RESEARCH NOTE

16 August 2021

CANE ISLAND DIGITAL RESEARCH

Estimating the Impact of Mempool Backlog on Bitcoin Price

Executive Summary

- **Mempool data can provide powerful insight into bitcoin price rallies,** even if temporary**.** In the past two instances, mempool data signaled significant advanced notice of both price rallies and subsequent declines.
- **Bitcoin's design promotes a feedback loop**, whereby high demand constricts liquidity and pushes prices even higher.
- This research shows how **the mempool can be used to quantify the size of a bubble**, regardless of the initial cause.
- **Cane Island intends to modify its Metcalfe Value model** to incorporate the impact of mempool transaction count on price. This change will take effect on October 1, 2021.

The Problem

Bitcoin's price is a function of its user growth (Grinberg [2011], Velde [2013], Putnam et. al. [2018], Andolfatto et. al. [2019]). This diffusion function is colloquially known as an adoption curve, and the formula that best explains the relationship between this adoption curve and price is Metcalfe Value (Alabi [2017], Pele [2019], Peterson [2018, 2019a, 2019b]). Metcalfe value can be approximated using a technique called Lowest Price Forward (Cane Island [2018], Peterson [2019a]). However, bitcoin's actual price exhibits numerous and substantial deviations from this theoretical value, mostly to the upside (Figures 1a, 1b).

Reasons for Deviation from Metcalfe Value

The valuation models developed by Cane Island have a conservative bias. By design, model values reflect the low end of the estimate, and intentionally exclude other factors which likely have a short-term impact on price.

These other factors include transaction volume and transaction size. These factors have been shown to have a low impact on the long-term price of bitcoin and other digital assets [Peterson, 2019b].[1]

FIGURE 1a
Bitcoin Price and Metcalfe Value

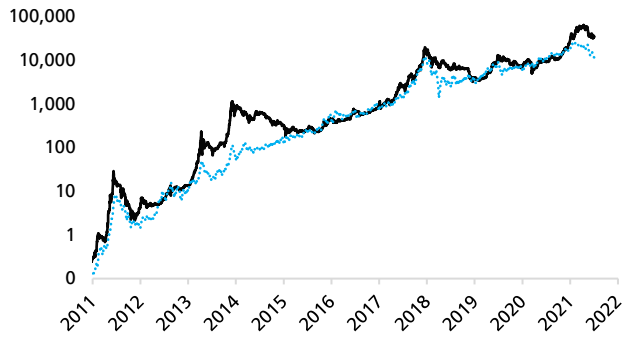
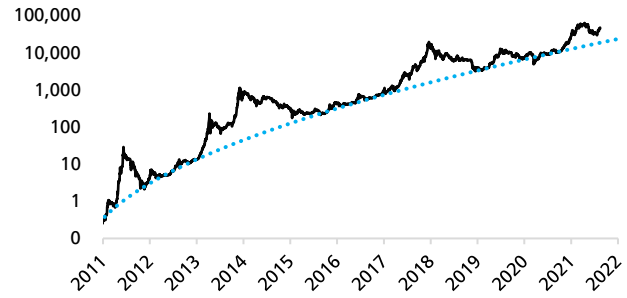


FIGURE 1b
Bitcoin Price and Lowest Price Forward Trend



Assuming a model is reasonably correct, the reasons for bitcoin's actual price to deviate from model values can be grouped into five categories:

1. Price manipulation, as was the case in 2013 when Mt. Gox operated bots to effect economically meaningless transactions and thereby induced traders to acquire bitcoin at inflated prices (see

[1] This finding is consistent with the "digital commodity" analogue of bitcoin. For example, gold's price has risen over centuries even though its use for transactions has steadily declined over that same period.

Anonymous [2014], Suberg [2017], Gandal [2018], Chen [2019], and Peterson [2021]).

2. Behavioral considerations, such as acting on misinformation,[2] the propensity to trade,[3] and widespread belief in erroneous valuation models.[4]
3. Leverage, including short selling and short squeezes [Peterson, 2015].
4. For altcoins, high correlation with bitcoin. The most likely explanation for this correlation is the lack of models which specifically account for fundamentals of specific tokens, or the lack of fundamentals altogether (in the case of newly issued tokens). Thus, the valuation approach is the application of ratios to capitalizations to estimate relative value.
5. Transaction activity, and a design feature that creates short-term stresses on liquidity.[5]

The subject of this research note is Item 5.

The Mempool

When a bitcoin transaction is transmitted to the network, it first gets verified by all of the bitcoin nodes available (i.e. computers participating in the bitcoin network). After it successfully passes verification by a node, it sits inside that node's "Unconfirmed Transactions" area called the "mempool" (short for memory pool).[6] The transaction waits to be processed ("confirmed") by a miner [Beigel, 2021]. In database terminology, this holding area is known as a "pending queue."

A high number of transactions in the mempool indicates congested traffic. This results in longer average confirmation time and, as explained later, higher fees. The *mempool count* metric tells how many transactions are causing the congestion whereas *mempool size* (bytes) is a better metric to estimate how long the congestion will last ["Mempool", 2021].

How Excess Demand Creates Liquidity Problems

Excess demand creates a feedback loop of increasing prices and decreasing liquidity. First, there is a trigger event. This event could be price manipulation, activity by a "whale" [Gheorghe, 2019], investor herd behavior (a.k.a "FOMO"), or news which the market perceives as material.

Transactions flow into the mempool at a "high" rate.[7] However, mempool transactions are not processed on a first-come, first-served basis. Rather, senders bid (with bitcoin) to have their transactions placed at the top of the pending queue. When the mempool begins to grow large, senders typically increase fees to induce miners to process the transactions faster.

This transaction-fee-bidding process is by design, and it is a function of the limitation that transaction blocks are processed at an average, predetermined rate of one block every ten minutes. The limit to the number

[2] This is certainly true in cases where exchanges were falsifying trading volumes to induce traders to act (Hougan, et. al. [2019]).

[3] Trading can create a feedback loop which causes price to deviate substantially from value (Black [1986]).

[4] Halving theories and stock-to-flow models have been debunked several times and "blind faith in one specific outcome…leaves one's investment subject to the whims and beliefs of the crowd while surrendering returns to the randomness of luck." See Putnam et. al. [2019], Fenton [2019], Heater [2020], Stevens [2020], and Tapon [2020].

[5] Liquidity and supply are often confused. *Liquidity* refers to the ease with which an asset or security can be converted into ready cash without materially affecting its market price. It is a function of matching buyers and sellers at or near current market price. *Supply* is the quantity of an asset that is available for sale at any price.

[6] While there are technically many mempools, this Research Note will refer to all aggregate pending transactions as "the mempool."

[7] "High" would be a rate greater than 300,000 transactions per day, which is approximately the design limit for bitcoin.

of transaction blocks able to be processed is enforced by network *difficulty*.[8]

Increased transaction flow and a fixed transaction processing time combine to create two issues:

1. decreased liquidity; and
2. a cycle of increasing demand for bitcoin.

Coins in the mempool cannot be transacted, otherwise, they would violate the prohibition against double-spending. In the very short term, this reduces the number of bitcoin available. Second, because transaction fees are paid in bitcoin, there is an additional demand for bitcoin to pay fees to miners. These fees are attached to the transaction and also reside in the mempool. While awaiting processing, the transacted bitcoin and associated fees are in limbo unable to be spent or otherwise transacted. This is analogous to an unsettled trade in traditional finance.

With short-term liquidity restricted, price rises. This often creates yet more demand for bitcoin. Miners, aware of increasing fees and mempool sizes, can exacerbate the squeeze by holding out for larger transaction fees. This feedback loop continues until demand is exhausted or another triggering event causes a price decline (Figure 2). Once demand is satiated, the backlog clears out quickly, mempool transaction counts drop, and price follows, usually more slowly (Figure 3).[9]

Methodology

Daily mempool data was obtained from *blockchain.com* and extends back to 2016. Because each bitcoin node builds its own version of the mempool by connecting to the bitcoin network, the mempool dataset must be aggregated from a few instances of up-to-date bitcoin nodes. The administrators of the dataset maintained by *blockchain.com* claim to "gather as much information as possible to provide accurate mempool metrics," ["Mempool", 2021].

FIGURE 2
Excess Demand Feedback Loop

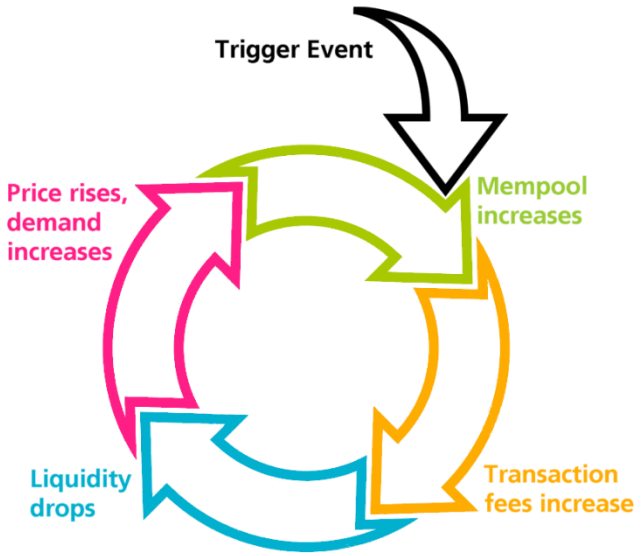
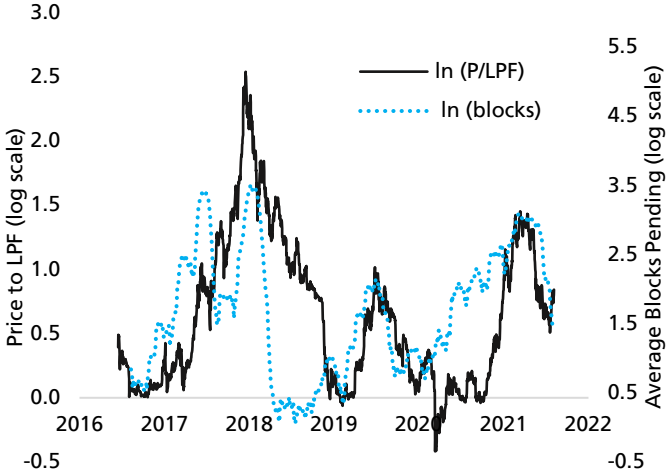


FIGURE 3
Price Bubbles and Mempool Backlogs



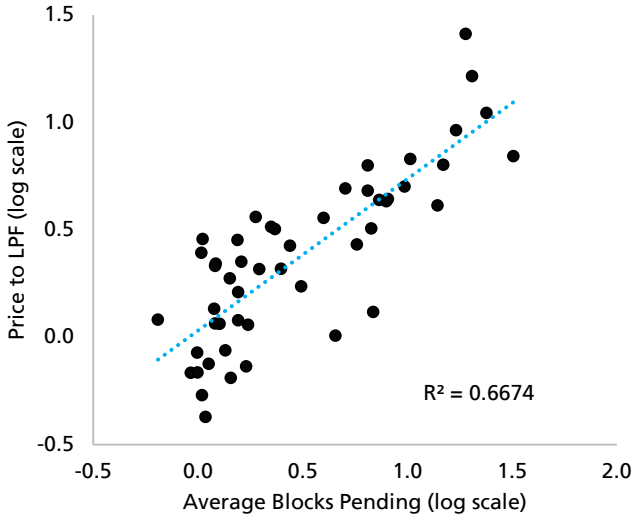
[8] "To compensate for increasing hardware speed and varying interest in running nodes over time, the proof-of-work difficulty is determined by a moving average targeting an average number of blocks per hour. If they're generated too fast, the difficulty increases." [Nakamoto, 2008].

[9] Possible explanations for why price lags fundamentals in bear markets are Recency Bias, Anchoring Bias, and Disposition Effects.

While not every pending transaction is in this dataset, the dataset itself is assumed to be large enough that changes in counts over time are probably indicative of changes in the universe of pending transactions.

Mempool transaction counts are averaged over 60 days and scaled to estimated block sizes. The log of this estimated pending block count can be compared to $log(P/LPF)$ or $log(P/MV)$ where P is price, LPF is Lowest Price Forward, and MV is Metcalfe Value. Figure 4 shows how each major price peak corresponds to mempool backlogs.

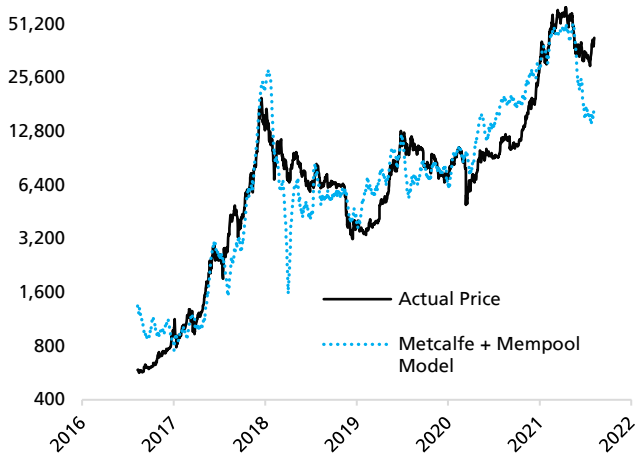
FIGURE 4
Price Bubbles vs Mempool Backlogs
Monthly data points with outliers excluded



This relationship is used to estimate the impact of mempool backlogs on bitcoin price. Mempool backlogs may make up as much as 13% of bitcoin's monthly price movements.

An "excess demand" value is then applied to Metcalfe Value (or Lowest Price Forward, as desired) (Figure 5). The resulting goodness of fit of daily lognormal model prices to actual price is improved from 0.87 to 0.89 and RMSE of daily lognormal differences improves by 34%. The correlation between the old model and the new model is 97%.

FIGURE 5
Metcalfe Value with Mempool Backlog Adjustment



Conclusion

In "To the Moon," Peterson [2021] asserts price manipulation as a possible trigger for the 2017 and 2019 bubbles. That research only indicated manipulation as a possible but likely explanation for the *existence* of bubbles. This research differs in that it does not address the root cause of bubbles, but instead shows how the mempool can be used to *quantify* the size of a bubble regardless of the cause.

It could be that widespread belief in halving effects increases demand enough to act as a trigger that causes mempool backlogs. While these would almost certainly cause prices to spike, such incidents arise from a type of self-fulfilling prophecy best explained by behavioral finance, and not necessarily one created by the underlying economics of halving events.

Nevertheless, the mempool itself contains valuable information about demand and therefore bitcoin's price. Although there are only three recent periods to examine, mempool activity predicted bitcoin price spikes well in advance in two of the three instances (2019 and 2021). Mempool declines foreshadowed bitcoin price drops in two of the three instances (2017 and 2019).

The mining process inherently contributes to price spikes, because bitcoin has no means by which to moderate high transaction demand. As software developers say, it is a feature, not a bug.

Also, consider the following: it may only be a matter of time before exchanges or other actors systematically and unscrupulously flood the mempool with economically meaningless transactions, such as high-frequency wash trades. This would artificially constrict liquidity and cause bitcoin's price to spike. Similar activity has already been suspected of impacting some altcoins ["Bitcoin SV", 2020].

Lastly, based on this research, Cane Island intends to modify its Metcalfe Value model to incorporate the impact of mempool transaction count on price. This change will take effect on October 1, 2021.

A Final Word of Caution

The mempool has been a good indicator of price bubbles in the past. There is reason to think it will not be as indicative in the future. As more transaction activity moves off-chain, the transaction count in the mempool should decrease.

For example, the Lightning Network provides the ability to process transactions on a "side-chain." These transactions are processed and settled quickly, then aggregated into a single (or few) transaction(s). It is this aggregate transaction that is submitted to the bitcoin network for confirmation. Whereas the core bitcoin network can process about seven transactions per second, a transaction-of-transactions block expands this capability to theoretical billions, with the same or fewer blocks.

In this case, the mempool would contain fewer, but larger, transactions. It may be possible at that point to examine median or average transaction size in the mempool for clues as to bitcoin demand and price impact.

References

Alabi, K. (2017). "Digital Blockchain Networks Appear to Be Following Metcalfe's Law." *Electronic Commerce Research and Applications*, 24, 23–29. doi:10.1016/j.elerap.2017.06.003.

Andolfatto, D., & Spewak, A. (2019). "Whither the Price of Bitcoin?" *Economic Synopses*, Vol. 1, doi:10.20955/es.2019.1.

Anonymous. (2014). "Proof of massive fraudulent trading activity at Mt. Gox, and how it has affected the price of bitcoin." *The Willy Report*, willyreport.wordpress.com/2014/05/25/the-willy-report-proof-of-massive-fraudulent-trading-activity-at-mt-gox-and-how-it-has-affected-the-price-of-bitcoin/

Beigel, O. (2021). "What Is the Bitcoin Mempool? A Beginner's Explanation." *99 Bitcoins*, www.99bitcoins.com/bitcoin/mempool/.

"Bitcoin SV Volume Is Heavily Manipulated, Data Finds." (2020). *Bitcoinist.com*, www.bitcoinist.com/bitcoin-sv-volume-is-heavily-manipulated-data-finds .

Black, F. (1986). "Noise." *The Journal of Finance*, 41(3), 529. doi:10.2307/2328481.

Cane Island Digital Research. (2019). "Why Bitcoin's Price Is Never Looking Back." http://www.cane-island.digital/research-notes.

Chen, W., J. Wu, et al. (2019). "Market manipulation of bitcoin: Evidence from mining the Mt. Gox transaction network." *IEEE INFOCOM 2019*, IEEE Conference on Computer Communications.

Fenton, A. (2019). "Halving 'Myth': Is Everyone Wrong about the Bitcoin Halving?" *Micky*, micky.com.au/halving-myth-why-everyones-wrong-about-bitcoins-halving-price-spike/ .

Gandal, N., J. Hamrick, et al. (2018). "Price Manipulation in the Bitcoin Ecosystem." *Journal of Monetary Economics*, 95, 86–96.

Gheorghe, F., et al. (2019). "What Causes the Infamous Bitcoin 'Bart Pattern?'" *BeInCrypto*, www.beincrypto.com/what-causes-the-infamous-bitcoin-bart-pattern/ .

Grinberg, R. (2011). "Bitcoin: An Innovative Alternative Digital Currency." *Hastings Science & Technology Law Journal*, 4(1), 159-208.

Heater, M. (2020). "Lost in Space - Bitcoin and the Halving." *Strix Leviathan*, www.strixleviathan.com/blog/2020/4/1/bitcoin-halving-speculation .

Hougan, M., H. Kim & M. Lerner. (2019). "Economic and non-economic trading in bitcoin: Exploring the real spot market for the world's first digital commodity." *Bitwise Asset Management*, www.sec.gov/comments/sr-nysearca-2019-01/srnysearca201901-5574233-185408.pdf .

"Mempool-Count." (2021). *Blockchain.com*, www.blockchain.com/charts/mempool-count .

Nakamoto, S. (2008). "Bitcoin: A Peer-to-Peer Electronic Cash System." https://bitcoin.org/en/bitcoin-paper .

Pele, D.T. and M. Mazurencu-Marinescu-Pele. (2019). "Metcalfe's Law and Herding Behaviour in The Cryptocurrencies Market." *Economics Discussion Papers*, No. 2019-16, Kiel Institute for the World Economy. http://www.economics-ejournal.org/economics/discussionpapers/2019-16 .

Peterson, T. (2015) "Leverage and Return" & "Long-Short Return Calculation" in Performance Measurement for Alternative Investments, *Risk Books*, London.

—, —. (2018). "Metcalfe's Law as a Model for Bitcoin's Value." *Alternative Investment Analyst Review*, 7(2), 9-18.

—, —. (2019a). "Bitcoin Spreads Like a Virus." *SSRN*, https://ssrn.com/abstract=3356098 .

—, —. (2019b). "Why Bitcoin Dominates." *SSRN*, https://ssrn.com/abstract=3417334 .

—, —. (2021). "To the Moon: A History of Bitcoin Price Manipulation." *Journal of Forensic and Investigative Accounting*, 13(2), (forthcoming).

Putnam, B. and E. Norland. (2018). "An in-depth look at the economics of bitcoin." *CME Group*, https://www.cmegroup.com/education/featured-reports/an-in-depth-look-at-the-economics-of-bitcoin.html .

Stevens, R. (2020). "Ethereum Creator Vitalik Buterin Shoots DOWN $280,000 Bitcoin Model." *Decrypt*, www.decrypt.co/32366/vitalik-buterin-bitcoin-stock-to-flow .

Suberg, W. (2017). "Mt. Gox trial update: Karpeles admits 'Willy bot' existence." *Cointelegraph*, www.cointelegraph.com/news/mt-gox-trial-update-karpeles-admits-willy-bot-existence.

Tapon, F. (2020). " 8 Flaws in Bitcoin's Stock-to-Flow Model Will Doom It." www.francistapon.com/Work/WanderLearn-Podcast/8-Flaws-in-Bitcoin-s-Stock-to-Flow-Model-Will-Doom-It .

Velde, F. (2013). "Bitcoin: A primer." *Chicago Fed Letter*, 317, https://www.chicagofed.org/publications/chicago-fed-letter/2013/december-317 .

Disclosures

Cane Island Digital Research Notes are research memoranda that have not undergone peer review and are not intended for formal publication in any academic journal. No assurance can be made as to its accuracy or completeness.

This document is for information purposes only. Opinions expressed herein are solely those of Cane Island Alternative Advisors, LLC, unless otherwise specifically cited. Material presented is believed to be from reliable sources and no representations are made by our firm as to other parties' informational accuracy or completeness. All data was obtained from coinmetrics.io and blockchain.com.

The information presented herein does not constitute an offer to sell or the solicitation of an offer to sell or buy any security in any jurisdiction. This document does not contain sufficient information for a prospective investor to make an investment decision and any information contained herein should not be used as a basis for this purpose.

The contents of this document do not constitute a recommendation or take into account the particular investment objectives, financial situations, or needs of any prospective investor. Investors should not construe the contents of this document as legal, tax, or investment advice, and should consult with their own advisor(s) concerning an investment in digital assets, cryptocurrency, or any security or commodity. Past performance is not necessarily indicative of future performance.

The price and value of assets referred to in this research and the income from them may fluctuate. Fluctuations in exchange rates could have adverse effects on the value or price of, or income derived from, certain investments.

Cane Island Alternative Advisors, LLC, its manager, and its affiliates may own securities mentioned in this document for its client portfolios. This document contains information from third-party sources which has not been verified. With respect to information that may be shown, no guarantee can be made as to its accuracy or suitability for any purpose.

Cane Island Alternative Advisors, LLC is a registered investment advisor offering advisory services in the State of Texas and in other jurisdictions where exempted or permitted. Registration does not imply a certain level of skill or training.

www.cane-island.digital