DIGITAL ASSET RESEARCH

Lead-Lag Report
19-Nov-2020

BTC SPOT PRICE DISCOVERY UPDATE – Q3 2020

SUMMARY

- **Q3 2020** quarterly update of DAR's public lead-lag study, evaluating price discovery in the **BTC spot market** using volatility events. See Appendix 1 for links to prior reports.
- **110 exchanges** were included, and **21 Volatility Events** were analyzed
- Includes **17** Vetted exchanges and **15** Watchlist exchanges
- Watchlist exchanges were price leaders **51.55%** of the time, and Vetted Exchanges were price leaders **24.74%** of the time
- In Q3 2020, **71.43%** of the time a Vetted or Watchlist exchange was in the top 3 exchanges to lead price discovery
- In Q3 2020, Watchlist exchanges gained close to 10% of price leadership share over Vetted exchanges compared to the Q2 2020 period
- Please contact DAR for analysis of other crypto asset markets

OVERVIEW

One of the concerns in the lightly regulated digital asset markets is where price discovery happens. DAR's lead-lag study intends to help illuminate and show where price formation is occurring in the bitcoin spot market. Each quarter, DAR looks at distinct moments of price volatility and, for each of those moments, determines which exchanges were first to experience that event (lead), and which exchanges followed (lag.)

METHODOLOGY RECAP

DAR utilizes a multistep quantitative process designed to measure the lead-lag relationship of Bitcoin trading between various spot exchanges inspired by multiple academic papers[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. The exchange's reported trades in that time window are then incrementally shifted forward and backward in time. The relative time shift needed to reach the highest possible correlation value indicates which exchange experienced the volatility event first and which reflected that price discovery after. For a full discussion of the methodology, please refer to the initial study.

There are multiple methods to assess lead-lag relationships and this method is by no means the only applicable one.

Exchange Vetting

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 are not known to report inflated volumes and have robust policies and practices in place to prevent manipulative practices by clients.

Watchlist Exchanges have passed only DAR's preliminary vetting, which includes data science testing and some qualitative diligence. These exchanges are not known to report inflated volumes or have manipulated trades but may not have the institutional policies and practices in place in order to prevent future manipulation and to pass full vetting.

Disqualified Exchanges fail to meet the requirements of our vetting process, failing data science tests for manipulation, qualitative diligence, or a liquidity threshold.

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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.

RESULTS

This quarter 110 exchanges were included in the study, and 21 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 **110** exchanges analyzed, the following entities appeared as Price Leaders in Q3 2020.

FIGURE A – *BTC PRICE LEADER TALLY*

Vetted	
Exchange	Price Leader Appearances
Liquid	13
Bitstamp	11
Coinbase	2
Zaif	1
Gemini	1
Luno	1

Watchlist	
Exchange	Price Leader Appearances
Binance	18
Huobi	16
Bequant	6
Hitbtc	6
Bhex	4
Bitrue	2
ZB	2
Coinex	1
Oceanex	1
Lakebtc	1

Diqualified	
Exchange	Price Leader Appearances
Okex	16
Catex	4
MXC	3
Bitmart	2
Gopax	2
Exx	2
Alterdice	2
Kryptono	2
Bitmax	2
Coinone	1
Whitebit	1
Kucoin	1
Bithumb	1
Mercado_bitcoin	1
Coinsbank	1
Cryptology	1
Livecoin	1

Source: Digital Asset Research

This quarter, Watchlist exchanges were price leaders **51.55%** of the time, and Vetted Exchanges were price leaders **24.74%** of the time.

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

Exchange	Price Leader Appearances
Binance	18
Huobi	16
Okex	16
Liquid	13
Bitstamp	11
Bequant	6
Hitbtc	6
Bhex	4
Catex	4
MXC	3

***Q3 2020** Price Leader Appearances*

Vetted Watchlist Disqualified

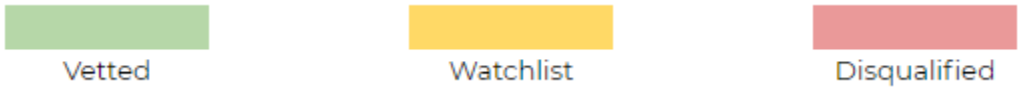
Source: Digital Asset Research

See Appendix 3 for a list of exchange participation by quarter. Not all exchanges have been considered each quarter.

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 **76.29%** of the time, and **71.43%** of the time a Vetted or Watchlist exchange was in the top 3 exchanges to lead price discovery.

FIGURE C – *FREQUENCY OF APPEARANCES*

	Number of Times Ranked				
Exchange	First	Second	Third	Fourth	Fifth
Binance	9	4	5	0	0
Huobi	3	4	4	3	2
Okex	1	7	2	4	2
Liquid	1	4	3	4	1
Bitstamp	0	1	2	4	4
Bequant	0	0	0	3	3
Hitbtc	0	0	0	3	3
Bhex	0	0	0	2	2
Catex	2	0	1	0	1
MXC	2	1	0	0	0



Source: Digital Asset Research

HISTORICAL COMPARISON

Figure D shows the 10 most frequent Price Leaders for each quarter going back to Q2 of 2019, with "n" representing 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

Q3 2020 (n=21)	
Binance	18
Huobi	16
Okex	16
Liquid	13
Bitstamp	11
Bequant	6
Hitbtc	6
Bhex	4
Catex	4
MXC	3

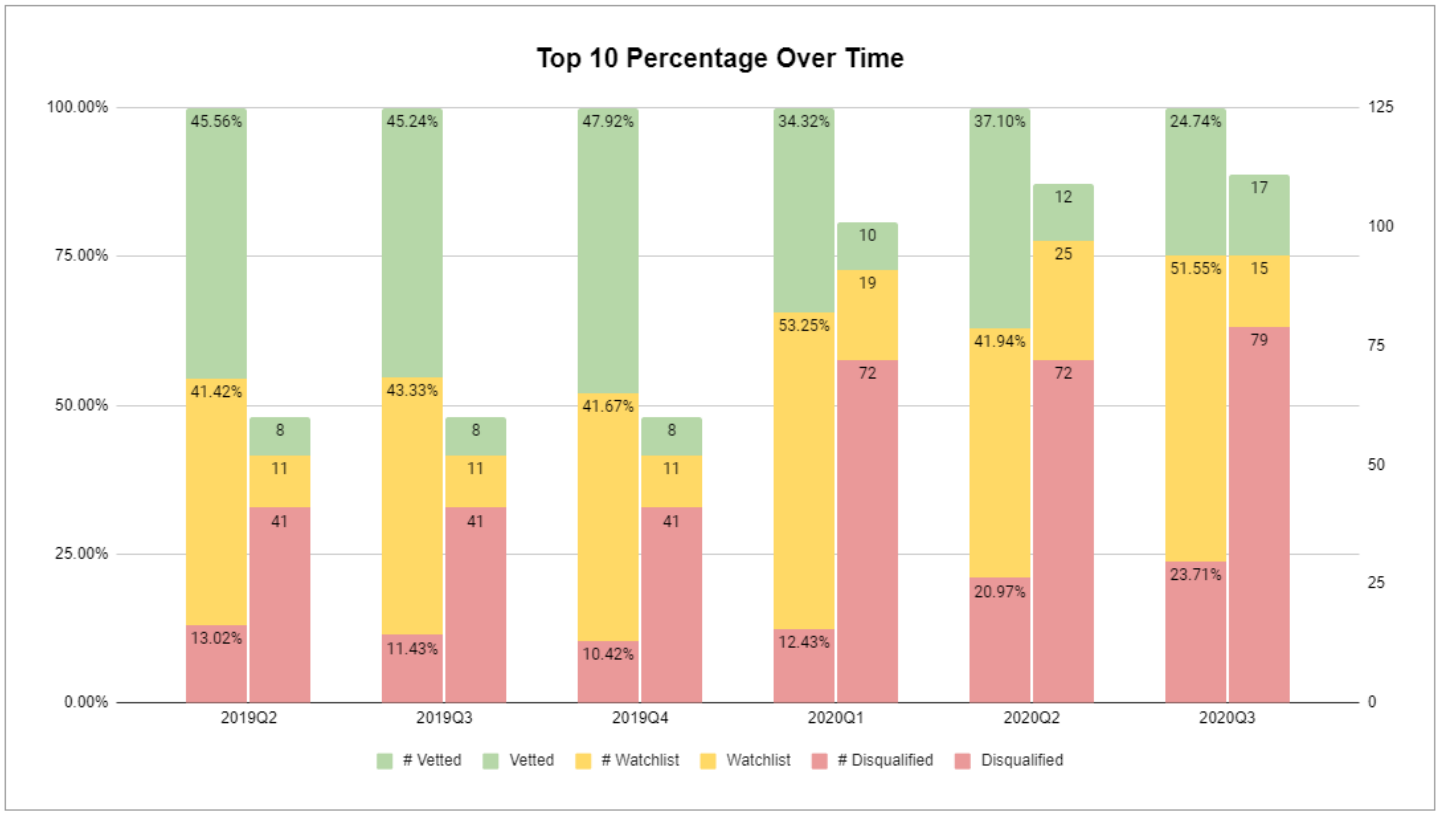
**See Appendix 3 for quarterly exchange participation. Not all exchanges have been evaluated in all quarters.*

Vetted Watchlist Disqualified

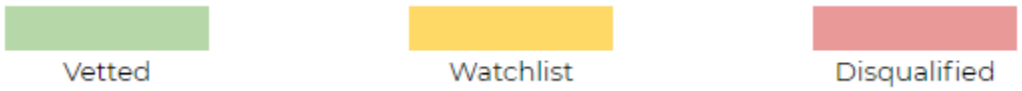
Source: Digital Asset Research

Although each quarter has seen different Price Leaders, the lead-lag test results from the past six quarters showed a relatively stable distribution of Price Leaders between Vetted, Watchlist, and Disqualified exchanges until the most recent quarter. In Q3 2020, Watchlist exchanges gained close to 10% over Vetted exchanges and Disqualified exchanges gained close to 5% over Vetted exchanges as shown in Figure E, below.

FIGURE E – *PRICE LEADERS DISTRIBUTION*



** Figure E does not include perpetuals. Exchanges were added or removed according to DAR's methodology. See Appendix 3 for quarterly exchange participation.*



Source: Digital Asset Research

PERPETUALS

In the digital asset markets, derivatives increasingly play an important role within the trading ecosystem, including perpetual products. DAR's Q3 20 Lead-Lag study included 5 of the market's largest Bitcoin perpetual products.

Please contact DAR for analysis of price discovery in other derivative markets and contract types.

FIGURE F – *TOP 10 PRICE LEADERS PERPETUAL COMPARISON*

Exchange	Price Leader Appearances
Binance	18
Huobi	16
Okex	16
Liquid	13
Bitstamp	11
Bequant	6
Hitbtc	6
Bhex	4
Catex	4
Mxc	3

***Q3 2020** Price Leader Appearances Without Perpetuals*

Exchange	Price Leader Appearances
Binance	18
Okex	16
Huobi	15
Liquid	13
Bitstamp	11
Bequant	5
Hitbtc	5
Bhex	4
Catex	3
MXC	3

***Q3 2020** Price Leader Appearances With Perpetuals*

Perpetual	
Exchange	Price Leader Appearances
Bitmex^P	3
Binance^P	0
Bybit^P	0
Deribit^P	0
Okex^P	0

Vetted Watchlist Disqualified Perpetual

Source: Digital Asset Research

APPENDIX

1.0 Prior Lead-Lag Reports

- An Analysis of Price Discovery in Bitcoin Spot Markets (Initial Report)
- BTC Spot Price Discovery Update Q1 2020
- BTC Spot Price Discovery Update Q2 2020

2.0 Volatility Event Example Analysis

Figure G shows an example of a volatility moment that happened on 27-Jul-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. The full green rows on the heat map shows that Catex and MXC led other exchanges during this specific volatility event when the price of BTC increased by more than 10% within 24 hours.

FIGURE G – *VOLATILITY MOMENT 27-JUL-2020 16:57:42*

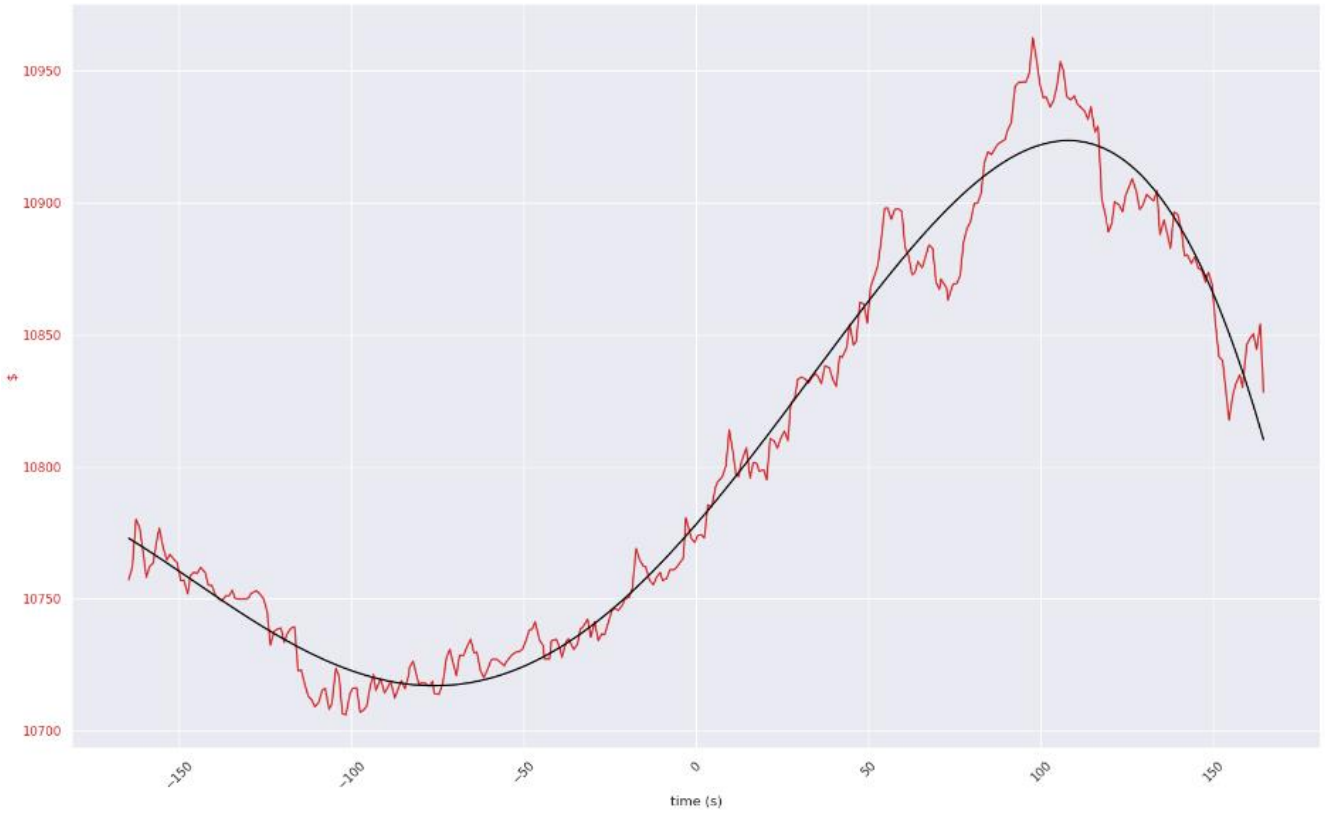


FIGURE H – *EXCHANGE HEATMAP 27-JUL-2020 16:57:42*

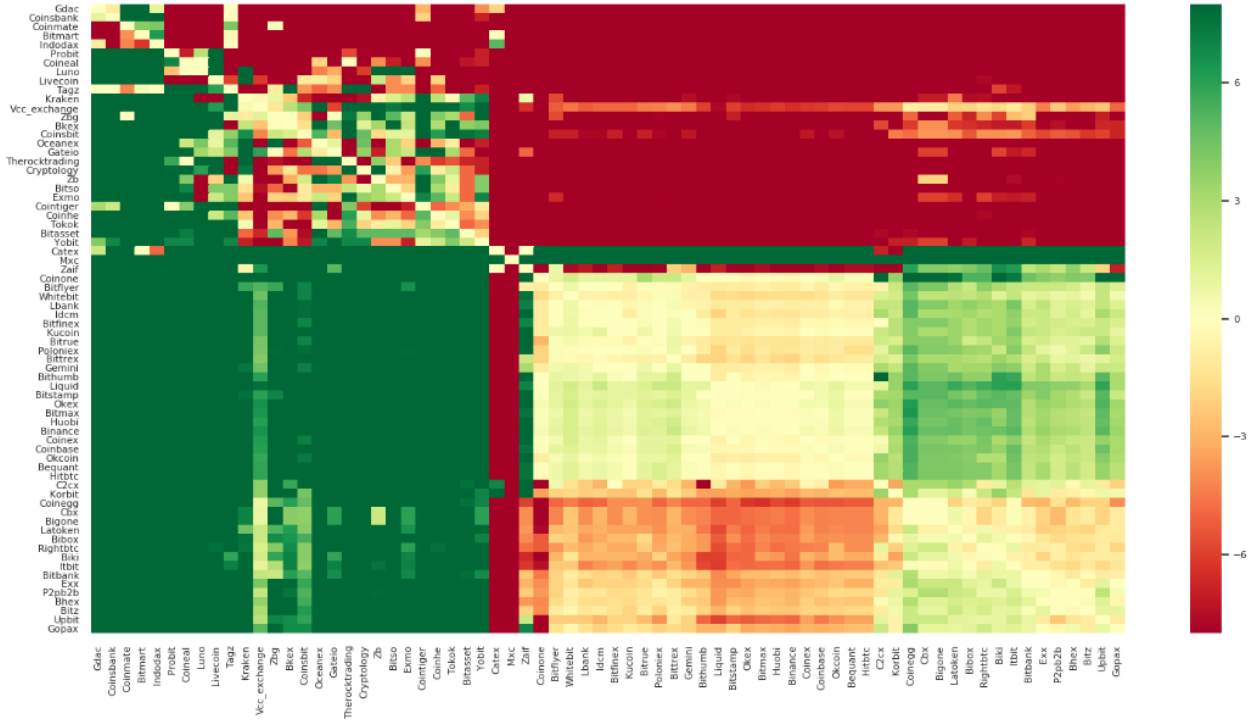
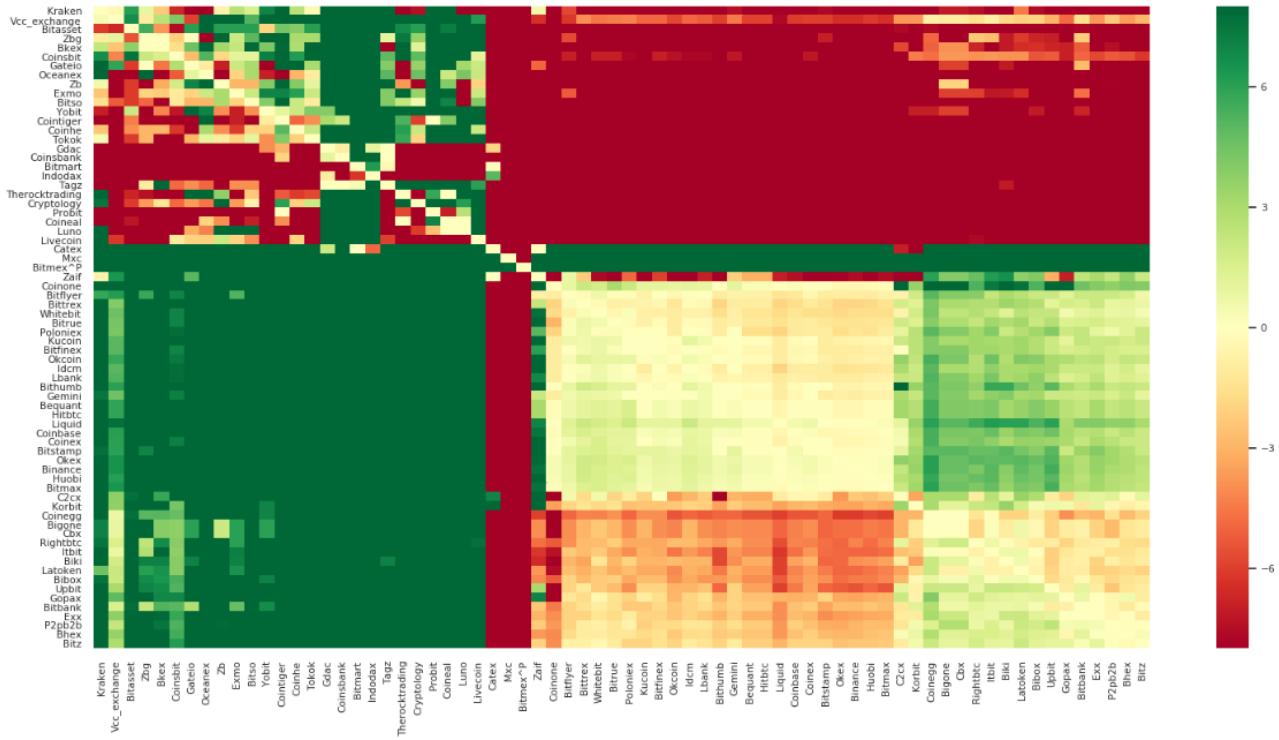


FIGURE I – *EXCHANGE HEATMAP 27-JUL-2020 16:57:42 WITH PERPETUAL*



3.0 Lead-Lag Exchange Universe

Exchange	Q3 2020	Q2 2020	Q1 2020	Q2-Q4 2019
Alterdice	x	x		
BBX	x	x	x	
BCEX	x	x	x	
Bequant	x	x	x	
BHEX	x	x	x	x
Bibox	x	x	x	x
BigONE	x	x	x	
Biki	x	x	x	
Bilaxy	x	x	x	
Binance	x	x	x	x
Binance US	x	x		
Binance^P	x	x		
Bitasset	x	x	x	
Bitbank	x	x	x	x
Bitbay	x	x		
Bitfinex	x	x	x	x
BitFlyer	x	x	x	x
Bitforex	x	x	x	x
Bithumb	x	x	x	x
BitKonan				x
Bitlish				x
BitMarket				x
Bitmart	x	x	x	x
Bitmax	x	x	x	
BitMEX^P	x	x		x
Bitrue	x	x	x	
Bitso	x	x	x	
Bitstamp	x	x	x	x
Bittrex	x	x	x	x
Bitubu	x	x	x	
BitZ	x	x	x	x
BKEX	x	x	x	
Bleutrade	x	x	x	x
BTC-Alpha	x	x	x	
BTC Markets	x	x	x	
BTCBox	x	x	x	x
BTCTurk	x	x	x	
BW	x	x	x	x
Bybit^P	x	x		
C2CX	x	x	x	
Catex	x	x	x	
CBX	x	x	x	
CCX Canada	x	x		
Cexio	x	x	x	x
Chaoex	x	x	x	
Cobinhood				x
Coinall	x	x		
Coinbase	x	x	x	x
Coinbene				x
Coincheck*	x			
Coineal	x	x	x	
Coinegg	x	x	x	
Coinex	x	x	x	
Coinfield	x	x	x	
Coinfloor				x
Coingi				x
Coinhe	x	x	x	
Coinmate	x	x	x	x
Coinmex	x	x	x	
Coinnest				x
Coinone	x	x	x	x
Coinsbank	x	x	x	x
Coinsbit	x	x	x	
Coinsuper	x	x		

Exchange	Q3 2020	Q2 2020	Q1 2020	Q2-Q4 2019
Cointiger	x	x	x	x
COSS				x
CRXzone				x
Cryptology	x	x	x	
Deribit^P	x	x		
Digifinex*	x		x	
DSX	x	x	x	x
EXMO	x	x	x	x
Exrates	x	x	x	
EXX	x	x	x	x
Fifty Five	x	x	x	
GateIO	x	x	x	x
GDAC	x	x	x	
Gemini	x	x	x	x
Gopax	x	x	x	
Graviex				x
Hcoin	x	x	x	
HitBTC	x	x	x	x
Huobi	x	x	x	x
Huobi Russia	x	x	x	
IDAX	x	x		x
IDCM	x	x	x	
Independent Reserve				x
Indodax	x	x	x	
itBit	x	x	x	x
Korbit	x	x	x	x
Kraken	x	x	x	x
Kryptono	x	x	x	
KuCoin	x	x	x	x
LakeBTC	x	x	x	x
LATOKEN	x	x	x	
LBANK	x	x	x	
Liquid	x	x	x	x
Livecoin	x	x	x	x
LMAX	x	x	x	
Luno	x	x	x	
Mercado Bitcoin	x	x	x	
Mercatox	x	x		
MXC	x	x	x	
OceanEx	x	x	x	
OKCoin	x	x	x	x
OKEx	x	x	x	x
OKEx^P	x	x		
OMGFIN	x	x	x	
p2pb2b	x	x	x	
Poloniex	x	x	x	x
Probit	x	x	x	
RightBTC	x	x	x	
Simex	x	x	x	x
Sistemkoin	x	x	x	
SouthXchange				x
STEX	x	x	x	x
TagZ	x	x	x	
TheRockTrading	x	x	x	x
Tidebit	x	x	x	
Tidex	x	x	x	x
Tokok	x	x	x	
Upbit	x	x	x	x
VCC Exchange	x	x	x	
Vindax	x	x	x	
Whitebit	x	x	x	
Yobit	x	x		x
Zaif	x	x	x	x
ZB	x	x	x	x
ZBG	x	x	x	

Vetted Watchlist Disqualified Perpetual

4.0 Definitions

Terminology Definitions	
Disqualified Exchanges*	Digital Asset Exchanges that fail to meet the vetting process requirements failing data science tests for manipulation, qualitative diligence, or a liquidity threshold.
Know Your Customer (KYC)	A process implemented by financial services firms to verify customers' identities in order to identify and prevent market manipulation and other fraudulent activities.
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 (lead), and which saw the price movement at a later time (lag.)
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 are not known to report inflated volumes and have robust policies and practices in place to prevent manipulative behavior by customers.
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 are not known to report inflated volumes or have manipulated transactions but may not have institutional policies and practices in place in order to prevent future manipulation and pass full vetting.

*Contact DAR for full details on the Vetting criteria and process

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