Stablecoins: Survivorship, Transactions Costs and Exchange Microstructure

Bruce Mizrach *1

¹Department of Economics, Rutgers University, New Brunswick, NJ USA

First Draft: April 27, 2021 Revised: December 27, 2021

Abstract

Seven of the ten largest stablecoins are backed by fiat assets. The 2016 and 2017 vintages of stablecoins have failure rates of 100% and 50% respectively. More than one-third of stablecoins have failed. Tether has a 39% share of 1.77 trillion USD in 2021Q2 transactions, and USD Coin 28%. The top three stablecoins have an average velocity of 28.3. Tether transacted between 3.8 million unique addresses, 63% of the ERC-20 token network. Six of the top ten tokens have unconcentrated Herfindahl indices, but Gemini, Pax and Huobi have single holders with more than 50% of the supply. The median Tether transaction fee is similar to the cost of an ATM transaction, but they are three to four times more for Dai and USDC. Fees, which are proportional to the price of Ethereum, are rising though. Median fees for Tether rose 3,628% over the last year, and 1,897% for USD Coin. 24 hour exchange turnover in Tether is nearly \$120 billion. This is comparable to the daily volume at the NYSE and almost 15 times the daily flow in money market mutual funds. Narrow bid-ask spreads and depth have attracted active HFT participation.

Keywords: Stablecoins; transactions; fee; hazard function; market microstructure; cryptocurrency.

JEL Codes: G12; G23.

^{*}Correspondence: Department of Economics, Rutgers University, 75 Hamilton Street, New Brunswick, NJ 08901 USA. email: mizrach@econ.rutgers.edu, (908) 913-0253 (voice) and (425) 795-9942 (fax).

1 Introduction

The financial industry has continued to develop new forms of payment. Credit and debit cards and automated clearinghouse (ACH) transactions were the key developments of the late 20th century. Venmo and PayPal came along in the early 21st.

Credit and debit cards still dominate, making up 62% of purchases.¹ Transaction costs are still substantial. Credit card transactions are nearly instantaneous, but the merchants pay fees of 1 to 3%². Debit cards fees are closer to 1%,³ yet consumers can face stiff payments for overdrawing their account. Venmo is very convenient, but it also charges 3% for credit card transactions.⁴ Paypal's recent growth has largely been driven by opening up to credit card companies.

There were 7.3 billion ACH transactions with a total value of \$18.4 trillion in the second quarter of 2021⁵ with a median cost of \$0.29.⁶ ACH transactions are quite slow though, and can take up to five days. The G7 Working Group (2019) notes that there are still many gaps in the payment system, particularly for cross-border transactions. With respect to fees, speed and network size, there are substantial opportunities for new financial technologies.

Stablecoins try to harness the distributed ledger technology of Bitcoin and other digital assets, while maintaining price stability of fiat assets and other stores of value. Regnard-Weinrabe et al. (2019) note that there are three major types of stablecoins: (1) Fiat/commodity collateralized; (2) Crypto-collateralized; (3) Non-collateralized. Each type differs on the collateral backing the tokens. Among the top tokens I study, the coins are either fiat or crypto-collateralized.

Collateralized stable coin companies are expected to actually hold the assets against which their coin is pegged (e.g., US dollar or gold). They issue new units as they expand their underlying assets.⁷

The valuation of crypto-collateralized coins is maintained through over-collateralization and stability mechanisms. In the case of Dai, smart contracts called Collateralized Debt Positions bring Dai into circulation. You can only retrieve your collateral by paying back the debt.⁸

Non-collateralized stable coins use algorithms to dynamically expand and contract the supply of tokens to maintain a predetermined peg. There are a number of prominent failures: SagaCoin (SAGA) which replicated the IMF SDR; Havven (HAV), now rebranded as

¹Aaron Black, "Meet the New Payment Champions Same as the Old Ones, Wall Street Journal, January 11, 2019.

²https://paymentdepot.com/blog/average-credit-card-processing-fees/

³https://www.cardfellow.com/blog/debit-card-transaction-fees/

⁴https://venmo.com/about/fees

⁵https://www.nacha.org/news/strong-growth-continues-ach-network-volume-climbs-nearly-10-second-quarter-2021

⁶Association for Financial Professionals, https://www.afponline.org/docs/default-source/default-document-library/pub/2015-payments-cost-benchmarking-report

⁷https://academy.binance.com/en/glossary/stablecoin

⁸Why is Dai Stable?, https://medium.com/icovo/why-is-dai-stable-9a9fa84feca7

⁹https://www.sogur.com/

Synthetix;¹⁰ and Basis,¹¹ call into question the viability of the mechanism.

Table 1 contains the top ten Ethereum network stable coins, pegged to the U.S. dollar, ranked by market cap as of the end of the second quarter of 2021.¹²

Table 1:	Top	Ten	Stablecoins	by	Market	Capitalization

Name	Symbol	First Transaction	Collateral	Market Cap \$bn.
Tether	USDT	2017-11-28	Asset backed	\$30.91
USD Coin	USDC	2018-09-10	Asset backed	\$24.33
Binance USD	BUSD	2019-09-10	Asset backed	\$10.06
Dai	DAI	2019-11-13	Defi	\$5.15
TrueUSD	TUSD	2019-01-04	Asset backed	\$1.18
Paxos Standard	PAX	2018-09-10	Asset backed	\$0.84
Huobi USD	HUSD	2019-07-20	Asset backed	\$0.57
Terra USD	UST	2020-12-03	Defi, algo stabilized	\$0.34
Gemini Dollar	GUSD	2018-09-09	Asset backed	\$0.23
Synth USD	sUSD	2020-05-11	Defi, algo stabilized	\$0.15

The market capitalization is based on the circulating supply on the Ethereum network at the end of 2021Q2.

Ethereum technology has come to dominate the world of smart contracts, and this has led most of the leading stable coins to adopt the ERC-20 (Ethereum Request for Comments-20) standard, originally proposed by Fabian Vogelsteller in November 2015.¹³ The standard makes tokens interoperable, and it requires that the total supply of tokens and the balance of any address be transparent to the network.

Etherscan reports 14 over 904 tokens based on the ERC-20 standard. It also lists more than 199,000 verified smart contracts. 15

The Ethereum network is more transparent than the interbank or equity market networks. Any participant in the network can see all of the transactions in and out of Ethereum stablecoins at the level of a blockchain hashtag.

1.1 Tether

Tether was created by iFinex, the same company that runs the Bitfinex exchange and was originally called "RealCoin." It was launched on the Bitcoin blockchain using the Omni Layer Protocol on October 6, 2014. ¹⁶. The token I study here is an ERC-20 token that was issued

¹⁰https://blog.havven.io/

¹¹https://www.coindesk.com/basis-stablecoin-confirms-shutdown-blaming-regulatory-constraints

 $^{^{12}}$ Several tokens including Tether are issued on more than one network. I am showing the supply on the Ethereum blockchain.

¹³https://ethereum.org/en/developers/docs/standards/tokens/erc-20/.

¹⁴https://etherscan.io/tokens Retrieved on December 11, 2021.

¹⁵https://etherscan.io/chart/verified-contracts Retrieved on December 10, 2021

¹⁶Blockdata (2018)

after a \$31 million hack in late 2017.¹⁷ I first detect the token on the Mainnet on November 28, 2017. As of October 2021, 49.6% of Tether is on the Tron network, 46.7% is on Ether, 1.8% is still on Ommi, 1.6% on Solana, and 0.3% is on EOS, Algorand, Liquid, and SLP.¹⁸

The company originally represented Tether as something like a currency board: holding "one U.S. dollar ("USD") in reserve 'backing' the tether... Every tether is always backed 1-to-1, by traditional currency held in our reserves. So 1 USDT is always equivalent to 1 USD."

In March 2019, Tether stepped back from this claim instead reporting that ¹⁹ "Every tether is always 100 percent backed by our reserves, which include traditional currency and cash equivalents and, from time to time, may include other assets and receivables from loans made by Tether to third parties, which may include affiliated entities..."

The New York Attorney (NYAG) pursued a fraud case²⁰ against both Bitfinex and Tether, documenting a series of questionable bank transfers. The NYAG has banned trading with New York persons and entities and fined the company \$18.5 million. The Commodity Futures Trading Commission also fined iFinex an additional \$41 million for misrepresentation of their collateral.²¹ Griffin and Shams (2020) have shown that Tether's price was manipulated to support Bitcoin.

In accordance with the ruling by the NYAG, Tether released a breakdown of their reserves on March 31, 2021.²² Tether holds 75.85% of its assets in cash and cash equivalents, 12.55% in secured loans, 9.96% in corporate bonds. The statement was not backed by an auditor.

None of this has slowed the growth of the Tether stable coin. Between March 2019 and June 2021, the market cap grew on the Ethereum network grew from \$2.04 billion to \$30.91 billion. Tether represents approximately 42% of stablecoin market capitalization and 39% of all stablecoin transactions.

1.2 USD Coin

USD Coin is a stable coin developed by the fintech company Circle and the digital asset exchange Coinbase. Coinbase originally claimed that each USD Coin is backed by U.S. dollars in "a bank account." Following an an auditor's report Grant Thornton on July 16, 2021, Coinbase modified this claim to say that "Each USDC is backed by one dollar or asset with equivalent fair value, which is held in accounts with US regulated financial institutions." Based on Grant Thornton's report, USDC is 61% cash and cash equivalents (which includes bank accounts, money market funds and other securities with less than 90 days maturity), 13% Yankee CDs, 12% U.S. Treasuries, 9% commercial paper, 5% corporate bonds, and 0.2% municipal and U.S. agency bonds.

¹⁷https://tether.to/2017/11/

¹⁸These data were retrieved from wallet.tether.to/transparency on October 11, 2021.

¹⁹https://investingnews.com/daily/tech-investing/blockchain-investing/tether-admits-not-fully-backed-us-dollar/
²⁰James (2021)

²¹https://www.cftc.gov/PressRoom/PressReleases/8450-21

²²https://tether.to/wp-content/uploads/2021/05/tether-march-31-2021-reserves-breakdown.pdf

²³https://www.coinbase.com/usdc: "Each USDC is backed by one US dollar, which is held in a bank account. Using the Internet time machine, I can verify this claim was on their website until July 20, 2021.

On August 22, 2021, Circle announced that "it will now hold the USDC reserve entirely in cash and short duration US Treasuries. These changes are being implemented expeditiously and will be reflected in future attestations by Grant Thornton."

USD Coin, with 36% of transaction volume, along with Tether's 39%, dominate the stablecoin market.

1.3 Binance USD

Binance USD (BUSD) is a USD-denominated stable coin approved by the New York State Department of Financial Services (NYDFS) launched in September 2019 in partnership with Paxos and Binance.

The NYDFS maintains a "green list" of approved virtual currencies.²⁴ At the moment, the list includes thirteen currencies including Bitcoin, Ethereum and Litecoin. The two leading stable coins on the list are Binance USD and Paxos (both standard and gold are approved).

Binance USD is backed by U.S. dollar deposits which it claims are in FDIC insured U.S. based institutions.²⁵ Paxos is the custodian and issuer of the BUSD.

1.4 Dai

Bahachuk (2020) notes that Dai was conceptualized by a group called MakerDAO. It is built on a decentralized Ethereum technology called the Maker Protocol. DAO stands for Decentralized Autonomous Organization. The DAO holds four types of collateral, Ethereum, Basic Attention Token (BAT), wrapped Bitcoin, and USD Coin. There are strong financial incentives to keep the currency over-collateralized.

Kozhan and Viswanath-Natraj (2021) model the DAO stabilization mechanism both theoretically and empirically. They find that while the Dai price covaries negatively with risky collateral, the introduction of USDC as collateral has led to an increase in peg stability.

1.5 TrueUSD

TrueUSD provides real-time reports on the state of their collateral through the fintech firm Armanino.²⁶ At the time I first tried to retrieve the report in March 2021, the auditing firm supplied a "ripcord" message, indicating that they had not been able to verify the collateral for more than 72 hours. In private communication with Armanino, I received the following reply: "TrueUSD was sold to a 3rd-party and therefore the AT-C 205 reporting has ceased until the new owners have completed the onboarding process. All other TrueCurrencies are still owned by TrustToken and have live TrueCurrencies." ²⁷

²⁴https://www.dfs.ny.gov/apps_and_licensing/virtual_currency_businesses/virtual_currencies

²⁵https://www.binance.us/en/busd

²⁶https://www.armaninollp.com/software/trustexplorer/real-time-audit/

²⁷Communication between the author and Patrick Clancy, Senior Manager for Strategic Growth, March 8, 2021.

Since at least early June 2021, Armanino has resumed attestation reports of True USD. The report of June 15, 2021 states that the new owner of is Techteryx, Ltd. based in Shenzhen. As for collateral, the audit states: "The USD balance, held in escrow accounts in U.S.... and Hong Kong depository institutions, includes USD cash and cash equivalents that include short-term, highly liquid investments of sufficient credit quality that are readily convertible to known amounts of cash."

1.6 Paxos

Paxos comes in two flavors, the standard and the gold backed version. I discuss the standard Pax here. Pax maintains USD domiciled depository accounts at a 1:1 ratio with the number of Paxos outstanding. The collateral includes both cash and U.S. Treasuries. Paxos Trust Company has engaged Withum,²⁸ a New Jersey based auditing firm, to provide monthly statements about tokens outstanding and the collateral holdings. The technology is based on the ERC-20 standard. On August 24, 2021, Paxos Standard was rebranded²⁹ as Pax Dollar (USDP).

1.7 Huobi

The Huobi USD is a stable coin pegged to the U.S. dollar and backed by USD in reserve accounts.³⁰ Attestation reports³¹ are provided by Eide Bailly, which reports that the company is based in the British Virgin Islands. As of December 2021, going to the Huobi USD website comes with this warning: "Currently, individual / institutional clients from Mainland China, the United States, Iraq, Cuba, Iran, Sudan, Syria, Bangladesh, Ecuador, Tunisia, Libya, Venezuela, etc. are not available to use this service."

1.8 Terra USD

Terra USD is a USD pegged stablecoin, collateralized by a digital coin Luna. It is algorithmically stabilized, requiring destruction of one dollar of Luna for every newly minted Terra USD token.³²

1.9 Gemini Dollar

Gemini may be best known for its founders, the Winklevoss brothers. Gemini is on the green list of the New York State Department of Financial Services, and guarantees a portion of reserves through the FDIC. Gemini is audited monthly by BPM LLP, and the Ethereum

²⁸https://www.withum.com/our-locations/

²⁹https://www.paxos.com/the-digital-dollar-that-always-equals-a-dollar-paxos-standard-pax-is-now-pax-dollar-usdp/

³⁰https://www.huobi.com/en-us/usd-deposit/

³¹https://www.stcoins.com/attestation/file?id=29

³²Do Kwon, "Announcing TerraUSD (UST)— the Interchain Stablecoin, https://medium.com/terra-money/announcing-terrausd-ust-the-interchain-stablecoin-53eab0f8f0ac, September 21, 2020.

smart contract has been audited by Trail of Bits, a leading information security research and development firm. 33

Gemini has the most transparent disclosure³⁴ of where it holds its' assets: "The Gemini dollar accounts are held and maintained by State Street Bank and Trust Company and within a money market fund managed by Goldman Sachs Asset Management, invested only in U.S. Treasury obligations."

1.10 Synth sUSD

sUSD is a token made by the Synthetix team³⁵ which tracks the price of USD. Users provide collateral when creating sUSD. It can also be mined.³⁶

Synthetix requires all synthetic tokens, or synths for short, be backed at a collateralization ratio (C-Ratio) of 500%. Synthetix reported an aggregate collateralization ratio of 553% on June 16, 2021.³⁷

I was not able to determine the current holdings backing the synths. As of December 2021, Synth reports that the debt pool is in "Maintenance Mode. Data is out of date and a new version is coming soon."

Summarizing, the top three stablecoins hold USD, Treasuries and other cash equivalents. There are varying degrees of transparency about where the assets are held. Only one of the top ten (Gemini) names the bank where deposits are held. Two of the top three, USD Coin and Binance, provide (at least partial) FDIC insurance. Dai, Terra USD and sUSD hold digital assets as collateral.

Lyons and Viswanath-Natraj (2020) make the analogy between stablecoin projects and currency pegs. They argue that even well collateralized stablecoins may face instability. Grobysa et al. (2021) find that lagged Bitcoin volatility Granger-causess stablecoin volatility. Hoang et al. (2021) show that Tether returns are highly correlated with BTC, even at the daily frequency. For these reasons, I turn to survival analysis in the next section.

2 Survival Analysis

The analysis of digital assets has been influenced by the spectacular returns of a handful of successful assets, most notably Bitcoin (BTC).

I construct a complete set of token transactions on the Mainnet. Between 2016 and the frist quarter of 2021, there are more than 260,000 distinct tokens on the network.

To focus the analysis on the active tokens, I only include the 5,143 tokens with at least 10,000 transactions. I graph the growth in Figure 1.

³³https://www.gemini.com/dollar

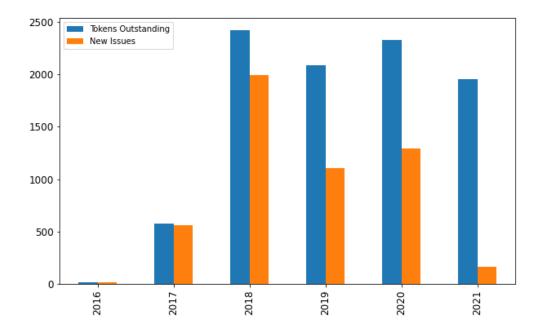
 $^{^{34} \}rm https://assets.ctfassets.net/jg6lo9a2ukvr/2efRs3l0q3EKSv1WPwSvqe/871de898c778d2499d6a11acf697ae71/Gemini_Dollar_Examination_Report_01-29-21.pdf$

³⁵https://synthetix.exchange/

³⁶https://defipulse.com/usd/SUSD

³⁷https://stats.synthetix.io/

Figure 1: Ethereum Active Digital Tokens Outstanding

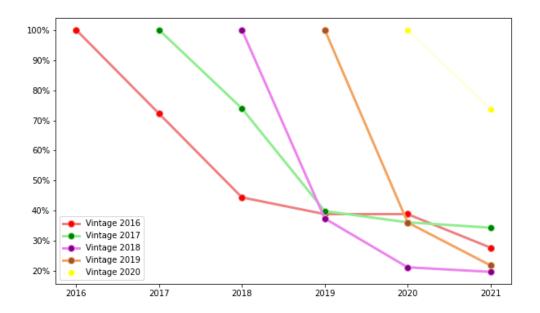


Note: Issue dates are based on the token's first transactions on the Mainnet. I only include tokens with at least 10,000 cumulative transactions.

Gorton and Zhang (2021) compare these developments to the free banking era that began in 1830s. While Gorton and Zhang claim that private currencies did not contribute to banking panics, they do concede that "varying discounts made actual transactions (and legal contracting) very difficult...There was constant haggling and arguing over the value of notes in transactions." The National Bank Act of 1863, they note, effectively ended the era of privately issued bank notes.

I also find that many tokens have failed, particularly those started in recent years. I plot a hazard function in Figure 2.

Figure 2: Hazard Function for Ethereum Tokens



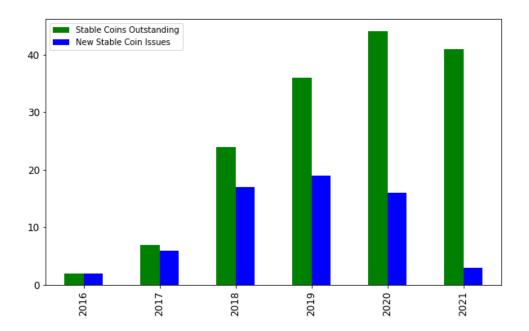
Note: I classify a project as dead if volume falls below 1% of the peak quarterly volume.

There were 1,953 active tokens outstanding at the end of the first quarter of 2021. The peak year for issuance was 2018 when 1,995 tokens were issued.

With stable coins, the effects of survivorship are much more concerning because they are not designed to provide any capital gains.

From CoinMarketCap, Nomics, and CoinCodex I identify 91 active and inactive stable-coin projects. 65 of the 91 transact on the Ethereum Mainnet. These 65 are the most active and include all the stablecoins in the top 5,000 in market capitalization. I graph the growth of Ethereum stablecoins in Figure 3.

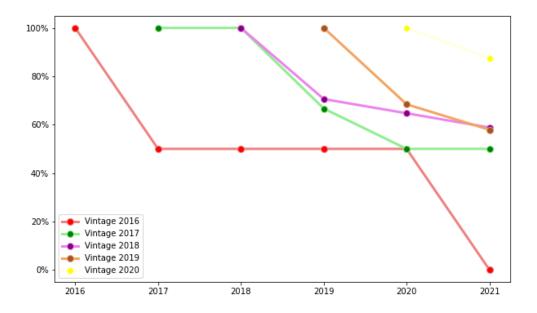
Figure 3: Ethereum Stablecoins Outstanding and New Issues



Note: The projects are from CoinCodex, CoinMarketCap and Nomics. The vintage date is from the first transaction on the Mainnet.

I plot survivor probability in Figure 4 for the 65 ERC-20 stable coins on the Mainnet. The vintage is the first year that the token transacts on the Mainnet.

Figure 4: Stablecoin Hazard Function



Note: The projects are from Blockdata, CoinCodex, CoinMarketCap and Nomics. The vintage date is from the first transaction on the Mainnet. I classify a project as dead if volume falls below 1% of the peak quarterly volume.

DigixDao (DGD) and Xaurum (XAU) are the failures from the 2016 vintage. Both were backed by gold reserves. There were six tokens in the 2017 vintage. Three are still active: Monolith (TKN); Noku (Noku); and Tether. There were 17 coins in the 2018 vintage including Paxos, USD Coin, and Gemini from our top ten. There were also seven failures, including Pecunio (PCO), and TrueVND (TVND).

2019 was the peak year of new tokens with 19. Binance USD, Dai, Huobi and True USD, in our top ten, launched that year. Eight coins have failed. Issuance slowed in 2020, with sixteen new stablecoins. sUSD and Terra USD are part of that vintage. Two tokens have already failed from the 2020 vintage: Trust Token (TRU) and Xank (XANk).

Jalan et al. (2021) study the gold based stablecoins. The authors find that while gold was stable during the COVID crisis, the gold-backed digital assets were as unstable as Bitcoin, despite have no formal or statistical linkage to the leading digital asset.

The hazard functions understate the failure rates of stable coins since many projects never move past the initial offering stage. Using data from Blockdata (2018), I can identify 103 projects from June 2019. At the time, 67 projects were active, with more than 30 projects under development. One of those projects, still not live, is the Libra coin proposed by Facebook. Libra has been rebranded as Diem and has plans to "... support single-currency

stable coins (e.g., USD, EUR, and GBP) and a multi-currency coin (XDX)."³⁸ Facebook has launched a digital wallet called Novi that currently operates with Pax Dollar (USDP).³⁹

3 Transaction Volume

I report daily estimates of transactions in each of the top ten stable coins for the second quarter of 2021.

Table 2: Transactions Volumes for Top Ten Stablecoins

Token Name	Transaction Volume (\$bn)	No. Transactions (mn)
Tether USD	692.94	15.3603
USD Coin	628.44	6.4196
Dai Stablecoin	198.95	1.8601
Binance USD	166.10	0.2121
Huobi USD	31.39	0.0424
Paxos Standard	16.93	0.0691
TrueUSD	14.57	0.1185
Synth sUSD	10.94	0.1002
Terra USD	6.43	0.0825
Gemini Dollar	3.21	0.0828

The totals are for Ethereum network transactions in 2021Q2.

There are \$1.769 trillion in stablecoin transactions in the second quarter of 2021. Tether has a 39.2% market share, USD Coin 35.5%, Dai 11.2%, and Binance 9.4%. All of the other coins have less than a 1% market share.

I graph the growth of stablecoin transactions in Figure 5.

³⁸https://www.diem.com/en-us/vision/

³⁹https://www.novi.com/

Figure 5: Stablecoin Quarterly Transaction Volume

Note: The data are from the Ethereum Mainnet The legend is in order of 2021Q2 market share.

2020-01

2021-01

2021-05

Over the last year, top stablecoin transaction volume has risen 1,123%, from \$157.56 billion in 2020Q2 to \$1,769.90 billion in 2021Q2. The fastest growth rate was for Synth USD, 5,833%. Among the top four coins, USD Coin grew the fastest in the last year, 3,674%, to nearly equal the total for Tether.

3.1 Velocity

250

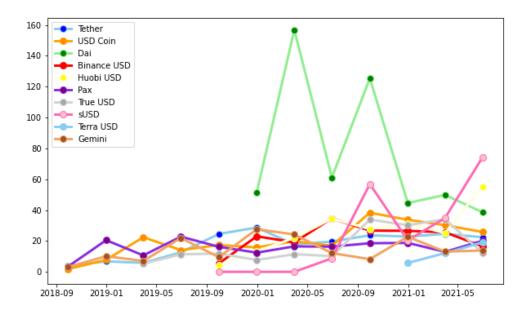
0 2018-09

2019-01

2019-05

I take the transaction volume and divide by circulating supply over time. I have this information from the Mainnet which I compute at the last block for the end of the quarter. I plot velocity in Figure 6.

Figure 6: Stablecoin Velocity



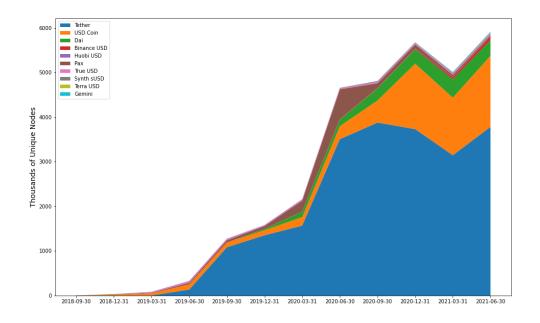
Note: The data on supply is just for tokens circulating on the Ethereum Mainnet.

Dai has the highest velocity among the four leading stablecoins, 38.6. USD Coin is second at 25.8, and Tether is third, at 22.4, and Binance USD is fourth at 16.5. The four token (unweighted) average is 25.8. By comparison, the M1 velocity in 2019Q4 was 5.5, the last quarter not impacted by Covid-19.

3.2 Network size

The Mainnet provides counterparty information from the transaction initiator and recipients. I define a counterparty as a wallet or smart contract and include internal transfers in the totals. I calculate the number of unique counterparties each quarter for each of the tokens. The time series is plotted in Figure 7.

Figure 7: Stablecoin Network Size



Note: The data are from the Ethereum Mainnet and include wallets, smart contracts, and internal transfers.

In the second quarter of 2021, Tether transactions involve 3.8 million unique counterparties. USD Coin has 1.6 million. Dai has 355,000. Binance USD has 77,900. The remaining tokens have fewer than 50,000 counterparties.

3.3 Holders

The Mainnet allows us to compute the holdings of any ERC-20 token by wallet address. Figure 8 shows the distribution of Tether holdings on March 15, 2021.

Tether USD Top 100 Token Holders

Source: Etherscan.lo

Oxa929922c91076433155c777ce9a910f0d1e490c

Oxa929922c91076433155c777ce9a910f0d1e490c

Oxa929922c91076433155c777ce9a910f0d1e490c

Oxa62747393198f70f7lec65a582d23dba7e5ab3 (tluobi 9)

Oxa567cafb8bf2a83bbca4c9f3591142(bdebe8dd

Oxa65c7afb8bf2a83bbca4c9f3591142(bdebe8dd

Oxa7ac0fb4f2d84898e4d9erb4dab3c24507a6d503

Figure 8: Tether Top Holders

Note: The graphic is from Blockchain.info for March 15, 2021.

Note that the top holder is just a network address node, 0xA929...490C. Other large holders include exchanges, Huobi, Binance (using at least three nodes) and Bittrex. There are also three decentralized exchanges, Curve.fi⁴⁰, Sushi Swap⁴¹ and Uniswap.⁴² Fritsch (2021) notes the two key aspects of decentralized exchanges (DEX): (1) they allow users to retain custody of their tokens; and (2) they utilize automated market makers. He estimates \$500 billion in trading volume for all decentralized exchanges in the first half of 2021. Park (2021) discusses flaws in the automated market making mechanism on most DEX, and estimates they may be raising transaction costs as much as 50 basis points on a substantial fraction of trades.

To provide comparison across the top stablecoins, I report the largest holder and Herfindahl (HHI) index for the ten largest stablecoins in Table 3.

Gemini, Paxos, and Huobi USD have the most concentrated holdings. For all three, the largest holder has more than 50% of the issue. Gemini's top holder is Curve.fi. Paxos and Huobi's largest holders are unnamed addresses, 0xe62...d4819b0322a for Paxos and 0xA9290...0D1e490C for Huobi.

⁴⁰https://curve.fi/rootfaq: "Curve is an exchange liquidity pool on Ethereum designed for (1) extremely efficient stablecoin trading (2) low risk, supplemental fee income for liquidity providers, without an opportunity cost. Curve allows users (and smart contracts like 1inch, Paraswap, Totle and Dex.ag) to trade between DAI and USDC with a bespoke low slippage, low fee algorithm designed specifically for stablecoins and earn fees. Behind the scenes, the liquidity pool is also supplied to the Compound protocol or yearn.finance where it generates even more income for liquidity providers."

⁴¹https://docs.sushi.com/: "SushiSwap is an automated market-making (AMM) decentralized exchange (DEX) currently on the Ethereum blockchain."

⁴²https://uniswap.org/faq/: "Uniswap is a protocol for creating liquidity and trading ERC-20 tokens on Ethereum. It eliminates trusted intermediaries and unnecessary forms of rent extraction, allowing for fast, efficient trading. Where it makes tradeoffs decentralization, censorship resistance, and security are prioritized. Uniswap is open-source software licensed under GPL."

Table 3: Concentration of Stablecoin Holdings

Stablecoin	Max Share	HHI
Gemini USD	76.12%	0.5837
Paxos Standard	69.15%	0.4806
Houbi USD	56.97%	0.4377
Binance USD	43.94%	0.2993
Synth sUSD	19.37%	0.0969
Terra USD	15.46%	0.0645
Dai Stablecoin	15.91%	0.0418
True USD	8.84%	0.0219
USD Coin	6.62%	0.0155
Tether	4.71%	0.0058

I retrieve from Etherscan all wallets with more than 1% of the stablecoin on March 15, 2021.

I compare my stablecoin HHI estimates to those in the banking industry for context. At the county level, Meyer (2018) found an average HHI of 0.3468. All of the tokens except for Gemini, Paxos, and Huobi are below that level. Based on Department of Justice (DOJ) merger guidelines, anything above 0.18 is "highly concentrated". Mergers which raise the HHI by 0.02 are also considered worth reviewing. By DOJ standards, six of the top ten tokens are "not concentrated."

4 Fees and Interest

Transferring ownership of a stablecoin requires intermediaries called *miners* to update the blockchain network. The fees they earn are transparent to all network participants.

4.1 Aggregate transfer fees

A transfer begins with two counterparties, identified by addresses, on the blockchain, with the owner requesting to process a transfer. I will use a real example to help understand the nomenclature:

In the example in Table 4, wallet 0xb3eb794a375d802876f67f59d5494b2078f0bdd8 initiates a transfer of 99.742115 Tether (USDT) to wallet 0x32034114ac386374d2f3e3057d61fdc3222c49ee. Once the transaction begins, a hash number is assigned to the transfer. All of the information in the example is public to the network, and I have retrieved it from the Mainnet.

The transfer request is publicized on the network and miners must make the effort to insert the transaction into the blockchain. The miners compete and pricing varies considerably with network congestion.

Table 4: Tether Transaction Example

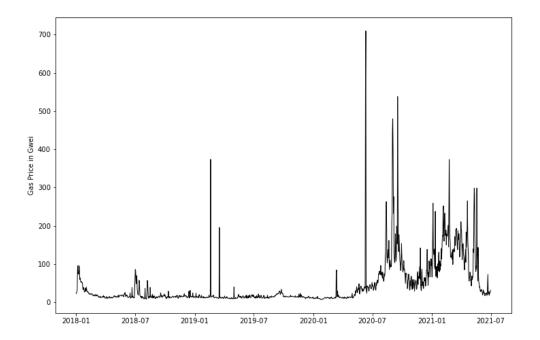
Field	Entry
Timestamp	Mar-21-2021 12:00:40 AM +UTC
From	0xb3eb794a375d802876f67f59d5494b2078f0bdd8
То	0x32034114ac386374d2f3e3057d61fdc3222c49ee
Contract	0xdac17f958d2ee523a2206206994597c13d831ec7 (Tether)
Tokens Transferred	99.742115
Transaction Hash	0xd79cf3fea1ca4ddaac0f42f98c496159dbe8be1582c17ffbf146096573a373ef
Block	12078834
Gas Price (Ether Gwei)	140.4887
Miner	0xd224ca0c819e8e97ba0136b3b95ceff503b79f53 (UUPool)
Transaction Fee (Ether)	0.0078967293383
USD/ETH price	\$1,783.94 (at timestamp)
Fee in USD	\$14.08729134

The transfer was included in Block 12078834. The miner UUPool completed the block in forty seconds. It charged a fee (priced in ether) using what is called the gas price. This name reflects the fact that the miner must use computer time to incorporate the transfer into the blockchain.

Gas prices are typically quoted in Gwei, billions of wei, the smallest divisible unit of ether. The gas price for this transaction was 140.4887 Gwei, or 140.4887 $\times 10^{-9}$ in ether terms. The transaction used 56,209 units of gas, making the ether cost of the transaction 7.90×10^{-3} ether.

I plot historical daily average ether gas prices in Figure 9.

Figure 9: Average Ether Gas Prices Jan. 1, 2018-June 30, 2021



Note: The data are from Etherscan, https://etherscan.io/chart/gasprice.

Average prices have ranged from 7.32 to 709.71 Gwei between January 2018 and June 2021. There is also substantial intra-daily fluctuation not captured in this figure. On March 14, 2021, for example, gas prices ranged from 70 to 600 Gwei.

The USD price of ether at the timestamp of the transaction completion in Table 4 was \$1,783.94, so the dollar cost of the transaction was \$14.09.

4.1.1 Internal transactions

Internal transactions are transactions between smart contracts. ERC-20 tokens are themselves smart contracts, but a chain of token transfers may include numerous internal transfers with additional intermediaries.

I discuss an example in Table 5. The transaction is two swaps, on the largest decentralized exchange, Uniswap, that result in the exchange of Gemini Dollar for USD Coin.

In calculating the network size, I include the wallet that supplies Gemini USD to the swap pools, the automated market maker smart contracts, and the wallet receiving the USD Coin. I will average the gas fee across all of the steps of the transaction.

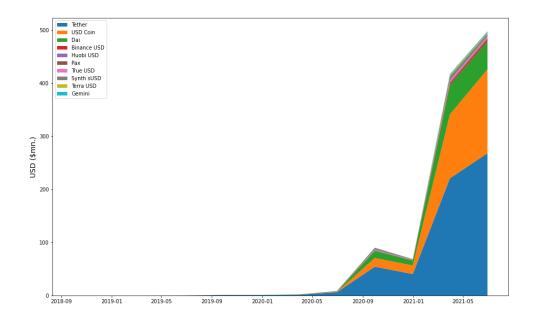
These assumptions have little impact on the fees for Tether and USDC. Only 0.2% of Tether and 1.4% of USD Coin transactions involve multiple steps like in Table 5. For Dai, while the number is higher, 10.8%, it has little effect on the distribution of transaction fees.

Table 5: Internal Transactions

Field	Entry
Transaction Hash	0x00085bce0480ffae3a717aa1af9f72cecb7566b2ed8ce4cb50b4e8cc225eebe2
Date	Jan-19-2021 07:54:01 AM
Transaction Action:	
Swap	10,623.08 GUSD for 7.87795 Wrapped Ether On Uniswap V2
Swap	7.87795 Ether For 10,779.054879 USDC On Uniswap V2
Gas Price (Ether Gwei):	132.28
Transaction Fee (Ether):	0.06074
USD/ETH price:	\$1,367.65 (at timestamp)
Total Fee in USD:	\$83.07

I aggregate fees over the last three years for all the top ten stable coins and plot them in Figure 10

Figure 10: Quarterly Transaction Fees for Top Stablecoins



Note: I compute fees in Ether from the Mainnet and convert them to USD using daily 12:00 GMT Ethereum prices.

The total fees from 2021Q2 are \$497.74 million and are dominated by three coins. USDT generates \$268 million in fees (53.9%), USDC \$158 million (31.8%), and Dai, \$52 million (10.6%). The other seven coins only generate \$18.7 million in fees, led by Synth sUSD at \$5.0 million.

4.2 Cross-section of fees

My examples show that transaction costs can vary substantially. Since block insertion time is influenced by the transfer fee, both costs and time to completion can be hard to predict. The cost of transfers has also been rising over time because of network congestion and the upward trend in Ether prices.

4.2.1Tether fees

Token Value

Gas Used

Obs.

Gas Price (Gwei)

Transaction Fee (USD)

Transaction Fee (%)

I begin the discussion on fees for Tether transactions because it is by far the largest by market capitalization.

To identify a large selection of representative transactions, I first gather the 19 network addresses that hold 1% or more of Tether on March 15, 2021. I then search for all transfers involving those counterparties on the Mainnet between October 1, 2018 and June 30, 2021. I wound up with a sample of 11.78 million transactions. There are 1.34 million unique senders and 2.30 million unique recipients. The most frequent sender is the Huobi exchange, 0x1062a747393198f70f71ec65a582423dba7e5ab3. This address initiates 1.68 million (14.2%) of the transactions. The most frequent recipient is the Binance exchange, which receives 2.31 million (19.6%) of the transfers.

Summary statistics are in Table 6.

std. dev. 1%25%50% 75%mean 53,733 1,575 7,123 500,000 2,962,469 9 400 104.46 144.519.5040.00 75.00 135.00

31,121

\$0.62

0.03

56,197

\$3.44

0.20

137,195

\$12.62

1.13

23,465

\$0.05

0.00

99%

500.00

385,472

\$123.06

67.14

Table 6: Tether (USDT) Transactions

109,512

\$47.60

0.97

87,684

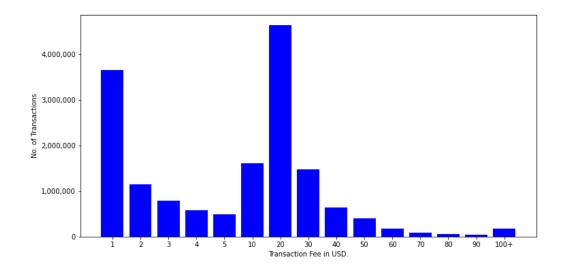
\$12.98

11,783,050

0.58

The median fee is \$3.44 with a median percentile fee of 0.20%. I plot a histogram of fees in USD in Figure 11.

Figure 11: USDT Transaction Fee Histogram - USD



Note: The histogram describe transaction fees in USD for 11.8 million Tether (USDT) token transfers from the largest holders of Tether between October 2018 and June 2021.

31% of fees are under \$1.00, and 47.6% are less than the average \$3.08 fee for out-of-network ATM transactions. There is a long tail though: 13.7% of fees are over \$25 and 1.5% have fees of over \$100.

The fees in percentage terms are in Figure 12

⁴³https://www.bankrate.com/banking/checking/checking-account-survey/

4,000,000 -1,000,000 -1,000,000 -

0.5%

10%

Figure 12: USDT Transaction Fee Histogram - Pct.

Note: The histogram describes fees as a percent of the transferred amount for 11.8 million token transfers from the largest holders of Tether between October 2018 and June 2021.

The median fee is 0.20%. Unfortunately, there are bad surprises though. More than 175,000 transactions (0.67%) have fees which exceed the transferred value.

There are economies of scale. Transactions over \$10,000 have a median fee of 0.011%. Transfers under that amount have a median fee of 0.38%.

4.2.2 USD Coin fees

I create a sample of 3.87 million USD Coin transactions between October 2018 and June 2021 from the largest holders of the token as I did with Tether. Descriptive statistics are in Table 7

	mean	std. dev.	1%	25%	50%	75%	99%
Token Value	94,155	2,356,790	3	350	1,826	9,969	1,192,906
Gas Price (Gwei)	111.10	210.90	2.00	40.00	80.00	138.01	580.00
Gas Used	212,782	234,922	41,588	133,328	$175,\!654$	206,165	1,266,310
Transaction Fee (USD)	\$30.04	\$88.87	\$0.05	\$4.43	\$13.03	\$35.75	\$237.21
Transaction Fee $(\%)$	0.95	1.17	0.00	0.15	0.84	3.84	196.95
# Obs.	3,874,858						

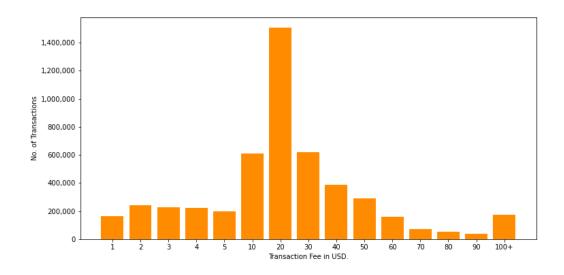
Table 7: USD Coin (USDC) Transactions from Largest Holders

There are 454.2 thousand unique senders and 287.6 thousand unique recipients. The top sender, with 1.27 million transfers (32.9%), is Uniswap: 0x55fe002aeff02f77364de339a1292923a15844b8. The top recipient is again Uniswap with 1.19 million (30.8%) of the inbound transfers.

Transaction costs are higher for USD Coin than Tether. The median fee is \$13.03 with a median percentile fee of 0.84%. The gas used in the median transaction, 175,654, is nearly three times the amount for Tether transactions.

I plot a histogram of fees in USD in Figure 11.

Figure 13: USDC Transaction Fee Histogram - USD



Note: The histogram describes transaction fees in USD for 3.8 million token transfers from the largest holders of USD Coin between October 2018 and June 2021.

Only 17% of fees are below the ATM threshold of \$3.00. More than a third of fees are above \$25.00, and 4.6% are above \$100.

The fees in percentage terms are in Figure 14

1,200,000 1,000,000 800,000 No. of Transactions 600,000 400,000

0.5%

10%

20%

Figure 14: USDC Transaction Fee Histogram - Pct.

Note: The histogram describes percentage transaction fees for 3.8 million token transfers from the largest holders of USD Coin between October 2018 and June 2021.

30% Transaction Fee in Pct

4% of fees are larger than the transferred amount. Bigger trades (>\$10,000) pay a median fee of 0.044%, but smaller trades have a median of 1.65%.

4.2.3 Dai Stablecoin

200,000

0

I create a sample of 1.8 million Dai transactions between October 2018 and June 2021. This is a sample from all holders of more than 1% of the stablecoin. There are 143,569 unique senders, and 123,136 unique recipients. The most active sender and recipient is Uniswap (0xa478c2975ab1ea89e8196811f51a7b7ade33eb11) which initiates 29.8% of the transfers and receives 28.9%.

Descriptive statistics are in Table 8

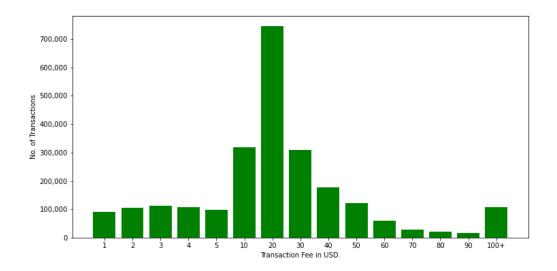
Table 8: Dai Stablecoin Transactions

	mean	std. dev.	1%	25%	50%	75%	99%
Token Value	94,359	3,925,343	1.33026	313	1,951	13,132	872,241
Gas Price (Gwei)	112.61	335.50	1.01	41.00	78.62	130.00	600.00
Gas Used	274,600	$329,\!336$	84,633	128,491	$174,\!296$	268,470	1,766,001
Transaction Fee (USD)	\$33.55	\$127.57	\$0.08	\$4.34	\$11.68	\$32.51	\$333.46
Transaction Fee $(\%)$	0.89	1.16	0.00	0.10	0.65	3.14	469.86
# Obs.	1,811,045						

The average Dai transaction is similar in size to USD Coin, 94,350 tokens for Dai versus 94,155 for USDC. Fees are also similar, although the average fee for USDC is about \$3.00 lower.

A histogram of fees in USD is in Figure 15.

Figure 15: USDC Transaction Fee Histogram - USD



Note: The histogram describes USD transaction fees for 1.8 million token transfers from the largest holders of Dai stablecoin between October 2018 and June 2021.

17% of fees are below the \$3.00 ATM threshold. More than 31% are above \$25 and almost 6% are above \$100.

The fees in percentage terms are in Figure 16

500,000 -400,000 -300,000 -100,000 -

0.5%

10%

Figure 16: Dai Transaction Fee Histogram - Pct.

Note: The histogram describes percentage transaction fees for 1.8 million token transfers from the largest holders of Dai stablecoin between October 2018 and June 2021.

30%

The median fee in percentage terms is 0.65% which is between Tether and USD Coin, but closer to the latter. Bigger transfers (>\$10,000) pay lower fees, 0.0038%, but these are still higher than the fees for institutional size trades for the USDT and USDC. There are 534 transfers in which fees exceed the transferred amount.

4.3 Interest rates

0

A major trend in the digital asset space is DeFi, Decentralized Finance, which includes the decentralized exchanges (DEX) I discussed earlier. The DeFi Pulse reports that, as of December 20, 2021, over \$95.7 billion has been committed to DeFi projects. I list the seven largest projects with assets of over five billion USD in Table 9

Table 9: Largest DeFi Projects

Name	Chain	Category	Locked (USD bn.)
Maker	Ethereum	Lending	\$17.88
Curve Finance	Multichain	DEXes	\$14.02
Aave	Multichain	Lending	\$11.00
InstaDApp	Ethereum	Lending	\$10.81
Convex Finance	Ethereum	Assets	\$9.99
Compound	Ethereum	Lending	\$9.74
Uniswap	Ethereum	DEXes	\$8.29

Assets from: https://defipulse.com/ Retrieved on December 20, 2021.

I focus in this section of lending projects in which owners of digital assets can earn interest by allowing other traders to borrow their coins. A sample of current rates for stablecoins is in Table 10

Table 10: Defi Lending Rates

_	Compound	Aave	dYdX	Fulcrum	BlockFi	Nexo	Celsius	Bitfinex	Poloniex	Maker	Coinbase
DAI	3.04%	2.77%	0.00%	5.18%	8.50%	8.00%	4.60%	9.13%			2.00%
USDC	2.70%	2.82%	0.00%	6.35%	7.50%	8.00%	8.50%		6.17%		4.00%
USDT	2.50%	2.69%			9.22%	7.50%	8.00%	8.50%			3.87%

Rates from https://defirate.com/lend/. Retrieved on December 20, 2021.

The interest rates are substantial but not guaranteed. A number of fees reduce the actual returns. Most projects charge a fee on inbound fiat money. Conversion rates to stablecoins are usually at prices away from the best prices on exchanges. Withdrawals are also limited.

The savings rates in the high single digits on BlockFi, Celsius, and Nexo have attracted a great deal of attention from investors and concerns from regulators. SEC Chairman Gensler wrote: "The world of crypto finance now has platforms where people can trade tokens and other venues where people can lend tokens. The American public is buying, selling, and lending crypto on these venues...I believe we need additional authorities to prevent transactions, products, and platforms from falling between regulatory cracks." HelickFi which also offer credit cards has attracted attention from several state regulators, including New Jersey which issued a cease and desist order on July 19, 2021, preventing them from opening any new accounts. As of December 20, 2021, BlockFi continues to operate in New Jersey.

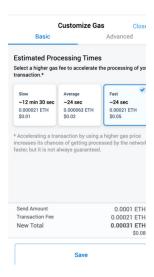
 $^{^{44}} https://www.warren.senate.gov/imo/media/doc/gensler_response_to_warren_-_cryptocurrency_exchanges.pdf$

⁴⁵https://cointelegraph.com/news/blockfi-faces-regulatory-heat-a-sign-of-possible-crypto-lending-regulations

4.4 Speed

The speed in which any transfer gets executed is a function of the price you are willing to pay. In Figure 17, I show a screen shot from the popular Metamask⁴⁶ Wallet App.

Figure 17: Price and Speed in the MetaMask Wallet App



Note: The example is from Chris Winfrey, "Gas Spectrum Transactions.," Medium, June 17, 2019. https://medium.com/authereum/gas-spectrum-transactions-bd34b65107b It

estimates network congestion and provides expected times for the transaction to complete based on the amount you are willing to pay. The risk with setting the price too low is that your transaction may never complete.

Etherscan provides⁴⁷ a time series of the average transfer speed in the block chain. The median over 2015-2021 is 14.13 seconds, with a maximum of 30.31 seconds. This data is helpful, but it does not address the fact that some transactions can take days or weeks or sometimes never complete. There is also no guaranteed time delivery, regardless of rate.

4.5 Trends over time

Ethereum prices rose dramatically in 2021. They averaged \$1,536.97 in 2021Q1 and \$2,590.91 in 2021Q2, up from an average of \$494.15 in the last quarter of 2020. The increase over the last year is 1,168%.

As Donmez and Karaivanov (2021) note, miners pay a flat fee for Ethereum transfers between two wallets. They charge 10 to 20 times more though for smart contract interactions which include our ERC-20 tokens. Gas fees rise with network congestion, particularly after the network reaches 90% capacity. As gas fees and Ethereum prices rise, dollar transfer costs

⁴⁶ https://metamask.io/

⁴⁷https://etherscan.io/chart/blocktime

rise with them. I graph the trend in transfer costs for the major stablecoins in Figure 18. The median fee for Tether reached \$15.47 in the second quarter of 2021.

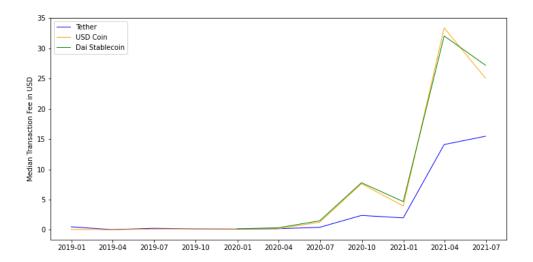
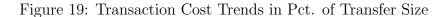


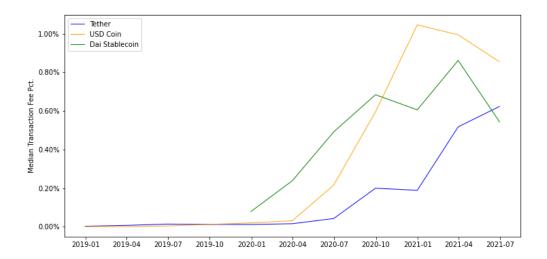
Figure 18: Transaction Cost Trends in USD

Note: I use the sample from Section 4.1 for each of the three major tokens and show the rise in median fees, measured in USD per transfer, over time.

Between the second quarter of 2020 and the second quarter of 2021, median USD fees on Tether are up 3,628%. USDC median fees are \$25.06, up 1,897%, and Dai at \$27.21, up 1,724%. These increases reflect higher gas prices, 91% for USDT, 113% for USDC, and 99% for Dai, as well as the increase in Ethereum prices.

The rise in median fees has made the median transfer cost in percentage terms much higher. For USD Coin, it exceeded 1% in the 2020Q4 and 2021Q1.





Note: I use the sample from Section 4.1 for each of the three major tokens and show the rise in median fees, measured in percentage of the transferred amount, over time.

These rise in transfer fees has already spawned blockchain innovations. The first is that more transactions are migrating to cheaper and faster blockchain networks. One example is the the public open source Solana.⁴⁸ The second is the upgrade of the Ethereum network to version 2.0.⁴⁹ The new standard includes a change in the fee structure using Ethereum Improvement Proposal⁵⁰ (EIP) 1559 which replaces the first price auction procedure in place of a base fee. It is too early to tell how these changes will impact stablecoin fees. Catalini et al. (2020) also raise concerns about the security of new network protocols.

5 Microstructure

The Mainnet had an average transaction time of 13.17 seconds per block⁵¹ in 2021Q2 which is far too slow for low latency trading activity. This largely explains why the vast majority of trading volume in stablecoins occurs off chain on centralized exchanges.⁵²

I study the five active stablecoins with market capitalization over \$500 million and with \$100 million in daily turnover.

 $^{^{48}}$ https://docs.solana.com/introduction. Solana reports block formation time of 599 milliseconds on December 27, 2021 at 16:48:11 GMT.

⁴⁹https://ethereum.org/en/eth2/

⁵⁰https://notes.ethereum.org/@vbuterin/eip-1559-faq

⁵¹https://etherscan.io/chart/blocktime

⁵²New, faster networks like Solana have achieved latencies under a second, and they are attracting a growing share of the decentralized exchange activity.

5.1 Trading volume

I first provide trading volumes across all major currencies and digital asset cross rates in Table 11. Tether has more than 11,000 market pairs in which there is a combined average daily volume of nearly \$120 USD billion. This is comparable to the average daily turnover on the New York Stock Exchange.

Table 11: Most Active Stablecoins - All Currency Pairs

Name	Symbol	No. Market Pairs	Avg. Daily Volume (USD bn.)
Tether	USDT	11,008	\$119.72
Binance USD	BUSD	352	6.68
USD Coin	USDC	773	\$2.49
Dai	DAI	379	0.52
Paxos Standard	PAX	177	0.09

The table reports the average daily volume across all currency pairs and exchanges in the stablecoin for the second quarter of 2021. Source: CoinMarketCap.

I just want to clarify that these transactions are *not* part of the transfer volume studied earlier. From the perspective of the blockchain, these trades are internal to a single wallet and not reported on the Mainnet.

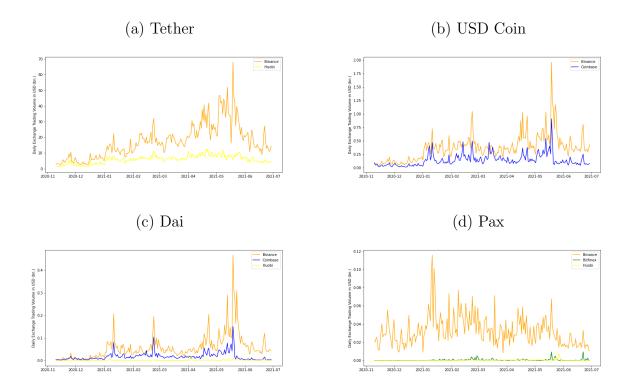
I study the five most active digital asset exchanges. These exchanges have more than 50% of the market share for the USD stable currencies I study. I report market shares in Table 12.

Table 12: USD Stablecoin Exchange Market Shares

	Binance	Bitfinex	Coinbase	Huobi	Kraken
Tether	61%	< 1%	< 1%	18%	< 1%
USD Coin	64%	< 1%	19%	<1%	< 1%
Dai	71%	< 1%	16%	19%	< 1%
Binance USD	100%	NA	NA	NA	NA
Paxos Standard	89%	2%	NA	2%	NA

The table reports average daily market shares across all currency pairs in the stablecoin on the exchange for the second quarter of 2021. Source: CryptoCompare API.

Figure 20: Trading Volume by Exchange of Major Stablecoins



Note: Volumes (in billions of USD) are from the CryptoCompare API for all currency pairs in the stablecoin.

I report the daily trading volume for the four major currencies that trade across multiple exchanges in Figure 20.

Binance is the most active exchange in Tether, with a daily average volume of \$26 billion in the second quarter of 2021. The only other exchange-currency pair with over one billion in daily volume is Tether on Huobi (\$7.4 billion daily average). USD Coin on Binance at \$512 million has the third largest average daily volume.

The exchanges do occasionally handle much larger volumes. Binance trades more than \$68 billion in Tether on May 19, 2021. All of the other stablecoins have major spikes on that date across all exchanges.

5.2 Bid-ask spreads

The four pairs I study for Tether are BUSD/USDT on Binance, USDT/USD on Bitfinex, USDT/HUSD on Huobi, and USDT/USD on Kraken. For USD Coin, I analyze three pairs: USDC/USDT on Binance, BTC/USDC on Coinbase, and USDC/HUSD on Huobi. I analyze four pairs of Dai, DAI/USD on Bitfinex, Coinbase, and Kraken and DAI/USDT on Huobi. Finally, for PAX, I study PAX/USDT on Binance and PAX/USD on Bitfinex.

I next report the median bid-ask spreads for the four currencies by exchange-pair in

(a) Tether (b) USD Coin 0.01409 0.0800 0.01209 0.0100% 0.05009 0.0080 0.0060 0.03009 0.02009 2021-04-04 2021-04-24 2021-05-14 2021-06-03 2021-03-15 2021-04-04 2021-04-24 2021-05-14 (c) Dai (d) Pax 0.14009 0.1000 0.08009 0.10009 0.08009 0.04009 0.0200% 0.02009

Figure 21: Median Bid-Ask Spreads (Pct.) by Exchange of Major Stablecoins

Note: The best-bid or offer is computed from direct API feeds for each exchange.

Figure 21.

All of the exchanges maintain generally stable bid-ask spreads of 0.01% or lower in Tether. Bitfinex is most often the tightest. With Tether trading near \$1.00, this is a cost of 0.0001\$ for most transactions.

I consider USD Coin in two categories. On Binance, you exchange USD Coin for Tether. On Huobi, you are exchanging for Houbi USD. On Coinbase, which sponsors USD Coin and provides unlimited parity trades⁵³ between the coin and the USD, you are exchanging for Bitcoin. Binance bid-ask spreads are uniformly at the typical 0.01%. Huobi is frequently double that at 0.02%. On Coinbase, since you are trading for a risky asset, the bid-ask spread of 0.03% is similar to the BTC-USD rate.

Bid-ask spreads are much higher for Dai except on Coinbase which has a median average of 0.017%. Huobi and Kraken are over 0.03%.

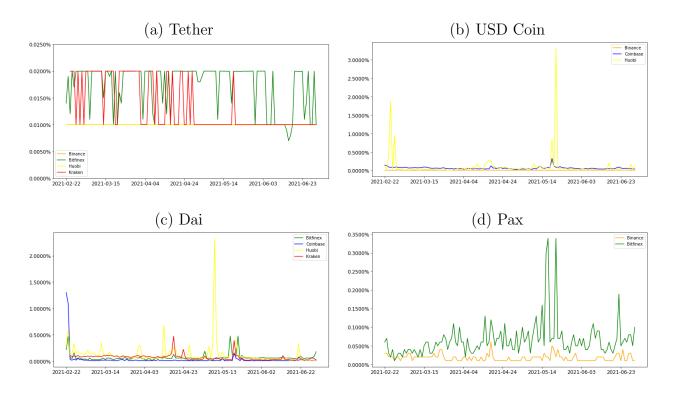
Paxos orders are at the 0.01% bid-ask spreads nearly every day on Binance, but it generally quotes at 0.02% spreads on Bitfinex.

On occasion, the spreads increase significantly though. I plot in Figure 22 the 95th percentile of bid-ask spreads for each of the currency-exchange groups.

With Tether, even trading on the exchange with the widest spreads, Kraken, a trader

 $^{^{53}}$ https://www.coinbase.com/usdc: "For customers with a US dollar bank account, one USDC can always be redeemed for US\$1.00.

Figure 22: 95th Percentile Bid-Ask Spreads by Exchange of Major Stablecoins



Note: The best-bid or offer computed from direct API feeds from each exchange.

would face a spread of 0.02% or more less than 5% of the time. This is quite important because as Bianchi et al. (2020) show, deviations in Tether from parity impact the out-of-sample returns on a broad index of digital currencies.

Huobi has occasional break downs in their usual tight spreads for USD Coin. 5% of the time you would trade against a bid-ask spread of more than 3.31%.

With Dai, on Coinbase, bid-ask spreads occasionally exceed 1%. On Huobi, they sometimes exceed 2.0%. On Kraken and Bitfinex, the 95th percentile spreads never exceed 0.5%.

Pax is quite stable. Spreads reach 0.06% on the thinnest days at Binance and 0.3% on Bitfinex.

I now turn to measure how much you can trade at the best bid or offer.

5.3 Depth

I calculate depth as

$$0.5 \times [\text{bid depth} + \text{ask depth}],$$

in thousands of USD for the five currency-exchange groups. Figure 23 provides data on the token-exchange pairs.

Tether is by far the deepest market. Binance displays a median depth that averages more than 8.3 million Tether. The depth has also been increasing in the second quarter of 2021. Huobi is the second deepest in Tether, but it is not even 20% as deep as Binance. The only coin with comparable exchange depth is USD Coin on Binance, which has a median depth which averages 545,000.

Paxos has a depth of 118,000 on Binance and and 97,000 on Bitfinex. Dai, on all four exchanges I am streaming, Bitfinex, Coinbase, Huobi and Kraken, would see market orders of more than 10,000 Dai likely breaking through the BBO; the largest depth on those four exchanges is 9.38 thousand on Bitfinex.

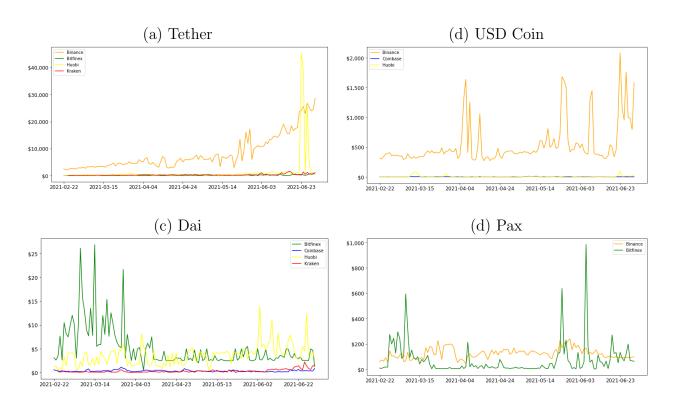
5.4 High frequency trading

High-frequency trading (HFT) has become an important part of the digital asset trading environment. Aleti and Mizrach (2021) found HFT market share at Coinbase of 15.5% for Bitcoin. The authors did not examine stablecoins though, and they looked at a different set of exchanges apart from Coinbase. Recent industry discussion suggests that HFT activity has increased, with the arrival of equity HFT firms like Jump Trading and DRW. Industry estimates suggest that 80 to 90% of the trading on Bitfinex is from HFT firms.⁵⁴.

One measure of HFT activity is the cancellation to execution ratio. I can compute these estimates for only a subset of the exchanges, Binance, Bitfinex and Coinbase, where the API provides accurate timestamps of the orders. These estimates are in Figure 24.

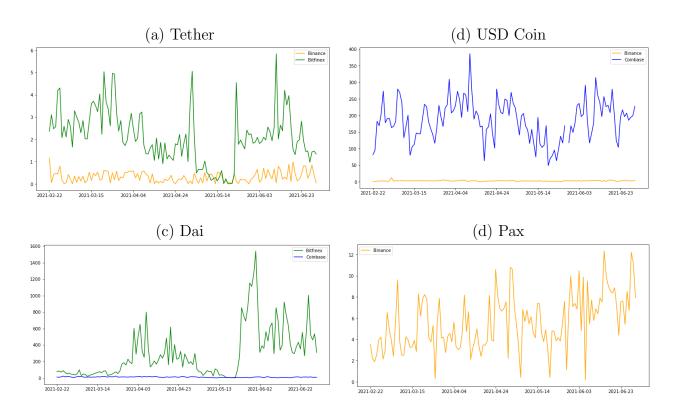
⁵⁴https://www.supercryptonews.com/over-80-of-trading-volume-on-bitfinex-is-generated-by-hft-firms/: "From Jump to DRW, a lot of HFT firms] are diving in headfirst because of a lack of opportunities in the traditional high frequency, low latency trading,"

Figure 23: Median Depth (USD thsd.) by Exchange of Major Stablecoins



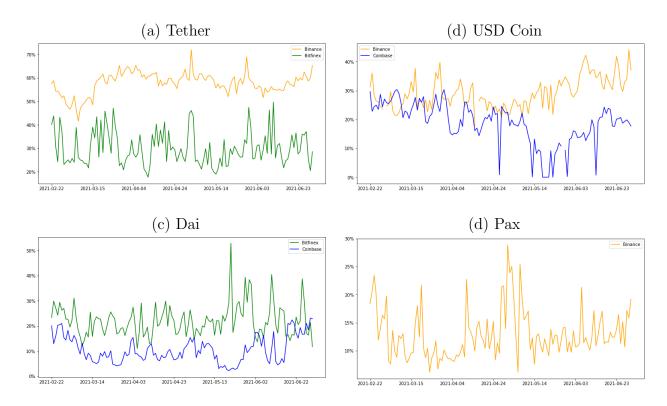
Note: The depth (in thousands of USD) is one-half the sum of displayed depth at the best-bid and offer computed from direct API feeds for each exchange.

Figure 24: Cancellation/Execution Ratios of Major Stablecoins



Note: Cancellations are computed from direct API feeds from each exchange.

Figure 25: HFT Pct. of Order Cancellations



Note: Cancellations are computed from direct API feeds from each exchange. Thresholds are 500 milliseconds on Binance and Bitfinex and 50 millseconds on Coinbase.

Cancellation to execution (CE) ratios are under six on Binance for Tether, USD Coin, and Pax. This is low compared to the typical US large cap equity. The SEC Midas website⁵⁵ reports a 22-day moving average of 9.06 for the last month of 2020. Along with the narrow spreads, this suggests liquidity providers face little risk of adverse selection.

Dai has higher CE ratios: nearly 12 on Coinbase and almost 300 on Bitfinex. Pax has a CE ratio of 5.56 on Binance.⁵⁶

A second measure is the percentage of cancellations under 500 milliseconds. These are orders which are lifted (either through trades or cancellation) from the order book before any non-HFT trader could react to them. I report estimates in Figure 25.

My highest share of HFT activity is 57.7% for Tether on Binance. Tether on Bitfinex and USD Coin on Binance are in the 30% range. Coinbase has less HFT activity. 18.7% of USD Coin cancellations are below the HFT threshold.

The HFT shares for Dai and Pax are lower, between 11 and 21%. The highest is at Bitfinex, 22% for Dai, which is consistent with industry discussion.

There appear to be a variety of motivations for the HFT trading in stablecoins. The first

⁵⁵https://www.sec.gov/marketstructure/datavis/ma_stocks_canceltotrade.html

⁵⁶Trading activity is so low for Dai on Bitfinex, I exclude the pair from this figure. There are many days in which the CE ratio is over 1,000 though.

is to arbitrage small price discrepancies on an exchange or across exchanges.⁵⁷ The second is as an on-exchange store of value. Getting assets into an exchange to exploit trading opportunities can be quite slow. Coinbase, for example, requires 35 confirmations for a token transfer, so it can easily take ten minutes to transfer stablecoins between exchanges.⁵⁸.

There is an open debate on whether the HFT activity is stabilizing for the digital asset markets, see e.g. Alexander and Heck (2020), but it is clear that stablecoins will be a part of that discussion.

6 Conclusion

I have analyzed the collateral structure of the ten leading stablecoins by market capitalization. Seven of the ten coins are backed by fiat assets. Three hold digital assets, and two of those are algorithmically stabilized.

While this paper has analyzed the successful tokens, failure rates of stablecoin projects are almost as high for other digital assets. The 2016 and 2017 vintages of stablecoins have failure rates of 100 and 50%. In total, more than 1/3 of the stablecoins that passed the offering stage have failed.

I estimate \$1.77 trillion in stablecoin transactions in the second quarter of 2021. Tether leads stablecoin transactions, with a 39% market share. USD Coin is now a close second at 36%. Dai has the highest velocity at 38.6. USD Coin is second at 25.8, and Tether is third at 22.4.

The Ethereum blockchain provides a great deal of transparency at the level of the hash tag address. In the second quarter of 2021, Tether transactions involve 3.8 million unique counterparties. USD Coin has 1.6 million. Dai has 355,000. The remaining tokens have fewer than 50,000 counterparties.

The Mainnet provides the hashtag identity of the largest holders of any stablecoin. I compute Herfindahl indices for the stablecoin network. Gemini, Paxos, and Huobi have the most concentrated holdings. For all three, the largest holder has more than 50% of the supply.

The total fees from 2021Q2 for the top ten stablecoins are are \$497.74 million. USDT generates \$268 million in fees (53.9%), USDC \$158 million (31.8%), and Dai, \$52 million (10.6%).

The median transaction fee for Tether is \$3.44 or 0.2% of the transferred amount. 0.67% of transfers have fees which exceed the transferred amount. USD Coin and Dai have higher median transfer fees, \$13.03 for USDC and \$11.38 for Dai. For both of these stablecoins, more than 25% of transactions are in excess of 3% of the amount transferred.

A major obstacle for the Mainnet is that network congestion is raising gas fees. As the price of Ethereum has risen, so have transfer fees. Median fees for Tether rose 3,628% year-over-year in the second quarter of 2021, They rose 1,897% for USD Coin, and 1,724% for

 $^{^{57}\}mathrm{Ryan}$ Adams, "How to make money trading stable coins," lhttps://newsletter.banklesshq.com/p/how-to-make-money-trading-stable coins

⁵⁸https://suredbits.com/lightning-201-high-frequency-trading/

Dai.

With the rapid growth of DeFi projects, reaching \$96 billion at the end of 2021, there are opportunities to earn attractive interest rates in stablecoins. I can only conjecture whether these rates will stay high if non-stablecoin asset prices collapse again or if regulators will allow this type of lending to continue.

The last stage of my analysis shows that the major digital asset exchanges provide low cost, deep markets in the major stablecoins. 24 hour turnover in Tether is over \$120 billion. This is more than the daily turnover of all the FANG stocks (Facebook Amazon, Netflix, and Google, now Alphabet). It is almost 15 times the daily flow in money market mutual funds.⁵⁹

Bid-ask spreads are nearly always \$0.0001 on Tether, and the most liquid exchange, Binance, typically displays more than eight million dollars in depth. USD Coin has similar spreads, but much smaller depth. The spreads and depth are sufficient that there is active high frequency trading participation, between 20 and 50%, in many of the liquid tokens.

The Basel Committee on Banking Supervision (2021) has started the discussion on capital requirements for digital assets. The seven tokens backed by cash equivalents may qualify as Group 1a assets requiring little or no reserves. The three tokens that hold digital assets would likely fall into Group 1b with much higher capital set asides. The President's Working Group on Financial Markets⁶⁰ has proposed that stable coin issuers become insured depository institutions. There is an ongoing debate, see e.g. Malloy and Lowe (2021), about whether central banks should offer competing digital currencies and how they should be funded. The instability of the private offerings should impact both discussions.

⁵⁹The average outflow from the sector was \$533.6 billion in 2020Q4, https://fred.stlouisfed.org/series/MMMFTAQ027S. This averages to \$8.08 billion per day, assuming 66 trading days.

⁶⁰President's Working Group on Financial Markets, and Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency (2021)

References

- Aleti, S., & Mizrach, B. (2021). Bitcoin Spot and Futures Market Microstructure. *Journal of Futures Markets*, 41, 194–225.
- Alexander, C., & Heck, D. (2020). Price Discovery in Bitcoin: The Impact of Unregulated Markets. *Journal of Financial Stability*, 50, Article Number 100776.
- Bahachuk, V. (2020). What is the Stablecoin DAI? https://linen.app/articles/what-is-the-stablecoin-dai
- Basel Committee on Banking Supervision. (2021). Consultative Document, Prudential treatment of cryptoasset exposures. https://www.bis.org/bcbs/publ/d519.pdf
- Bianchi, D., Rossini, L., & Iacopini, M. (2020). Stablecoins and cryptocurrency returns: What is the role of Tether? SSRN. https://dx.doi.org/10.2139/ssrn.3605451
- Blockdata. (2018). Stablecoins: An overview of the current state of stablecoins. https://blockdata.tech/stablecoin-report
- Catalini, C., Jagadeesan, R., & Kominers, S. D. (2020). Markets for Crypto Tokens, and Security under Proof of Stake. SSRN. https://dx.doi.org/10.2139/ssrn.3740654
- Donmez, A., & Karaivanov, A. (2021). Transaction Fee Economics in the Ethereum Blockchain. *Economic Inquiry*. DOI:%2010.1111/ecin.13025
- Fritsch, R. (2021). Concentrated Liquidity in Automated Market Makers. *Archiv.org.* https://arxiv.org/abs/2110.01368v1
- G7 Working Group, T. (2019). Investigating the impact of global stablecoins. https://www.bis.org/cpmi/publ/d187.pdf
- Gorton, G. B., & Zhang, J. Y. (2021). Taming wildcat stablecoins. SSRN. https://dx.doi.org/10.2139/ssrn.3888752
- Griffin, J. M., & Shams, A. (2020). Is Bitcoin Really Untethered? *Journal of Finance*, 75, 913–64.
- Grobysa, K., Junttilab, J.-P., Kolaric, J. W., & Sapkotad, N. (2021). On the stability of stablecoins. SSRN. https://dx.doi.org/10.2139/ssrn.3764457
- Hoang, L. T., Klaus, & Baur, D. G. (2021). How stable are stablecoins? *European Journal of Finance*. https://dx.doi.org/10.2139/ssrn.3519225
- Jalan, A., Matkovskyy, R., & Yarovaya, L. (2021). Shiny" crypto assets: A systemic look at gold-backed cryptocurrencies during the COVID-19 pandemic. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3796837
- James, L. (2021). In the Matter of Investigation by Letitia James, Attorney General of the State of New York, of iFinex Inc., BFXNA Inc., BFXWW Inc., Tether Holdings Ltd., Tether Operations Ltd., Tether Ltd., Tether Intl. Ltd. Respondents. https://ag.ny.

- gov/sites/default/files/ $2021.02.17_{--}$ settlement_agreement_-_execution_version.b-t_signed-c2_oag_signed.pdf
- Kozhan, R., & Viswanath-Natraj, G. (2021). Decentralized Stablecoins and Collateral Risk. SSRN. https://dx.doi.org/10.2139/ssrn.3866975
- Lyons, R. K., & Viswanath-Natraj, G. (2020). What Keeps Stablecoins Stable? *NBER Working Papers*, 27136.
- Malloy, M., & Lowe, D. (2021). Global Stablecoins: Monetary Policy Implementation Considerations from the U.S. Perspective. Finance and Economics Discussion Series, Federal Reserve Board, 2021-20.
- Meyer, A. (2018). Market Concentration and Its Impact on Community Banks. *Regional Economist*.
- Park, A. (2021). The Conceptual Flaws of Constant Product Automated Market Making. SSRN. https://dx.doi.org/10.2139/ssrn.3805750
- President's Working Group on Financial Markets, and Federal Deposit Insurance Corporation, and Office of the Comptroller of the Currency. (2021). Report on Stablecoins. https://home.treasury.gov/system/files/136/StableCoinReport_Nov1_508.pdf
- Regnard-Weinrabe, B., Vasu, H., & Al Nakib, H. D. (2019). Stablecoins. https://corpgov.law.harvard.edu/2019/02/10/stablecoins/