BTC SPOT PRICE DISCOVERY UPDATE – Q2 2020

SUMMARY

- This report, covering Q2 2020, is a quarterly update of DAR's lead-lag study. The initial report, which covered the period Q2-Q4 2019, can be found here, and the Q1 2020 update can be found here.

- The Q2 2020 Lead-Lag study evaluates price discovery in the BTC spot market. This quarter, 109 exchanges were included in the study, and 15 Volatility Events were analyzed.

- Watchlist and Vetted exchanges respectively lead price discovery by **41.94% and 37.10%** of the time in Q2 2020.

- In Q2 2020, **72.07%** of the time a Vetted or Watchlist exchange was in the top 3 exchanges to lead price discovery

OVERVIEW

One of the primary concerns in the digital asset space is market manipulation and the effect of manipulated trade data on price. DAR's lead-lag study intends to help shine a light on this concern by determining where price formation is occurring in the bitcoin spot market. Each quarter, DAR looks at moments of high price volatility and, for each of those moments, determines which exchanges were first to experience that event, and which exchanges followed.

Our Q1 2020 lead-lag study indicated that price discovery in the bitcoin spot market takes place on DAR's Vetted and Watchlist exchanges 87.57% of the time. In this report, we'll update our findings for Q2 of 2020.

METHODOLOGY RECAP

DAR utilizes a multistep data science process designed to measure the lead-lag relationship of Bitcoin trading between various spot exchanges inspired by multiple academic journals[1]. DAR looks for volatility events, defined as a change in the price of bitcoin by more than $100 in a 5.5-minute window. For each volatility event, DAR determines the correlation value between each exchange that experienced that event. DAR then incrementally shifts each exchange's reported trades in that time window forward and backward in time. The time shift needed to reach the highest possible correlation value indicates which exchange experienced the volatility event first. For a full breakdown of our methodology, please refer to the initial study.

There are multiple methods to assess lead-lag study and DAR's method is by no means the only applicable one.

DAR uses a vetting methodology that looks at both quantitative and qualitative criteria to classify exchanges into the following categories: Vetted, Watchlist and Disqualified. Vetting results are updated each quarter. A full vetting methodology is available from DAR upon request.

Vetted Exchanges have passed all quantitative and qualitative criteria. These are the most trustworthy exchanges that do not report inflated volumes and have robust policies and practices in place.

Watchlist Exchanges have passed only DAR's preliminary vetting, which includes data science testing and some qualitative diligence. These exchanges do not report known inflated volumes but may not have institutional policies and practices in place in order to pass full vetting.
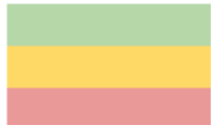
Disqualified Exchanges fail to meet the requirements of our vetting process, either for failing data science tests, qualitative diligence, or a liquidity threshold.

This quarter 109 exchanges were included in the study, and 15 volatility events were analyzed. For each event, the first 5 exchanges to experience an event are considered "Price Leaders" for that single event. Out of **109** exchanges analyzed, the following entities appeared as price leaders in Q2 2020.

FIGURE A – *BTC PRICE LEADER TALLY*

Vetted	
Exchange	Price Leader Appearances
Liquid	10
Bitstamp	9
Coinbase	4
Bitflyer	1
Gemini	1

Watchlist	
Exchange	Price Leader Appearances
Huobi	8
Binance	5
Bequant	5
Hitbtc	5
Kucoin	3
Gateio	2
Zaif	1
Coinex	1
Bitrue	1
Upbit	1
Bittrex	1

Diqualified	
Exchange	Price Leader Appearances
Huobi_russia	8
Tagz	5
Bitmax	3
Okex	2
Hcoin	2
Bitubu	2
huobi_russia	2
Mxc	2
Cryptology	1
P2pb2b	1
Coineal	1
Tidex	1
Livecoin	1
Oceanex	1
Whitebit	1
Tokok	1
vindax	1
Lakebtc	1
bcex	1
Omgfin	1
Stex	1

Vetted
Watchlist
Disqualified

Source: Digital Asset Research

This quarter, Watchlist exchanges lead price discovery **41.94%** of the time, and Vetted Exchanges lead **37.10%** of the time.

Figure B, below, shows that 8 out of the 10 exchanges that acted as Price Leaders most often in Q2 of 2020 come from DAR's Vetted or Watchlist exchanges, emphasizing the fact that digital asset exchanges which failed to pass DAR's exchange vetting process have limited impact on price discovery.

FIGURE B – *TOP 10 PRICE LEADER APPEARANCES*

Exchange	Price Leader Appearances
Binance	78
Liquid	56
Huobi	54
Coinbase	53
Hitbtc	47
Bitstamp	34
Okex	33
Gemini	24
Bitfinex	21
Bitflyer	18

Q2 - Q4 2019 Price Leader Appearances

Exchange	Price Leader Appearances
Binance	35
Liquid	25
huobi_russia	21
Hitbtc	19
Bequant	19
Huobi	17
Coinbase	13
LMAX	8
Gemini	6
Bitstamp	6

Q1 2020 Price Leader Appearances

Exchange	Price Leader Appearances
Liquid	10
Bitstamp	9
Huobi	8
Huobi_russia	8
Binance	5
Tagz	5
Bequant	5
Hitbtc	5
Coinbase	4
Kucoin	3

Q2 2020 *Price Leader Appearances*

Vetted   Watchlist   Disqualified

Source: Digital Asset Research

Note: In the initial report (Q2 - Q4 2019), we analyzed 61 exchanges in each quarter. In Q1 2020, we analyzed 102 exchanges.

In Q2 2020, Gemini and LMAX fell off the list of most frequent Price Leaders, and Tagz and Kucoin were added. Huobi Russia, a Disqualified exchange to make the top 10 Price Leaders list this quarter, was disqualified only because it is based in Russia, a country with capital controls. It has, however, passed all DAR's data science vetting tests, and is not known to be reporting inflated trades. Tagz, the only other Disqualified exchange to appear as a frequent price leader this quarter, has since announced a forced closure shutdown, ceasing all operations as of 30-July-2020.

Figure C, below, shows the number of times each of the 10 most frequent Price Leaders were first, second, third, fourth or fifth, to experience a volatility event. Out of the top ten Price Leaders, Vetted or Watchlist exchanges were first to experience the event **79.03%** of the time, and **72.07%** of the time a Vetted or Watchlist exchange was in the top 3 exchanges to lead price discovery.

FIGURE C – *FREQUENCY OF APPEARANCES*

Exchange	Number of Times Ranked				
	First	Second	Third	Fourth	Fifth
Liquid	1	4	4	1	0
Bitstamp	0	0	3	3	3
Huobi	2	2	0	2	2
Huobi_russia	3	2	2	0	1
Binance	4	0	1	0	0
Bequant	0	1	2	0	2
Hitbtc	0	0	2	1	2
Tagz	1	0	2	2	0
Coinbase	0	1	0	1	2
Kucoin	0	0	0	1	2

Vetted   Watchlist   Disqualified

Source: Digital Asset Research

HISTORICAL COMPARISON

Figure D shows the 10 most frequent Price Leaders for each of the last four quarters. "n" is the number of volatility events analyzed in that quarter.

FIGURE D – *QUARTERLY COMPARISONS*

Q2 2019 (n=43)	
Binance	30
Coinbase	22
Hitbtc	21
Huobi	19
Liquid	18
Okex	15
Bitfinex	14
Bitstamp	14
Gemini	9
EXX	7

Q3 2019 (n=53)	
Binance	40
Huobi	30
Liquid	30
Coinbase	25
Hitbtc	21
Okex	15
Bitflyer	14
Bitstamp	14
Gemini	12
BITFOREX	9

Q4 2019 (n=10)	
Binance	8
Liquid	8
Bitstamp	6
Coinbase	6
Hitbtc	5
Huobi	5
Gemini	3
Okex	3
STEX	2
ZB	2

Q1 2020 (n=39)	
Binance	35
Liquid	25
huobi_russia*	21
Hitbtc	19
Bequant*	19
Huobi	17
Coinbase	13
LMAX*	8
Gemini	6
Bitstamp	6

| Q2 2020 (n=15)	
Liquid	10
Bitstamp	9
Huobi	8
Huobi_russia*	8
Binance	5
Tagz*	5
Bequant*	5
Hitbtc	5
Coinbase	4
Kucoin	3

Exchanges that were not included in the initial study (Q2-Q4 2019)

Vetted   Watchlist   Disqualified

Source: Digital Asset Research

Although each quarter has seen different Price Leaders, the lead-lag test results from the past five quarters showed a relatively stable distribution of Price Leaders between Vetted, Watchlist, and Disqualified exchanges. In Q1 2020, Watchlist exchanges gained more than 10% over Vetted exchanges. In Q2 2020, Watchlist exchanges lost more than 10% to Disqualified and Vetted exchanges as shown in Figure E, below.

FIGURE E – *PRICE LEADERS DISTRIBUTION*
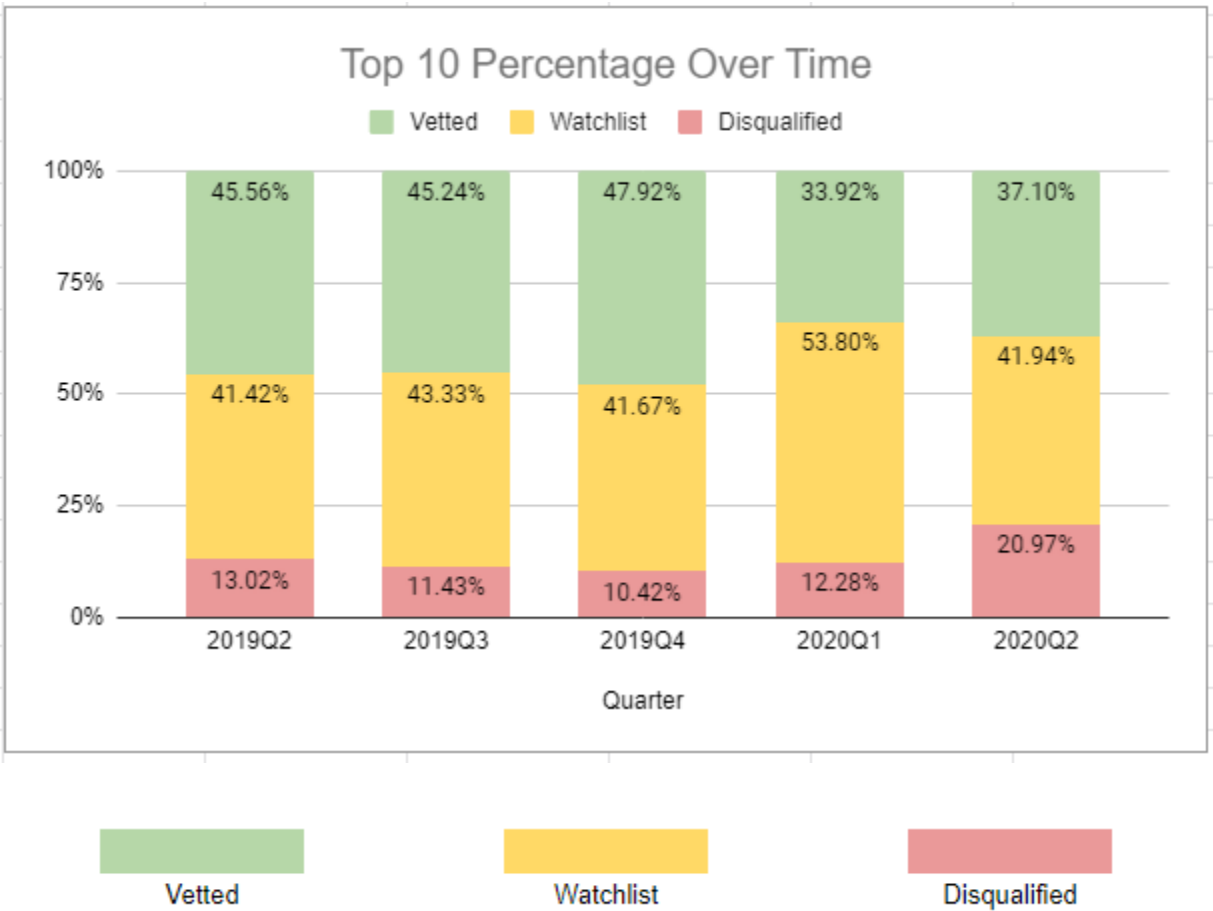
Source: Digital Asset Research

PERPETUAL DATA

In the digital asset markets, derivatives increasingly play an important role within the trading ecosystem, including perpetual products. DAR's Q2 20 Lead-Lag study included 5 of the market's largest Bitcoin perpetual products.

Figure F shows that the incorporation of perpetual data has a significant impact on Bitcoin price discovery, with Binance, OKEx, and BitMEX making top 10 price leader appearances, replacing Coinbase, Kucoin, and HitBTC.

FIGURE F – *TOP 10 PRICE LEADERS PERPETUAL COMPARISON*

Exchange	Price Leader Appearances
Liquid	10
Bitstamp	9
Huobi	8
Huobi_russia	8
Binance	5
Tagz	5
Bequant	5
Hitbtc	5
Coinbase	4
Kucoin	3

Q2 2020 *Price Leader Appearances Without Perpetual Data*

Exchange	Price Leader Appearances
Binance^P	13
Okex^P	9
Huobi_russia	7
Liquid	7
Tagz	5
Huobi	5
Binance	5
Bitmex^P	3
Bequant	3
Bitstamp	3

Q2 2020 *Price Leader Appearances With Perpetual Data*

Perpetual	
Exchange	Price Leader Appearances
Binance^P	13
Okex^P	9
Bitmex^P	3
Deribit^P	2
Bybit^P	1

Vetted   Watchlist   Disqualified   Perpetual

Source: Digital Asset Research

1.0   Volatility Event Example Analysis

Figure G shows an example of a volatility moment that happened on 10-May-2020. The red line shows the price of Bitcoin across all exchanges in this study during the time period and the black line is the polynomial utilized to test the volatility moment.

One way to visualize the data across multiple exchanges is by a heat map. Figures H shows the heat map for this particular event. The matrix shows the lead or lag time in seconds for each pair of exchanges in this single time window. Each exchange on the left (Y axis) is compared to each exchange on the bottom (X axis). Green (positive) numbers mean that the exchange on the left is leading the exchange at the bottom of the heatmap. Whereas red (negative) numbers mean that the exchange on the left is lagging against the exchange at the bottom of the heatmap.

During this specific volatility moment, Binance led other exchanges the most, as shown by the full green row on the heatmaps.

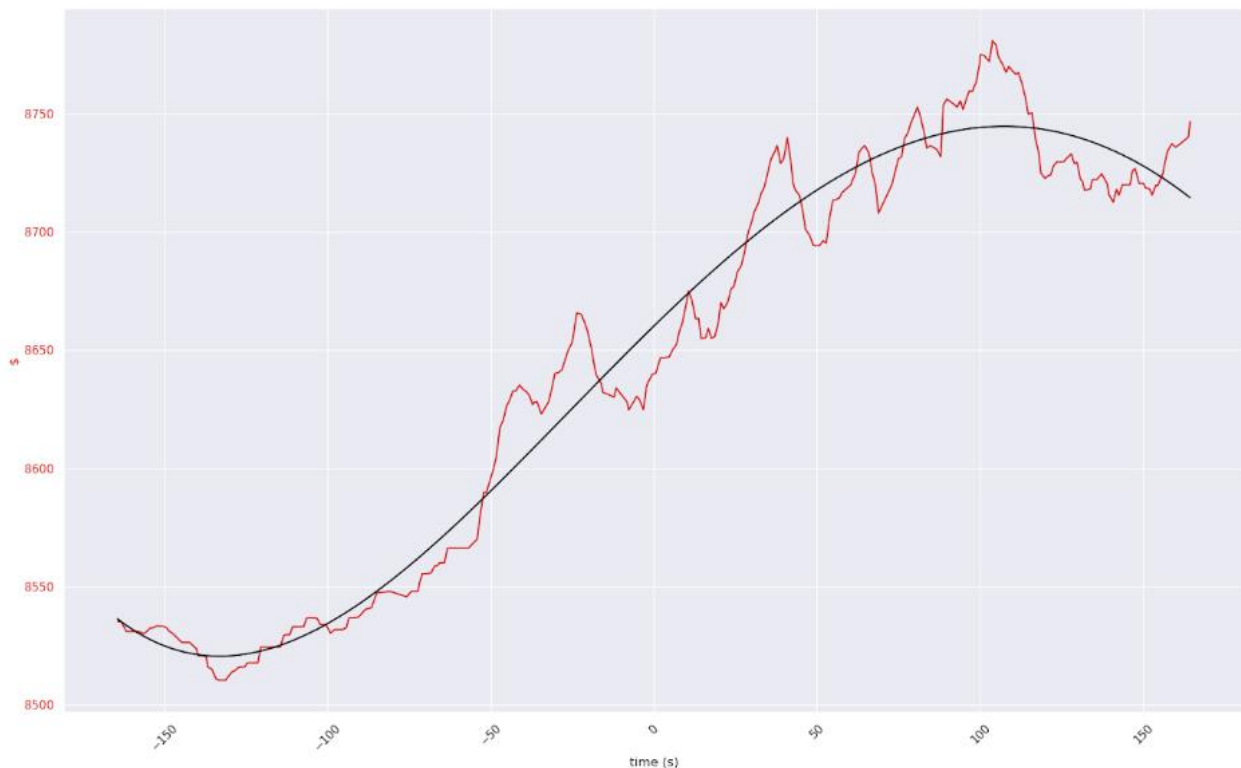### FIGURE G – *VOLATILITY MOMENT 10-MAY-2020 19:59:28*

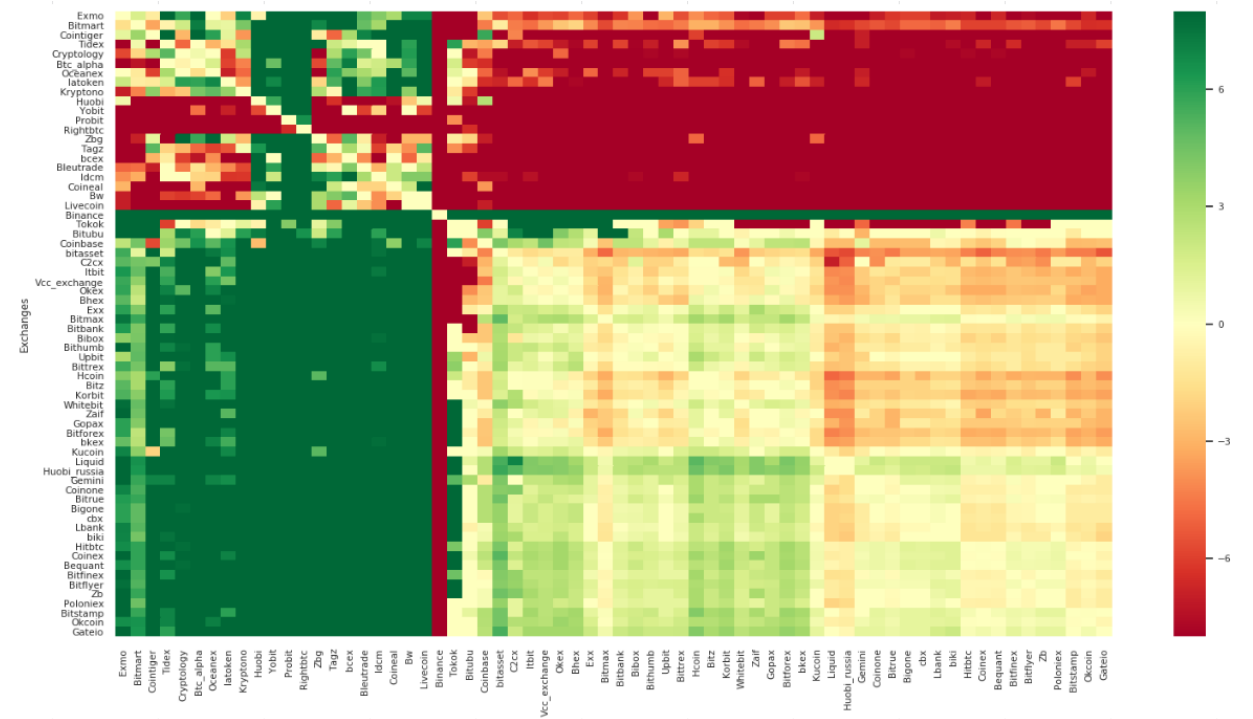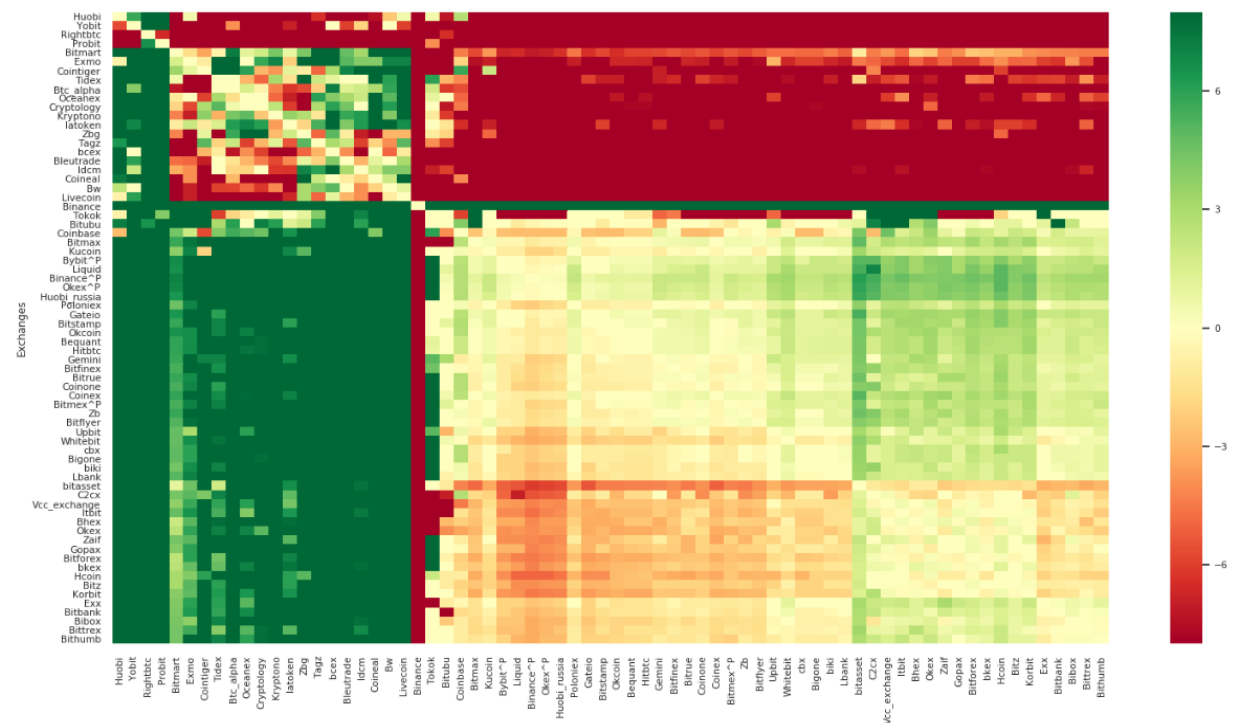# FIGURE H – *EXCHANGE HEATMAP 10-MAY-2020 19:59:28 WITHOUT PERPETUAL*

FIGURE I – *EXCHANGE HEATMAP 10-MAY-2020 19:59:28 WITH PERPETUAL*

2.0   Q2 2020 Exchange Sources

Exchange Sources - Q2 2020

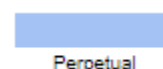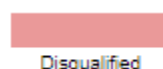|						
alterdice*	Bitforex	Bw	Coinone	Hitbtc	luno	Therocktrading
Bbx	Bithumb	Bybit^P*	coinsbank	Huobi	Mercado_bitcoin	tidebit
bcex	Bitmart	C2cx	Coinsbit	Huobi_russia	mercatox*	Tidex
Bequant	Bitmax	Catex	coinsuper*	idax*	Mxc	Tokok
Bhex	Bitmex^P*	cbx	Cointiger	Idcm	Oceanex	Upbit
Bibox	Bitrue	ccx_canada*	Cryptology	Indodax	Okcoin	Vcc_exchange
Bigone	bitso	Cexio	Deribit^P*	Itbit	Okex	vindax
biki	Bitstamp	chaoex	dsx	Korbit	Okex^P*	Whitebit
bilaxy	Bittrex	coinall*	Exmo	Kraken	Omgfin	Yobit*
Binance	Bitubu	Coinbase	exrates	Kryptono	P2pb2b	Zaif
Binance^P*	Bitz	Coineal	Exx	Kucoin	Poloniex	Zb
binance_us*	bkex	coinegg	fifty_five	Lakebtc	Probit	Zbg
Bitasset	Bleutrade	Coinex	Gateio	latoken	Rightbtc	
Bitbank	Btc_alpha	Coinfield	Gdac	Lbank	simex	
bitbay*	btc_markets	coinhe	Gemini	Liquid	sistemkoin	
Bitfinex	btcbox	coinmate	Gopax	Livecoin	Stex	
Bitflyer	btcturk	coinmex	Hcoin	lmax	Tagz	

Exchanges that were not included in Q1 2020

Vetted | Watchlist | Disqualified | Perpetual

3.0   Q1 2020 Exchange Sources

Exchange Sources - Q1 2020

Bbx*	Bitfinex	bitubu*	cbx*	Coinone	Gateio	Korbit	Mercado_bitcoin*	sistemkoin*	Zaif
bcex*	Bitflyer	Bitz	Cexio	Coinsbank	Gdac*	Kraken	mxc*	Stex	ZB
Bequant*	Bitforex	bkex*	Chaoex	Coinsbit*	Gemini	Kryptono*	Oceanex*	tagz*	Zbg*
Bhex	Bithumb	Bleutrade	Coinbase	Cointiger	Gopax*	Kucoin	Okcoin	Therocktrading	
Bibox*	Bitmart	Btc_alpha*	Coineal*	Cryptology*	hcoin*	Lakebtc	Okex	Tidebit*	
Bigone*	Bitmax	Btc_markets*	Coinegg*	Digifinex*	Hitbtc	latoken*	omgfin*	Tidex	
biki*	bitrue	Btcbox	Coinex*	Dsx	Huobi	Lbank*	P2pb2b*	Tokok*	
Bilaxy*	Bitrue*	Btcturk*	Coinfield*	Exmo	Huobi_russia*	Liquid	Poloniex	Upbit	
Binance	bitso*	Bw	coinhe*	Exrates*	Idcm	Livecoin	Probit*	vcc_exchange*	
bitasset	Bitstamp	C2cx*	Coinmate	Exx	Indodax	LMAX*	Rightbtc*	vindax*	
Bitbank	Bittrex	Catex*	coinmex*	fifty_five*	Itbit	Luno*	Simex	Whitebit*	

Exchanges that were not included in the initial study (Q2-Q4 2019)

Vetted | Watchlist | Disqualified
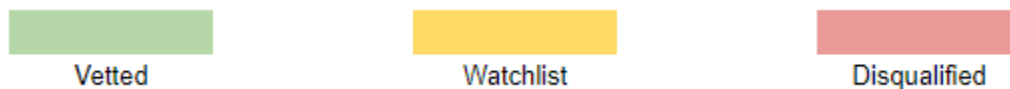
4.0   Q2-Q4 2019 Exchange Sources

Exchange Sources - Q2 to Q4 2019						
BHEX	Bitlish	BW	Coinone	Gemini	KuCoin	STEX
Bibox	BitMarket	CEX.IO	CoinsBank	Graviex	LakeBTC	The Rock Trading
Binance	BitMart	Cobinhood	CoinTiger	HitBTC	Liquid	Tidex
Bitbank	Bitmex^P	Coinbase	COSS	Huobi	LiveCoin	Upbit
Bitfinex	Bitstamp	Coinbene	CRXzone	IDAX	OKCoin	YoBit
Bitflyer	Bittrex	Coinfloor	DSX	Independent Reserve	OKEx	Zaif
BitForex	BitZ	Coingi	EXMO	itBit	Poloniex	ZB
Bithumb	Bleutrade	CoinMate	EXX	Korbit	SIMEX	
BitKonan	BTCBox	Coinnest	Gate.io	Kraken	SouthXchange	

Vetted	Watchlist	Disqualified	Perpetual
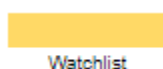
5.0   Definitions

Terminology Definitions	
Disqualified Exchanges	Digital Asset Exchanges that fail to meet the requirements of our vetting process, either for failing data science tests, qualitative diligence, or a liquidity threshold.
Lead-Lag Relationship	A means to determine where price formation occurs by looking at the correlation of price movements between exchanges during a specific time window, and determining which exchange(s) saw the price movement first, and which saw the price movement at a later time.
Price Leaders	Digital asset exchanges that were among the first 5 exchanges to experience price movement in a single volatility event.
Vetted Exchanges	Digital Asset Exchanges that have passed all of DAR's quantitative and qualitative criteria. These are the most trustworthy exchanges that do not report inflated volumes and have robust policies and practices in place.
Volatility Events	A change in the price of bitcoin of more than $100 in either direction within a 5.5-minute window, identified by looking at trades on a 30 second rolling basis. Qualifying events are also filtered by shape, and must see price movement in both directions.
Watchlist Exchanges	Digital Asset Exchanges that have passed only DAR's preliminary vetting, which includes data science testing and some qualitative diligence. These exchanges do not report known inflated volumes but may not have institutional policies and practices in place in order to pass full vetting.

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[1] de Jong, F.C.J.M. & Donders, M.W.M., 1996. "Intraday Lead-Lag Relationships between the Futures-, Options and Stock Market," Discussion Paper 1996-108, Tilburg University, Center for Economic Research; de Jong, Frank & Nijman, Theo, 1997. "High frequency analysis of lead-lag relationships between financial markets," Journal of Empirical Finance, Elsevier, vol. 4(2-3), pages 259-277, June; Kawaller, Ira G & Koch, Paul D & Koch, Timothy W, 1987. " The Temporal Price Relationship between S&P 500 Futures and the S and P 500 Index," Journal of Finance, American Finance Association, vol. 42(5), pages 1309-1329, December.