes in response to heightened market risk.

With that grounding, let's now look at the spread graphs for the six exchanges that have BitLicenses.

⁷¹ Data collected by Bitwise.

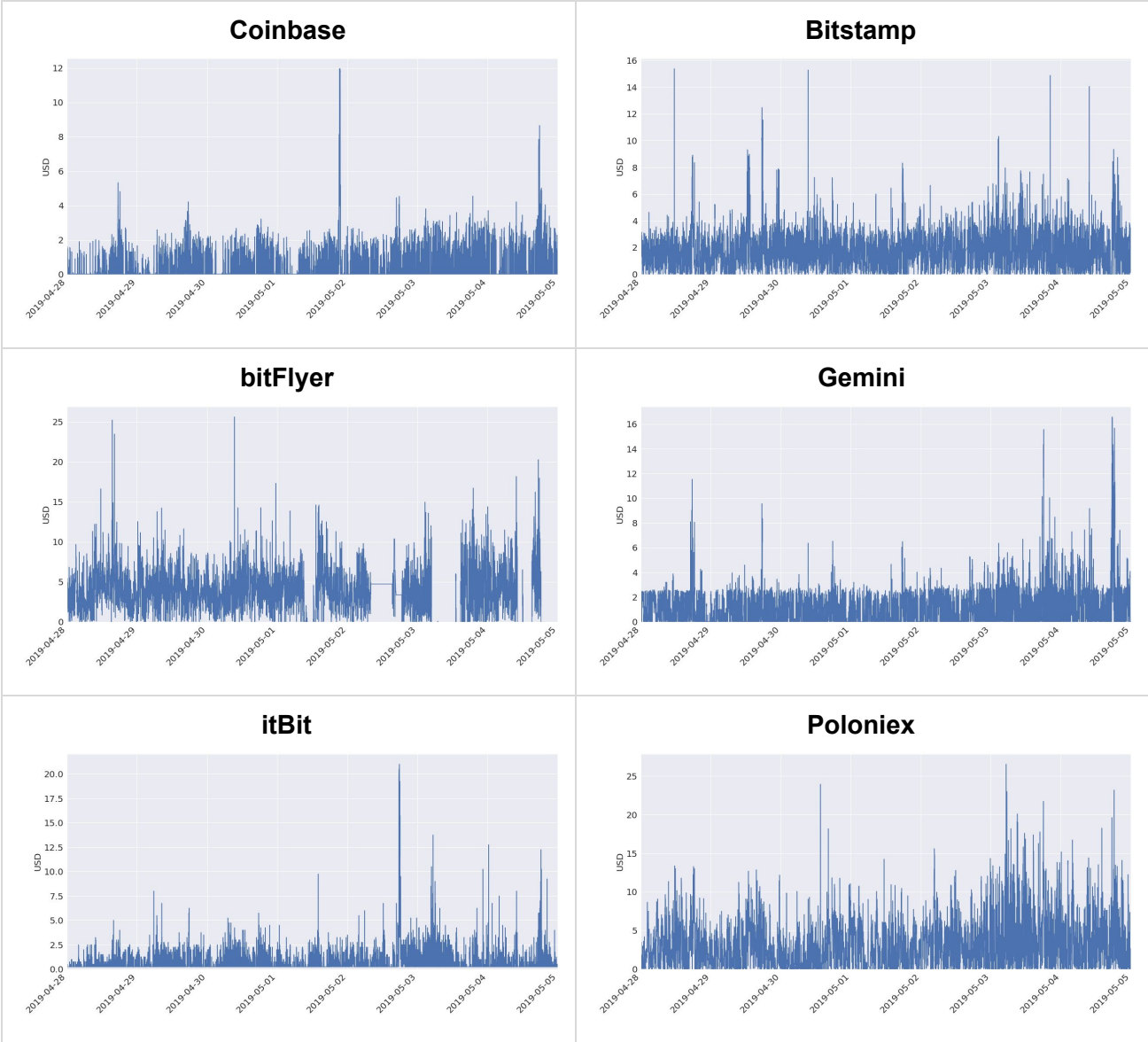


Figure 12: Bid/ask spread on exchanges with BitLicenses during 4/28/19 - 5/5/19⁷²

[Note: The scale of the y-axis is dynamic to fit the range of spread values for each exchange, so you should not infer higher or lower spreads by the height of the blue lines without reflecting on the numbers in the y axis.⁷³]

These spread graphs are revealing. While they vary, they also share a number of key characteristics.

⁷² Data collected by Bitwise.

⁷³ We could have charted these six exchanges within the same scale since the range of values are similar, but for many of the exchanges outside of these six, the spreads peak into the hundreds of dollars range, and therefore cannot practically be charted on a singular scale. For consistency we charted all graphs with a dynamic scale.

First, the spreads on all six exchanges are generally low, typically under \$5. There are spikes on each graph that exceed \$10, but those spikes are short lived.

Also, the spreads vary over time, and exhibit a consistently spiky form, suggesting a live market responding to live events.

There are differences between the graphs as well.

For instance, four of the exchanges—Coinbase, Gemini, itBit, and Poloniex—have spreads that base as low as \$0.01, while the others—Bitstamp and bitFlyer—have spreads that more frequently hover slightly above the x-axis. This difference is driven by differences in the exchanges' fee structures. Specifically, the former group of exchanges have separate fee schedules for “makers” (traders that place orders that are later lifted, adding liquidity to the market) and “takers” (traders that place orders that lift existing orders, taking liquidity from the market). This maker/taker fee model is quite common in traditional equity exchanges, as it allows exchanges to incentivize liquidity by making it cheaper to add liquidity than to subtract it from the market. Coinbase⁷⁴, Gemini⁷⁵, and Poloniex⁷⁶ have fee structures that, for high volume traders, charge zero fees for maker volume, while itBit actually rebates for maker volume.⁷⁷ These fee structures allow market makers to theoretically quote the market on both sides of the orderbook only a single cent apart from where they think the true market price is, leading to median bid/ask spreads that approach or reach the \$0.01 minimum.

Bitstamp⁷⁸ and bitFlyer⁷⁹ have fee schedules that do not distinguish between makers and takers, and never reach zero, which is why their spreads anchor higher. With bitcoin trading at \$5,000, a 10 basis point fee (the lowest fee on Bitstamp) leads to a \$5 minimum profitable spread, while bitFlyer's lowest fee tier of 2 basis points leads to a \$1 minimum profitable spread. In practice, of course, both exchanges regularly show spreads inside these theoretical minimums, because traders can place one-sided orders that probe the space inside these spreads. Still, the slight gap above the x-axis is noticeable.

We've explained the interaction between the fee schedules and bid/ask spreads on exchanges in quite detail above, not because the two modalities are specifically important, but rather to describe how spreads come into existence and to show the relative scale at which reasonable spreads should reside.

⁷⁴ Coinbase fee schedule: <https://support.pro.coinbase.com/customer/en/portal/articles/2945310-fees>

⁷⁵ Gemini fee schedule: <https://gemini.com/api-fee-schedule/#overview>

⁷⁶ Poloniex fee schedule: <https://poloniex.com/fees>. Note that Poloniex's spread graph resembles Bitstamp's in many ways, in that it is not firmly based at zero in the way Coinbase Pro, Gemini and itBit are. This is likely because Poloniex's zero maker fee only comes into existence for traders that process more than \$20m in BTC volume in the last thirty days, and Poloniex's relatively low volume (it has the lowest average daily volume of the group) limits the number of traders reaching this threshold.

⁷⁷ itBit fee schedule: <https://www.itbit.com/fees>

⁷⁸ Bitstamp fee schedule: <https://www.bitstamp.net/fee-schedule>

⁷⁹ bitFlyer fee schedule: <https://bitflyer.com/en-us/commission>

Now let's look at spread graphs of exchanges that are outside of our reference set, and show how they go against the characteristics we've pointed out above in different ways.

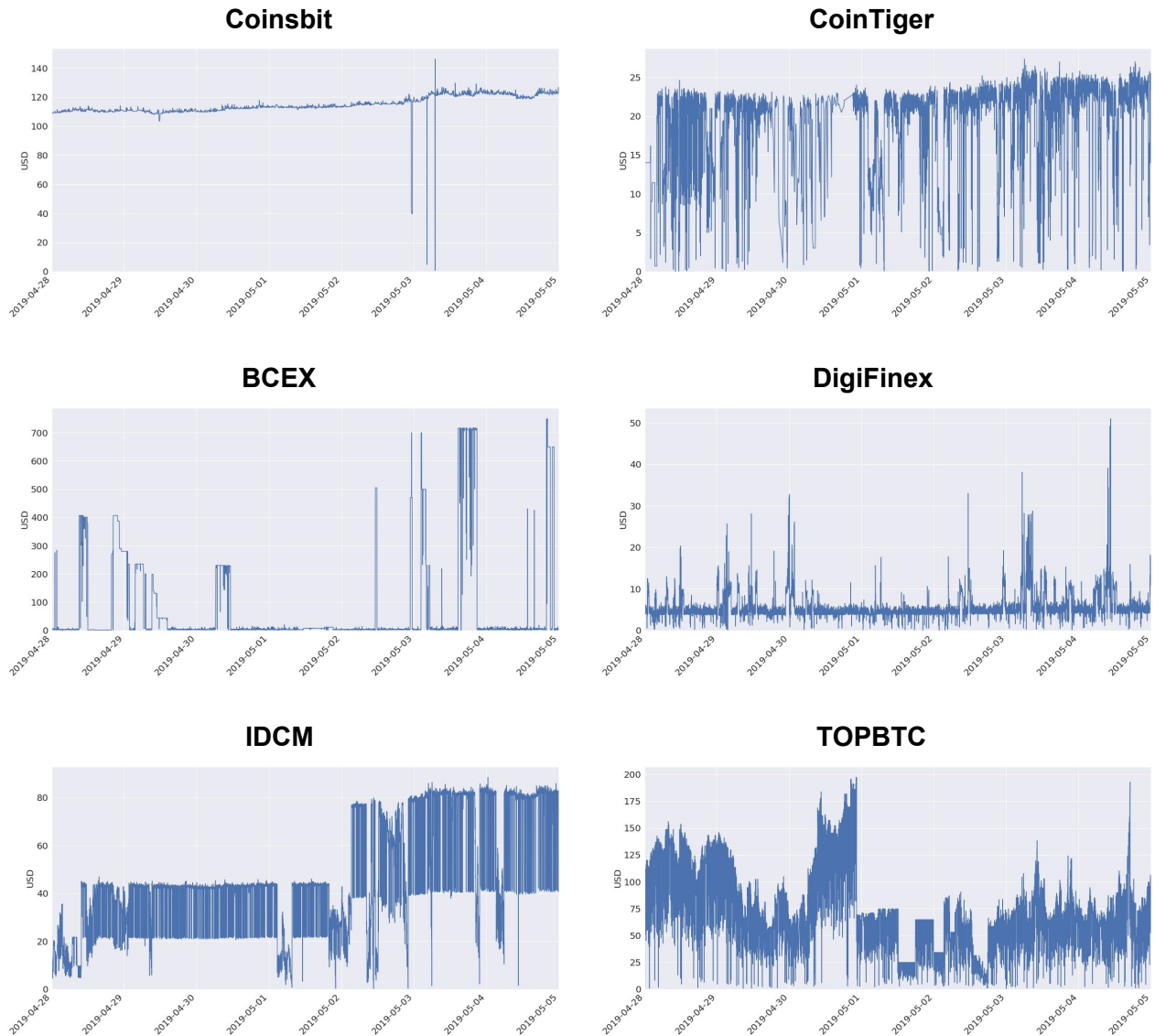


Figure 13: Bid/ask spread on exchanges with fake volume during 4/28/19 - 5/5/19⁸⁰

Coinsbit maintains an improbable spread value above \$110 the entire week. Given that trades only occur when bid and asks cross, it's hard to imagine any trades occurred on Coinsbit (let alone the

⁸⁰ Data collected by Bitwise.

tens of millions of dollars' worth of trades they report⁸¹). CoinTiger shows spreads that mostly float in the \$20-25 range, but occasionally and strangely drop down to \$0-15.

BCEX has low spreads (less than \$10) for most of the week, but also has multi-hundred dollar spreads for hours on end, the highest being more than \$700. Digifinex has spreads anchored at an oddly floating and narrow band of \$4-6.

IDCM's spreads are unusual because they oscillate within specific and high bands for multiple days. For example, between April 29th and May 1st, the spread continuously oscillated between \$22 and \$43. TOPBTC is a similar case except its spread band continuously moves up and down besides a few flat step-function changes between May 1st and May 2nd.

Again, there is no economic reason that bid/ask spreads should be anchored on high dollar amounts or oscillate in artificial patterns if there is true liquidity on the exchange where traders repeatedly cross the bid/ask spread. These spread graphs are tell tale signs of wash trading bots created and maintained either by exchanges themselves or traders in need to inflate their account's volume.

We refer to observing the spread graphs for such signs as Spread Patterning Analysis and this is used as another indicator in our determination of real or fake volume on any given exchange. The full list of spread graphs for the 83 exchanges can be found in Appendix I.

C. The List Of Exchanges With Real Volume

73 of the 83 exchanges Bitwise analyzed failed one or more of the three tests listed above.⁸²

The 10 exchanges that passed all of Bitwise's tests are listed in Table 3, along with their average daily volume during the month of April 2019:

⁸¹ Coinsbit had an ADV of \$25M in April according to CoinMarketCap.com.

⁸² We're also excluding South Korean exchanges here because their volumes are isolated from the globally connected bitcoin market due to capital controls.

Exchange	Daily Volume
Binance	\$217,602,085
Bitfinex	\$78,164,783
Coinbase Pro	\$73,225,467
Kraken	\$61,267,275
Bitstamp	\$58,635,892
bitFlyer	\$26,984,684
Gemini	\$14,581,046
itBit	\$12,150,837
Bittrex	\$7,806,571
Poloniex	\$4,069,706
Total	\$554,488,345

Table 3: Average daily volume on 10 real volume exchanges for April⁸³

In sum, our data-driven screens suggest that \$10.5 billion out of the \$11 billion in reported average daily spot bitcoin volume, or roughly 95% of all reported volume, is either fake volume or wash-trading.

Of note, this percentage aligns with the findings from the Bitwise Study, which examined a similar group of exchanges from March 4-9, 2019. Though the absolute numbers were smaller, due to lower bitcoin prices and less trading activity, the percentages were identical: The Bitwise Study showed the real average daily spot bitcoin volume to be \$273 million, compared to \$6 billion in reported volume, meaning roughly 95% of the volume was fake.

D. How And Why Exchanges Fake Volume

The fact that bitcoin exchanges inflate self-reported trading volumes should not surprise anyone familiar with self-reported data sets. Wall Street is famous for inflating and selectively interpreting

⁸³ Data from Kaiko. April 1-30, 2019.

data to skew results in M&A league tables, OTC trading league tables, index benchmarking tables, and other self-reported data sets.⁸⁴

1. Methods for Exaggerating Volume

Exchanges engage in inflating volume in multiple ways. We believe that these include but are not necessarily limited to the following:

- a. **Fraudulent Printing:** The bluntest way for exchanges to inflate volume statistics is simply to print more volume to their tape. Exchanges may have algorithms that simply post trades that have never occurred.
- b. **Exchange-Level Wash Trading By Placing Orders:** A second way exchanges inflate volume is by engaging directly in wash trading on their own platforms, simultaneously buying and selling a single asset with itself or an affiliated party. This is equivalent to fraudulent printing.
- c. **Paid Third-Party Wash Trading:** A third way exchanges inflate volume is by directly paying market makers to engage in wash trading as a way of boosting volumes.^{85 86}
- d. **Trade Mining:** Trade mining occurs when an exchange economically incentivizes trading activity by paying traders to trade. These payments are typically made using an exchange-specific coin. For instance, an imaginary exchange (let's call it FakeExchange) may charge you \$1 to trade but rebate \$1.10 worth of FakeCoin for every \$1 in fees you rack up.^{87 88}

⁸⁴ See, for example, "M&A Investment Bank Rankings Are In A League of Their Own For Flaws," Ed Hammond, Financial Times, March 14, 2014.

<https://www.ft.com/content/4a592c58-a8cc-11e3-b50f-00144feab7de>

⁸⁵ "Wash Traders Charge Exchanges Thousands For Wash Trading," Paddy Baker, Crypto Briefing, April 17, 2019. <https://cryptobriefing.com/wash-traders-exchanges-fake-volume>

⁸⁶ Although not relevant for this paper because it doesn't impact the bitcoin market, reports suggest that exchanges also force "alt-coins" to pay third-party market makers to increase trading volume on their exchange as a pre-condition of maintaining the listing of that coin on the venue or support its price. See, for example, "Crypto Exchange Tells ICO to Put Aside \$1 Million For "Market Making" to Support The Price," Trustnodes.com, March 25, 2019.

<https://www.trustnodes.com/2019/03/25/crypto-exchange-tells-ico-to-put-aside-1-million-for-market-making-to-support-the-price>

⁸⁷ See, for example, "Brave New Coin Drops Exchanges Offering "Trade Mining" From Its Prices," Andrew Gillick, Brave New Coin, July 17, 2018.

<https://bravenewcoin.com/insights/brave-new-coin-drops-exchanges-offering-trade-mining-from-its-prices>

⁸⁸ See also "\$250 Million In Fake Volume On Bithumb Generated Daily By Exploitative User," Omar Faridi, CryptoGlobe, September 3, 2018.

<https://www.cryptoglobe.com/latest/2018/09/250-million-in-fake-volume-on-bithumb-generated-daily-by-exploitative-user>

- e. **Fee-Tier Wash Trading:** The fifth way exchanges inflate volume may be to offer benefits such as lower fee tiers or preferential trading to traders that attain high volumes of trades.

2. Motivations for Exaggerating Volume

Exchanges have two powerful motivators for exaggerating volume, and have historically suffered little negative consequence for doing so.

- a. **Trader Lead-Generation Through League Table Dominance:** CoinMarketCap and other major data aggregators are a significant source of lead-generation for new exchanges. Binance CEO Changpeng Zhao noted that CoinMarketCap is “the highest traffic website in our space, and the biggest referrer for all exchanges.”⁸⁹ New exchanges looking to build volume are more likely to attract attention if they are at the top of popular and oft-cited league tables than if they are at the bottom of those lists.
- b. **Listing Fees From ICOs:** The other significant reason exchanges inflate their volume is to attract listing fees from initial coin offerings. During the ICO boom of 2017 and 2018, and still to this day, it was common for newly listed coins to pay significant fees to list their tokens on various exchanges. Third-party reports put these fees at \$1-3 million per exchange per coin.⁹⁰ While many of the most reputable exchanges refused to do business with these ICOs, other, newer exchanges did so repeatedly.

E. Binary Or Shades Of Gray: Do Exchanges With Fake Volume Have Any Real Volume?

Following the publication of the Bitwise Study, certain observers asked if our analysis was overly binary; if there were exchanges that had a blend of fake and real volume.

One such comment was included in the April 18, 2019, Comment Letter submitted by Bill Blake in reference to NYSE Arca’s Rule 19b-4 Filing regarding the Bitwise Bitcoin ETF Trust. Blake wrote:

“They [Bitwise] make a good case that a lot of claimed volume on bitcoin exchanges is faked or padded. However they seem to overreach. If they are to be believed of the 81 largest bitcoin exchanges, 71 of them fake 100% of their volume and 10 have 100% real volume. Nobody has a mixture of the two. This seems unlikely. It seems far more likely that some of the exchanges are faking all their volume, some are faking some of their volume, and some are faking none of their volume. However that would mean that Bitwise’s claim that there is only \$273 in ADV is unlikely to be true. The “true” number is certainly higher.”

⁸⁹ Changpeng Zhao, posting on Twitter as @CZ_binance, a verified Twitter account, on March 18, 2019. https://twitter.com/cz_binance/status/1107833648802197504

⁹⁰ “CRYPTO: Token and Coin Exchange Listing Fees,” Autonomous Next, April 3, 2018. <https://next.autonomous.com/thoughts/crypto-exchange-listing-fees>

This is a valid point. There likely is a gray area between exchanges with 100% real volume and exchanges with 100% fake volume. If you browse through the Appendix of all 83 exchanges you will find the occasional exchange not included in our list of 10 real exchanges that doesn't seem outright fake. For example, let's look at Gate.io in Figure 14.

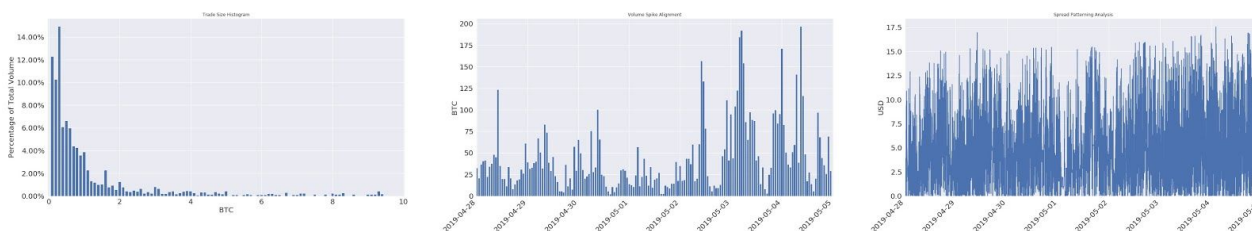


Figure 14: All three analyses applied to Gate.io⁹¹

The Gate.io charts show some anomalies. For instance, you don't see the behaviorally driven spikes around 1.0 or 2.0 bitcoin BTC, as you would expect. Similarly, the hourly volume chart seems more patterned than our reference group exchanges, with seven similar-looking slopes and a muted volume peak on May 3 (which, on our reference exchanges, was substantially higher than surrounding peaks). Finally, the Spread Patterning Analysis looks slightly off as well, with a high median spread around \$4.⁹²

However, it's definitely not as black and white as the other examples we looked at. We could reasonably argue with someone about whether Gate.io is a fake volume exchange or not, or whether some percentage estimate of its volume should be applied to our total volume statistics.

The reality is, however, that Gate.io does not have enough volume for this question to meaningfully alter our conclusions: Gate.io reported \$12 million in average daily volume in the month of April⁹³ where the total daily volume of the 10 real volume exchanges was \$554 million.⁹⁴ Even if we counted all of Gate.io's volume as real, none of our analysis would change.

To better answer Blake's question about what the "higher" volume number might be, we need to focus on the heavyweights amongst the exchanges we've classified as fake.

When we shared the Bitwise Study on Twitter after it became public on March 21, 2019, it went viral within the crypto community.⁹⁵ A fortunate side effect of that attention was that the public closely examined our work, and people raised questions about select exchanges that were not included in our list of 10 exchanges that they nonetheless believed had real-world footprints. There were only three such exchanges with meaningful volume: HitBTC, Huobi, and OKEx.

⁹¹ Data collected by Bitwise.

⁹² Data collected by Bitwise.

⁹³ CoinMarketCap.com. April 1-30, 2019.

⁹⁴ Data from Kaiko. April 1-30, 2019.

⁹⁵ Public tweet from the @BitwiseInvest account with over 1 million impressions, 29,000 engagements, 2600 likes and 1300 retweets: <https://twitter.com/BitwiseInvest/status/1109114656944209921>.

Exchange	April ADV
HitBTC	\$127,010,643
Huobi	\$128,043,683
OKEx	\$228,879,610

Table 4: Exchanges classified as fake volume with possible real-world footprints⁹⁶

Any one of these exchanges' volumes turning out to be predominantly real would impact our analysis meaningfully. So let's look at them one by one.

The easiest one to review is OKEx.

The Trade Size Histogram for OKEx is notably suspicious, with no round-number spikes, a curious, atypical rise in volume between 1 and 6 BTC, and a deeply unusual long tail of volume above 6 bitcoin that is both surprisingly flat and much fatter than other exchanges.

The clincher, however, is the Volume Spike Analysis. OKEx's volume graph shows a wall of nearly constant hourly volume that betrays none of the natural rhythms of the reference exchanges; even the "spike" on May 3 is extremely muted compared to our reference exchanges. While there may be a smattering of real bitcoin volume on OKEx, the charts are clear: the vast majority of bitcoin volume here is entirely fake.

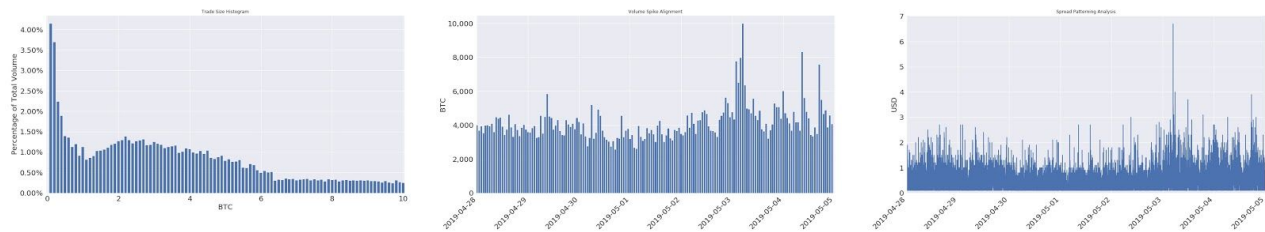


Figure 15: All three analyses applied to OKEx⁹⁷

It is also easy to show that HitBTC volume is almost entirely fake. For starters, the Trade Size Histogram drops straight down to an eerily flat line, with almost no volume after 0.5 BTC; it also does not show any of the behaviorally driven spikes at 1, 2, or other round numbers of BTC. Additionally, the hourly volumes are also completely detached from the reference set of exchanges, with most of the week's volume happening between 4/29 and 4/30, suggesting that volume on HitBTC was not influenced by the same events that influenced every other real volume exchange. We believe HitBTC's volume is predominantly wash trading, done in small trade sizes.

⁹⁶ CoinMarketCap.com. April 1-30, 2019.

⁹⁷ Data collected by Bitwise.

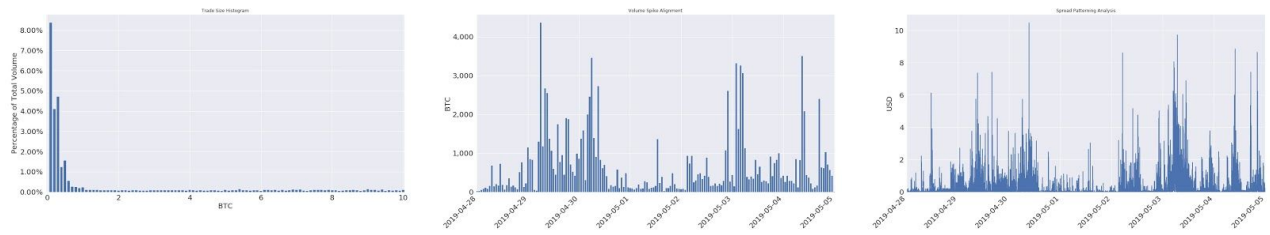


Figure 16: All three analyses applied to HitBTC⁹⁸

Huobi is the trickiest. On first glance, everything looks good. The Trade Size Histogram has the right downwards trend-line with the behavioral spike at 1 BTC. The volume graph spikes at the right time of the week with the rest to the market. Spreads are in a reasonable place with low values anchored near zero.

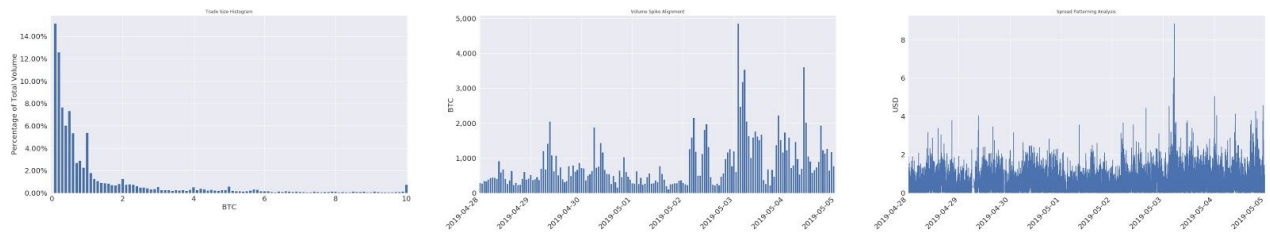


Figure 17: All three analyses applied to Huobi⁹⁹

However, before the Bitwise Study went public on 3/21/19, Huobi's Trade Size Histogram looked very different. For example, look at the Trade Size Histogram during the week of 3/17/19 - 3/24/19 in Figure 18.

⁹⁸ Data collected by Bitwise.

⁹⁹ Data collected by Bitwise.

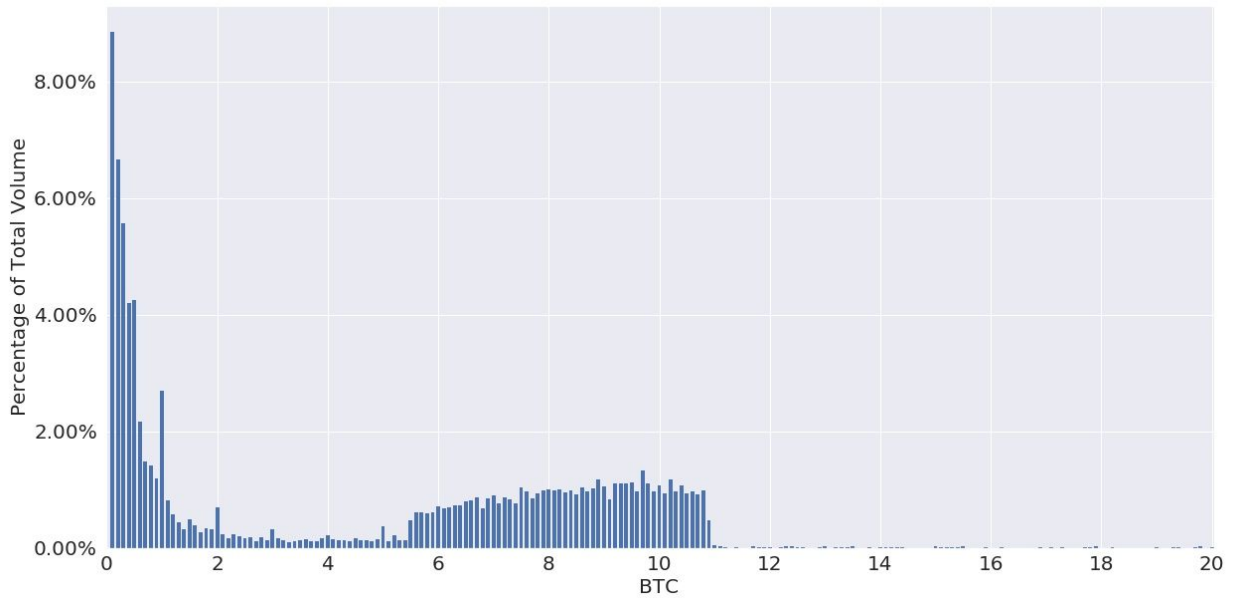


Figure 18: Trade Size Histogram for Huobi during 3/17/19 - 3/24/19¹⁰⁰

[Note: The x-axis has been extended from 0 - 10 BTC to 0 - 20 BTC to include the abrupt drop of the anomalous pattern at 10.9 BTC. Each bar still represents a trade size bucket of 0.1 BTC.]

This pattern is highly anomalous.

There is an odd resurgence of trade volume at a defined range of large trade size buckets (5 - 11 BTC) where normally very little trade volume occurs.

Figure 19 shows a six week period surrounding March 21, 2019.

¹⁰⁰ Data collected by Bitwise.

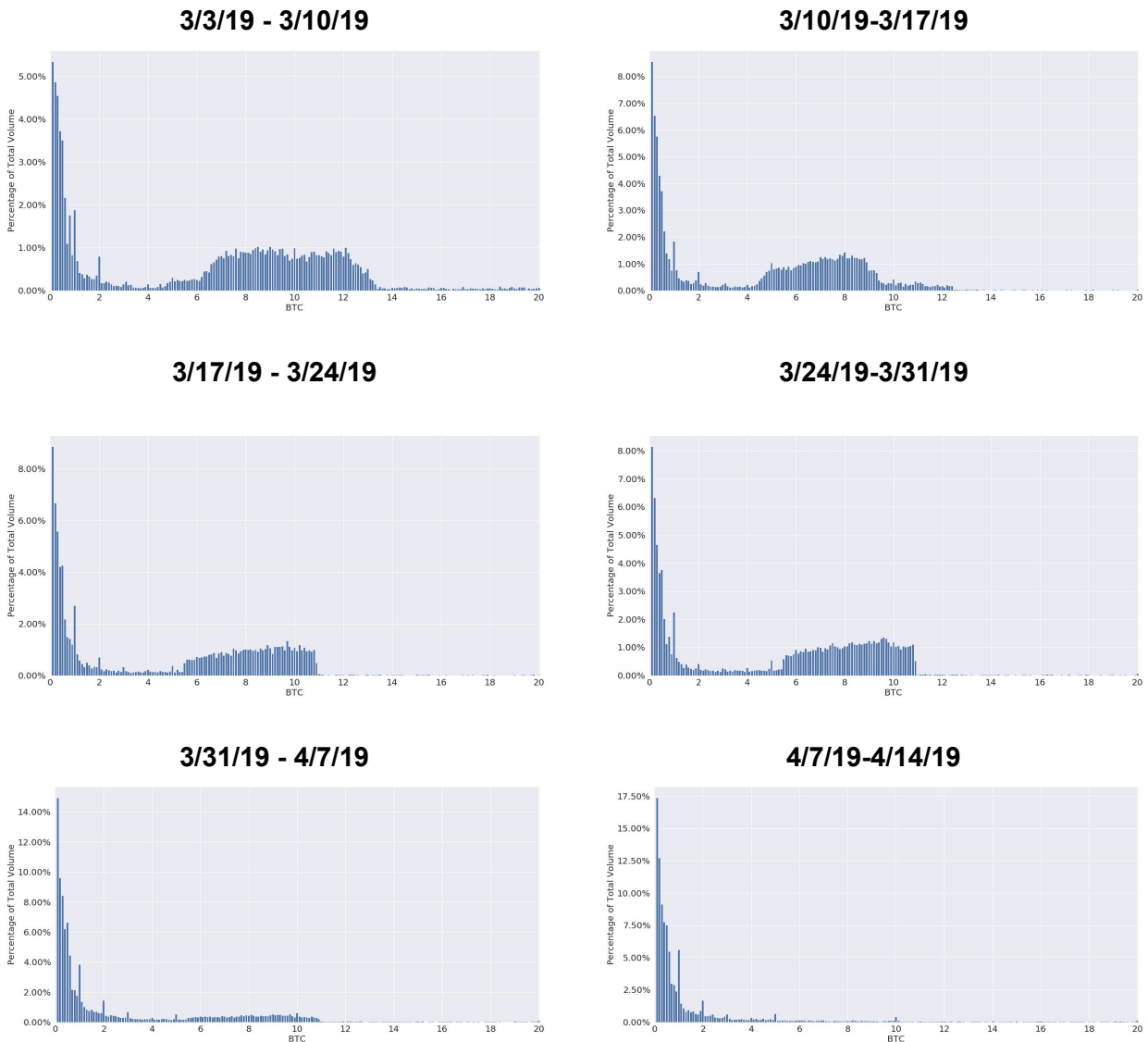


Figure 19: Trade Size Histograms for Huobi for a six week period from 3/3/19 to 4/14/19¹⁰¹

The anomalous pattern—resurgence of large trade sizes—was a consistent pattern in Huobi’s Trade Size Histograms until the Bitwise Study was published on March 21, 2019¹⁰², then it completely disappeared within three weeks.

Given the strong shift and notable timing, right around the public release of the Bitwise Study, there’s a reasonable chance those engaging in wash trading at Huobi changed their trade size signatures to be more inline with our detection methods. We also recognize that Huobi might have

¹⁰¹ Data collected by Bitwise.

¹⁰² We have checked the existence of this anomalous pattern back to the start of 2019.

taken action to clean up wash trading on their platform within that time frame, but that view is challenged by the fact that Huobi’s reported bitcoin trade volume did not meaningfully drop during that time.

While we have not made an effort to estimate the amount of real volume hidden inside the fake volume at HitBTC, Huobi and OKEx, three independent, third-party researchers have. These represent all of the available estimates of real vs. fake volume at these exchanges that we are aware of.

	HitBTC	Huobi	OKEx
Blockchain Transparency Institute ¹⁰³	> 90%	> 60%	> 90%
TheTie ¹⁰⁴	82.8%	90.8%	94.0%
Sylvain Ribes ¹⁰⁵	67.8%	88.2%	94.9%
Average	80.2%	79.7%	93.0%

Table 5: Percentage fake volume estimated by third-party researchers

They all seem to agree that OKEx’s volume is nearly entirely fake, and there is a strong consensus that the vast majority of volume on HitBTC and Huobi are fake as well.

If you take a simple weighted average of these estimates and apply it to their reported volume statistics of these three exchanges for April, you’ll find the estimated real volume in Table 6.

Exchange	Third-Party Estimate Of Real ADV
HitBTC	\$25,148,107
Huobi	\$26,035,549
OKEx	\$16,097,866
Total	\$67,281,522

Table 6: Estimated real average daily volume based on fake volume percentage estimated by third-party researchers

¹⁰³ Blockchain Transparency Institute. <https://www.bti.live/exchanges>

¹⁰⁴ TheTie. <https://twitter.com/TheTIEIO/status/1107671178423033858>

¹⁰⁵ Sylvain Ribes.

<https://medium.com/@sylvainartplayribes/chasing-fake-volume-a-crypto-plague-ea1a3c1e0b5e>. The research itself averages the fake volume of multiple trading pairs to provide an estimate for a given exchange, but we’ve pulled the BTC/USD number directly.

Incorporating this volume into our reporting would take the real average daily spot bitcoin trading volume in April from \$554 million to \$622 million, for an increase of 12%.

While this adjustment is non-negligible, we do not believe it would materially change the conclusions of this paper or the previous Bitwise Study.

IV. The True Size And Remarkable Efficiency Of The Real Bitcoin Spot Market: Arbitrage, Regulatory Oversight and Other Key Characteristics

The Bitwise Study elicited an enormous amount of media coverage in the national and crypto media alike. Most of that coverage focused on the most salacious aspect of the report: The finding that 95% of the reported volume in the ecosystem was fake or non-economic in nature. For example:

- **The Wall Street Journal:** “Most Bitcoin Trading Faked By Unregulated Exchanges, Study Says”¹⁰⁶
- **CNBC:** “Majority of Bitcoin Trading Is A Hoax, New Study Finds”¹⁰⁷
- **Forbes:** “95% of Reported Bitcoin Trading Volume Is Fake, Says Bitwise”¹⁰⁸

These headlines, while accurate, neglect the second half of the story from our Study: that after you remove the fake volume and fake data from the equation, you are left with an extremely efficient and orderly market, and one that is backstopped by a regulated derivatives market of significant size.

A. What Does The Real Bitcoin Spot Market Look Like?

1. The Real Bitcoin Spot Market Is Substantially Smaller Than Conventional Wisdom Believes

The real bitcoin spot market is substantially smaller than conventional wisdom holds. As mentioned, while leading data aggregators like CoinMarketCap report nearly \$11 billion in average daily spot bitcoin volume for April, the real number among exchanges that Bitwise is confident have real (and not inflated) volume was \$554 million, suggesting 95% of reported volume is fake.

[If you include estimates from “gray” exchanges, the number is roughly \$625 million in real volume, which still suggests that 94% of the reported volume is fake.]

¹⁰⁶ “Most Bitcoin Trading Faked By Unregulated Exchanges, Study Says,” Paul Vigna, The Wall Street Journal, March 22, 2019.

<https://www.wsj.com/articles/most-bitcoin-trading-faked-by-unregulated-exchanges-study-finds-11553259600>

¹⁰⁷ “Majority of Bitcoin Trading Is A Hoax, New Study Finds,” Kate Rooney, CNBC, March 22, 2019.

<https://www.cnbc.com/2019/03/22/majority-of-bitcoin-trading-is-a-hoax-new-study-finds.html>

¹⁰⁸ “95% of Reporting Bitcoin Trading Is Fake, Says Bitwise,” Charles Bovaird, Forbes.com, March 22, 2019.

<https://www.forbes.com/sites/cbovaird/2019/03/22/95-of-reported-bitcoin-trading-volume-is-fake-says-bitwise>

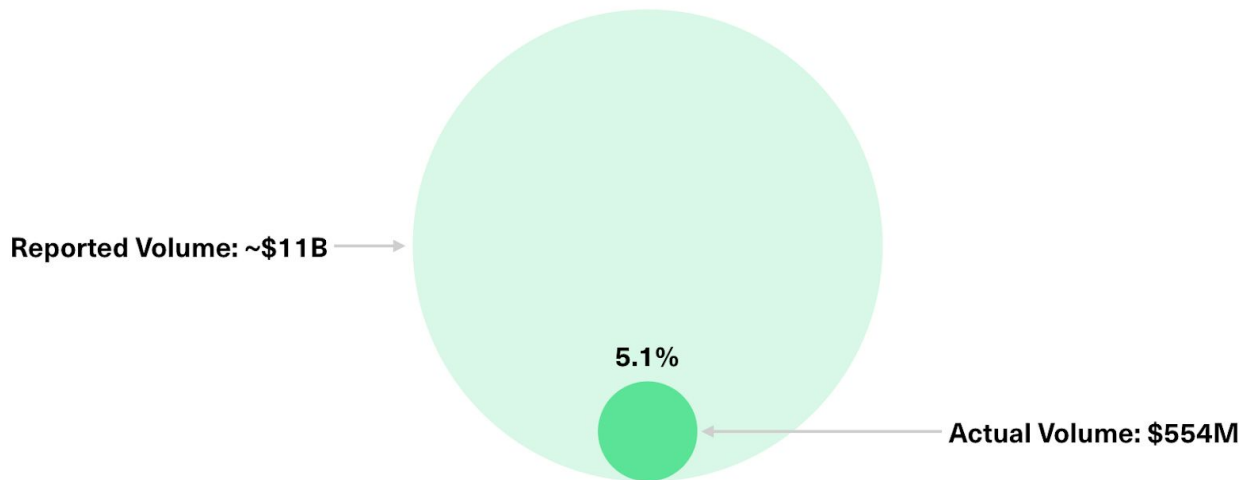


Figure 20: Reported volume vs actual volume on bitcoin spot markets¹⁰⁹

2. The Real Bitcoin Spot Market Is Substantially More U.S.-Focused Than Conventional Wisdom Believes

Historically, one baffling fact about reported bitcoin volume has been that the volumes on U.S.-based exchanges have always seemed so small.

Reported Exchange Volume By Domicile

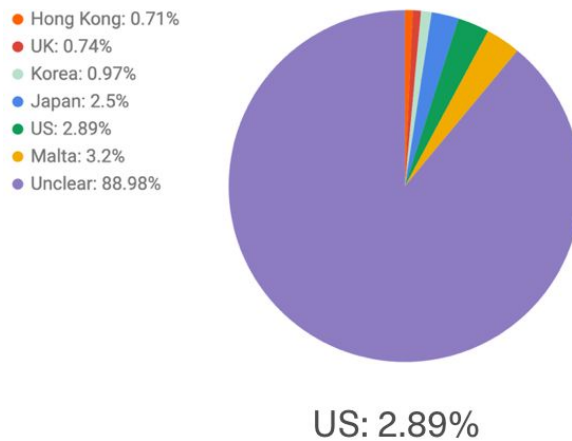


Figure 21: Reported exchange volume by domicile¹¹⁰

It is difficult to ascertain the domicile of many of the exchanges that have large amounts of fake volume; their websites often provide incomplete information, and what registration data exists often

¹⁰⁹ Data from CoinMarketCap.com and Kaiko. April 1-30, 2019.

¹¹⁰ Data from CoinMarketCap.com. April 1-30, 2019.

locates those exchanges in tax-shelter domiciles like The Seychelles. But it is relatively easy to determine which exchanges are domiciled in the U.S., since U.S. law requires those companies to register in various manners or face prosecution. Using this information, we can say that just under 3% of reported bitcoin trading volume can be traced to exchanges domiciled in the U.S.

That is surprising to say the least.

The U.S. is the world's largest economy, accounting for 23.9% of global gross domestic product, according to the World Bank.¹¹¹ Wealth is even more concentrated in the U.S., with U.S. citizens controlling 31% of the world's wealth.¹¹² It would be surprising if citizens controlling 31% of the world's wealth accounted for only 3% of trading volume for a globally fungible asset.

Moreover, studies that look at publicly traceable data suggest that the U.S. has a relatively large real-world footprint in the bitcoin and blockchain space.

For instance, one recent study found that the U.S. was the source of nearly four-times the amount of web traffic to bitcoin exchanges compared to any other country in the world, accounting for 33% of all bitcoin exchange web traffic among the top 20 country sources in the world. Japan and Korea were second and third.¹¹³ Another study found that U.S.-based investors accounted for 79% of venture capital investments into crypto and blockchain related companies.¹¹⁴

The reason these real-world footprints mis-align with reported volume statistics is that the reported volume statistics are fake.

In reality, 31% of all reported volume takes place on exchanges domiciled in the U.S. market, with the remainder distributed amongst exchanges domiciled in Malta, Hong Kong, the UK, and Japan.

¹¹¹ World Development Indicators, World Bank. Data as of 2017. As reported on Wikipedia:

[https://en.wikipedia.org/wiki/List_of_countries_by_GDP_\(nominal\)](https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal))

¹¹² "Global Wealth Report 2018: U.S. and China In The Lead," Credit Suisse, October 18, 2018.

<https://www.credit-suisse.com/corporate/en/articles/news-and-expertise/global-wealth-report-2018-us-and-china-in-the-lead-201810.html>

¹¹³ "How Are Crypto Traders Distributed Across The World," Datalight, April 29, 2019. Note that web traffic sources exclude traffic from computers operating under virtual private networks, or VPNs, which may lead to a systematic undercounting of traffic from countries that engage in broad-based internet censorship, such as China.

<https://datalight.me/blog/researches/longread/how-are-crypto-traders-distributed-across-the-globe/#notes>

¹¹⁴ "Venture Capital Firms Go Deep and Wide With Blockchain Investments," Diar, Volume 2, Issue 39, October 1, 2018. <https://diar.co/volume-2-issue-39>

Exchange	April ADV ¹¹⁵	Domicile
Binance	\$217,602,085	Malta ¹¹⁶
Bitfinex	\$78,164,783	Hong Kong ¹¹⁷
Coinbase	\$73,225,467	U.S. ¹¹⁸
Kraken	\$61,267,275	U.S. ¹¹⁹
Bitstamp	\$58,635,892	U.K. ¹²⁰
Bitflyer	\$26,984,684	Japan ¹²¹
Gemini	\$14,581,046	U.S. ¹²²
ItBit	\$12,150,837	U.S. ¹²³
Bittrex	\$7,806,571	U.S. ¹²⁴
Poloniex	\$4,069,706	U.S. ¹²⁵

Table 7: Domicile of exchanges with real volume

These real volume numbers align more easily with related real-world statistics, including GDP, wealth, web traffic, and blockchain-related venture investments, than the reported volumes do.

3. The Real Bitcoin Spot Market Is Substantially More Regulated Than Conventional Wisdom Believes

Conventional wisdom holds that the bitcoin exchange market is almost entirely unregulated, a lawless morass of anything-goes capitalism dominated by shadowy, fly-by-night operations with unknown domiciles, unknown leadership, weak capitalization, and little commitment to the creation of a fair market.

¹¹⁵ Data from Kaiko.

¹¹⁶ Binance began as a Hong Kong-based company but moved its headquarters to Malta in 2018. While some databases list its domicile as unknown, most use Malta. See, for example, Crunchbase: <https://www.crunchbase.com/organization/binance#section-overview>.

¹¹⁷ Note that the Bitwise Study identified Bitfinex as being domiciled in Taiwan. That was based on the data reported in the New York Attorney General 2018 Virtual Markets Integrity Report. <https://virtualmarkets.ag.ny.gov>. Subsequent to this, however, the New York Attorney General came out with new information in its April 25, 2019, court order surrounding Bitfinex and Tether that suggests the exchange's true domicile is Hong Kong.

<https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=309312629>

¹¹⁸ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=225488472>

¹¹⁹ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=260965170>

¹²⁰ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=275566433>

¹²¹ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=274866493>

¹²² <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=283081550>

¹²³ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=300971681>

¹²⁴ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=309666812>

¹²⁵ <https://www.bloomberg.com/research/stocks/private/snapshot.asp?privcapId=309559982>

This is a fair reflection of the bitcoin exchanges that dominate the reported trading volume list.

Fcoin, for instance, the largest single exchange by reported volume for the period studied in this white paper, launched on May 24, 2018, and within two weeks claimed to have the largest crypto trading volumes in the world.¹²⁶ The exchange has been called a Ponzi scheme, and admits to sponsoring a wash-trading program that pays users to trade.¹²⁷ It's under no regulatory status in the U.S.

The second largest exchange, Coinbene, reporting over \$500 million in average daily trading volume in April, has spreads that consistently exceed \$10, a Trade Size Histogram that is strikingly similar to a bell curve, no verifiable real-world footprint, and no known regulatory status.

But the regulatory status of the ten exchanges with real trading volume is remarkably different.

Nine of the ten exchanges are regulated by the U.S. Department of Treasury's Financial Crimes Enforcement Network (FinCEN) division under its Money Services Businesses regulation, and six are regulated by the New York State Department of Financial Services under the BitLicense program. While these regulations do not compare directly to the regulations that attend national securities exchanges or futures exchanges, they do convey certain critical protections that are worth review.

¹²⁶ "FCoin to dethrone other top exchanges? Daily volume rose to \$17.3 billion within a month of its launch," Pinaz Kazi, BCFocus, July 2, 2018. <https://bcfocus.com/news/altcoin-news/fcoin-to-dethrone-other-top-exchanges-daily-volume-rose-to-17-3-billion-within-a-month-of-its-launch/17456>

¹²⁷ "FCoin Exchange Now Compared To Ponzi Scheme," Andrew Ancheta, Crypto Briefing, July 11, 2018. <https://cryptobriefing.com/fcoin-exchange-now-compared-to-ponzi-scheme>

Exchange	MSB	BitLicense
Binance		
Bitfinex	X	
bitFlyer	X	X
Bitstamp	X	X
Bittrex	X	
Coinbase Pro	X	X
Gemini	X	X
itBit	X	X
Kraken	X	
Poloniex	X	X

Table 8: Regulatory status of exchanges with real volume

What does the U.S. Department of Treasury FinCEN Division’s Money Services Business License Require?

According to the U.S. Department of Treasury, all virtual currency exchanges with operations or customers in the U.S. have been subject to the Bank Secrecy Act since 2011.¹²⁸ The Treasury clarified the need for such exchanges to register as MSBs on March 13, 2013, when it published FIN-2013-G001, “Application of FinCEN’s Regulations to Persons Administering, Exchanging or Using Virtual Currencies.”¹²⁹

The Money Services Business (MSB) license has a long list of requirements designed to ensure that FinCEN can police, control and punish attempts at money laundering. The obligations include:

¹³⁰

- Identifying people with ownership stakes or controlling roles in the MSB.

¹²⁸ FinCEN letter to U.S. Senator Ron Wyden regarding treatment of virtual currencies and virtual currency money services businesses. Department of the Treasury, February 13, 2018. <https://coincenter.org/files/2018-03/fincen-ico-letter-march-2018-coin-center.pdf>

¹²⁹ “Application of FinCEN’s Regulations to Persons Administering, Exchanging, or Using Virtual Currencies,” FinCEN, March 18, 2013 <https://www.fincen.gov/sites/default/files/shared/FIN-2013-G001.pdf>

¹³⁰ “Which Cryptocurrency Exchanges are Registered with FinCEN,” Christopher Casper, CoinIQ, October 3, 2018. <https://coiniq.com/crypto-exchange-fincen-registration>. Note that there are additional obligations and that this is not the full list.

- Establishing a formal Anti-Money Laundering (AML) policy in place with documentation, training, independent review, and a named compliance officer.
- Having strict customer identification and verification policies and procedures.
- Filing Suspicious Activity Reports (SARs) for suspicious customer transactions.
- Filing Currency Transaction Reports (CTRs) for cash-in or cash-out transactions greater than \$10,000.
- Maintaining a five-year record of currency exchanges greater than \$1,000 and money transfers greater than \$3,000.

What Does the New York State Department of Financial Services’s BitLicense Require?

The New York State Department of Financial Services began developing its BitLicense program in 2014, and the regulation officially came into place on August 8, 2015.¹³¹ The BitLicense program required all companies conducting business in New York to abide by a wide-ranging set of regulatory requirements designed for the “protection of New York consumers and to ensure the safety and soundness of providers of virtual currency products and services.” The regulations have been continuously updated since then.¹³²

The BitLicense has a substantially longer list of requirements than the MSB license. The obligations that attend the BitLicense include:¹³³

- Submission of audited financial statements including income statements, statement of assets/liabilities, insurance, and banking.
- Capitalization requirements set at NYDFS’s discretion in a manner that ensures the financial integrity of the licensee.
- Full reserves of custodial assets without selling or encumbering.
- Fingerprints and photographs of employees with access to customer funds.
- Qualified Chief Information Security Officer and annual penetration testing and audits.
- Documented business continuity and disaster recovery plan, independently tested annually.
- Independent exam by NYFDS.

Critically, the BitLicense was updated and expanded on February 7, 2018, to provide explicit protections and reporting requirements around fraud and market manipulation. In its release titled “DFS Takes Action to Deter Fraud and Manipulation in Virtual Currency Markets,”¹³⁴ the DFS wrote the following:

¹³¹ “Regulation of the conduct of virtual currency businesses,” NY-ADR, February 25, 2015. <https://govt.westlaw.com/nyreg/Document/I41a4b512b7e311e493b50000845b8d3e>

¹³² New York Codes, Rules and Regulations - Virtual Currencies: <https://govt.westlaw.com/nycrr/Browse/Home/NewYork/NewYorkCodesRulesandRegulations>

¹³³ “New York’s Final “BitLicense” Rule: Overview and Changes from July 2014 Proposal,” Davis Polk, June 5, 2015. https://www.davispolk.com/files/2015-06-05_New_Yorks_Final_BitLicense_Rule.pdf

¹³⁴ “DFS Takes Action to Deter Fraud and Manipulation in Virtual Currency Markets,” DFS press release, February 7, 2018. <https://www.dfs.ny.gov/about/press/pr1802071.htm>

In the guidance issued today, DFS directed virtual currency entities to adopt measures that include, at a minimum, effective implementation of a written policy that:

- *Identifies and assesses the full range of fraud-related and similar risk areas, including, as applicable, market manipulation;*
- *Provides effective procedures and controls to protect against identified risks;*
- *Allocates responsibility for monitoring risks; and*
- *As part of its procedures and controls to protect against identified risks, virtual currency entity must provide for the effective investigation of fraud and other wrongdoing, whether suspected or actual, including, as applicable, market manipulation.*

In addition, immediately upon discovering any wrongdoing, a virtual currency entity must submit to DFS a report stating all pertinent details known at the time of the report. Virtual currency entities must also submit to DFS, as soon as practicable, a further report or reports of any material developments relating to the originally reported events, along with:

- *A statement of the actions taken or proposed to be taken with respect to such developments, and*
- *A statement of changes, if any, in the virtual currency entity's operations that have been put in place or are planned in order to avoid repetition of similar events.*

In part in response to these regulations, there has been a strong trend towards exchanges adopting sophisticated third-party or robust internal tools for monitoring and identifying attempts at manipulative activity, as outlined below. (Note that not all exchanges disclose the specifics of their market surveillance partnerships.)

Exchange	Market Surveillance Tools	Since
Binance	N/A	N/A
Bitfinex	Irisium Market Surveillance	March 14, 2018 ¹³⁵
bitFlyer	N/A	N/A
Bitstamp	Irisium Market Surveillance	Nov 27, 2018 ¹³⁶
Bittrex	N/A	N/A
Coinbase Pro	Internal, "Coinbase Trade Surveillance Program" led by Peter Elkins, former head of market surveillance at NYSE	July 4, 2018 ¹³⁷
Gemini	Nasdaq SMARTS	April 25, 2018 ¹³⁸
itBit	N/A	N/A
Kraken	N/A	N/A
Poloniex	NICE Actimize	Feb 27, 2019 ¹³⁹

Table 9: Market surveillance tools adopted by exchanges with real volumes

What About Binance and Kraken?

Binance stands out as the only exchange not registered with the U.S. Department of Treasury as an MSB, and Kraken stands out as the only significant U.S. exchange that has failed to pursue a

¹³⁵ "Bitfinex Adopts Trade Surveillance Platform Irisium," Irisium press release, March 14, 2018. <https://www.irisium.com/news/bitfinex-adopts-trade-surveillance-platform-irisium>

¹³⁶ "Crypto Exchange Bitstamp Rolls Out Tech to Spot Market Manipulation," Anna Baydakova, CoinDesk, November 27, 2019.

<https://www.coindesk.com/crypto-exchange-bitstamp-rolls-out-tech-to-spot-market-manipulation>

¹³⁷ "Coinbase has been working on a new program to police its markets, and it has hired a former New York Stock Exchange exec to lead the effort," Frank Chaparro, Business Insider, July 7, 2018.

<https://www.businessinsider.com/coinbase-market-surveillance-program>

¹³⁸ "Gemini To Launch Market Surveillance Technology In Collaboration With NASDAQ," NASDAQ press release, April 25, 2018.

<http://ir.nasdaq.com/news-releases/news-release-details/gemini-launch-market-surveillance-technology-collaboration>

¹³⁹ "NICE Actimize Selected By Crypto Finance Leader Circle To Implement Markets Surveillance And Protections Strategy," NICE Actimize press release, February 27, 2019.

<https://www.niceactimize.com/press-releases/NICE-Actimize-Selected-by-Crypto-Finance-Leader-Circle-to-Implement-Markets-Surveillance-and-Protections-Strategy-254>

BitLicense.¹⁴⁰ These are not accidental oversights: Both exchanges have been proactive in expressing their viewpoints on crypto regulation, detailing a strong preference for self-regulation and broad concerns about regulatory overreach.¹⁴¹

This does not mean that they've sat idle with regards to AML, KYC, or other concerns; in fact, they have been aggressive in adopting internal tools to address these issues through technology.

For example, on October 17, 2018, Binance completed the roll-out of Chainalysis' compliance software suite, which uses "pattern recognition, proprietary algorithms and millions of open source references to identify and categorize thousands of cryptocurrency services to raise live alerts on transactions involved in suspicious activity."¹⁴² In November 2018, it partnered with Refinitiv (formerly the Finance & Risk division of Thomson Reuters) to implement an automated Know Your Customer (KYC) platform on its exchange.¹⁴³ The firm augmented this in March 2019 by partnering with IdentityMind, a reg-tech firm that bills itself as "the only real-time onboarding, transaction monitoring, and case management solution built for digital currency exchanges." IdentityMind says it offers comprehensive KYC and AML services built exclusively for the blockchain.¹⁴⁴

Kraken has been active in various self-regulatory efforts in crypto ecosystem since its creation. The firm was one of the initial founding members of the Digital Asset Transfer Authority, an industry group founded in 2014 with the goal of being the self-regulatory body for crypto.¹⁴⁵ It also played a key role in the establishment of Japan's self-regulatory body, JADA, which was formed at the behest of the Japanese government as part of its efforts to regulate the space.¹⁴⁶ It has also

¹⁴⁰ Bittrex has pursued a BitLicense, but was denied by the NYSDFS. "New York Rejects Bittrex Exchange's BitLicense Application," Nikhilesh De, CoinDesk, April 10, 2019.

<https://www.coindesk.com/new-york-rejects-bittrex-exchanges-bitlicense-application>

¹⁴¹ See, for instance, "Kraken's Position on Regulation," Kraken, April 22, 2018.

<https://blog.kraken.com/post/1561/krakens-position-on-regulation>

¹⁴² "Chainalysis Partners with Binance to Tackle Global Cryptocurrency Money Laundering," PR Newswire, October 17, 2018.

<https://www.prnewswire.com/news-releases/chainalysis-partners-with-binance-to-tackle-global-cryptocurrency-money-laundering-300732667.html>

¹⁴³ "Refinitiv Provides KYC Automation For Cryptocurrency Exchange Binance," Refinitiv, November 20, 2018.

<https://www.refinitiv.com/en/media-center/press-releases/2018/november/refinitiv-provides-kyc-automation-for-cryptocurrency-exchange-binance>

¹⁴⁴ "Binance Partners with IdentityMind to Enhance Compliance and Data Security Measures," Binance, March 25, 2019.

<https://www.binance.com/en/blog/317231329092952064/Binance-Partners-with-IdentityMind-to-Enhance-Compliance-and-Data-Security-Measures>

¹⁴⁵ "Virtual Currency Enthusiasts To Launch Self-Regulatory Group," Robin Sidel, The Washington Post, July 30, 2013.

https://www.washingtonpost.com/business/technology/bitcoin-industry-leaders-set-up-standards-group/2013/07/30/8ce4d73c-f94c-11e2-afc1-c850c6ee5af8_story.html

¹⁴⁶ "Japan Virtual Currency Firms To Launch Industry Group," Takashi Mochizuki, The Wall Street Journal, July 3, 2014.

<https://blogs.wsj.com/japanrealtime/2014/07/03/japan-virtual-currency-firms-to-launch-industry-group>

expressed its intention to register as a broker-dealer and an alternative trading service (ATS),¹⁴⁷ and through its February 2019 acquisition of Crypto Facilities, now owns an entity regulated under the UK's Financial Conduct Authority.¹⁴⁸

The goal in articulating these points of view is not to suggest that either Binance or Kraken's position is right, or that self-regulatory efforts exist *pari passu* with traditional regulation. Bitwise is a strong supporter of enhanced regulation and consumer protections in the crypto space. It's simply to acknowledge that the libertarian ethos that informed the earliest days of crypto remains present in the ecosystem, and to provide color on how these firms approach issues like AML and KYC guidelines absent direct regulatory guidance.

From the perspective of this study, the trading on these exchanges are real and prices are tightly integrated with other markets.

4. Trading Spreads On The Real Bitcoin Spot Market Are Substantially Tighter Than Conventional Wisdom Believes

In most traded financial instruments, there is a strong relationship between volume traded and average spreads.¹⁴⁹ It is common sense: The more people trade something, the more efficient that market should become.

But this isn't true if you look at the data from popular crypto aggregators. For example, Coinbene—an exchange that reports more than \$500 million in volume—has a median spread of \$12.22¹⁵⁰, while Coinbase with \$70 million in volume has a median spread of \$0.01.¹⁵¹

This confusion exists because the data and volume on many exchanges is fake. The reality is that the real bitcoin spot market is extremely efficient, with spreads that rank amongst the lowest for any quoted financial instrument in the world.

For the ten exchanges that pass all of Bitwise's tests, the average of the median spread on each exchange in April was \$1.31. The five most liquid real exchanges—Binance, Bitfinex, Coinbase, Kraken, and Bitstamp—had median spreads of just \$1.12, \$0.10, \$0.01, \$0.40, and \$1.75¹⁵²,

¹⁴⁷ "Crypto Exchange Kraken Says It Will Probably Register With The SEC," Lily Katz and Annie Massa, Bloomberg, May 15, 2018. <https://www.bloomberg.com/news/articles/2018-05-15/crypto-exchange-kraken-says-it-will-probably-register-with-sec>

¹⁴⁸ "Kraken Acquires Crypto Derivatives Platform And Index Providers, Crypto Facilities, In Nine-Figure Deal," Kraken press release, February 4, 2019. <https://blog.kraken.com/post/2089/kraken-acquires-crypto-derivatives-trading-platform-and-index-provider-crypto-facilities-in-nine-figure-deal-official-press-release>

¹⁴⁹ See, for example, "ETFs, Spreads and Liquidity," Matthew Hougan, Journal of Indexes, June 12, 2008. <https://www.etf.com/publications/journalofindexes/joi-articles/4221-etfs-spreads-and-liquidity.html>

¹⁵⁰ Data collected by Bitwise.

¹⁵¹ Data collected by Bitwise.

¹⁵² Data collected by Bitwise.

respectively. When you consider that bitcoin traded around \$5,000 in April, that means that the median spread on the largest real exchanges ranged from 0.01%-0.03% during the month.

The relationship between trading volume and spread size is not perfect, as it is constrained by exchange-level fees, tick size, and other factors. Still, the relationship is strong, and the spreads on real exchanges are extremely small.

5. The Regulated Bitcoin Futures Market Is Substantially Larger In Comparison To The Bitcoin Spot Market Than Conventional Wisdom Believes

The U.S. market for regulated bitcoin futures launched in December 2017, when both the Chicago Board Options Exchange (Cboe) and the Chicago Mercantile Exchange (CME) launched cash-settled bitcoin futures contracts. Since that time, volume for those contracts has grown substantially, with the vast majority linked to the CME’s contract.¹⁵³ The chart in Figure 22 shows the average number of contracts traded daily on a month-by-month basis since inception.

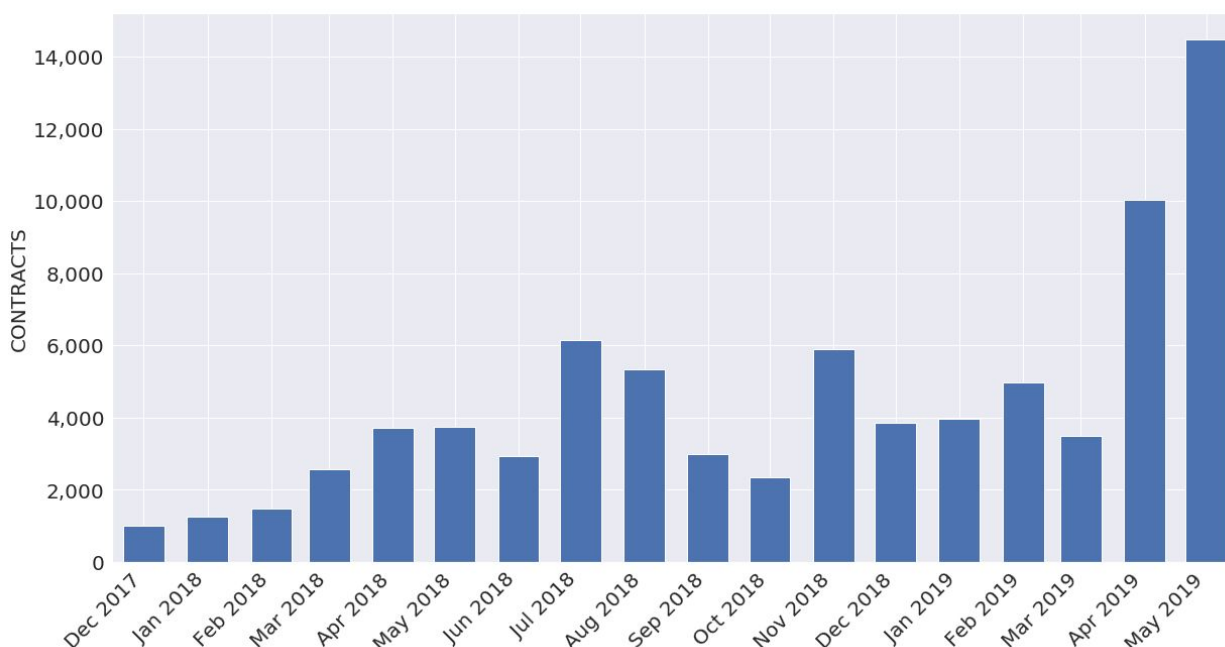


Figure 22: Average number of futures contracts traded daily by month since inception¹⁵⁴

¹⁵³ From December 2017 to April 2019, the combined average daily volume in bitcoin of CME and Cboe Bitcoin Futures has grown from 9,286 bitcoin to 69,177 bitcoin, representing a growth of 645%. During that same period, volume on CME has grown from 57% to 98% of the total regulated bitcoin futures market. Note that each CME Futures Contract represents 5 bitcoin, while each Cboe Futures Contract represents 1 bitcoin, so we compared volume in bitcoin rather than in number of contracts.

CME data from CME Group external email to clients and “CME bitcoin futures trading clocks in a number of new records in May,” The Block, May 21, 2019.

<https://www.theblockcrypto.com/tiny/cme-bitcoin-futures-trading-number-of-accounts-hit-new-records-in-may/>
 Cboe data from https://markets.cboe.com/us/futures/market_statistics/historical_data

¹⁵⁴ CME ADV for May 2019 is up to May 20. Data from CME.

The size of the regulated bitcoin futures markets is of critical importance, because it has been identified as one of the factors that can be considered in evaluating proposals to list a bitcoin ETF.

In its July 26, 2018, order disapproving the proposal to list the Winklevoss Bitcoin Trust¹⁵⁵ (the “Winklevoss Order”), the U.S. Securities and Exchange Commission noted the following:

While the record before the Commission ... does not support a conclusion that bitcoin derivatives markets have attained significant size, the Commission notes that regulated bitcoin-related markets are in the early stages of their development. Over time, regulated bitcoin-related markets may continue to grow and develop. For example, existing or newly created bitcoin futures markets may achieve significant size, and an ETP listing exchange may be able to demonstrate in a proposed rule change that it will be able to address the risk of fraud and manipulation by sharing surveillance information with a regulated market of significant size related to bitcoin, as well as, where appropriate, with the spot markets underlying relevant bitcoin derivatives.

This is a correct finding, given that the Rule 19b-4 Filing in support of the Winklevoss application did not address the issue of real and fake volume in the crypto market, and if you use the reported spot bitcoin volume as the measuring stick, the bitcoin futures market looks tiny. For example, the average daily volume for the CME and Cboe futures markets during April was a combined \$268 million, which is just 2.4% of the size of the reported \$11 billion in trading volume.

But if you use the real bitcoin spot market as the denominator, the regulated futures volume looks much more important. The real spot bitcoin volume in April was \$554 million, which means the bitcoin futures market was 48% the size of the spot market.

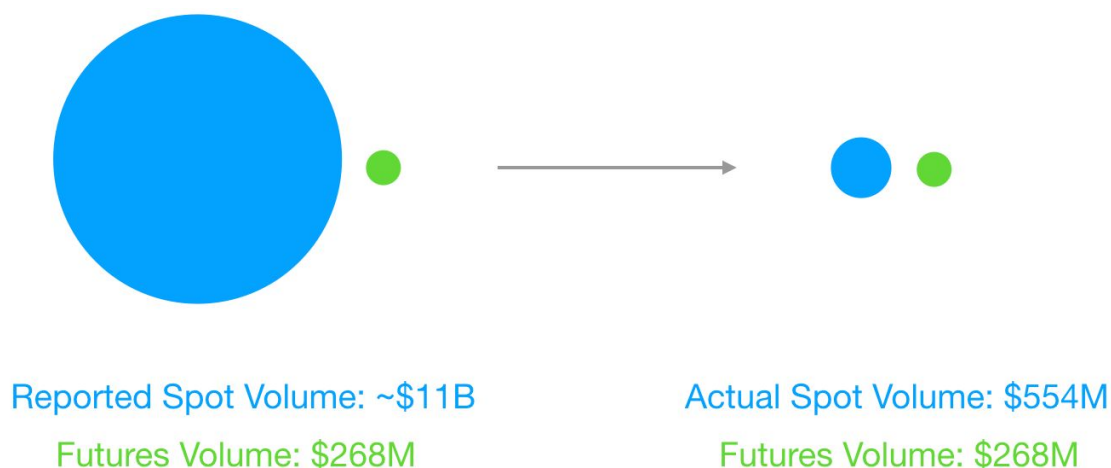


Figure 23: Comparison of futures volume to reported and actual spot volume¹⁵⁶

¹⁵⁵ “Order Setting Aside Action by Delegated Authority and Disapproving a Proposed Rule Change, as Modified by Amendments No. 1 and 2, to List and Trade Shares of the Winklevoss Bitcoin Trust,” Securities and Exchange Commission, July 26, 2018. <https://www.sec.gov/rules/other/2018/34-83723.pdf>

¹⁵⁶ Data from CME, Cboe, CoinMarketCap.com, and Kaiko. April 1-30, 2019.

The significance of the bitcoin futures market looms larger when you compare it to individual exchanges: If measured against real spot bitcoin exchanges, the CME would rank as the largest exchange, ahead of Binance and more than twice as large as the third largest exchange, Bitfinex.

Exchange	April ADV	Domicile
CME	\$257,799,672	US
Binance	\$217,602,085	Malta
Bitfinex	\$78,164,783	Hong Kong
Coinbase Pro	\$73,225,467	US
Kraken	\$61,267,275	US
Bitstamp	\$58,635,892	UK
bitFlyer	\$26,984,684	Japan
Gemini	\$14,581,046	US
itbit	\$12,150,837	US
CBOE	\$9,867,900	US
Bittrex	\$7,806,571	US
Poloniex	\$4,069,706	US

Table 10: Global bitcoin spot ADV vs. regulated bitcoin futures ADV by exchange¹⁵⁷

The significance of the regulated bitcoin futures has grown substantially over time, as shown in the chart below, which expresses regulated bitcoin futures volume as a percentage of real spot bitcoin volume on a month-by-month basis since the launch of those futures in December 2017.

¹⁵⁷ Data from CME and Kaiko.

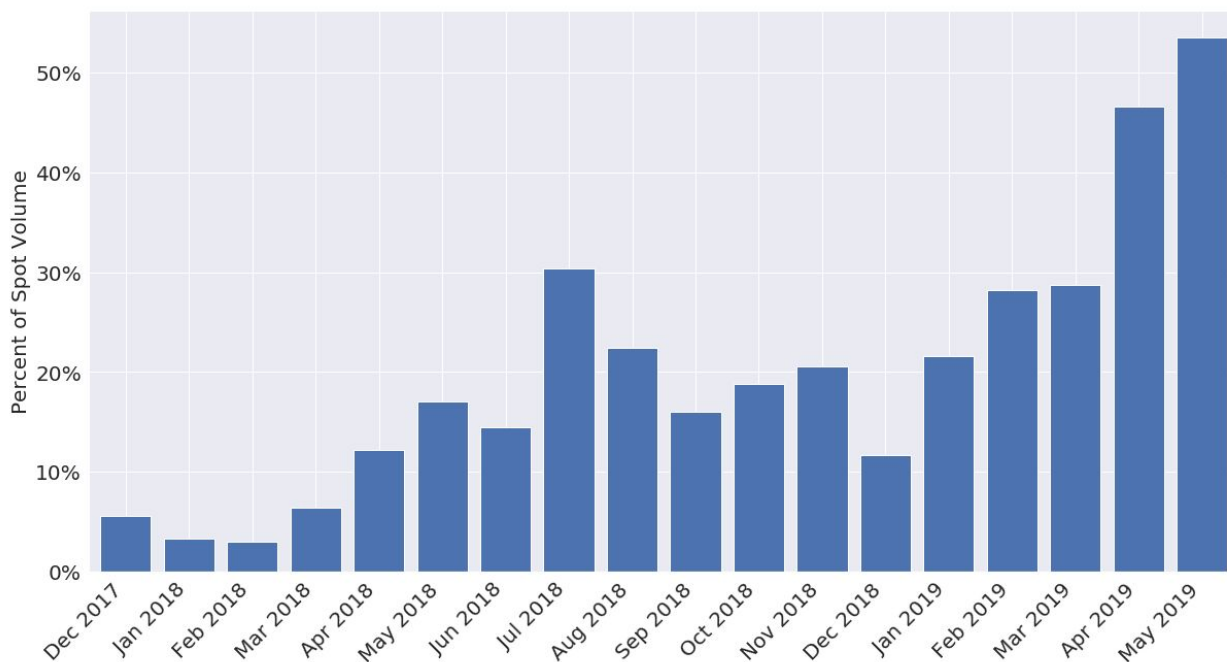


Figure 24: Regulated bitcoin futures volume as a percentage of real bitcoin spot volume by month¹⁵⁸

The Commission has defined a significant derivatives market as one where someone attempting to manipulate the spot market would be reasonably likely to have to trade in the derivatives market as well. The bitcoin futures market would clearly not satisfy that requirement if the bitcoin spot market were really trading \$11 billion per day, but our new understanding of the true size of the bitcoin spot market reshapes this discussion considerably.

B. The Remarkable Quality of Arbitrage Across Exchanges In The Real Bitcoin Spot Market

Most publicly traded financial instruments, including stocks, Treasuries and futures, have a single, widely agreed upon price. The “price” of Apple stock, for instance, is simply the last price at which the stock traded on the Consolidated Tape.¹⁵⁹ While there are currently 25 different National Securities Exchanges in the US¹⁶⁰, Regulation NMS requires them to coordinate into what amounts to a single market, ensuring that investors receive the best price when trading.

The bitcoin market, however, doesn’t have a single Consolidated Tape, nor anything similar to Regulation NMS that ensures that prices and spreads are coordinated across the 10 real volume

¹⁵⁸ Bitcoin futures volume and spot volume for May 2019 is up to May 20.

¹⁵⁹ The Consolidated Tape is overseen by the Consolidated Tape Network. It aggregates the last trade and volume statistics from all major national equity markets. The phrase “Consolidate Tape” is often used to refer to the entirety of the public equity market.

¹⁶⁰ Securities and Exchange Commission, National Securities Exchanges, as of May 10, 2019. <https://www.sec.gov/fast-answers/divisionsmarketregmrexchangesshtml.html>

spot bitcoin exchanges. Instead, it relies on effective arbitrage and institutional market makers to keep prices in-line.

In the aforementioned Winklevoss Order, the U.S. Securities and Exchange Commission noted the following regarding arbitrage analysis:

BZX, the Overdahl Letter, and the Lewis Letter offer no data or analysis regarding the actual effectiveness of arbitrage in the bitcoin spot market, either in terms of how closely prices are aligned across different bitcoin trading venues or how quickly price disparities are arbitrated away.

In this critique against unsubstantiated claims of effective arbitrage in the bitcoin spot market, the Commission laid out two clear criteria for demonstrating effective arbitrage:

- Analysis on how closely prices are aligned across different bitcoin trading venues; or
- How quickly price disparities are arbitrated away.

We will provide analysis on both criteria.

1. Real-Time Consolidated Spot Price

In order to conduct arbitrage analysis, it is first necessary to set a benchmark price for bitcoin; after all, you can't tell if an exchange deviates from the global price of bitcoin without first *establishing* the global price of bitcoin.

For the purposes of this study, we've decided to use an equal weighted price of the 10 real volume exchanges we're investigating arbitrage between. Every second, we take the last traded price of each of the 10 exchanges and equal-weight average them to calculate a real-time consolidated spot price, which we'll continue to refer as "consolidated price."

The reason we decided to use equal-weighting for the purposes of this paper, rather than some form of volume-weighting, is to remove any doubt or complication in interpretation of the arbitrage analysis results that one exchange only appears to trade closely to a consolidated price because it has an undue influence over the consolidated price compared to other exchanges.

2. The Low Levels Of Average Deviations

The first thing that many observers consider when evaluating arbitrage quality is simply to chart prices together: If you plot the price of bitcoin on all ten exchanges on the same chart, are they in-line with each other?

Clearly, by that measure, bitcoin passes: It is difficult to see meaningful gaps between the prices on each of the ten exchanges.

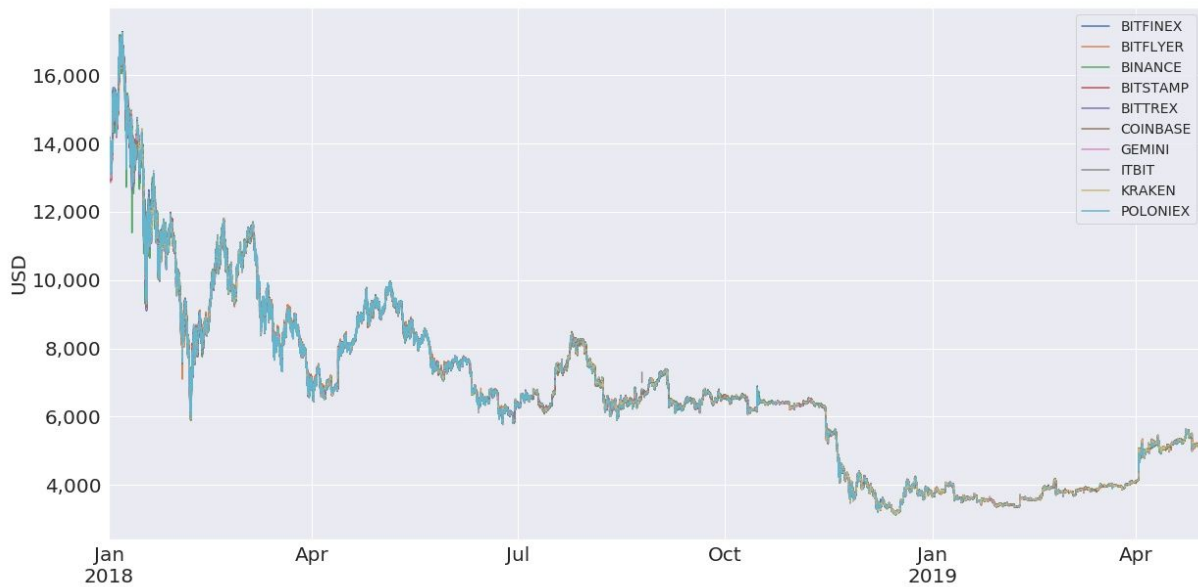


Figure 25: Bitcoin price on each of the 10 exchanges since January 2018¹⁶¹

However, a simple price chart is not a particularly scientific way to examine if prices are closely aligned. A better approach is to look at the average deviation of the price on each exchange from the consolidated price.

We examined the average deviation from the consolidated price for each exchange on a second-by-second basis from the beginning of 2019 and found that the exchanges trade incredibly tightly. The average deviation for any given exchange ranged from 0.06% (on Coinbase) to 0.20% (on Bitflyer), with the average deviation across all exchanges at 0.12%.

¹⁶¹ Data from Kaiko.

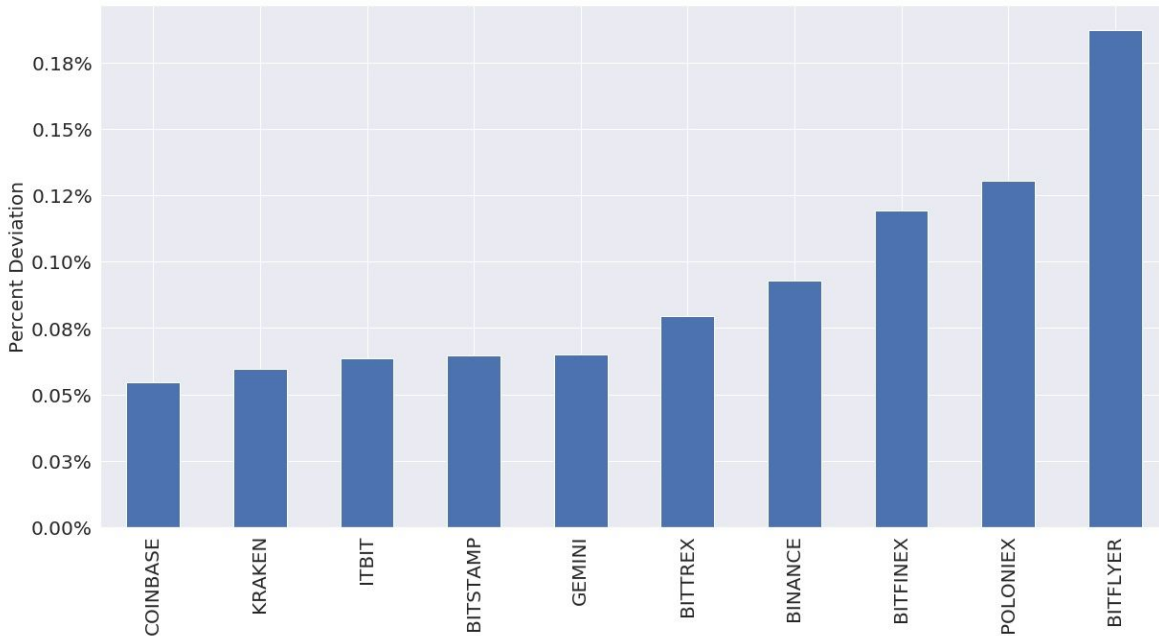


Figure 26: Average bitcoin price deviation from consolidated price by exchange¹⁶²

These results are well within the exchange-level arbitrage constraints for the system. “Taker” trading fees alone on the 10 exchanges, for instance, run from 0.04%¹⁶³ to 0.35%¹⁶⁴, which you would have to incur on both sides of the trade in order to immediately capture the arbitrage opportunity.

Given such constraints, 0.12% average deviation across the ten exchanges, a value well within the arbitrage band, is even more impressive. It suggests that institutional-quality arbitrageurs and algorithmic programs are in place that monitor the system and identify and capitalize on any pricing discrepancies to constantly keep the prices closely together.

3. The Speed At Which Pricing Discrepancies Are Arbitrated Away

Average deviations are one thing; another critical question is how fast significant deviations are arbitrated away. In the presence of strong arbitrage forces, deviations outside of the arbitrage band should be short-lived. That is exactly what the data shows for bitcoin.

We examined every instance in which the price of bitcoin on any particular exchange deviated by more than 1% from the consolidated price for the past 12 months starting from April 1, 2018. As the chart in Figure 27 shows, these instances—rare to begin with—were quickly arbitrated away.

¹⁶² Data from Kaiko.

¹⁶³ Binance Fee Schedule: <https://www.binance.com/en/fee/schedule>

¹⁶⁴ Gemini Fee Schedule: <https://gemini.com/api-fee-schedule/#overview>

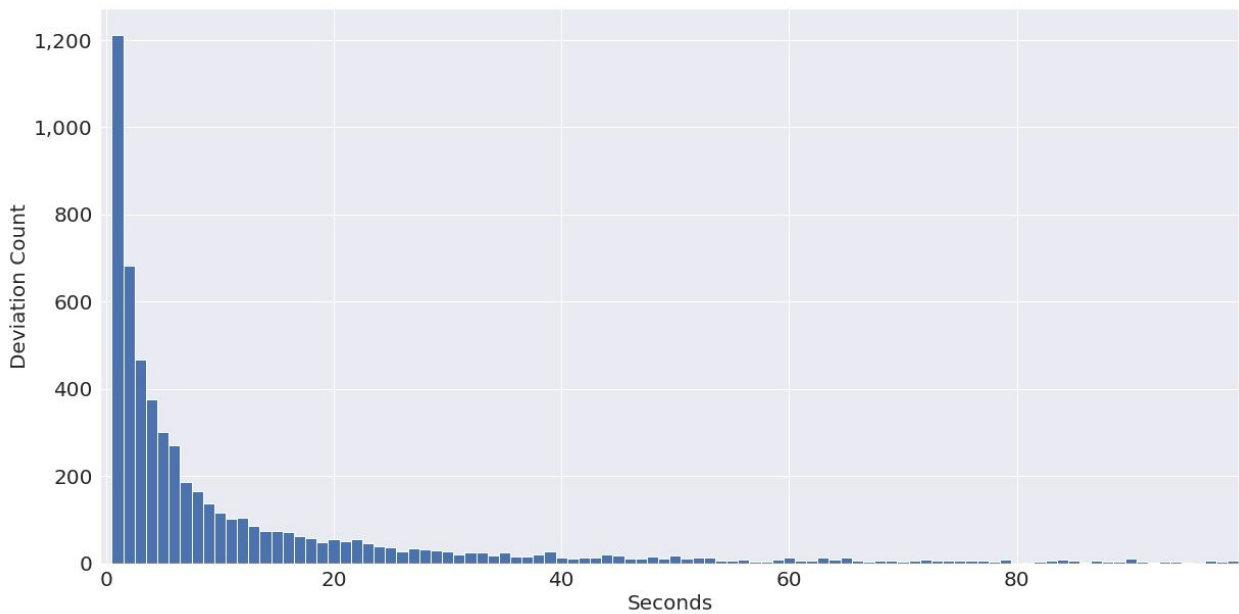
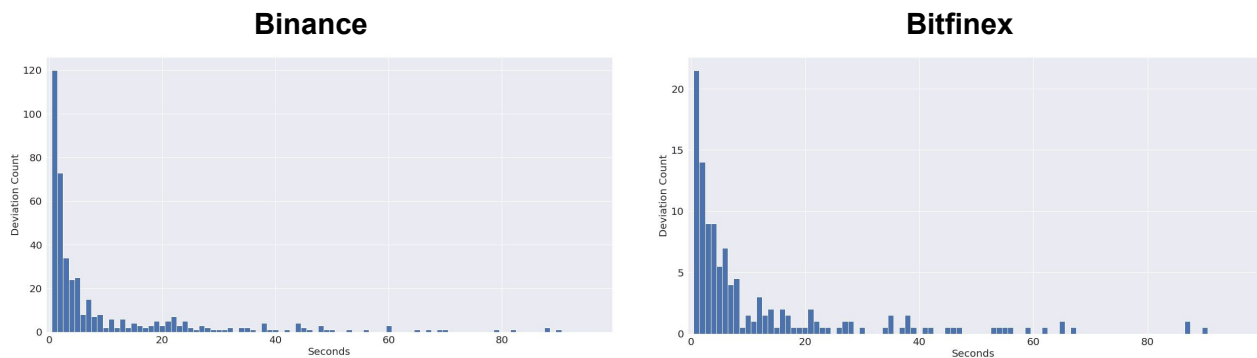


Figure 27: Histogram of duration of 1% price deviations from consolidated price across all exchanges¹⁶⁵

Each bar indicates the number of instances where one of the ten spot exchanges had a price deviation greater than 1% away from the consolidated spot for a specific number of seconds. For example, the first bar indicates that there were 1,200 instances of price deviations that lasted less than a single second. The second bar indicates that there were roughly 700 instances of price deviations that lasted between one and two seconds, and so on. In aggregate, more than 50% of all 1% pricing discrepancies were arbitrated away within 5 seconds, and more than 90% of all 1% pricing discrepancies were arbitrated away within 34 seconds.

The results are remarkably consistent across all exchanges, as shown on the charts below.



¹⁶⁵ Data from Kaiko.

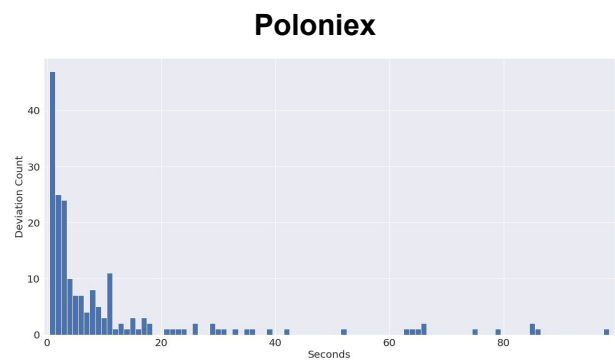
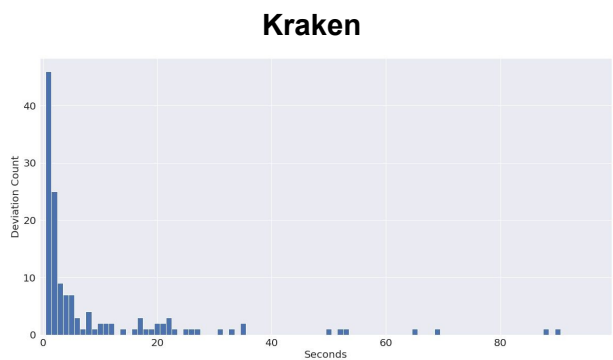
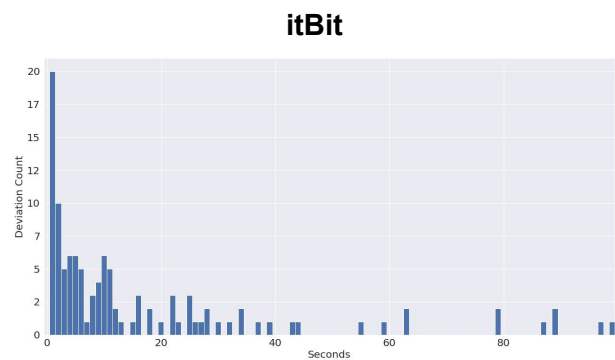
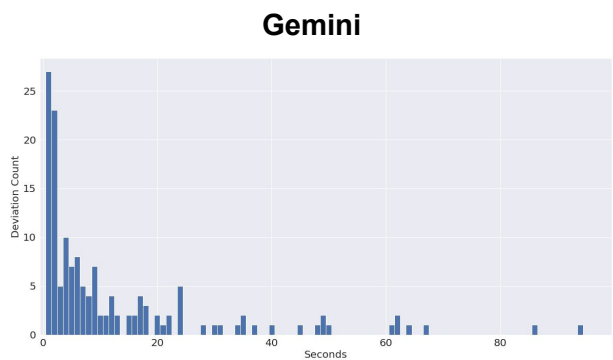
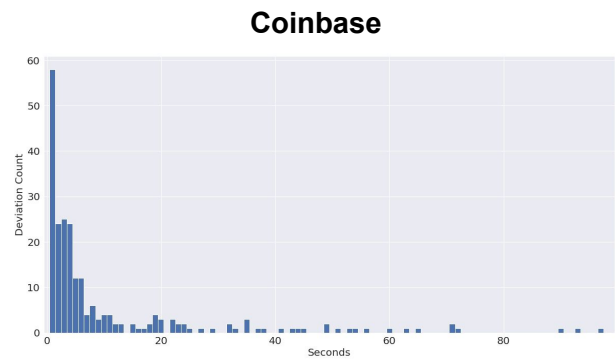
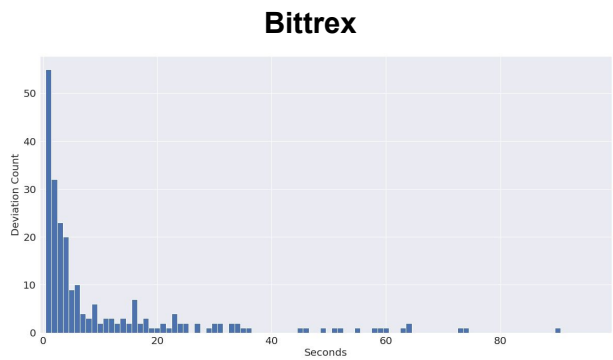
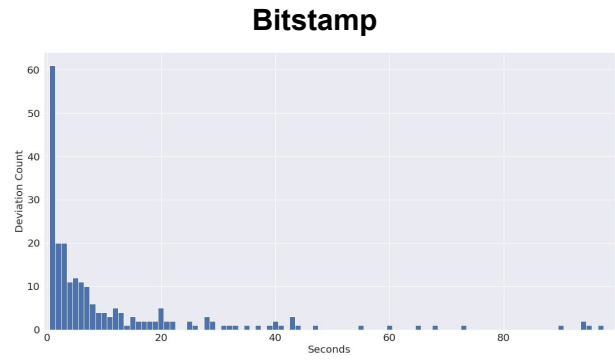
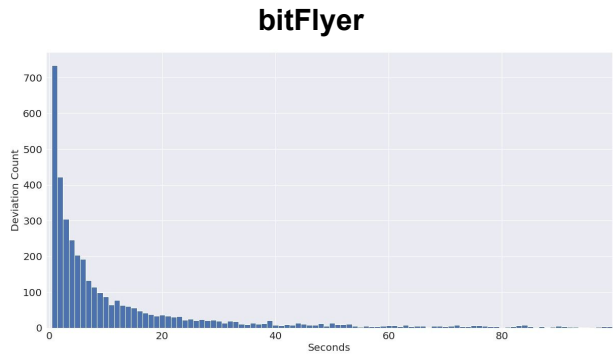


Figure 28: Histogram of duration of 1% deviations from consolidated price by exchange¹⁶⁶

¹⁶⁶ Data from Kaiko.

All 10 exchanges exhibit the same pattern of rapid arbitrage for deviations that exceed 1%.

These results demonstrate that prices between the 10 exchanges not only trade closely together but also have their disparities rapidly arbitrated away, meeting both criteria set forth by the Commission for demonstrating effective arbitrage.

It also suggests that while bitcoin does not have a Consolidated Tape maintained by regulations such as Regulation NMS, it has a global network of spot exchanges tightly arbitrated to trade in lockstep with each other, forming a single global price.

C. The Limitations Of Arbitrage Quality

Given the globally fungible nature of bitcoin, some observers may ask: Why do *any* deviations exist?

The answer is friction: Arbitrage works perfectly in a theoretical, frictionless world, but in the real-world, natural frictions intrude. For bitcoin, these frictions include:

Trading Fees

Each of the ten exchanges with significant real volume assess some level of trading fees, which puts a natural cap on arbitrage. For example, Binance's fees range from 0.02% to 0.10%, depending on your 30-day trading volume and whether you are a maker or a taker of liquidity.¹⁶⁷ Coinbase Pro's fees range from 0.00% to 0.25%, with the lowest fee reserved for traders who make liquidity (maker) and trade more than \$50 million in a 30-day window.¹⁶⁸

Withdrawal Fees

Exchanges may charge fees for withdrawing either cash or cryptoassets from the exchange. These fees can range from a little to a lot. Binance, for instance, charges 4.8 USDT to withdraw tether¹⁶⁹; Bitfinex, while charging similar amounts for tether withdrawals, charges 3% for substantial USD withdrawals.¹⁷⁰

¹⁶⁷ Binance Fee Schedule as of May 17, 2019: <https://www.binance.com/en/fee/schedule>

¹⁶⁸ Coinbase Fee Schedule as of May 17, 2019:

<https://support.pro.coinbase.com/customer/en/portal/articles/2945310-fees>

¹⁶⁹ Note: Binance adjusts withdrawal fees on a regular basis to reflect blockchain conditions. The latest fees are listed here: <https://www.binance.com/en/fee/schedule>. Data in the text as of May 17, 2019.

¹⁷⁰ Bitfinex Fee Schedule as of May 17, 2019: <https://www.bitfinex.com/fees>

Withdrawal Times & Hedging Costs

Exchanges can take significant amounts of time to process withdrawals, particular for fiat currency withdrawals; arbitrageurs must build this into their model and incorporate the hedging costs required before a trade can be executed.

Default And/Or Hack Risk

Arbitrageurs must keep assets at an exchange in order to capitalize on short-term price discrepancies. But some crypto exchanges have historically experienced hacks, and do not have the same level of financial security as traditional exchanges. By keeping assets on exchange, arbitrageurs expose themselves to the risk of loss. They may model this risk into their prices and may insist on wider arbitrage bands if risks are heightened.

Country and FX

Even without capital controls, arbitrage across borders is more difficult than arbitrage within a single country. FX movements between different fiat currencies create a confounding variable in the arbitrage process, and differing regulations may reduce the number of arbitrageurs operating in multiple country jurisdictions.

The existence of all of these frictions makes the extremely tight pricing observed in the data all the more impressive, and further strengthens confidence that effective arbitrage exists within this marketplace.

D. The Implications Of Discovering Effective Arbitrage Across Exchanges

All of the data suggests that effective arbitrage exists across the 10 exchanges with substantial, real spot bitcoin trading volume. Average deviations are small and easily explained by the natural frictions inherent to the marketplace, and when meaningful deviations appear they are rapidly arbitrated away.

This means that these exchanges form what amounts to a single market. Liquidity is shared between the exchanges, and bitcoin trades on these exchanges at what amounts to a single price.

E. Common Misunderstandings Regarding Pricing In The Bitcoin Spot Market

Popular data aggregators like CoinMarketCap.com regularly report bitcoin prices trading hundreds of dollars apart, and the popular media often talks about the arbitrage opportunities available in the bitcoin market.

These stories and this data are usually driven by one of three simple factors:

1. Wrong Prices: Exchanges that exaggerate and fake volume display prices that generally mirror the real bitcoin spot market. However, these algorithms are imperfect, since they rely on trend-following software rather than the presence of effective arbitrage. As a result, they show higher deviations from the consolidated price than exchanges with real volume.

2. Capital-Controlled Markets: Bitcoin prices on exchanges operating in capital controlled markets can trade at significant sustained premiums or discounts versus exchanges in the integrated global market. This is because capital controls makes it difficult or impossible to complete the arbitrage circuit, effectively stranding these economies as their own closed markets, subject to internal supply and demand issues. The difficulty in arbitraging prices in capital-controlled markets is documented in the January 9, 2018, Bloomberg article, "Bitcoin's 43% Arbitrage Trade Is A Lot Harder Than It Looks," by Julie Verhange, Whanwoong Choi and Kyungji Cho.¹⁷¹

Of note: Due to this restriction on arbitrage, Bitwise excluded exchanges domiciled in capital-controlled markets from this analysis. This included South Korean exchanges like Upbit, Bithumb, Coinone, and Korbit among others.¹⁷²

3. Stablecoin Conversion: Certain exchanges, including Binance, the largest bitcoin exchange, elect to conduct their trading in cryptographic stablecoins rather than in the U.S. dollar. These coins are intended to maintain a stable price of \$1.00, and many popular data aggregators (including CoinMarketCap.com) assume that they do that perfectly when calculating prices.

In reality, however, these stablecoins act like currencies, with values that fluctuate in and around \$1.00. Often, the fluctuations are small, but they can be significant in certain circumstances. The chart below shows the US dollar value of Tether, the most popular stablecoin, which has fluctuated between \$0.91 and \$1.05 over the course of the past year.

¹⁷¹ "Bitcoin's 43% Arbitrage Trade Is A Lot Harder Than It Looks," Julie Verhange, Whanwoong Choi and Kyungji Cho, Bloomberg, January 9, 2018. <https://www.bloomberg.com/news/articles/2018-01-09/bitcoin-s-43-arbitrage-trade-is-a-lot-tougher-than-it-looks>

¹⁷² Many of the Comment Letters that were submitted in response to the Winklevoss Bitcoin Trust application noted the large premiums that exist in markets like China and South Korea as an example of the market's inefficiency. These Comment Letters failed to take into account the nature of capital-controls.

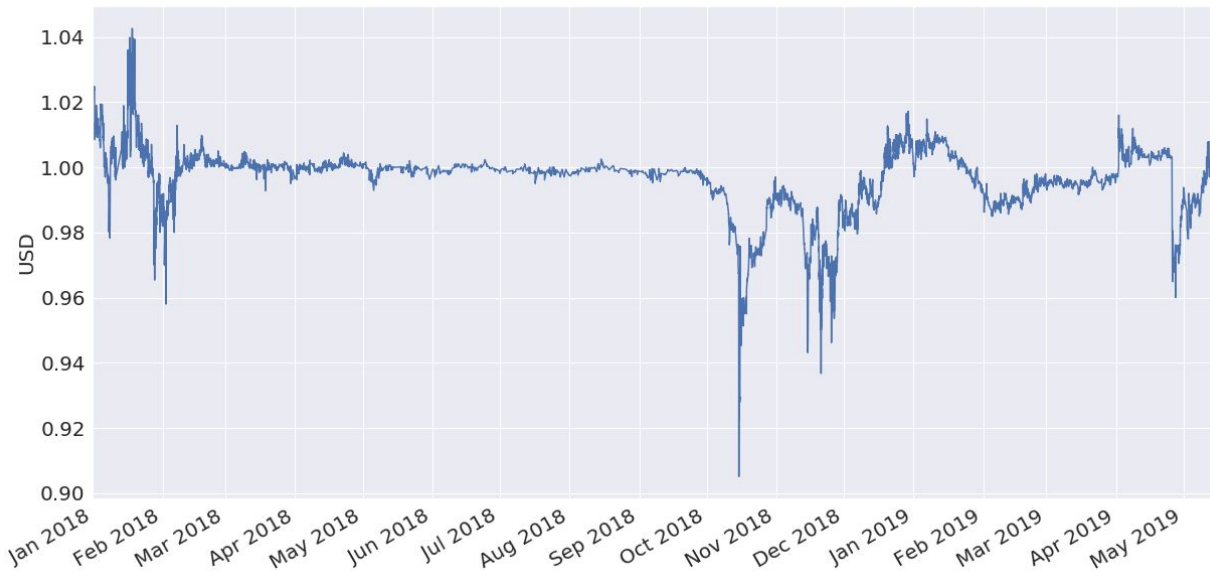


Figure 29: Price of Tether in USD since January 2018¹⁷³

Arbitrageurs actively incorporate the fluctuating nature of Tether and other stablecoins into the prices of bitcoin on different exchanges, but major data aggregators do not.

For instance, if bitcoin is trading for \$5,000 on a U.S. dollar exchange like Coinbase, and Tether is trading at a price of \$0.99, an exchange like Binance that trades a BTC-Tether pair will typically show a price of 5,050. This is economically equivalent to the price on Coinbase, as $5,050 * \$0.99 = \$5,000$. But CoinMarketCap will display Binance's price as if each Tether is worth \$1.00, meaning it will show a price of \$5,050, making it appear like Binance is trading at a premium. When Tether's price deviates more substantially from \$1.00, the impact can become large quickly.

Bitwise incorporates the currency conversion rate for stablecoins into its calculations, which eliminates much of the premiums and pricing discrepancies seen on popular websites.

F. Do Prices On Exchanges With Fake Volume Influence The Real Spot Market?

Following the initial publication of the Bitwise Study, which first revealed that 95% of all spot bitcoin trading volume is fake, one of the most common questions we received was: Does fake volume lead to fake prices? That is, is the real bitcoin spot market influenced by the prices printed on exchanges that fake volume?

¹⁷³ Data from Kaiko

How would fake prices influence the real market?

There are only two ways that the prices on exchanges with fake volume could influence prices on exchanges with real volume. Either:

1. Market actors could take prices on exchanges with fake volume as a legitimate market signal and adjust their view of the market as a result.
2. If arbitrage could exist between exchanges with fake volume and the real spot market, the invisible hand of arbitrage could spread the impact of the fake exchange's prices across the rest of the market.

In reality, arbitrage cannot exist between two exchanges where one does not have real and meaningful liquidity. So exchanges with a preponderance of fake volume cannot and do not participate in the coordinated central liquidity pool or automatically influence the consolidated price just by having a different price of their own.

So the remaining important question is the following.

Do market actors view exchanges with fake volume as legitimate market signals?

A preponderance of evidence suggests investors do not view the prices or volumes on exchanges with fake volume as legitimate market signals.

- **All regulated financial products draw prices from a subset of the 10 exchanges that Bitwise identifies as having real volume.**

There are a number of regulated financial products on the market today, including regulated bitcoin futures in the U.S. and listed bitcoin exchange-traded products in Europe. While each product has its own mechanism for pricing bitcoin, they all draw prices almost exclusively from a subset of the exchanges identified as having real volume in the bitcoin market.

This is remarkable, considering that Coinbase Pro, the highest in volume amongst the exchanges used for pricing regulated bitcoin products, ranked only 37th largest exchange on CoinMarketCap.com by average daily volume in April. The fact that no one selected any of the dozens of fake exchanges with larger reported volumes suggests that the institutional investor marketplace understands that real price discovery does not take place on such fake volume exchanges and are choosing to ignore them.

The listed products and their current pricing sources are as follows:

- **CME Bitcoin Futures:** Bitstamp, Coinbase Pro, itBit, Kraken¹⁷⁴
 - **CBOE Bitcoin Futures:** Gemini¹⁷⁵
 - **XBT Bitcoin Tracker One:** Bitstamp, Coinbase Pro, itBit¹⁷⁶
 - **Amun Bitcoin ETF:** Bitstamp, Coinbase Pro, Kraken, Gemini¹⁷⁷
- **Leading crypto arbitrage and execution-focused firms track only exchanges highlighted as having real volume.**

SFOX is a cryptocurrency prime dealer and trading platform that has processed more than \$11 billion in crypto trades for funds, family offices, and high-net worth individuals since 2014.^{178 179} They do not operate an exchange themselves but rather provide order routing and trading algorithms for best execution across multiple exchanges.

They are considered an expert on crypto trade execution and arbitrage, and have written widely on the topic.¹⁸⁰ The firm even has an automated Twitter feed that tweets out the existence of arbitrage-able gaps between exchanges in real-time.¹⁸¹

SFOX is incented to highlight as many executable trades as possible, as it makes money off of trading volume. Nonetheless, it only tracks prices on eight exchanges, all of which are members of the ten exchanges Bitwise identified as having real volume: Binance, bitFlyer, Bitstamp, Bittrex, Coinbase Pro, Gemini, itBit, and Kraken.¹⁸²

The fact that a leading crypto prime dealer, with every incentive to identify as many arbitrage opportunities as possible, only focuses on these eight exchanges, is telling.

¹⁷⁴ CME CF Bitcoin Reference Rate and Bitcoin Real-Time Index, CME Group, May 9, 2018.

<https://www.cmegroup.com/education/bitcoin/infographic-cme-cf-brr-and-brti.html>

¹⁷⁵ XBT-Cboe Bitcoin Futures, Cboe. <https://cfe.cboe.com/cfe-products/xbt-cboe-bitcoin-futures>

¹⁷⁶ Bitcoin Tracker One Factsheet: <https://xbtprovider.com/assets/documents/factsheets/XBT.pdf>

¹⁷⁷ Amun Bitcoin ETP Prospectus:

<https://amun.com/uploads/AMUN%20-%20Base%20Prospectus%20-%2013%20November%202018.pdf>

¹⁷⁸ "Why We Decided to Raise \$22.7 Million," SFOX, August 16, 2018.

<https://blog.sfox.com/why-we-decided-to-raise-22-7-million-bd27b01f1e93>

¹⁷⁹ SFOX: <https://www.sfox.com/about.html>

¹⁸⁰ "Bitcoin Arbitrage: How You Can (And Can't) Profit From It," SFOX, July 13, 2018.

<https://blog.sfox.com/bitcoin-arbitrage-how-you-can-and-cant-profit-from-it-e69b46fd526f>

¹⁸¹ SFOX Trading Twitter Account: <https://twitter.com/sfoxtrading>

¹⁸² "The SFOX Crypto Volatility Report: March 2019," SFOX, April 4, 2019.

<https://blog.sfox.com/the-sfox-crypto-volatility-report-march-2019-9c87aec4f604>. Our guess is that they exclude Poloniex because it is too small and illiquid to support meaningful arbitrage trading, and they exclude Bitfinex because it applies a 3% fee on withdrawals, raising certain challenges for institutional arbitrage activity.

- **Data Aggregator League Tables Are Extremely Volatile, With New Exchanges Popping Up All The Time**

The league tables on CoinMarketCap are extremely volatile, in a way that stretches the boundaries of credulity.

Consider, for instance, the number one exchange by reported volume in April, Fcoin, with \$1.7 billion in reported volume. It was also the number one exchange by reported volume in March, with \$802 million in average daily volume. But in February, it was the 55th largest reported exchange, with just \$12 million in reported volume. The crypto market moves fast, but rising from \$12 million in average daily volume to \$1.7 billion in average daily volume is hard to believe.

This volatility in reported volume rank has historically strengthened the market's understanding that these exchanges are fake and can safely be ignored.

While data aggregators have continued to report prices from exchanges with fake volume, real investors know the truth: That the volume on these exchanges is illusory and that many are outright frauds. The reality is that real investors simply ignore these fake exchanges and do not take their prices or volume as legitimate market signal. As the choice of exchanges used to price regulated financial products shows, everyone knows where the real market is.

V. An Evolving Marketplace: Important Developments That Have Transformed The Bitcoin Market Since December 2017

The bitcoin ecosystem moves fast. The first bitcoin was created only ten years ago; today, bitcoin's market capitalization exceeds \$100 billion.

That speed of development explains part of the delta between our finding that the bitcoin market is extremely efficient and the popular belief that holds the opposite point of view. The reality is that the bitcoin market has matured tremendously in recent years, and market of today has little in common with the bitcoin market only a few years ago.

A. The Improved Quality Of The Bitcoin Spot Market

The quality of the bitcoin spot market and the strength of arbitrage in that market has improved dramatically since the start of 2018.

The chart below examines the average deviation of the price of bitcoin on the 10 real spot bitcoin exchanges, as measured against the consolidated price, for each month since January 2018. The data shows a pronounced downward trend, indicating increasingly efficient arbitrage between the various exchanges.

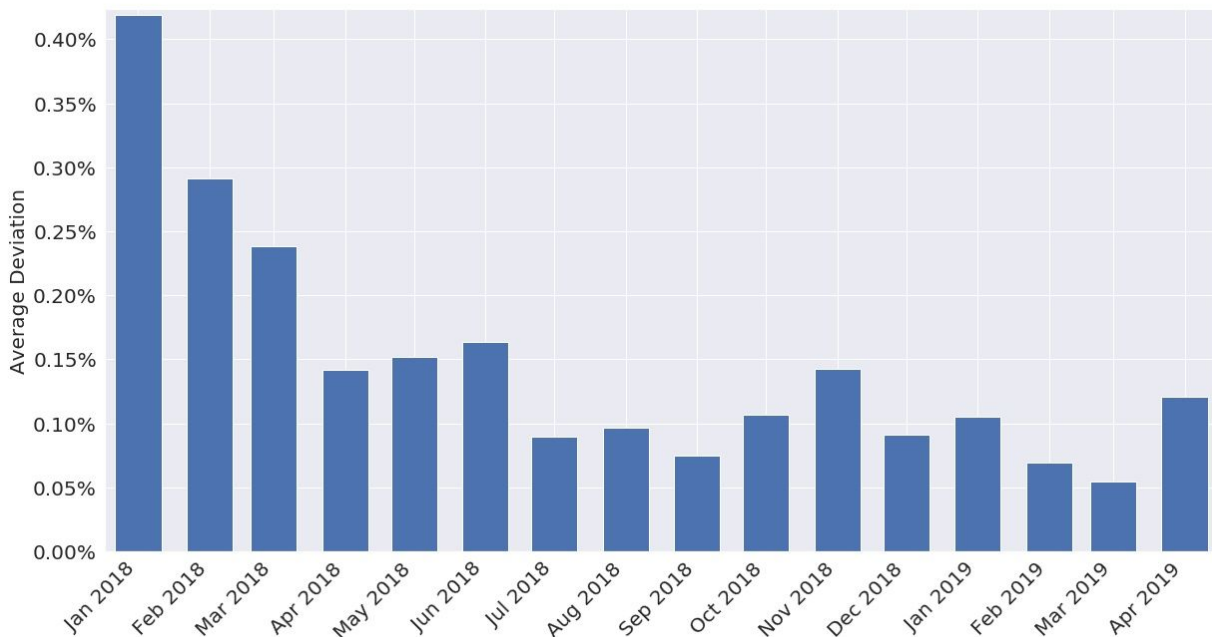


Figure 30: Aggregate average deviation of bitcoin price from consolidated price by month¹⁸³

¹⁸³ Data from Kaiko.

The bulk of the improvements occurred from January 2018 through April 2018, but even since April 2018, the trend has been positive. This comes despite high volatility and (at times) declining overall trading volume, and is driven by a large number of factors that reflect the growing maturity of the space.

B. The Growth Of The Regulated Bitcoin Futures Market

The December 2017 launch of regulated bitcoin futures on the CME and Cboe was a watershed event for the bitcoin market. It fundamentally improved the bitcoin market for the better.

1. Origins, Contract Design, Settlement Pricing and Key Differences

The Cboe launched the first regulated bitcoin futures contract in the U.S. on December 10, 2017.¹⁸⁴ The CME followed one week later on December 17, 2017.¹⁸⁵

Both contracts are monthly, cash-settled contracts, although they use different methodologies to determine the cash settlement price:

- **Cboe:** Draws prices from the 4pm Gemini exchange auction on the settlement day¹⁸⁶
- **CME:** Uses a volume-weighted median pricing methodology that draws prices from Bitstamp, Coinbase Pro, itBit, and Kraken, from 3:00pm - 4:00pm on the settlement day¹⁸⁷

The Cboe contract trades at a value of 1 bitcoin per contract, and trades 23.75 hours per day; the CME contract trades at a value of 5 bitcoin per contract, and trades 23 hours per day. There are other small technical differences relating to margin requirements, tick size, and available order types.

Despite the later launch date, the CME futures contract has dominated the market: On May 13, for instance, the CME futures contract traded \$1.2 billion in notional value, while the Cboe contract

¹⁸⁴ "Cboe announces bitcoin futures to start trading Sunday," Evelyn Cheng, CNBC, December 4, 2017. <https://www.cnbc.com/2017/12/04/cboe-announces-it-will-launch-bitcoin-futures-on-dec-10.html>

¹⁸⁵ "Exchange Giant CME Launches Bitcoin Futures," Alexander Osipovich and Gunjan Banerji, The Wall Street Journal, December 17, 2017.

<https://www.wsj.com/articles/exchange-giant-set-to-launch-bitcoin-futures-after-rival-stumbles-1513432800>

¹⁸⁶ XBT-CBOE Bitcoin Futures Contract Specifications - Final Settlement Value.

<https://cfe.cboe.com/cfe-products/xbt-cboe-bitcoin-futures/contract-specifications>

¹⁸⁷ CME CF Cryptocurrency Reference Rates, May 3, 2018.

<https://www.cmegroup.com/education/bitcoin/cme-cf-cryptocurrency-reference-rate-methodology.html>

Constituent Exchanges List can be found at

<https://www.cmegroup.com/education/constituent-exchanges-list.html>

traded just \$62 million in notional value.¹⁸⁸ Having lost the market to its competitor, in March, the Cboe announced that it would stop further issuance of its bitcoin futures following the June 2019 contract.¹⁸⁹ The consensus is that what limited volume takes place today on the Cboe will simply migrate to the already dominate CME contract. Thus, for simplicity's purposes, the following sections focus exclusively on the CME contract.

2. CME Bitcoin Futures Volume Is Strong and Growing

The CME's bitcoin futures contract has experienced strong and steady interest since its initial launch in December 2017, and extremely strong growth in recent months.

There are three ways to consider the growth of volumes in the bitcoin futures market.

The first is to consider that growth on a dollar basis. Since its launch in December 2017, bitcoin futures volume expressed in dollars has shown some variability. Volumes declined as prices declined in late 2018, but have strongly picked up in 2019 as interest in crypto has increased. Over the first 20 days of May 2019, for instance, the average daily volume was \$517M, the highest level ever for a month. Dollar volume hit an all-time high on May 13, 2019, with \$1.3 billion in notional volume trading hands.¹⁹⁰

¹⁸⁸ Bitcoin Futures Settlements, CME Group, May 13, 2019.

https://www.cmegroup.com/trading/equity-index/us-index/bitcoin_quotes_settlements_futures.html#tradeDate=05%2F13%2F2019

Cboe Futures Exchange Daily Market Statistics, Cboe, May 13, 2019

https://markets.cboe.com/us/futures/market_statistics/daily

Notional value approximated using open and close prices and total volume.

¹⁸⁹ "New CFE Products Being Added In March 2019–Update," Cboe, March 2019.

http://markets.cboe.com/resources/product_update/2019/New-CFE-Products-Being-Added-in-March-2019-Update.pdf

¹⁹⁰ Tweet from the official twitter account of CME Group on May 13, 2019.

<https://twitter.com/CMEGroup/status/1128058304092098562>

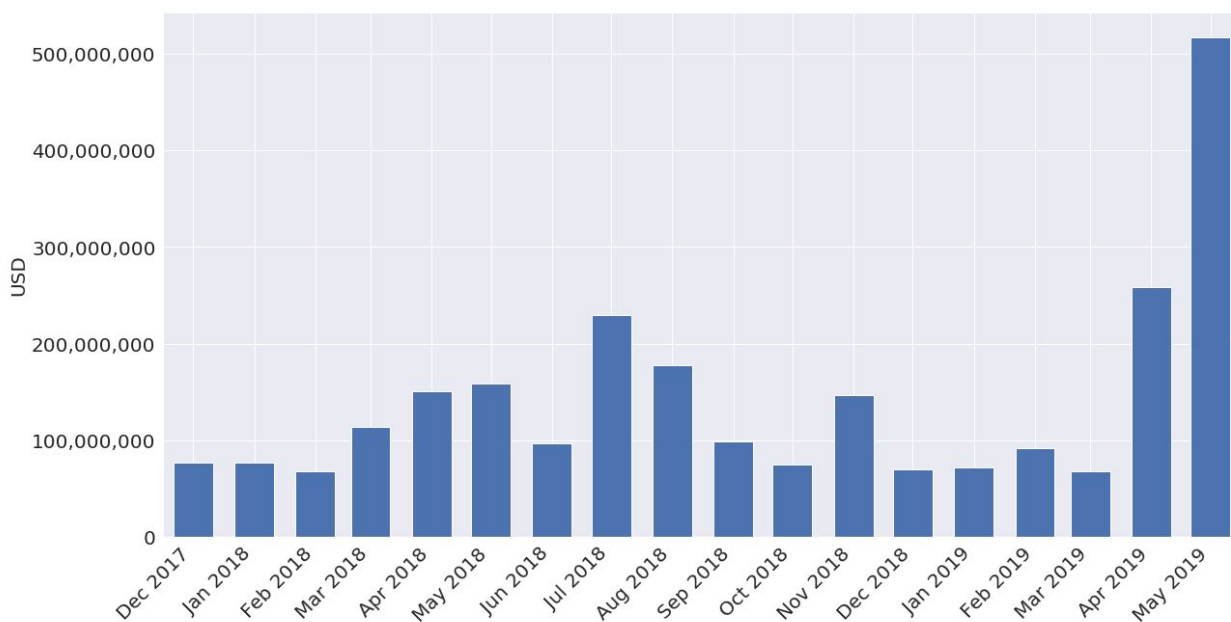


Figure 31: CME average daily volume in USD¹⁹¹

The second way to consider the growth of CME bitcoin futures is to examine things on a bitcoin basis.

Bitcoin prices are highly volatile. Bitcoin prices briefly traded above \$20,000 on December 17, 2017 (the day the CME bitcoin futures launched), and proceeded to trade down as low as \$3,400 in January 29, 2019, before rebounding.¹⁹² As a result, the value of 1 contract on the CME has ranged in value from roughly \$100,000 to \$17,000, which explains some of the variability in volumes show in the chart above.

If you express CME futures volume using bitcoin as the notional amount, the volume trends show strong and steady growth, with (again) a remarkable expansion in 2019.

¹⁹¹ CME ADV for May 2019 is up to May 20. Data from CME.

¹⁹² Data from Kaiko.

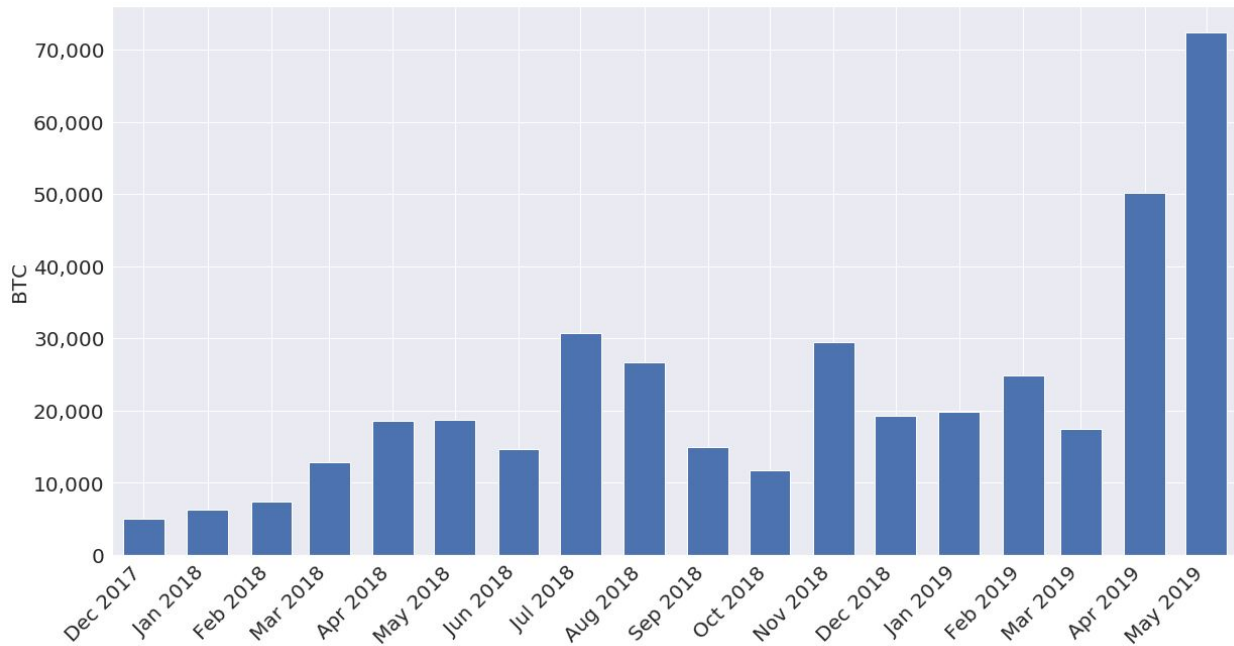


Figure 32: CME average daily volume in bitcoin¹⁹³

For the purposes of considering an ETF, however, the most important denomination is comparative: How do CME bitcoin futures volumes look expressed as a percentage of bitcoin spot volume?

This comparison yields the most interesting and important result, showing that CME bitcoin futures volume expressed as a percentage of real bitcoin spot volume has been strong and steadily growing.

¹⁹³ CME ADV for May 2019 is up to May 20. Data from CME.

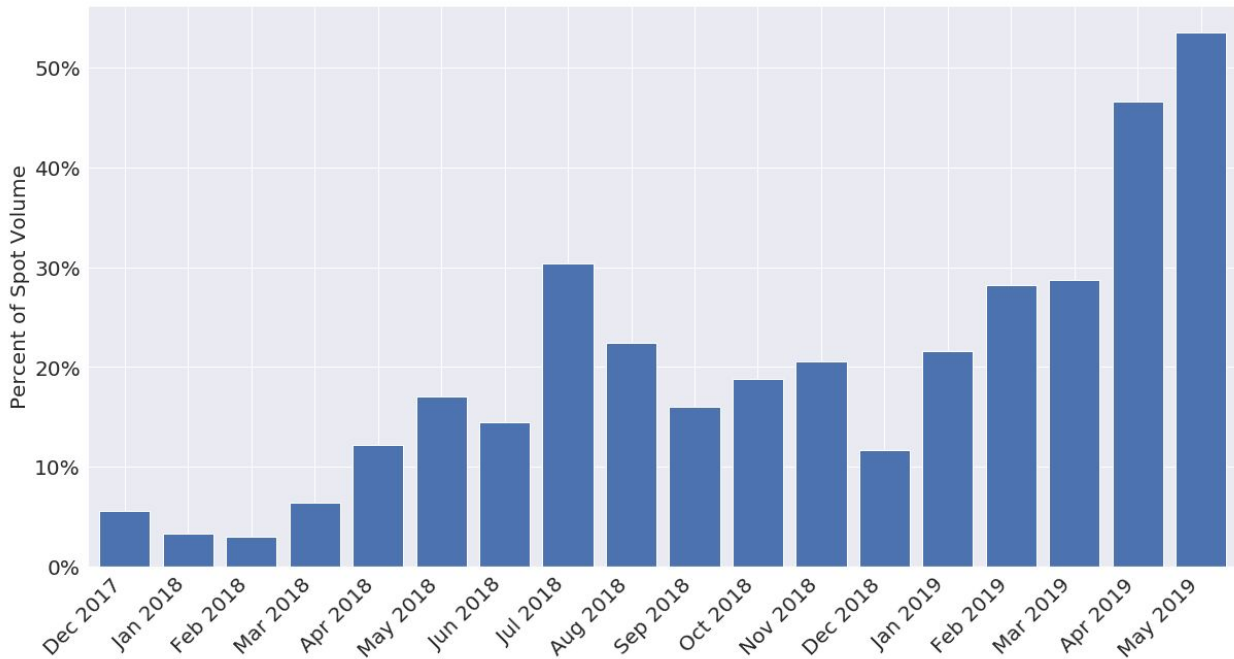


Figure 33: CME bitcoin futures volume as a percentage of real bitcoin spot volume¹⁹⁴

This relationship accelerated further in April and May, when volumes on the CME market have often exceeded those on the largest single spot bitcoin exchange, sometimes significantly. On May 13, for instance, CME volumes (\$1.3 billion) were two times as large as the largest spot bitcoin exchange, Binance (\$650 million).¹⁹⁵

3. Strong Arbitrage Exists Between The Bitcoin Futures Market and the Bitcoin Spot Market

The presence of a large regulated derivatives market in bitcoin futures only has implications for the bitcoin spot market if the two markets are linked by arbitrage and trade at effectively the same price.

Common sense suggests this would be true. The CME bitcoin futures contract settles at a price determined by four of the ten real bitcoin spot markets, and we have demonstrated that all real bitcoin spot markets trade effectively at a single price. Therefore, you would assume logically that the CME bitcoin futures market must trade at a price tightly linked to the bitcoin spot market's consolidated price.

But does it show up in the data?

¹⁹⁴ CME and bitcoin spot ADV for May 2019 is up to May 20. Data from CME and Kaiko.

¹⁹⁵ Bitcoin Futures Settlements from CME Group, May 13, 2019.

https://www.cmegroup.com/trading/equity-index/us-index/bitcoin_quotes_settlements_futures.html#tradeDate=05%2F13%2F2019

Binance trade volume and prices from Kaiko, May 13, 2019.

To answer this question, we will examine the same two criteria we considered when evaluating the quality of arbitrage between different bitcoin spot markets.

a. The Low Levels Of Average Deviations

As discussed, the first thing to consider is simply a price chart: If you chart the price of the CME bitcoin futures contract against the consolidated spot price of bitcoin, are they in-line with each other?



Figure 34: CME bitcoin futures contract price vs. consolidated spot price¹⁹⁶

The answer is clearly yes. While some minor discrepancies exist in the January-March 2018 time frame, after that, the two lines are virtually identical.

Next, let's look at the average deviation of the price of the CME contract and the consolidated spot price. Figure 35 examines that on a second-by-second basis since December 2017 when the contract launched.

¹⁹⁶ Data from CME and Kaiko.

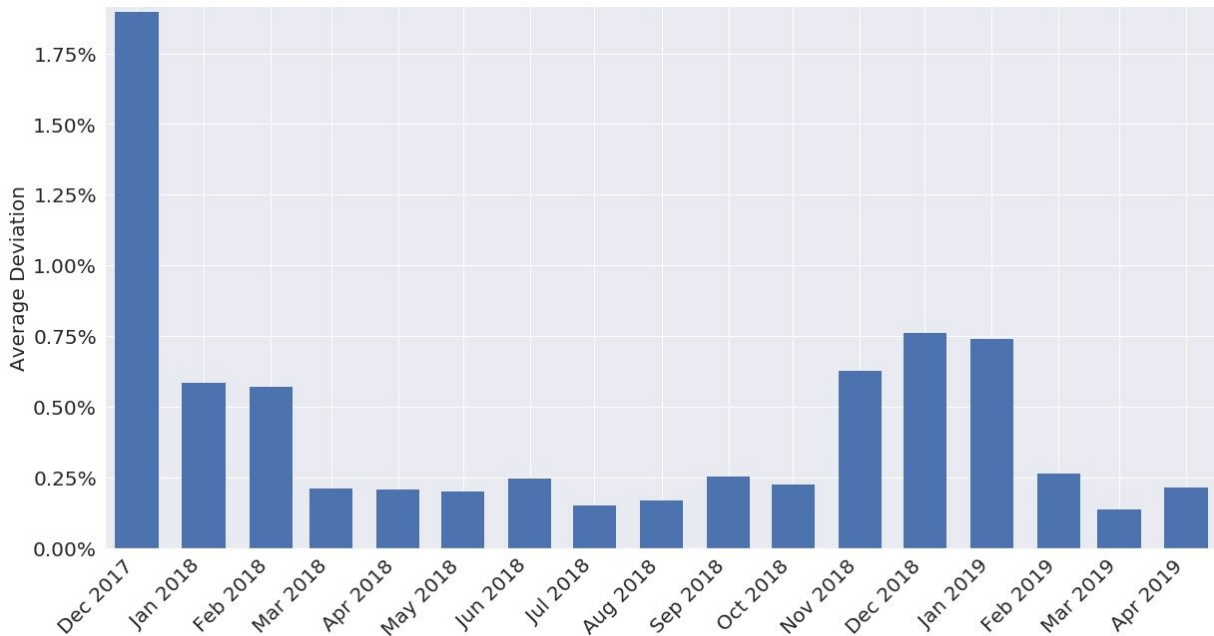


Figure 35: Average deviation of CME bitcoin futures contract price from consolidated spot price¹⁹⁷

A few things stand out. First, it clearly took some time for the contract to find its footing: Average deviations in the first month of its existence were nearly 2%. After that, however, average deviations came in substantially, largely hovering below 0.25%. This is similar to the average deviation we saw for individual spot exchanges, which ranged from 0.05%-0.20% over the same time frame.

The slightly wider deviations on the futures exchange is to be expected. Futures markets incorporate a “term structure.” That is, a futures contract is designed to settle at some specific date in the future, and may trade at a higher or lower price than the current spot market until that settlement date for a variety of reasons. When a futures contract trades at a higher price than the spot market, it is called “contango”; when it trades at a lower price, it is called “backwardation.” The existence of contango and backwardation is a feature of all futures markets.

The term structure of the bitcoin market has varied since the launch of bitcoin futures in December 2017. Most of the time, bitcoin futures have traded essentially in-line with the spot market, exhibiting neither significant contango nor significant backwardation. But backwardation and contango have appeared occasionally, with backwardation appearing much more frequently than contango.

The most significant periods of backwardation have occurred during pronounced pullbacks in the bitcoin spot market. For example, on November 14, 2018, the bitcoin market fell from \$6200 to \$5500 over just 5 hours, as concerns mounted around the planned but contentious bitcoin cash fork that was scheduled for November 15, 2018.¹⁹⁸ That strong downward move and rising concerns

¹⁹⁷ Data from CME and Kaiko.

¹⁹⁸ “What Caused Bitcoin Price & Crypto Market Meltdown On November 14?—An Analysis,” ICO Rush, Medium, November 15, 2018.

about bitcoin’s outlook drove the futures market into backwardation, and a generalized state of backwardation persisted through January 2019, when the bitcoin market stabilized. During much of this time, the front month bitcoin futures contracts traded at a discount to the spot, as shown on the chart below. The average backwardation during this period was 0.74%.

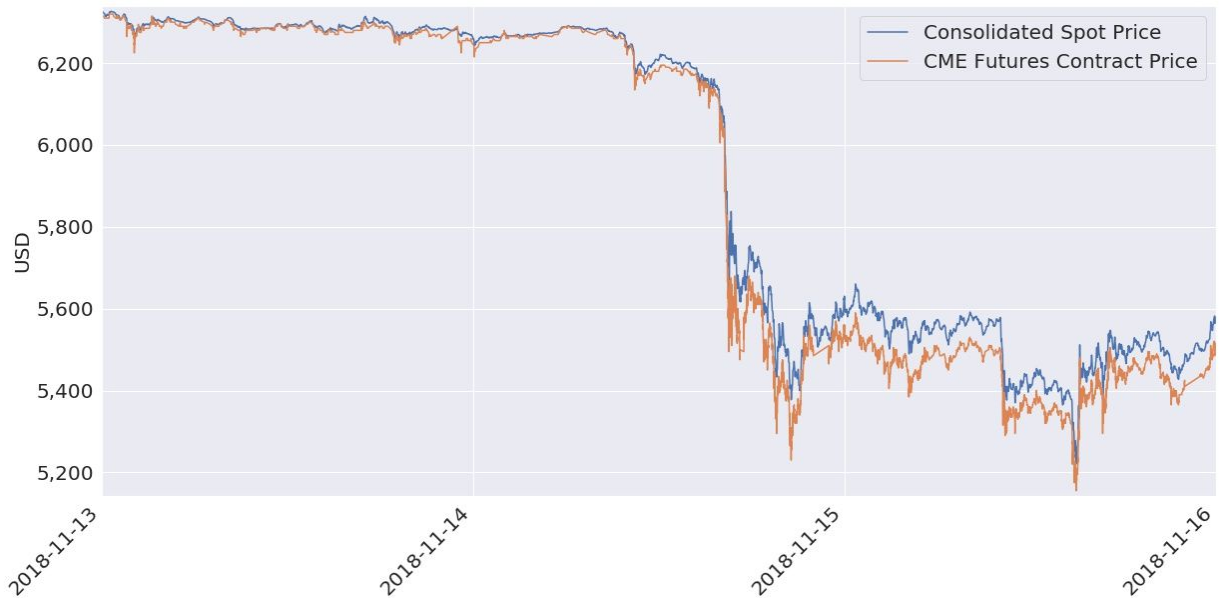


Figure 36: CME bitcoin futures contract price vs. consolidated spot price during November 2018¹⁹⁹

This relatively high level of backwardation explains why the average deviation between the CME futures price and the spot bitcoin price rose from November 2018 through January 2019, as shown in Figure 36. As the term structure of the futures market normalized, the average deviation between those prices settled back to its normal state, below 0.25%.

The level of backwardation in the bitcoin futures market is strictly constrained by arbitrage. Arbitrageurs that want to profit from backwardation must buy the (discounted) futures contract and then short spot bitcoin to establish a risk-free position. The reason backwardation can emerge and persist is that the cost of borrowing bitcoin to short in the spot market is relatively high, historically ranging from 5-10% per year (or 0.4%-0.8% per month). This monthly cost is directly in-line with the levels of observed backwardation during the November 2018 - January 2019 time frame.²⁰⁰

The extremely low average deviation between prices during normal months and the rationally constrained deviations during stress periods like November 2018 suggests that institutional-quality

<https://medium.com/@ICOrush/what-caused-bitcoin-price-crypto-market-meltdown-on-november-14-an-analysis-53b599aab708>

¹⁹⁹ Data from CME and Kaiko.

²⁰⁰ Note that these rates are declining as the market develops. See, for example, “Q1 2019 – Insights” from Genesis Capital: <https://genesiscap.co/insights/2019-q1-insights>

arbitrageurs are enforcing strong arbitrage between the CME futures market and the spot market at all times.

b. The Speed At Which Pricing Discrepancies Are Arbitrated Away

The other important test of the quality of arbitrage is how fast any price discrepancies that do appear are arbitrated away.

The chart below shows the speed at which 1% pricing discrepancies between the CME bitcoin futures price and the consolidated bitcoin price are arbitrated away. The data show that more than 50% of all 1% pricing discrepancies were arbitrated away within 1 second, and more than 90% of all 1% pricing discrepancies were arbitrated away within 49 seconds.

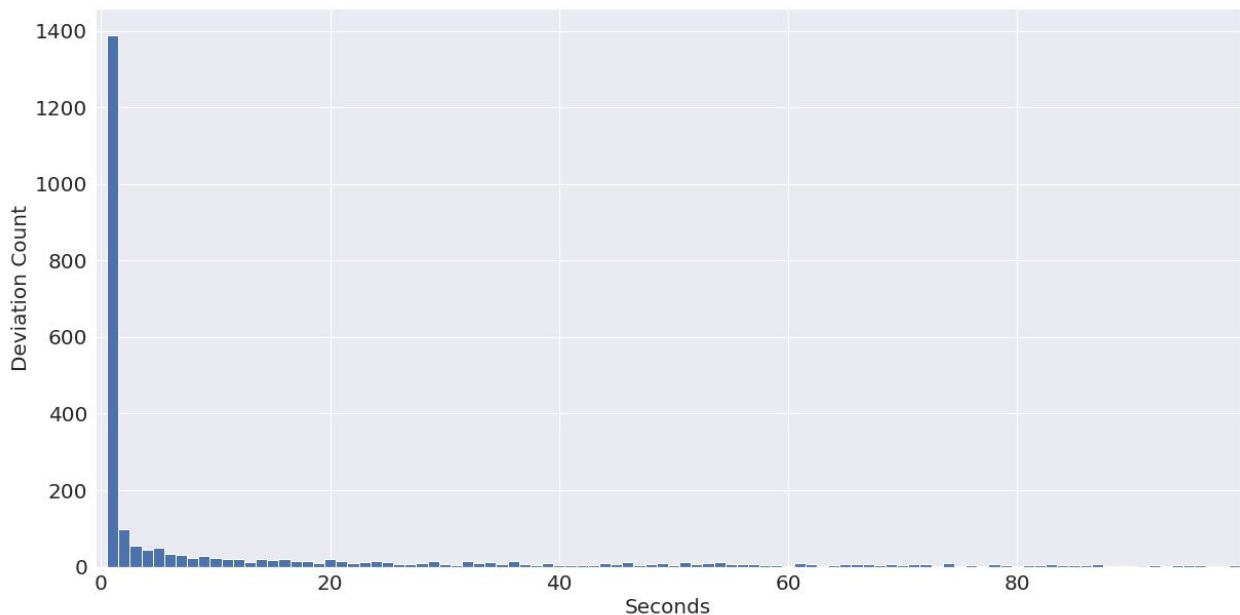


Figure 37: Histogram of duration of 1% deviations for CME bitcoin futures price from spot price²⁰¹

This data echoes the data seen when comparing individual spot bitcoin exchanges against one another. Significant deviations disappear rapidly.

These results demonstrate that the bitcoin spot price and CME price not only trade closely together but also have their disparities rapidly arbitrated away, meeting both criteria set forth by the Commission for demonstrating effective arbitrage between markets.

²⁰¹ Data from CME and Kaiko.

c. The Impact of Futures on the Bitcoin Market

The impact of the launch and growth of the bitcoin futures market on the broader bitcoin ecosystem is hard to overstate. The Federal Reserve Bank of San Francisco published a noteworthy analysis of this impact in its May 7, 2018, Economic Letter, “How Futures Trading Changed Bitcoin Prices,” noting:

Before December 2017, there was no market for bitcoin derivatives. This meant that it was extremely difficult, if not impossible, to bet on the decline in bitcoin price... This one-sided speculative demand came to an end when the futures for bitcoin started trading on the CME on December 17.²⁰²

The authors argue that the introduction of this two-sided market contributed directly to the bear market that bitcoin experienced in 2018, noting that bitcoin’s all-time high coincided exactly (to the day!) with the launch of the CME futures contract. They explain that this market-equalizing experience aligns well with the impact that the introduction of futures had on other markets historically, including most notably, the mortgage market in the late 2000s.

From our perspective, however, the futures market were critical because, by allowing short exposure, they gave arbitrageurs the tool they needed to properly engage in arbitrage. The impact of this is seen in the large improvements in the efficiency of the bitcoin spot market noted earlier in this paper.

C. The Emergence Of And Growth Of The Short Lending Market In Bitcoin

The ability for institutional investors to create two-sided markets in bitcoin expanded further in February 2018, when Genesis Capital rolled out the first institutional short lending market for bitcoin.²⁰³ While a nascent shorting market existed before this launch, it was not significant enough to support meaningful trading activity.

Genesis Capital, however, was significant: the firm would go on to handle \$1.1 billion in loan originations in 2018, roughly 60% of which were focused on bitcoin.²⁰⁴ In Q1 2019, the firm added another \$425 million in loan originations, 68% of which were focused on bitcoin.²⁰⁵

²⁰² “How Futures Trading Change Bitcoin Prices,” Galina Hale, Arvind Krishnamurthy, Marianna Kudlyak, and Patrick Shultz, Federal Reserve Bank of San Francisco, May 7, 2018. <https://www.frbsf.org/economic-research/publications/economic-letter/2018/may/how-futures-trading-changed-bitcoin-prices>

²⁰³ Genesis Global Capital—Institutional Digital Currency Lending, press release, February 27, 2018. <https://genesiscap.co/genesis-global-capital-press-release>

²⁰⁴ “Digital Asset Lending Snapshot,” Genesis Global Capital, Q4 2018. <https://genesiscap.co/q4-insights/>

²⁰⁵ “Digital Asset Lending Snapshot,” Genesis Global Capital, Q1 2019. <https://genesiscap.co/insights/2019-q1-insights>

Along with futures, short lending is a critical tool for arbitrageurs as they look to capitalize on short-term price dislocations in the bitcoin market.

D. The Expanded Presence Of Algorithmic Market Makers In The Bitcoin Market

Another source of improvement in the bitcoin trading market has been the entry of a large number of well-established, institutional, and algorithmic market makers into the bitcoin space in 2018. For example:

- Jane Street is one of the largest algorithmic market makers, employing more than 900 people and trading more than \$8 trillion across all financial products in 2018;²⁰⁶ it confirmed that it began trading bitcoin for clients in March 2018.²⁰⁷
- Susquehanna International Group is a privately held trading firm that employees 1900 people and makes markets in stocks, options and ETFs; it began trading bitcoin for itself in 2016, but opened up its platform to clients in June 2018.²⁰⁸
- FlowTraders is a publicly traded market making firm that is the largest market making firm in Europe, with a speciality in exchange-traded funds; it entered the bitcoin market in June 2018.²⁰⁹
- JUMP Trading is one of the top high-frequency trading firms in the derivatives market; in June 2018, it launched an OTC bitcoin trading platform to facilitate liquidity for institutional clients.²¹⁰

Today, these firms are among the largest traders of bitcoin and have brought a new level of order and efficiency to the market.

²⁰⁶ Jane Street Capital: <https://www.janestreet.com/what-we-do>

²⁰⁷ "One of the Most Secretive Firm's On Wall Street Has Been Trading Bitcoin," Frank Chapparo, Business Insider, March 16, 2018.

<https://www.businessinsider.com/secretive-wall-street-firm-jane-street-started-trading-bitcoin-2018-3>

²⁰⁸ "One Firm Is Way Ahead of Wall Street On Bitcoin," Nathaniel Popper, The New York Times, June 5, 2018. <https://www.nytimes.com/2018/06/05/technology/bitcoin-susquehanna.html>

²⁰⁹ "Europe's Top Speed Trading Firm Joins The Crypto Economy," Jamie Redman, Bitcoin.com, July 6, 2018. <https://news.bitcoin.com/europes-top-speed-trading-firm-flow-traders-joins-the-crypto-economy>

²¹⁰ "Jump Trading OTC Electronic Bitcoin Exchange Platform For Large Transactions," Bitcoin Exchange Guide, June 6, 2018.

<https://bitcoinexchangeguide.com/jump-trading-otc-electronic-bitcoin-exchange-platform-for-large-transactions>

E. The Dramatic Growth In The Bitcoin Custody And Custodial Insurance Market

The final driver of rising efficiency in the bitcoin market has been the dramatic expansion in the availability and level of service available from bitcoin custodians, as well as the emergence of a strong market for insurance on custodied bitcoin assets.

Many traditional financial firms have stayed away from the crypto space historically in part because of fears surrounding custody. This has historically harmed the quality of bitcoin markets, as it has meant fewer players operating in the market. Also, most custodians did not have significant insurance on custodied assets, which deterred certain institutional investors and traders from the market as well.

But the custody market blossomed in 2018 and 2019, to the point where today, investors have a wide array of choices of regulated custodians in the market.

Name	2017		2018		2019 (Expected)		Regulatory Structure
	Regulated	Insured*	Regulated	Insured*	Regulated	Insured*	
Kingdom Trust	X		X	X	X	X	South Dakota Trust Company
Gemini	X		X	X	X	X	New York Limited Purpose Trust Company
itBit	X		X		X	(X)	New York Limited Purpose Trust Company
Coinbase Custody			X	X	X	X	New York Limited Purpose Trust Company
BitGo			X		X	X	South Dakota Trust Company
Fidelity Digital Assets					(X)	X	Pursuing New York Limited Purpose Trust Company
Xapo					(X)		Pursuing New York Limited Purpose Trust Company
Anchorage					(X)	(X)	Pursuing multiple options
DACC					(X)	(X)	Pursuing multiple options

* This overview is based on Bitwise's analysis of the existing landscape and discussions with each institution, as well as public disclosures from each custody company. "Insured" means that the Custodian has disclosed some amount of insurance against theft, loss, fraud, or natural disaster causing a loss of the digital assets held in custody. Custodians (not just in crypto but in all asset classes) typically do not insure the full amount of assets held in custody, but maintain insurance ratios that are commensurate with the level of risk.

Table 11: Bitcoin custodian landscape

Whereas in 2017 there were just three regulated custodians, none of which had meaningful insurance, today there are five regulated custodians, and we anticipate as many as four additional firms gaining regulatory status this year. In addition, significant insurance is now commonplace: Coinbase Custody, for example, maintains a \$255 million policy from Lloyd's of London.²¹¹

The expansion of custody and insurance has enabled a larger number of market makers to confidently enter the market, which has additionally supported its efficiency.

²¹¹ For an interesting overview of the market for bitcoin custody (and Coinbase's specific approach), see, "On Insurance and Cryptocurrency," Philip Martin (Chief Information Security Officer, Coinbase), The Coinbase Blog, Medium, April 2, 2019. <https://blog.coinbase.com/on-insurance-and-cryptocurrency-d6db86ba40bd>

XI. Conclusion

In the past few years, the bitcoin market has undergone a massive and rapid evolution from its anarchic, grassroots past to its efficient, institutional present. Ten years ago, bitcoin barely existed; today, it's a \$100 billion market.

In times of rapid change, people's perceptions often anchor in the past. People who read about bitcoin today still think about Mt. Gox, when they should be thinking about Fidelity²¹²; they think about Silk Road, when they should be thinking about Whole Foods.²¹³ This vestigial anchoring is made worse by the poor quality of data that permeates large parts of the bitcoin ecosystem, which can create the perception that the market remains inefficient, chaotic and issue-prone.

In this white paper, we have tried to systematically clear away the bad data and reveal the market as it really is today.

The modern bitcoin spot market is both significantly smaller and significantly more efficient than commonly understood. It is a market that trades at extraordinarily tight spreads, with extremely effective arbitrage keeping prices in lockstep amongst all significant exchanges. It is a market that is supported by increasingly effective regulation at the spot bitcoin exchange level, backstopped by a significant and growing regulated bitcoin futures market. It is a market watched over by some of the most sophisticated institutional market makers in the world, who entered the market to serve the increasingly institutional user base that is interested in investing in bitcoin.

At the start of this white paper, we wrote the following:

"As a digital commodity, bitcoin's spot trading market should be among the most orderly and efficient in the world."

Once you clear away the noise, the data suggest that that is simply true.

²¹² Fidelity Digital Assets is the digital asset arm of Fidelity, the \$7.2 trillion asset management giant. It offers custody, trading and service for digital asset investments, including bitcoin. For more:

<https://www.fidelitydigitalassets.com/about-us>

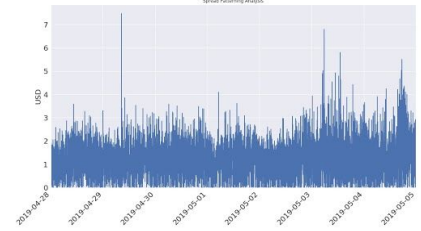
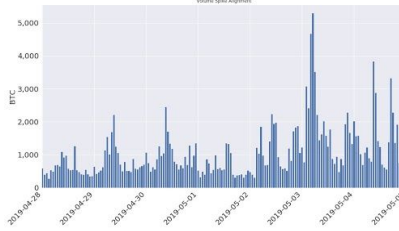
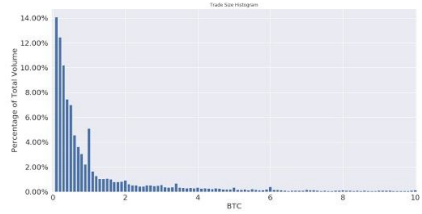
²¹³ "Bitcoin Comes to Whole Foods, Major Retailers in Coup for Digital Currency," Jeff John Roberts, Fortune, May 13, 2019.

<http://www.fortune.com/2019/05/13/bitcoin-comes-to-whole-foods-major-retailers-in-coup-for-digital-currency>

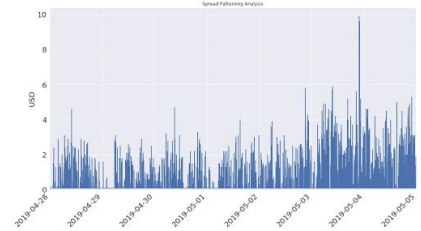
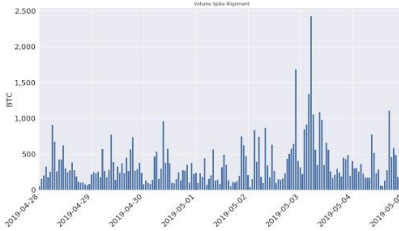
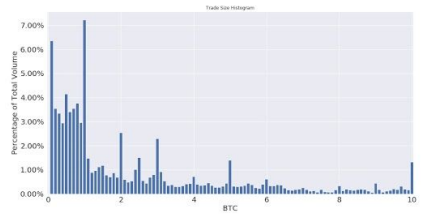
APPENDIX I. Exchange By Exchange Trading Data Analysis²¹⁴

1. Real Volume Exchanges

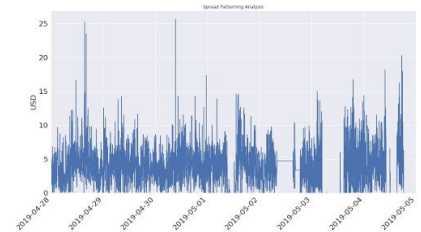
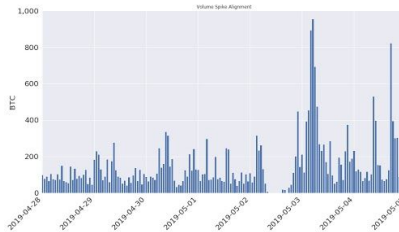
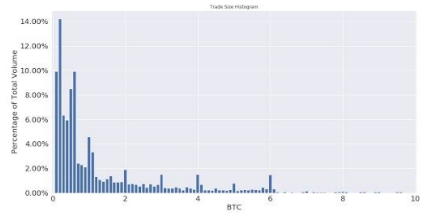
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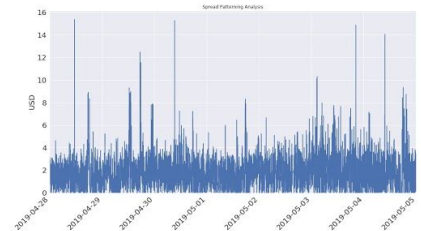
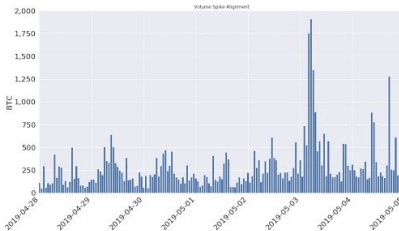
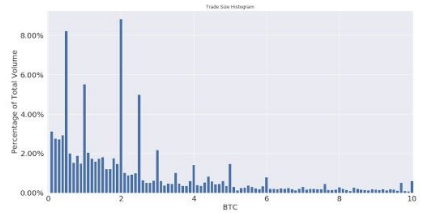
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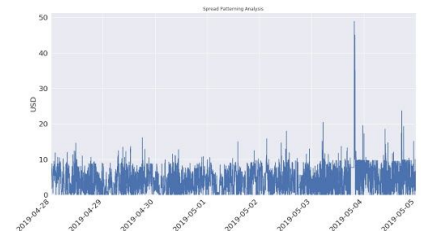
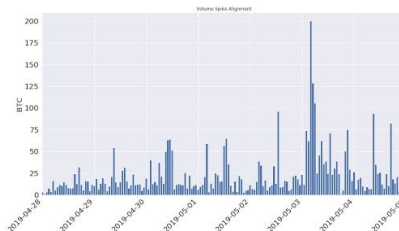
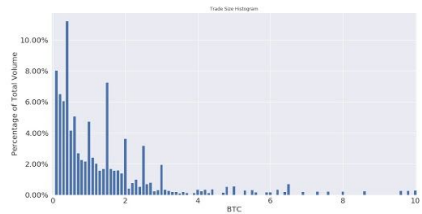
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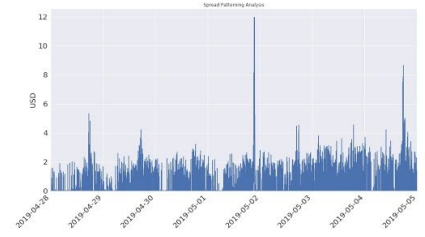
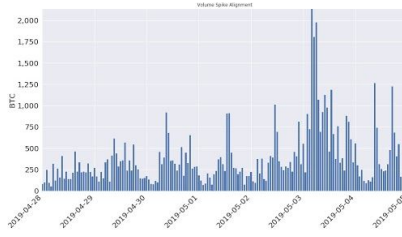
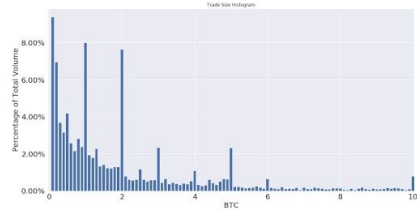


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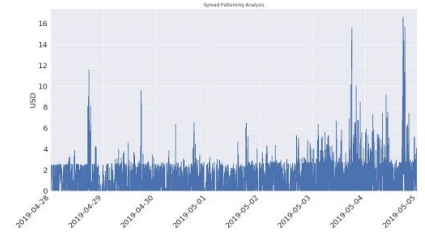
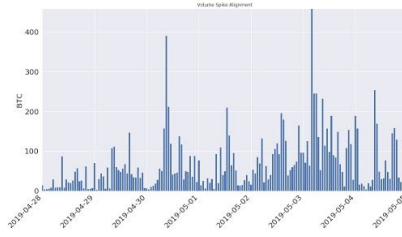
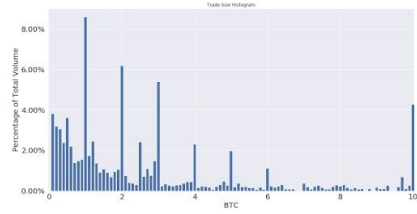


²¹⁴ Data collected by Bitwise.

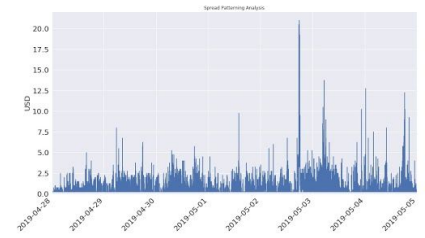
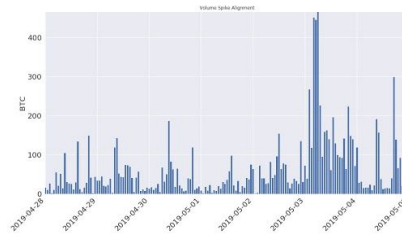
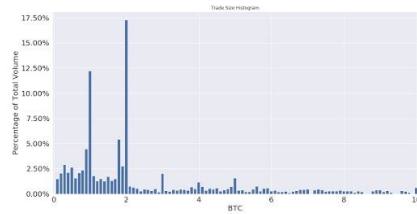
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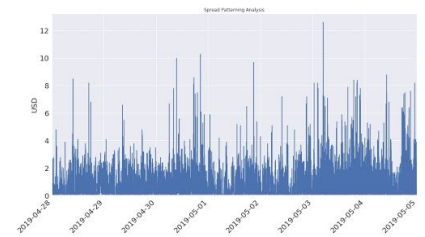
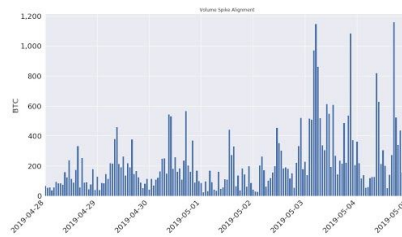
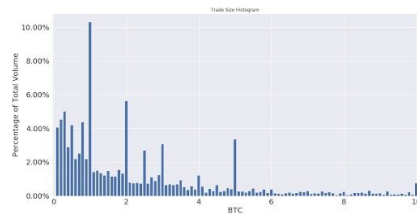
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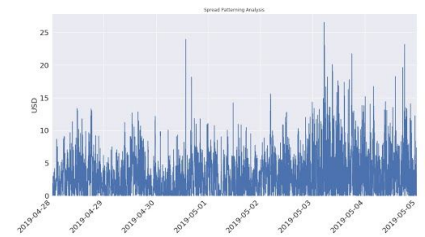
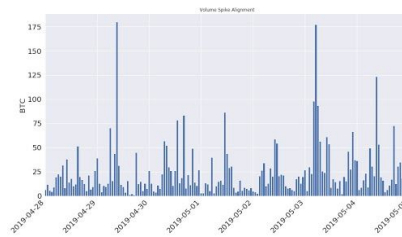
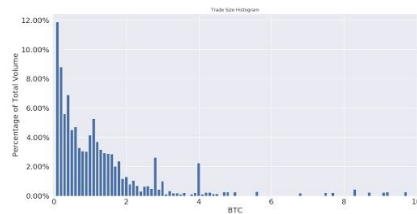
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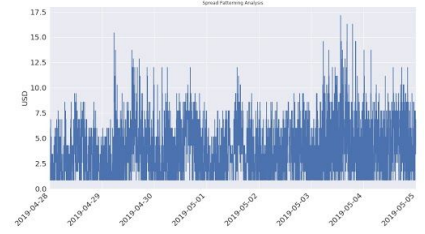
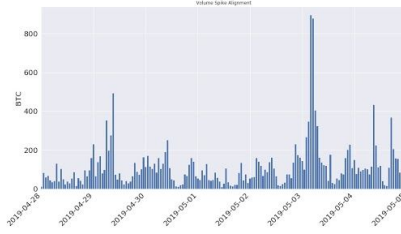
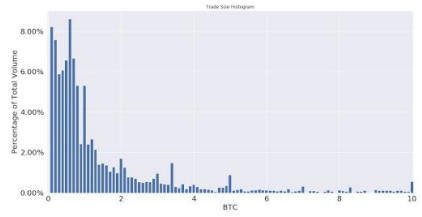


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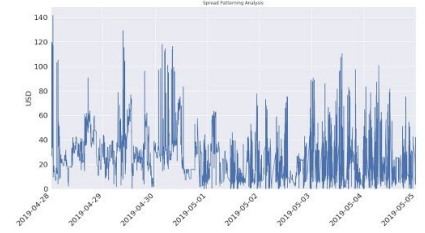
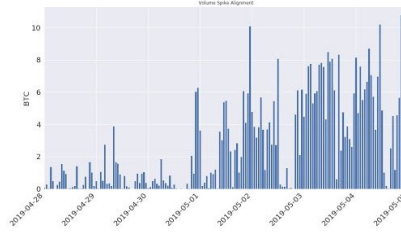
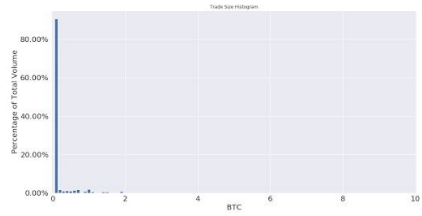


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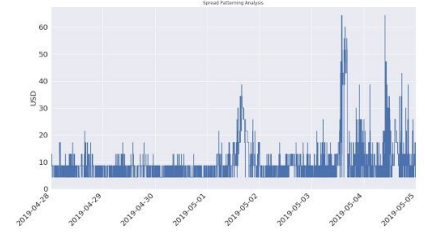
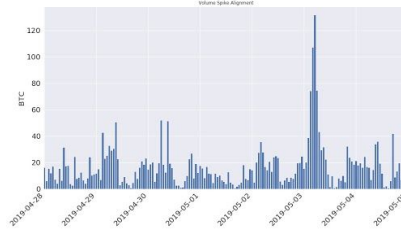
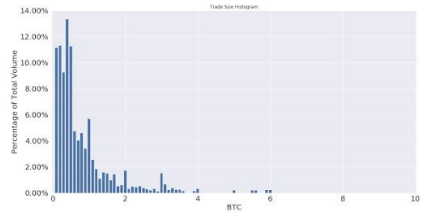
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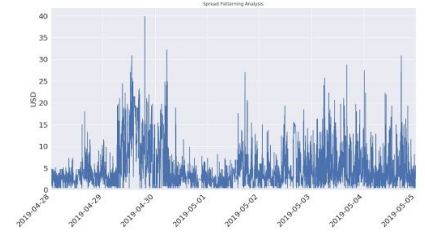
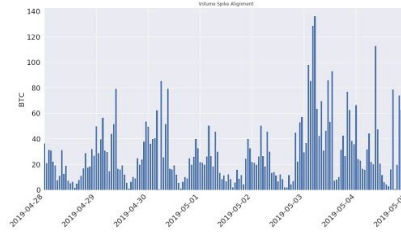
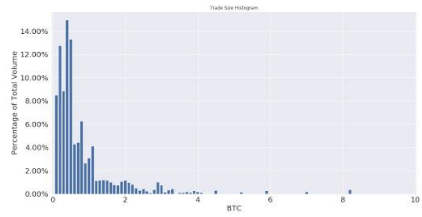
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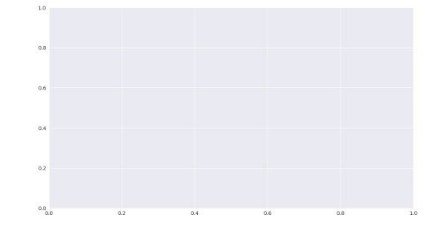
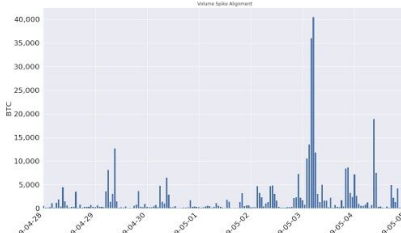
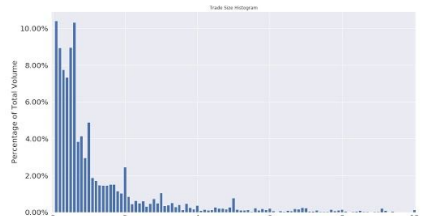
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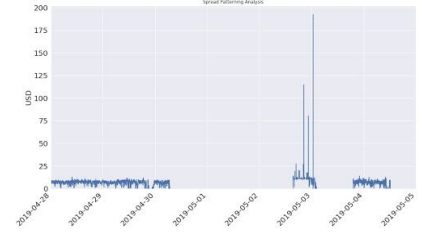
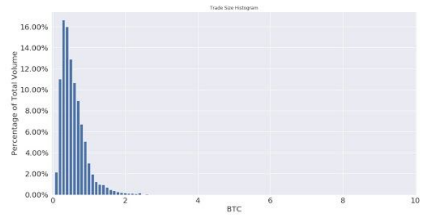


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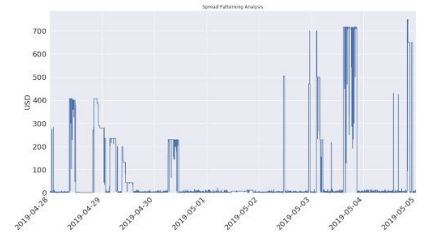
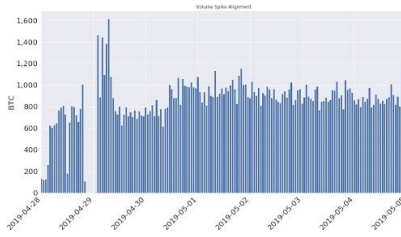
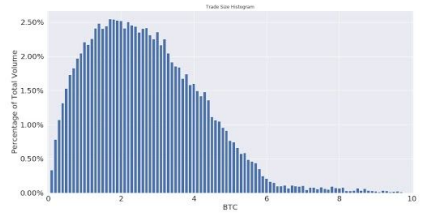


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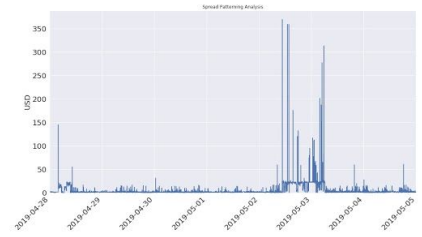
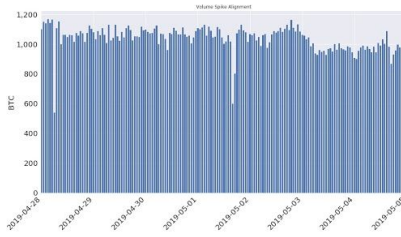
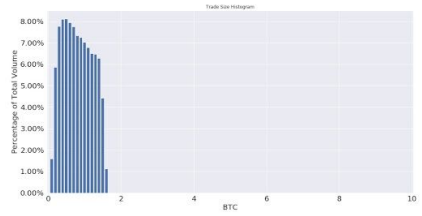
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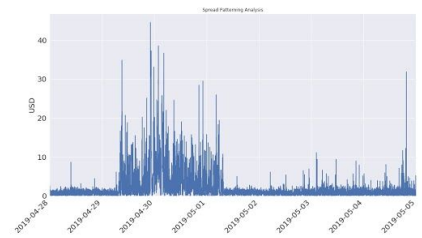
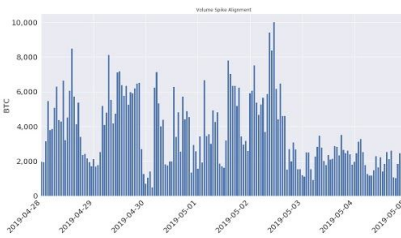
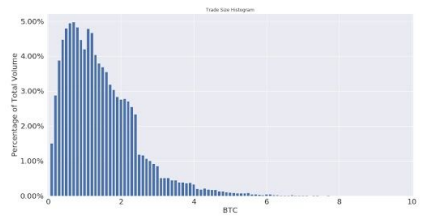
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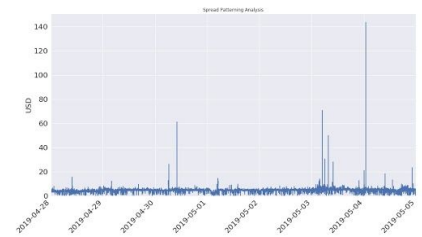
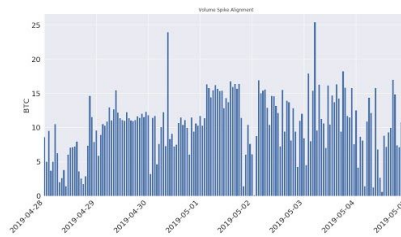
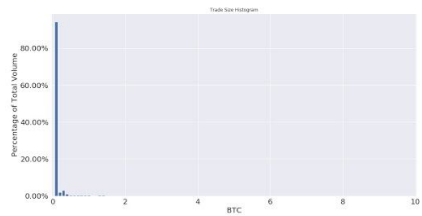
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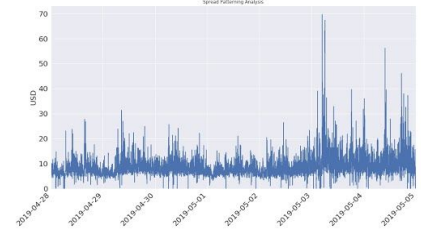
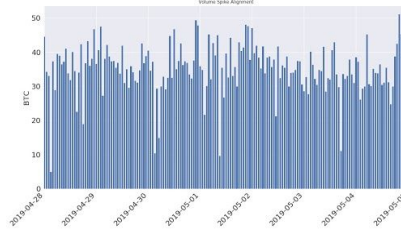
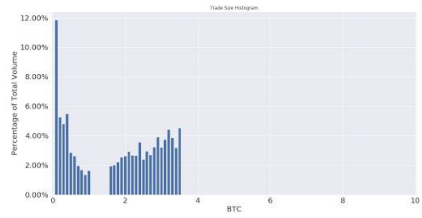
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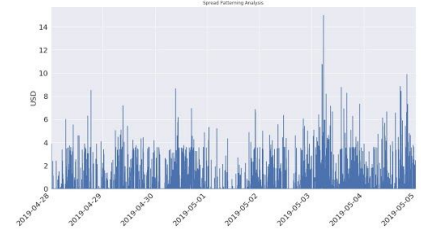
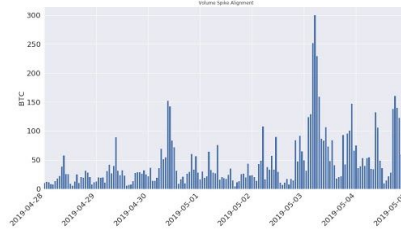
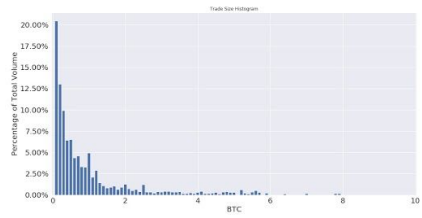
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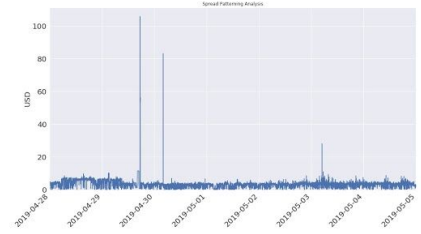
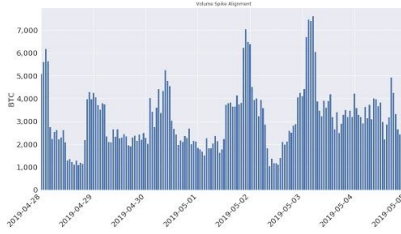
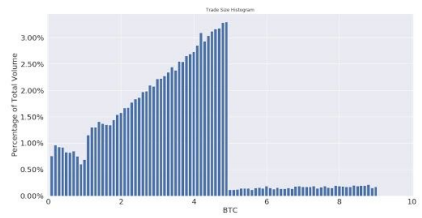
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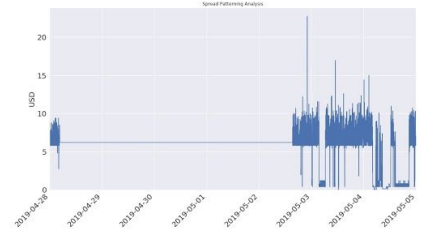
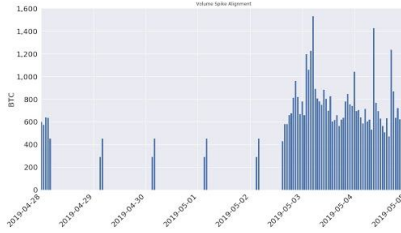
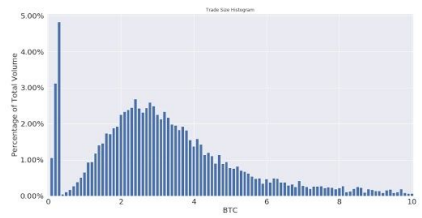
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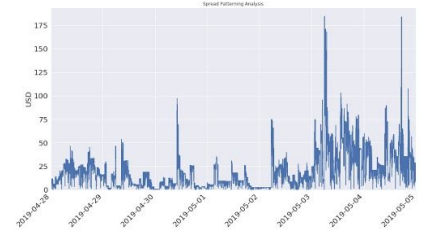
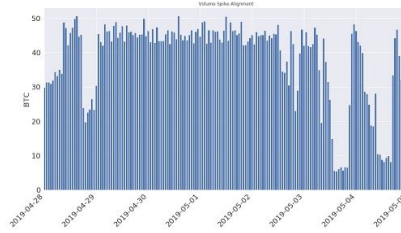
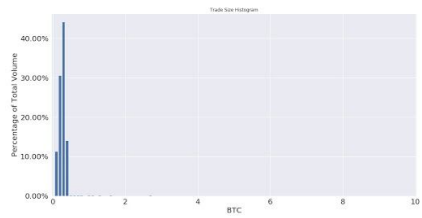
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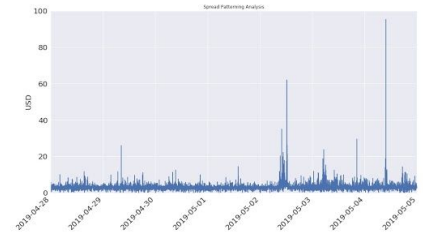
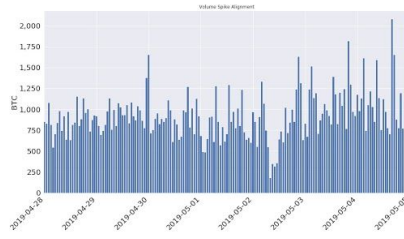
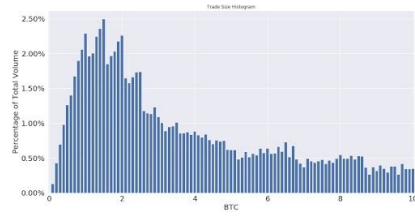
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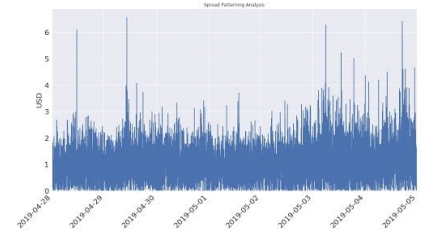
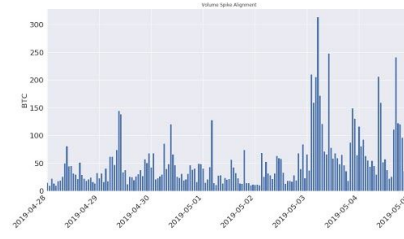
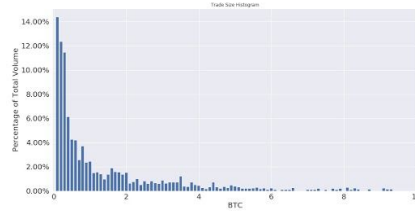
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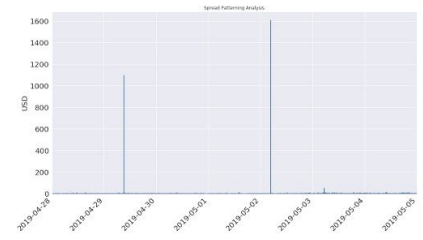
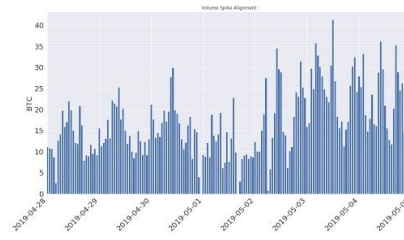
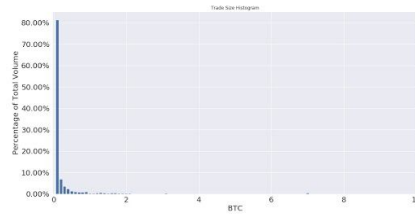
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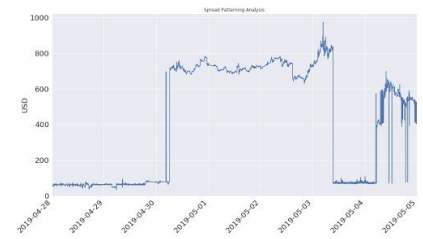
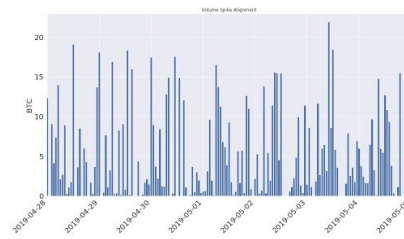
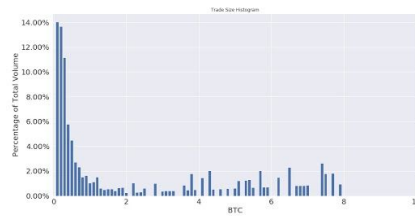
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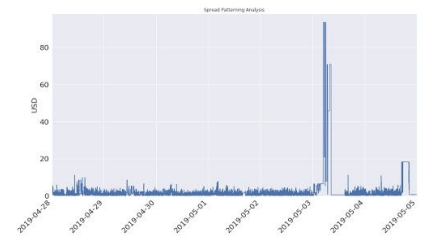
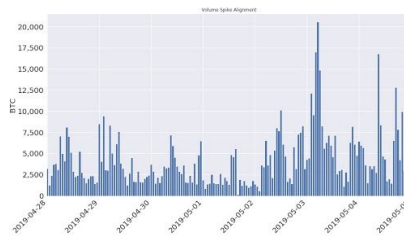
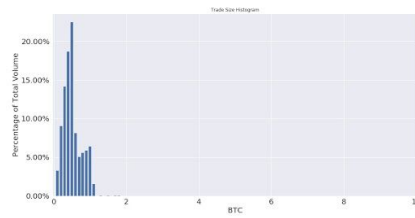
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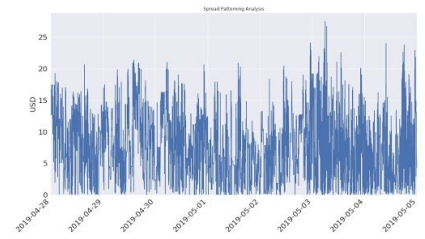
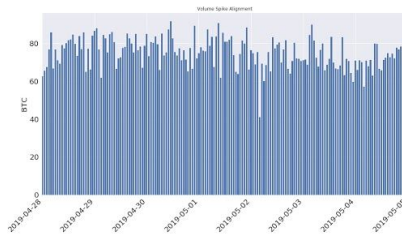
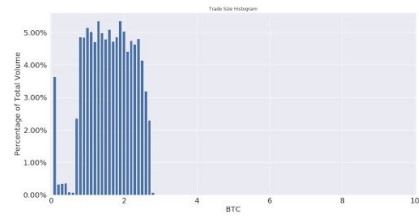
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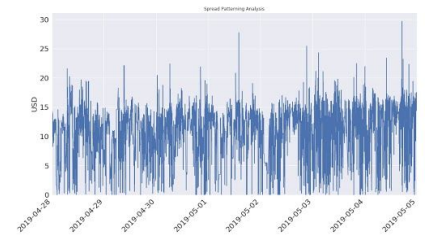
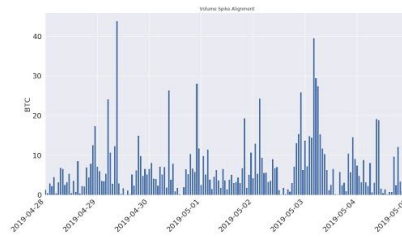
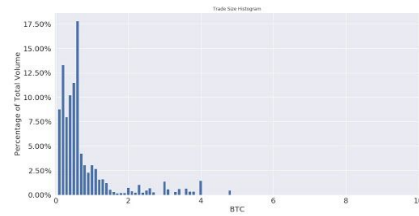
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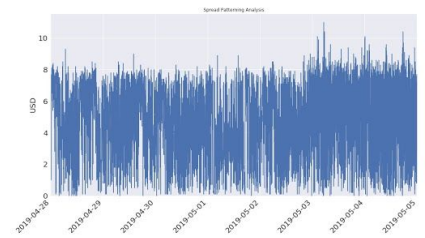
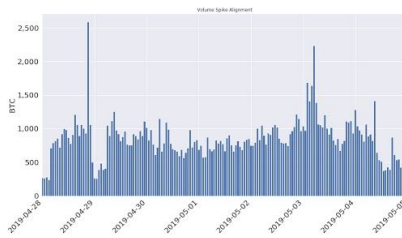
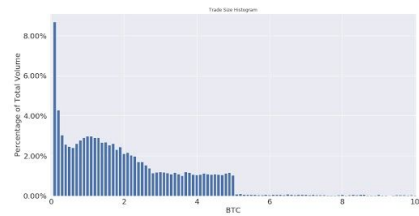
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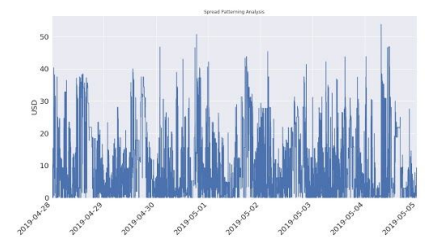
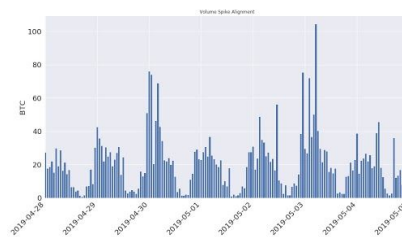
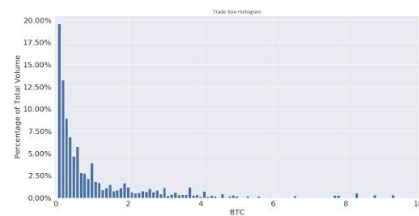
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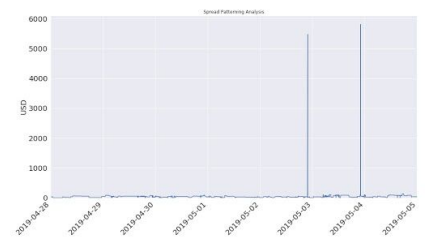
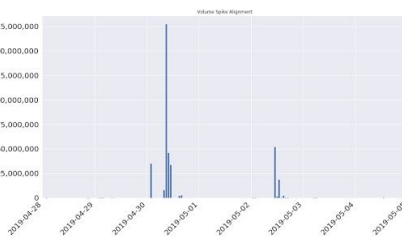
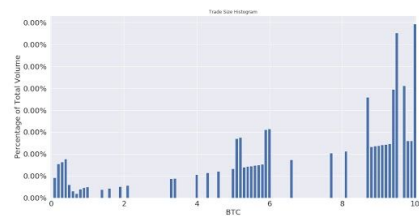
BW.com



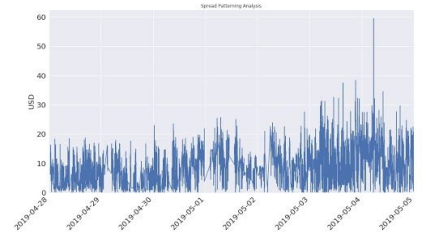
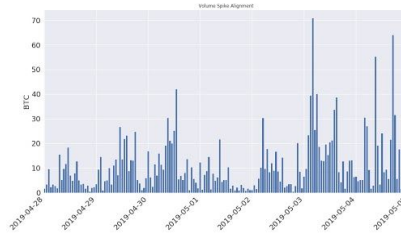
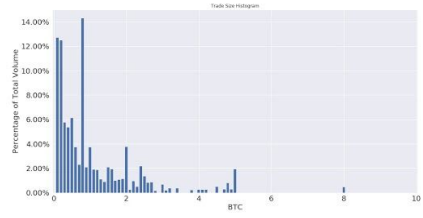
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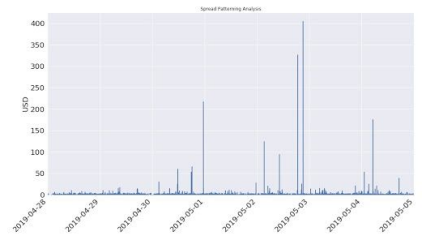
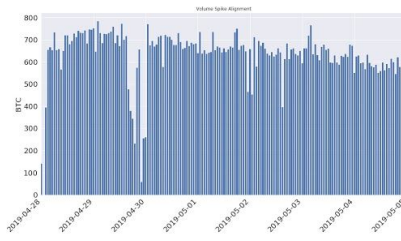
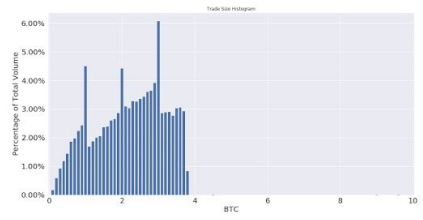
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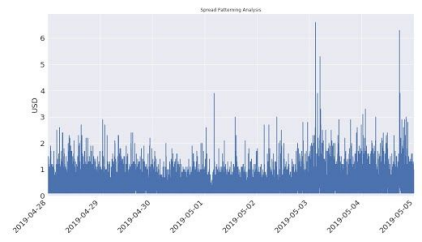
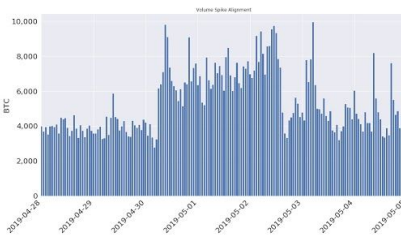
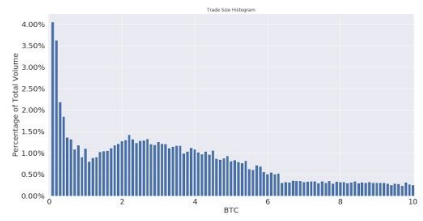
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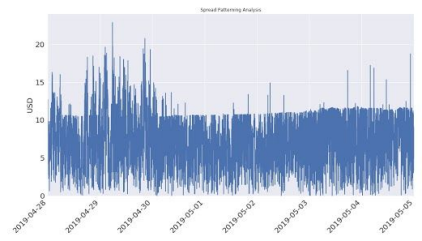
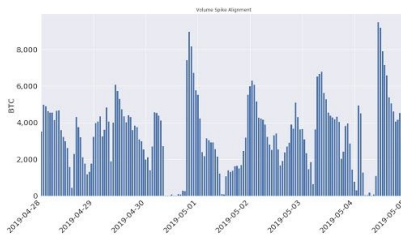
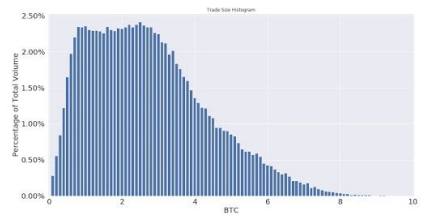
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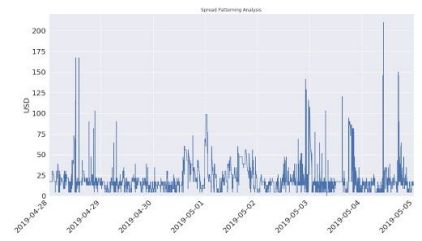
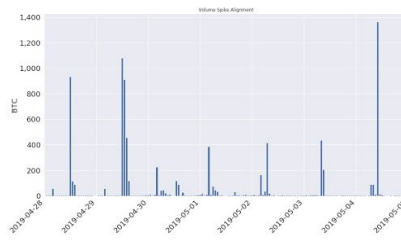
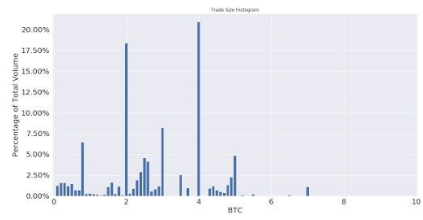
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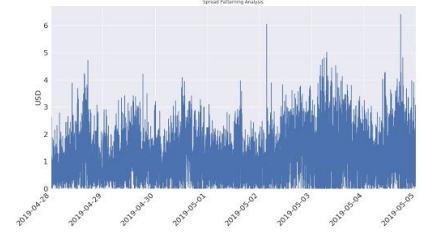
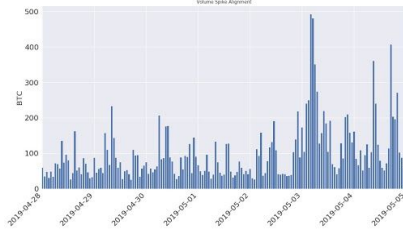
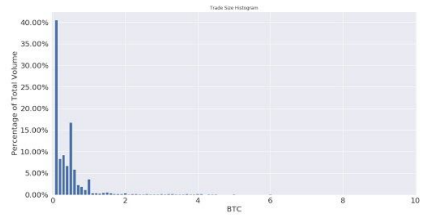
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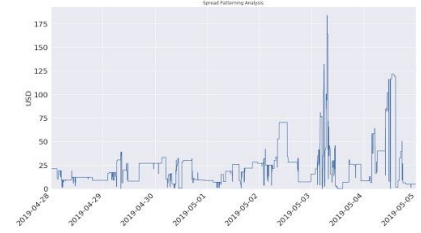
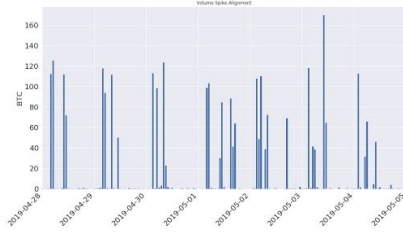
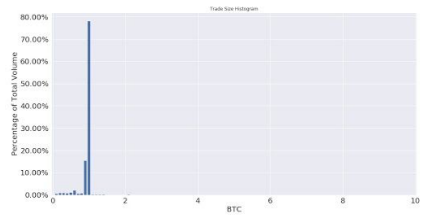
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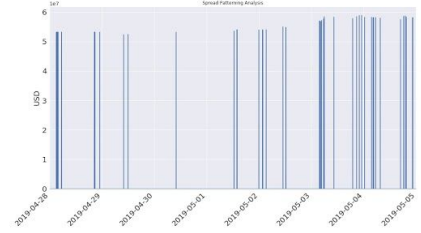
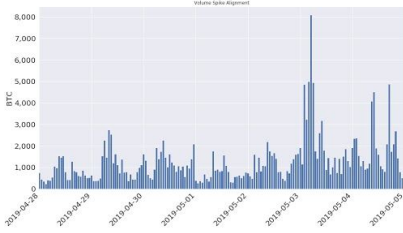
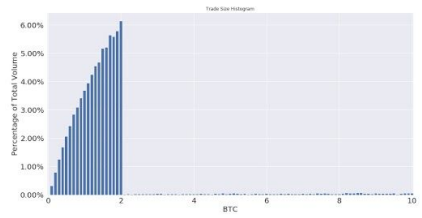
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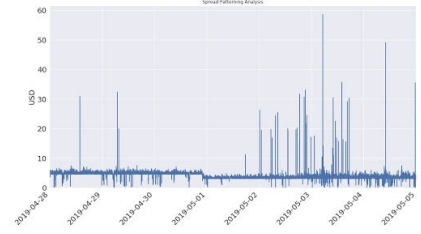
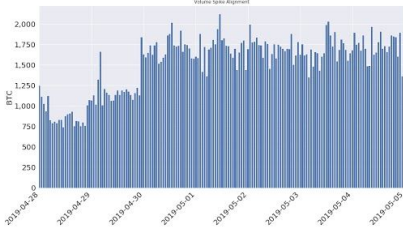
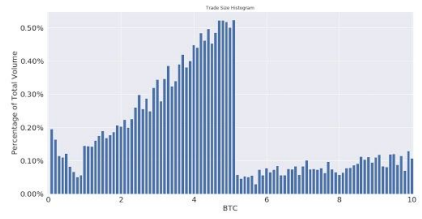
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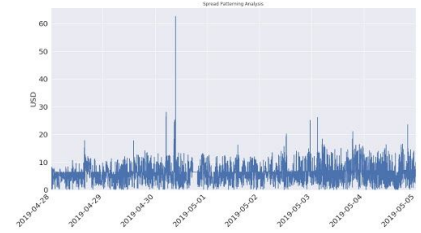
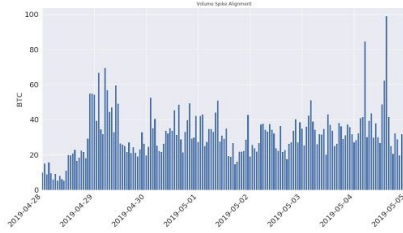
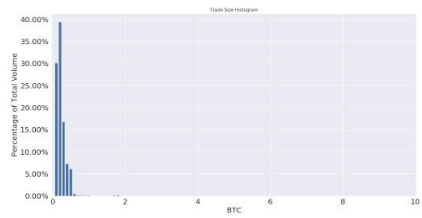
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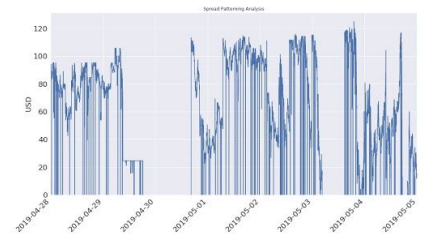
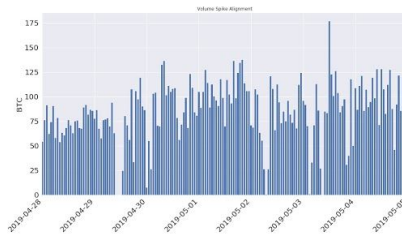
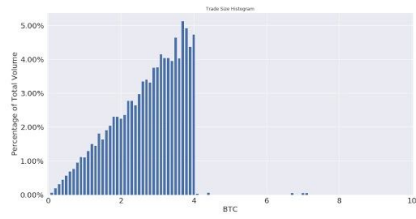
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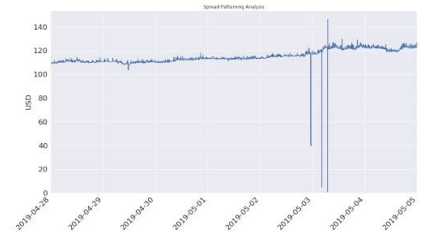
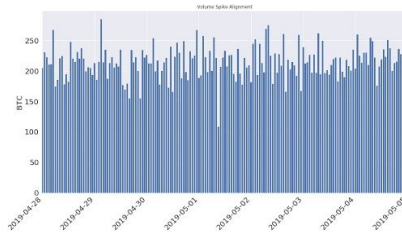
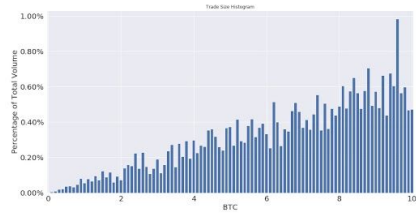
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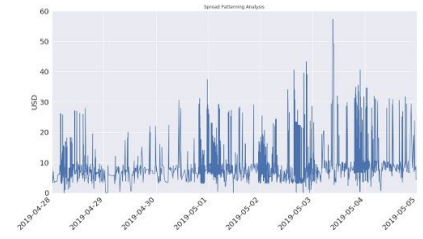
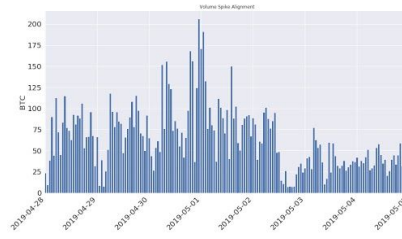
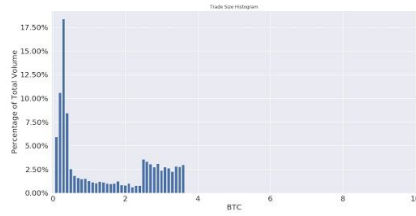
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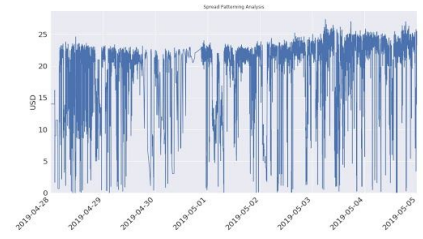
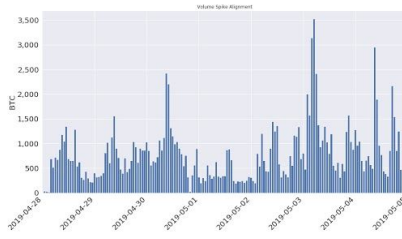
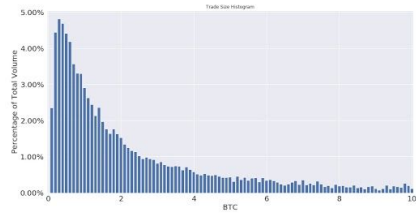
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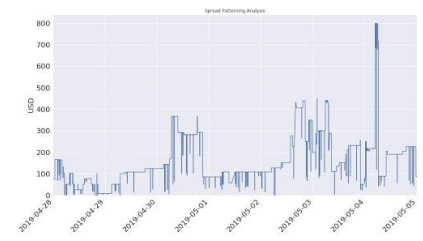
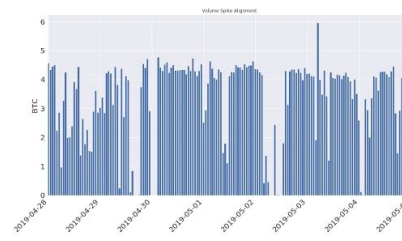
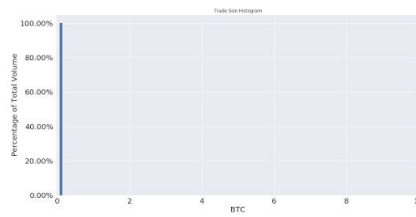
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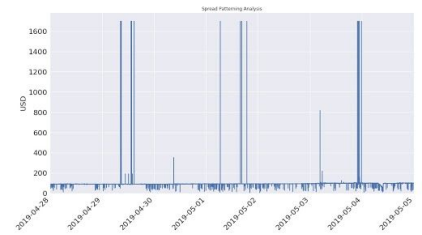
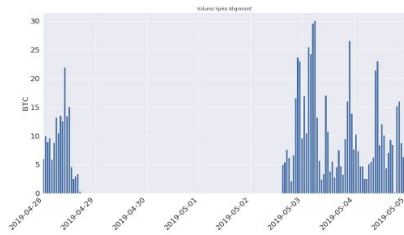
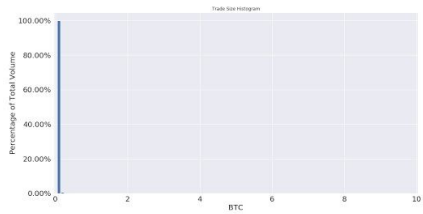
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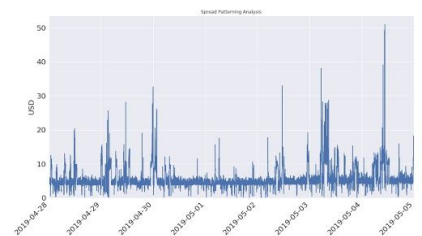
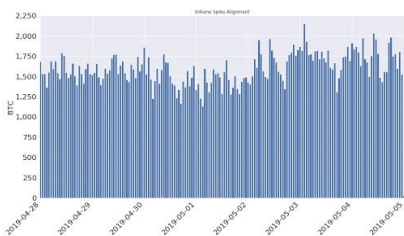
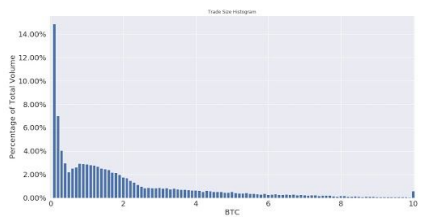
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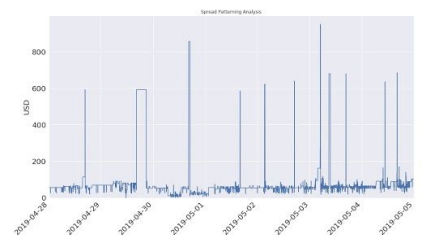
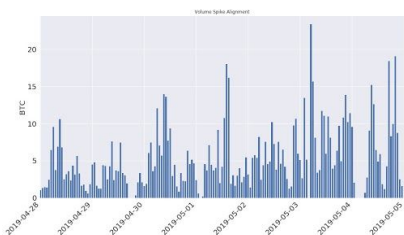
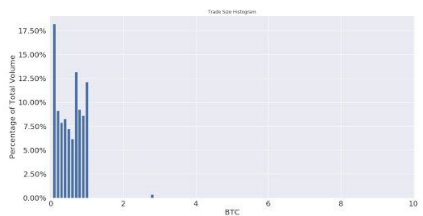
Cryptology



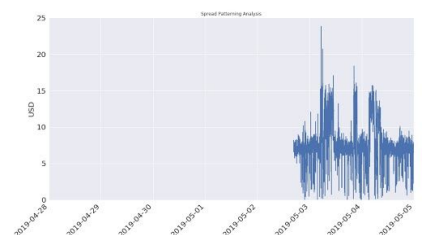
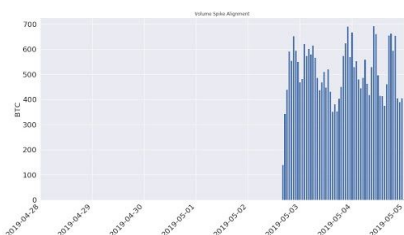
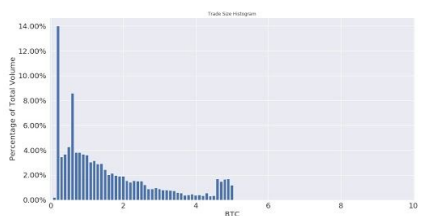
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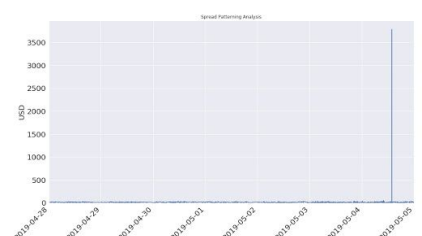
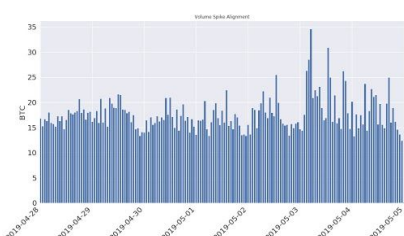
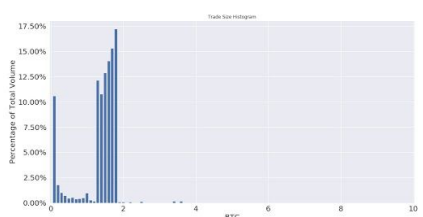
Digital Asset Exchange



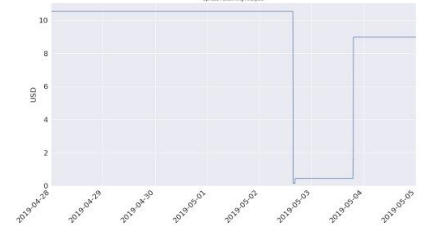
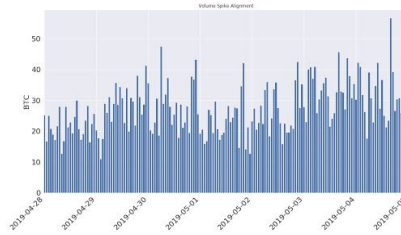
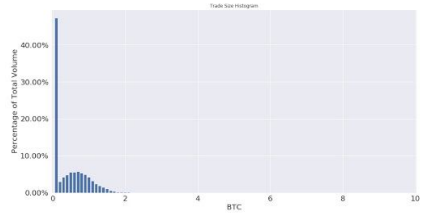
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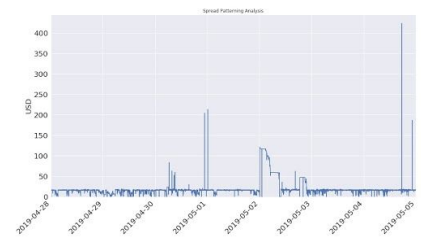
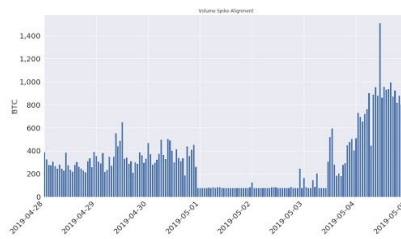
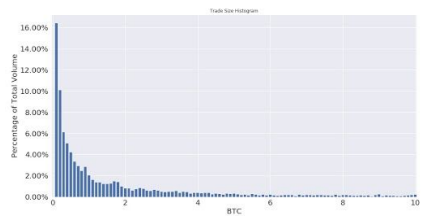
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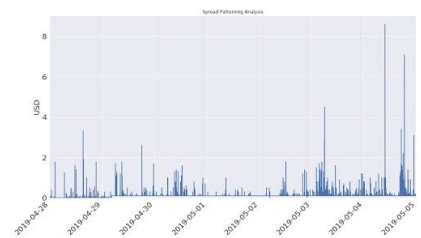
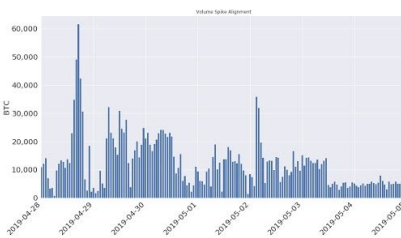
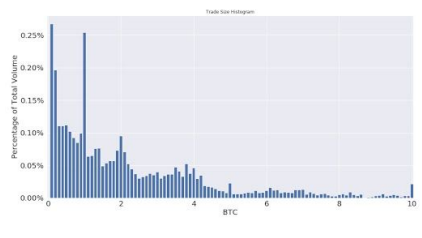
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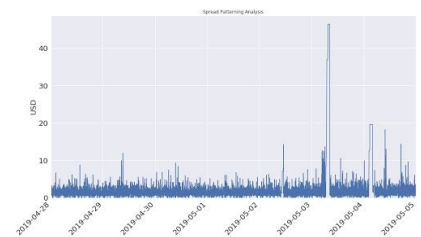
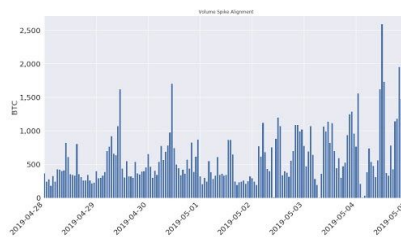
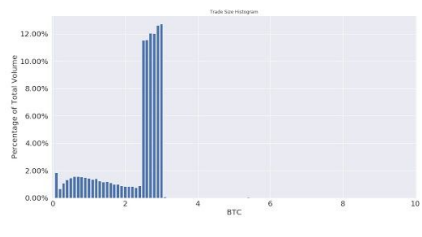
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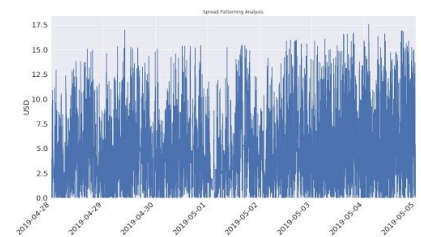
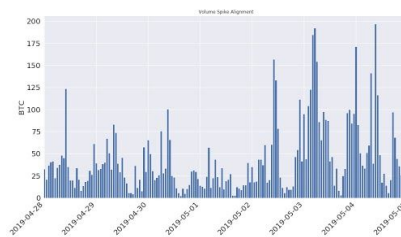
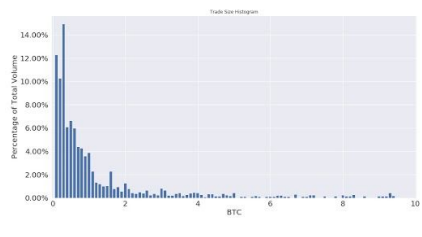
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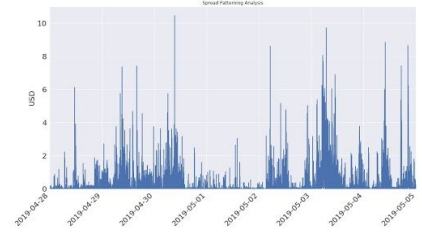
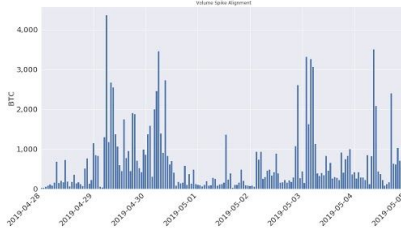
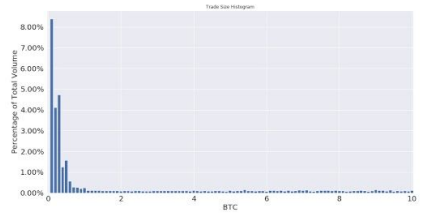
55 Global Markets



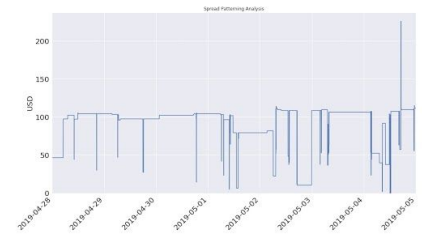
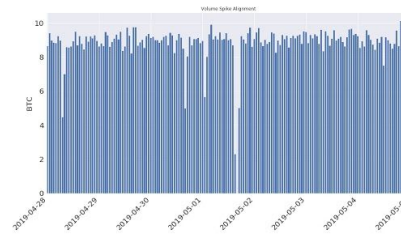
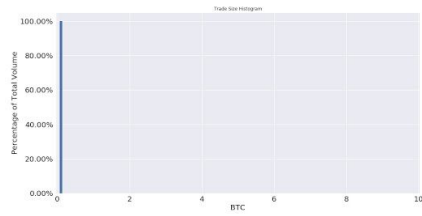
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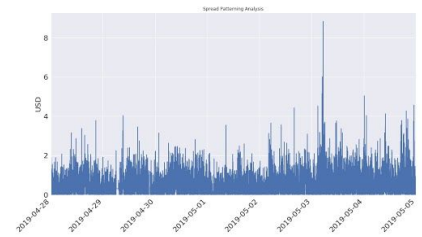
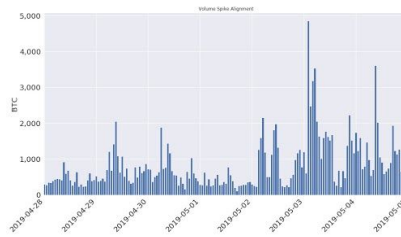
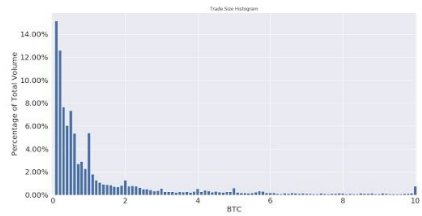
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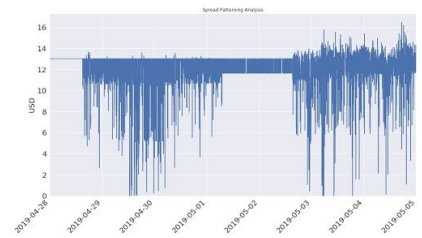
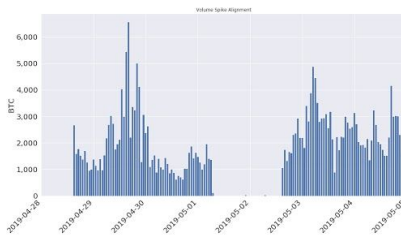
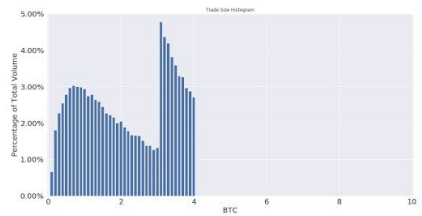
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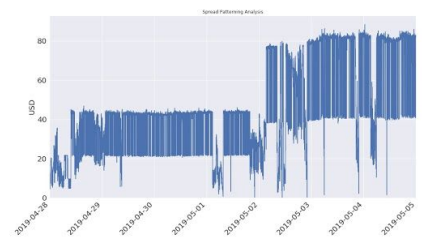
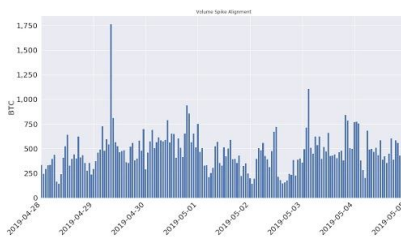
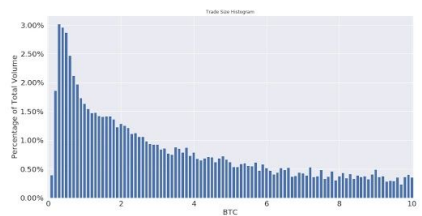
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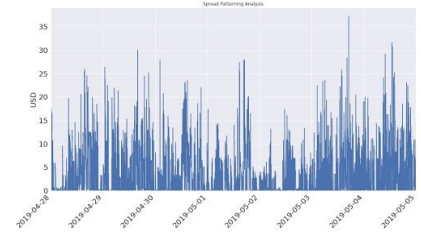
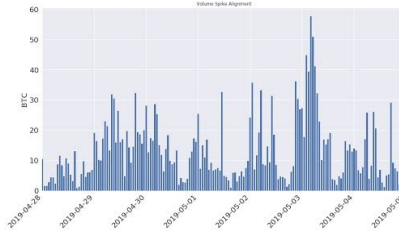
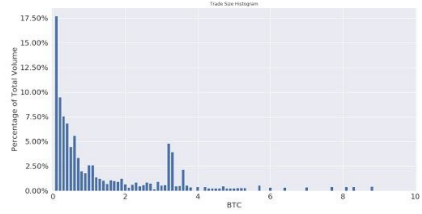
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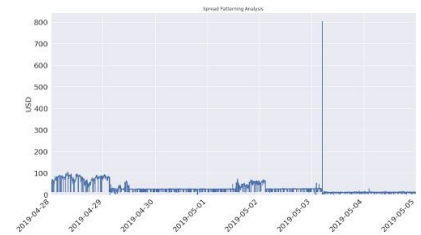
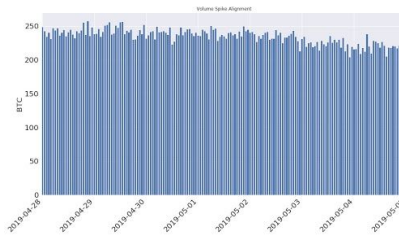
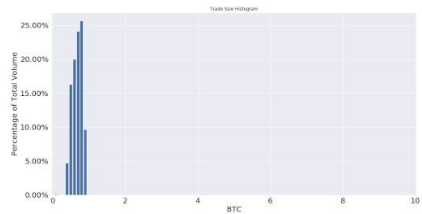
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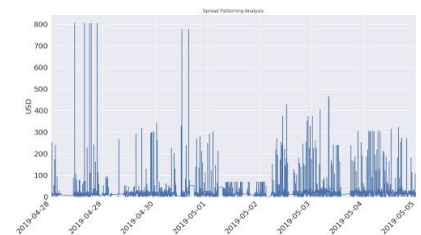
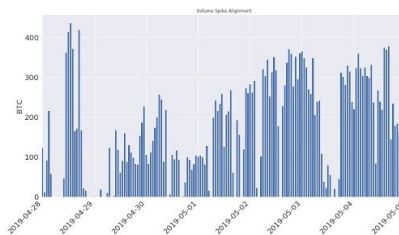
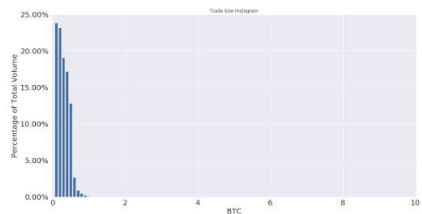
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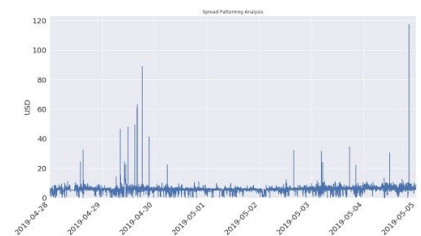
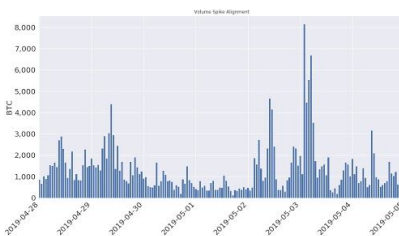
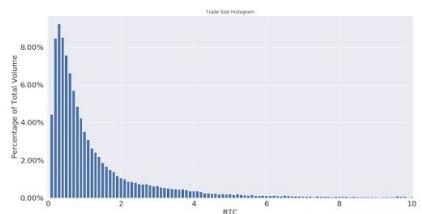
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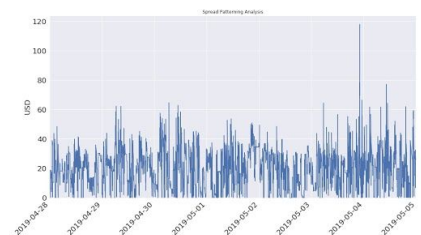
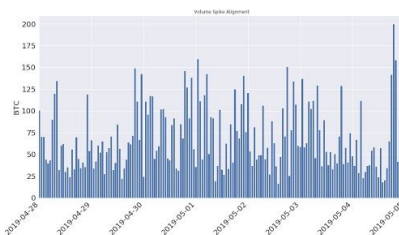
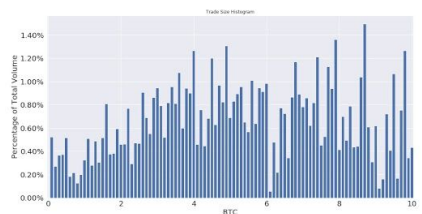
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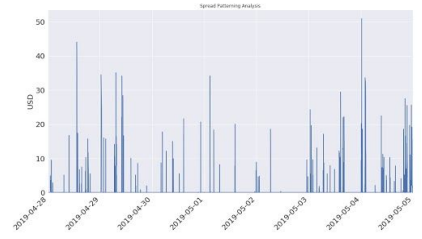
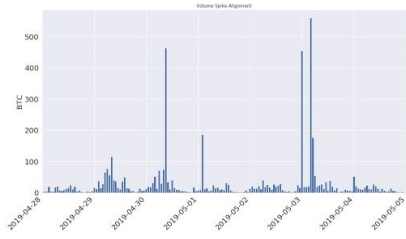
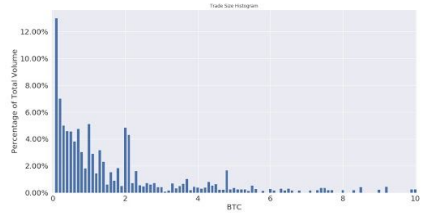
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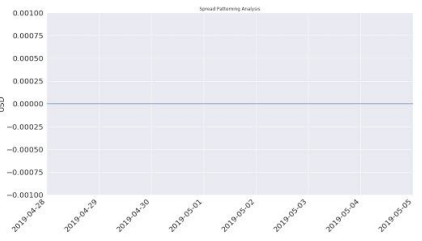
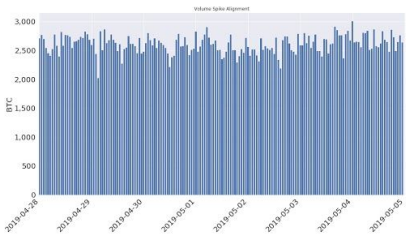
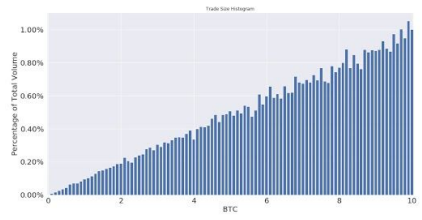
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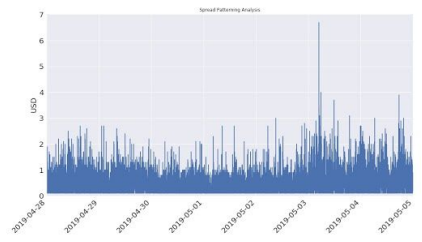
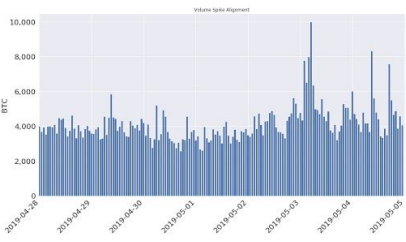
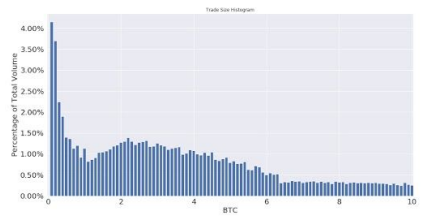
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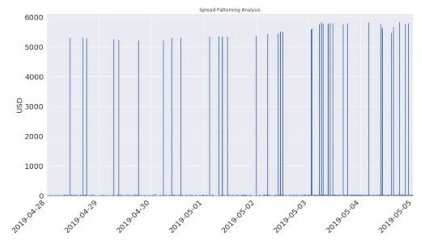
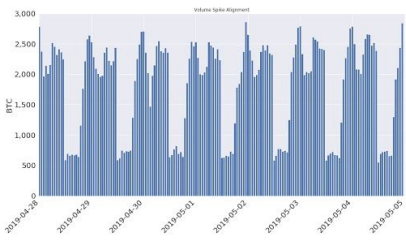
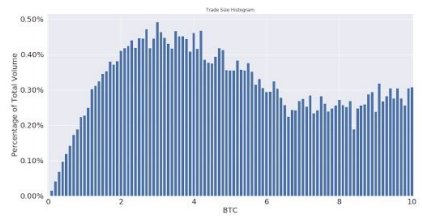
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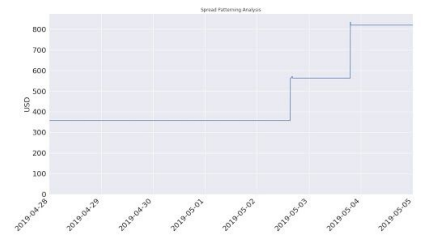
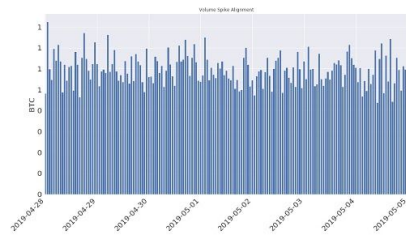
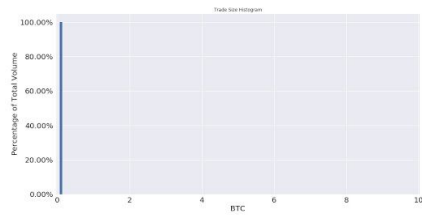
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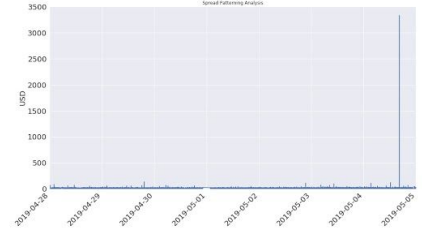
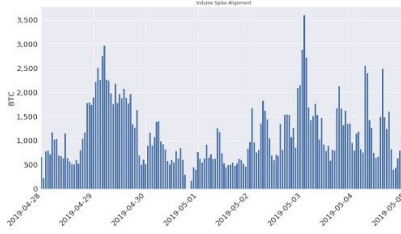
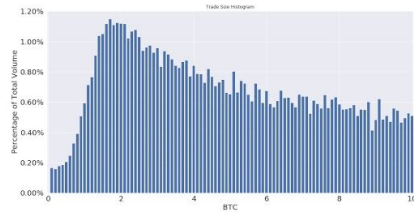
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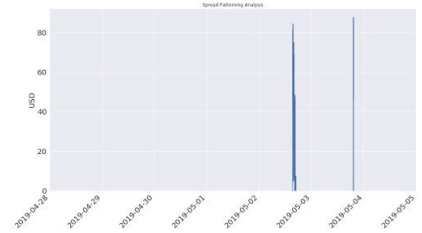
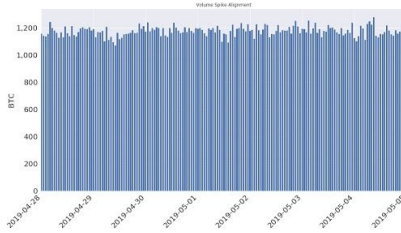
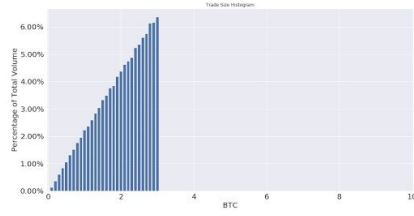
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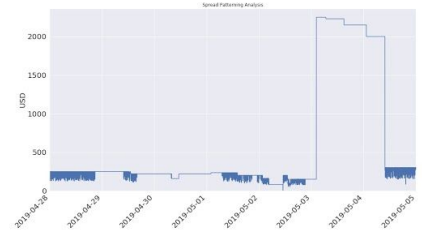
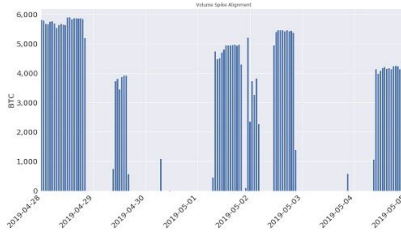
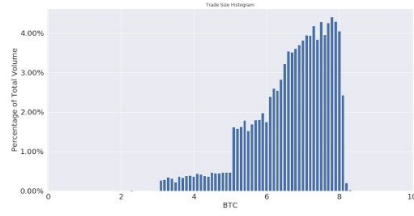
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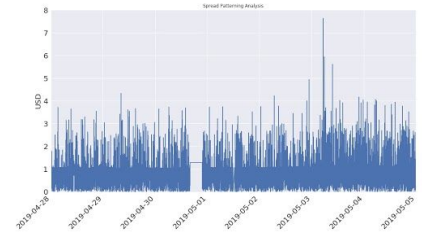
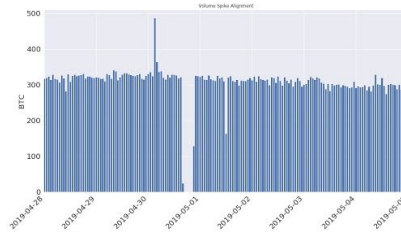
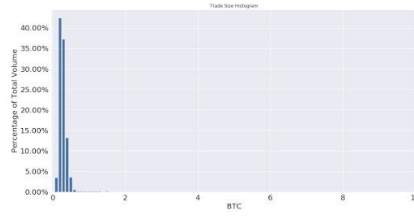
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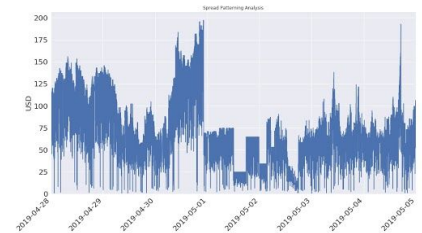
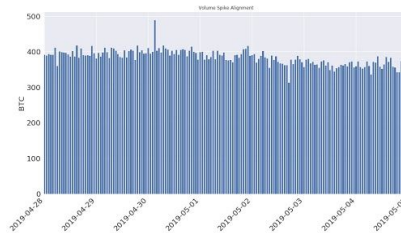
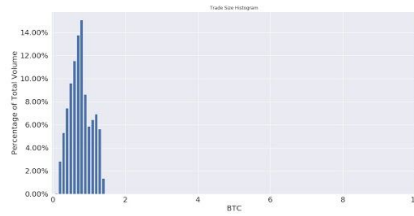
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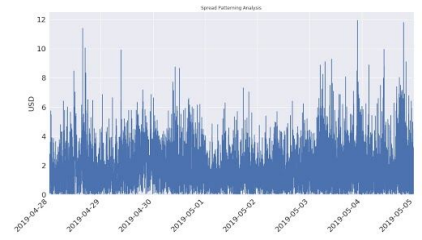
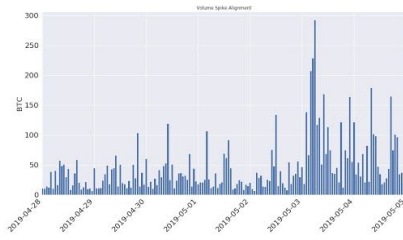
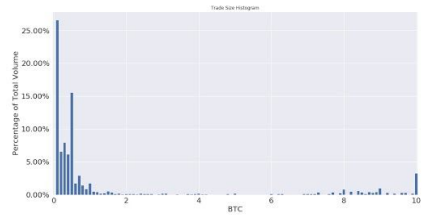
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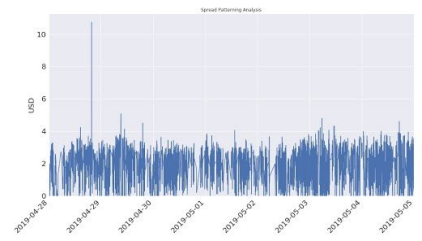
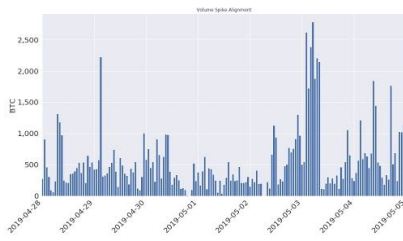
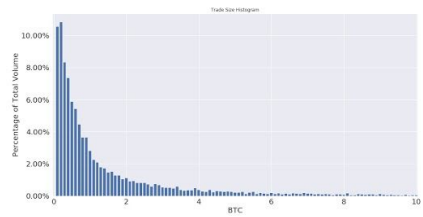
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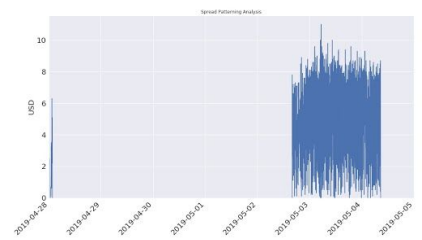
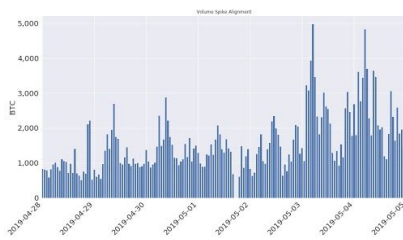
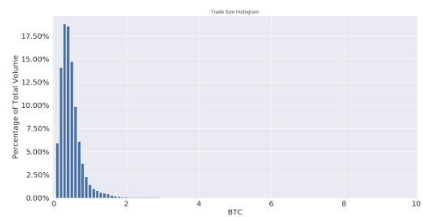
Zaif



ZB.COM



ZBG



APPENDIX II. Public Reception Of The Bitwise Presentation To The U.S. Securities And Exchange Commission

The Bitwise Study was published to the SEC.gov website on March 21, 2019, and received extensive media coverage from both the national and crypto media. Among the most significant stories were:

- **The Wall Street Journal:** “Most Bitcoin Trading Faked By Unregulated Exchanges, Study Says”²¹⁵
- **Bloomberg:** “U.S. Bigger-Than-Expected Source Of Crypto Trades, Firm Says”²¹⁶
- **CNBC:** “Majority of Bitcoin Trading Is A Hoax, New Study Finds”²¹⁷

The Study also received significant support in social media, with the public tweet about the Study from the @BitwiseInvest account attracting more than 1 million impressions, 29,000 engagements, 2600 likes and 1,300 retweets²¹⁸.

More important, however, was the reaction from leading data providers in the crypto space, who widely embraced the findings of the study:

- **OnChainFx:** Immediately defaulted its volume statistics to include only the 10 exchanges highlighted as having real volume in the Bitwise Study.²¹⁹
- **OpenMarketCap:** A new data provider that emerged including only the 10 exchanges highlighted as having real volume in the Bitwise Study.²²⁰

²¹⁵ “Most Bitcoin Trading Faked By Unregulated Exchanges, Study Says,” Paul Vigna, The Wall Street Journal, March 22, 2019.

<https://www.wsj.com/articles/most-bitcoin-trading-faked-by-unregulated-exchanges-study-finds-11553259600>

²¹⁶ “U.S. Bigger-Than-Expected Source of Crypto Trades, Firm Says,” Olga Kharif, Bloomberg, March 22, 2019.

<https://www.bloomberg.com/news/articles/2019-03-22/u-s-a-bigger-than-expected-source-of-crypto-trades-firm-says>

²¹⁷ “Majority of Bitcoin Trading Is A Hoax, New Study Finds,” Kate Rooney, CNBC, March 22, 2019.

<https://www.cnbc.com/2019/03/22/majority-of-bitcoin-trading-is-a-hoax-new-study-finds.html>

²¹⁸ <https://twitter.com/BitwiseInvest/status/1109114656944209921>

²¹⁹ “Introducing “Real 10” Volume and “Liquid Market Cap” on OnChainFx,” Messari, March 25, 2019.

<https://messari.io/article/introducing-real-10-volume-and-liquid-market-cap-on-onchainfx>

²²⁰ “How much are cryptocurrency volumes overstated?” Yin Wu, DIRT Protocol, March 26, 2019.

<https://medium.com/dirt-protocol/how-much-are-cryptocurrency-volumes-overstated-7a80873ffe69> and https://openmarketcap.com/exchanges/volume_difference

- **CoinMarketCap.com:** Immediately admitted that concerns about its data “are valid” and embarked on a serious initiative to improve transparency, disclosure and accuracy.²²¹

We also saw a number of thought leaders embrace the more positive side of the study’s findings, including Michael Casey, Senior Advisor for Blockchain Research at MIT’s Digital Currency Initiative.²²²

We expected to receive a significant amount of pushback from some or all of the exchanges identified as having high amounts of fake volume, but in practice, almost none occurred. Instead, we even saw some of the high profile exchanges with high degrees of fake volume admit that wash trading was a problem; a positive sign for the future of the industry.²²³

²²¹ “Crypto Aggregator Says Concerns Over Inaccurate Data Are Valid,” Olga Kharif, Bloomberg, March 25, 2019.
<https://www.bloomberg.com/news/articles/2019-03-25/crypto-aggregator-says-concerns-over-inaccurate-data-are-valid>

²²² “Exchange Volumes May Be Fake, But Bitcoin’s Value Is Real,” Michael J. Casey, CoinDesk, April 2, 2019.
<https://www.coindesk.com/exchange-volumes-may-be-fake-but-bitcoins-value-is-real>

²²³ “OKEx Comes Clean On Wash Trading Program,” Paddy Baker, CryptoBriefing, March 28, 2019.
<https://cryptobriefing.com/okex-wash-trading>