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Market behaviors around bankruptcy and frozen funds withdrawal: Trading stranded assets on FTX

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ABSTRACT

How do cryptocurrency markets react when an exchange allows trading but freezes withdrawals? This study examines the impact of liquidity funding shocks on the market liquidity of cryptocurrency markets and traders' behavior. We examine this issue using a natural experiment in major cryptocurrencies when the FTX exchange, while about to file for bankruptcy, prohibited most investors from withdrawing assets held by the exchange while allowing trading to continue. By using proprietary tick-by-tick data, we test price divergence between FTX and Binance and perform t-tests on the difference in magnitude of liquidity measures between the pre- and post-withdrawal halt periods. We find that a substantial amount of trading on FTX occurred during this stranded asset period, even though liquidity deteriorated as the bid-ask spread and implicit transaction costs increased sharply. We further find traders engaging in a revealing flight to safety by moving their investments in stablecoin Tether or even exiting the market. These findings not only shed light on the resilience of cryptocurrency markets in the face of liquidity crises but also offer insights into the mechanisms traders employ to navigate such tumultuous periods.

1. Introduction

Cryptocurrency exchanges are occasionally likened to traditional stock exchanges, such as the London or New York stock exchanges, which have withstood numerous financial crises. However, they differ significantly from these established institutions. While stock exchanges are frequently subject to rigorous regulation by the government and play a role in regulating share trading themselves, many cryptocurrency exchanges operate with minimal government regulation and provide little regulatory oversight. This obviously raises concerns about investors' protection and market integrity in the crypto-assets environment. Furthermore, with a stock exchange, clients' money is not directly handled by the exchange itself. Instead, investors have to transact through a broker who debits their trading account for purchases and credits their trading account with proceeds from sales. By contrast, a cryptocurrency centralized exchange (CEX) serves as both an exchange and a brokerage, facilitating the conversion of customers' fiat money into cryptocurrency or vice versa and functioning as a bank by safeguarding customers' crypto-assets as a custodian. This indirectly creates a regulatory conundrum which naturally raises the following questions: (i) How do traders and markets behave when a cryptocurrency exchange allows trading but unexpectedly halts digital fund withdrawals? (ii) In particular, to what extent do traders anticipate the exchange may file for bankruptcy protection and engage in trading that will maximize their expected asset recovery during the anticipated

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bankruptcy and administration? (iii) If so, what impact does the withdrawal halt on a major cryptocurrency exchange have on the liquidity of cryptocurrency markets? We exploit a natural experiment to answer these research questions.

Specifically, this study examines market quality on the FTX exchange *before* access to digital funds was frozen and *during*the period from 06:37 a.m. on November 8, 2022, to 3:28 a.m. (UTC time) on November 12, 2022, when trading was allowed on the exchange but nearly all withdrawals were halted.[1] We examine six main cryptocurrency pairs against Tether,[2] namely: Bitcoin (BTC); Ethereum (ETH); Dogecoin (DOGE); Litecoin (LTC); FTX's utility token (FTT); Binance coin (BNB). Our study examines the behaviour of market liquidity, as proxied by the bid-ask spread and market depth, and trading activity of the above six cryptocurrency trading pairs against Tether on the FTX during a symmetrical pre- and post-period surrounding the start of the withdrawals halt, and compares them with identical cryptocurrency pairs trading contemporaneously on Binance—the dominant cryptocurrency exchange.[3] The implications for market efficiency are assessed.

Our findings suggest that FTX's decision to halt the withdrawal of funds held by the exchange, is associated with an economically and statistically significant disruption in liquidity and other market quality measures. This deterioration manifests as heightened bid-ask spreads and an increase in market depth. Further, we find a sharp increase in both implicit transaction and adverse selection costs for the exchange's customers, with market makers realizing more profits due to their widened bid-ask spread compensating for the risks associated with such a *funding liquidity* crisis.

This is the first study, that we are aware of, to test the price behaviour of stranded assets on a major cryptocurrency exchange. From midday[4] November 8, 2022, to 3:28 a.m. UTC on November 12, 2022, FTX continued to allow trading but would generally not allow cryptocurrency withdrawals.[5] This presented traders with a novel set of incentives on how to prepare a portfolio to maximize potential asset recovery during the likely ensuing bankruptcy and administration of FTX. We thus also test how the prices of assets traded on FTX diverge from the market price of the same assets traded on other exchanges during this unique four-day period. We find enormous deviations from the market price for major cryptocurrencies, including stablecoins[6] Tether and DAI, as well as the Binance Coin (BNB), with stablecoin Tether, designed to maintain a price of $1, trading at around $1.20. BNB, the token of the rival exchange Binance, traded on FTX at prices over triple its value giving traders a substantial gain. Finally, consistent with Galati & Capalbo (2023), we conjecture a flight to safety by traders who preferred moving their investments to the safe haven Tether, with some also trying to exit the market by buying US dollars. This evidence is also consistent with total turnover showing wide movements of investments into the market during periods of uncertainty, such as the FTT token crash after its exchange was declared insolvent, and widespread seller-initiated transactions for all cryptocurrencies analyzed on the FTX exchange against the stablecoin Tether, indicating a flight to quality and attempts to exit the exchange.

Ozdamar et al. (2022) highlights differences in investment behaviors between institutional and retail investors in the crypto market, suggesting that their responses to market shocks, such as the FTX crisis, may also diverge, particularly in terms of flight-to-safety behavior. Institutional investors, with their access to sophisticated risk management tools and larger capital bases, may exhibit different strategic moves compared to the more sentiment-driven retail investors. This paper expands on this dichotomy by using *on-chain data*, to examine *who traded* during the stranded assets period and how these traders reacted to the withdrawal prohibition. Such an analysis not only enriches our understanding of market behavior under stress but also offers nuanced insights for tailoring policy interventions and investment strategies.

It is important to understand that all on-blockchain transactions are public in the cryptocurrency markets examined in this study, even if the identity of those sending or receiving cryptocurrencies is not publicly known. This provides market participants with ways to monitor major transactions and asset movements. For example, when Binance moved their FTT tokens, participants were able to track their movement in real-time. This has important implications for both price action and price efficiency. In the present case, the crisis at FTX was sparked by an investigative piece published about a week before the collapse of FTT. The time lag between the disclosure of this information and the collapse of the token and exchange has implications for market efficiency and transparency in financial markets. We examine the flows into, and out of, an FTX-owned, on-chain Ethereum wallet during this period, finding activity that correlates with a withdrawal halt, as well as a possible hack.

The strengths of this study lie in the unique data we have access to and in the exogenous shock we examine. We use a proprietary dataset from Refinitiv, a London Stock Exchange Group (LSEG) business, which allows us to examine every limit and market order on the collapsed exchange at the millisecond high-frequency level. Additionally, the dataset reveals who initiated the trade, permitting an investigation of buyers' and sellers' behaviours in trading against other digital assets or exiting the market. The additional on-chain data we use for the third analysis adds a "cherry on the cake". Last, our study permits an analysis of a situation without a known parallel in the existing literature, namely a period within which exchange clients were allowed to trade but could not access their digital funds stored in the same exchange. This setting is peculiar to cryptocurrency exchanges which act similarly to a commercial bank in their role as a custodian of clients' deposits.

Studying cryptocurrency markets, particularly in the context of shocks such as the FTX withdrawal prohibition, holds significant

[1] A limited number of Bahamian withdrawals were allowed from around the 10^{th} of November.

[2] Tether, or USDT, is a stablecoin designed to maintain a "stable" relationship-parity with the U.S. dollar.

[3] FTX accounted for between 5% to 9% of all cryptocurrency trading volume in 2022, making it a major exchange (arguably the third largest), albeit significantly smaller than Binance, its rival which accounted for around 39% to 62% of cryptocurrency trading volume.

[4] See information sources at https://www.theblock.co/post/184176/ftx-appears-to-have-stopped-processing-withdrawals-on-chain-data-show

[5] Some withdrawals to customers in the Bahamas took place around November 10, 2022.

[6] A stablecoin generally refers to a cryptocurrency designed to maintain a 'stable' $1 peg to the US dollar.

importance due to the burgeoning role these assets play in the global financial ecosystem. Unlike traditional financial markets, the crypto market's accessibility, decentralization, and blend of institutional and retail participation make it a unique field of study with implications for both policy-making and investment strategies. For policymakers, understanding the dynamics of this market can help in crafting regulations that ensure stability, protect investors, and encourage innovation. For investors, insights into the behavior of the market following major shocks can inform risk management and investment decisions. This study aims to shed light on these aspects, contributing to a more resilient financial system and informing stakeholders about the strategic behaviors that dominate in times of crisis.

This paper builds on previous literature on cryptocurrency markets, including papers on the May 2022 collapse of the Terra/Luna stablecoins (e.g. De Blasis et al., 2023; Briola et al., 2023, the bankruptcy of the Silicon Valley Bank (SVB) in March 2023 (e.g. Galati & Capalbo, 2023; Yousaf et al., 2023a; Yousaf & Goodell, 2023b; Aharon et al., 2023, and the November 2022 collapse of FTX and its FTT token (e.g. Yousaf et al., 2023b; Jalan & Matkovskyy, 2023; Yousaf & Goodell, 2023a. However, while previous research examines the impact of the bankruptcy of FTX on traditional financial assets (Yousaf et al., 2023b, tokens (Yousaf & Goodell, 2023a, and systemic risks in cryptocurrency markets (Jalan & Matkovskyy, 2023, it does not examine trader behaviours and the microstructure responses of crypto markets following such collapse. We extend this stream of research and fill the gap in the literature by investigating market liquidity, trading activity, and on-chain transactions in cryptocurrency markets around the FTX collapse and, more specifically, during an extraordinary period when most withdrawals were frozen. Moreover, this study makes an additional contribution to the literature as it enables us to test how markets behave when traders can buy and sell assets on the exchange that issued the token but not withdraw their digital funds.

The rest of the paper proceeds as follows. Section 2 review the related literature. Section 3 details the institutional background, while Section 4 describes the data and empirical methods used. Section 5 provides a discussion of the empirical findings for both the Ethereum wallet trading activity and the exchange market liquidity analyses. Section 6 concludes.

2. Literature review

The effect of financial crises on markets has been widely studied in the literature. Recent studies have examined the Global Financial Crisis (e.g. Baur, 2012; Fry-McKibbin et al., 2014; Kenourgios & Dimitriou, 2015, with some focusing on emerging markets (Celik, 2012; Boubaker et al., 2016, Asian markets (Yiu et al., 2010, European markets (Syllignakis & Kouretas, 2011, or foreign exchange markets (Ding & Vo, 2012 with bond, equity, and commodity markets (Diebold & Yilmaz, 2012. Others have investigated crises such as the Covid-19 pandemic (Akhtaruzzaman et al., 2021; Uddin et al., 2022, or both the Global Financial Crisis and the Covid-19 pandemic (Nguyen et al., 2022. The studies mentioned above find that the market turmoil resulting from financial markets' reaction to economic shocks causes volatility to spill across markets. The collapse of FTX is akin to an asymmetric information-based bank run where FTX's clients do not know how much liquidity FTX has, and FTX does not know how much liquidity will be demanded. Jacklin & Bhattacharya (2024) highlight the differences between bank panics and information-based bank runs. The latter allows for rationality in market participants.

As cryptocurrencies are increasingly coming into the limelight, recent studies delve into their behaviour during financial downturns. De Blasis et al. (2023) explore the trust in varying stablecoin structures by examining the ripple effects and distinct price changes amongst them. Stablecoins with robust reserves, clear transparency, and assured regulatory backing performed better compared to those clouded with regulatory ambiguity and unstable assets. They also identified a ripple effect across major cryptocurrencies during Terra and Luna's downturn around 12 May 2022. Using a parallel approach, another study by Galati & Capalbo (2023) examines the impact of Silicon Valley Bank's bankruptcy on stablecoins and Bitcoin. Contrary to prevailing findings, they find that the cryptocurrency sector was the only one deeply impacted by the downfall of SVB. This strand of research has also focused on the impact of the FTX failure. Specifically, Yousaf et al. (2023b) find the collapse had little impact on non-cryptocurrency assets, while Jalan & Matkovskyy (2023) find no significant increases in systemic risk as a result of the FTX collapse. Yousaf & Goodell (2023a) find reputational contagion across cryptocurrency assets as a result of the collapse. Our study provides more evidence to add to this literature.

The collapse in the value of FTT, the token issued by the bankrupted FTX exchange, also has parallels to the literature on private currencies. Hayek (2024) called for the denationalization of money. He argued that a monopoly, by definition, cannot adequately account for supply and demand, and natural market competition between private currencies would provide the most efficient solution. On a global level, however, national currencies can be seen to participate in global competition for trade. The US dollar was on one side of 88% of foreign exchange transactions in April 2019.[7]

Privately issued currencies are not new. The so-called 'wildcat' banks in the 19^{th} century United States, which issued private currency based on limited reserves, are mythologized as an era of anything goes fraud. Legendary for issuing worthless paper currency with redemption offices (enabling customers to convert that currency into another asset, often gold), in extremely remote locations, these banks are often described as a warning of the dangers of privately issued currencies. However, the real picture is more nuanced. Rolnick & Weber (2024) show that the vast majority of free bank failures occurred not due to wildcatting, but due to falling asset prices, as free banks held fixed liabilities and variable assets, including state bonds, which fluctuated greatly in value. Free banks refer to banks able to issue their own private banknotes with little to no regulation.

The Bank of Amsterdam (1609–1820) is an even older example and has been examined in detail by Frost et al. (2020). The bank

[7] See information source at https://www.federalreserve.gov/econres/notes/feds-notes/the-international-role-of-the-u-s-dollar-20211006.html

initially issued 'bank guilders' only in return for real deposits of silver or gold. The convenience of using these bank guilders in commerce meant they generally traded at a 5% premium to their face value. In 1683, the bank ended the redeemability of deposits into coins, arguably transforming the bank guilder from a proto-stablecoin into a pseudo-fiat currency. However, it was not until 1790 that the *agio* (or premium) on bank guilders versus other assets turned negative.

Furthermore, the efficient market hypothesis suggests that new information should be promptly and fully incorporated into market prices. Arguably, this is particularly true for cryptocurrencies like Bitcoin which have all transactions on a public record for everyone to see. However, there is evidence of herding behaviour and information cascades in the literature, calling into question how information is incorporated into prices. Tse & Hackard (2006) show that news of Mad Cow Disease in Canada led to a lagged set of reactions in the equities of affected companies (as well as the futures prices of affected commodities), with McDonald's stock significantly falling minutes before that of Wednesday, an important but lesser-known rival.

In this paper, we examine a situation unique to the literature, the nearly four-day period in which FTX halted withdrawals but allowed trading. To be sure, there are instances where exchanges are closed on a routine and scheduled basis such as on weekends and holidays. Trading shifts to other exchanges that are open and trade the same securities or to over-the-counter markets. There are also instances where exchanges are closed for an extended period. For instance, the New York Stock Exchange was closed from July 30, 1914, to December 12, 1914, with the start of World War 1. The New York Stock Exchange and the American Stock Exchange closed every Wednesday for about six months during 1968 due to a paperwork backlog - an event examined by French & Roll (2024). They report greater volatility on the Wednesdays the market was open before and after the backlog than the Tuesday close and Thursday open, which they attribute to the exploitation of private information. Again, trading may shift to other exchanges that remain open or over-the-counter markets. However, the FTX case differs from routine cases of exchange closure for weekends or holidays in that the issue was not trading on the FTX — it was open — but rather getting one's money out of the exchange.

A similar but not parallel stream of research looks at the detrimental impact that shocks, such as the financial crisis, have on market liquidity. The bulk of the available evidence thus far aligns with the notion that prohibitions on short-selling introduced during the 2007–2009 financial crisis harm market liquidity (see, e.g.,Beber & Pagano, 2013; Battalio & Shultz, 2011, among others). One notable study contributing directly to this topic is authored by Boehmer et al. (2013). Employing panel data methodologies, they examine the impact of a short-selling ban enforced from September 18 to October 8 in the United States. Their analysis capitalizes on the divergence between financial stocks affected by the ban and those unaffected. Their findings reveal a significant deterioration in liquidity for stocks subject to the ban, as evidenced by wider spreads and increased price impacts.

This conclusion is echoed by the research of Kolasinski et al. (2013). Investigating the effects of an emergency order in June 2008 that limited naked short selling for 19 stocks, they observe a similar adverse impact on liquidity. Marsh & Payne (2012) contribute further insights by studying order and transaction-level data from the United Kingdom. Their analysis demonstrates that following the imposition of the ban on financial stocks, bid-ask spreads widened, and market depth decreased significantly compared to exempt nonfinancial stocks. This occurred despite similar behavior in prices and order flows between the two groups of stocks prior to the ban.

Addressing the absence of a clear framework for assessing the FTX traders' decision-making in the post-shock equilibrium, this paper considers traders' revised expectations in light of the withdrawal prohibition. The prohibition acts as a dual signal: directly impacting traders' liquidity and indirectly signaling the heightened risk of FTX's bankruptcy. Upon the prohibition announcement, traders reassess the likelihood of FTX's bankruptcy and strategically rebalance their portfolios. Rational traders, recognizing these signals, are posited to reassess their portfolio strategies especially concerning assets that are perceived as "bad" in the pre-shock equilibrium. This rebalancing would involve divesting from assets perceived as "bad" in the pre-shock equilibrium but retained for short-term gains due to noise trader dynamics. Traders anticipating a lengthy bankruptcy process longer than the time for these "bad" cryptocurrencies to revert to their fundamental values would likely prefer to liquidate such assets to optimize their expected returns in a post-bankruptcy settlement. The paper hypothesizes that traders, aiming to maximize their expected returns in a post-bankruptcy scenario, will strategically divest from these "bad" assets in favor of more stable investments. This strategic behavior framework not only guides our analysis but also offers a basis for hypothesis development regarding market responses to regulatory or existential shocks in the cryptocurrency domain.

Building on this theoretical reasoning and previous literature mentioned above, we hypothesize that the FTX bankruptcy provoked panic in the cryptocurrency market, with traders buying and selling assets while incurring higher implicit transaction costs caused by the fall in other investors' (not running out of the market) willingness to trade in a period of turmoil. The shock is predicted to create illiquidity and inefficiency in the market translated into higher (lower) bid-ask spreads (market depth) and divergence in crypto prices.

3. Institutional details

FTX was a major cryptocurrency exchange before its collapse in November 2022. FTX was co-founded by Sam Bankman-Fried (SBF) and Gary Wang in 2019 after the success of Alameda Research, a cryptocurrency hedge fund to which it was closely linked and co-founded by SBF in 2017.[8] While it is unusual for an exchange to be 'backed' by a hedge fund, SBF and FTX found stunning and rapid success. From early 2022 until early November 2022, FTX accounted for between 5% and 9% of the total 2022 crypto trading

[8] The FTT Whitepaper (retrievable at https://docs.google.com/document/d/1u5MOkENoWP8PGcjuoKqRkNP5Gl1LLRB9JvAHwffQ7ec/edit) by FTX noted, "FTX is backed by Alameda Research, a $100million AUM quantitative cryptocurrency trading firm".

volume, compared to Binance's share of between 39% to 62%[9] making it an important, if not market-leading, cryptocurrency exchange. FTX was widely seen as one of the safer cryptocurrency exchanges, and SBF was widely regarded as a wunderkind.[10]

In addition to its role as a major exchange, FTX also created FTT, a cryptocurrency token that offered users some trading benefits on FTX, as well as the promise that its supply would steadily decrease through a series of "burns".[11] On January 1, 2021, FTT had a market capitalization of $544.06 million. A mere 9 months later, on September 10, 2021, FTT had an all-time high market capitalization of $9.61 billion. The tangled relationship between an array of entities including FTX and Alameda Research seems to suggest that FTX and affiliated companies were, collectively; an exchange, a broker, a dealer, the issuer of a cryptocurrency, and a hedge fund. This web of relationships ultimately appears to have led to both the rapid rise and eventual demise of both FTX and Alameda Research. Table 1 shows the volume and price history for FTT during the period of interest. A detailed timeline of all events is presented in the appendix.

When analyzing the prices of cryptocurrencies, it is sometimes important to know the difference between a token market capitalization and a 'fully diluted' market capitalization. Around 6 November 2022, the market capitalization of FTT was approximately $3 billion, while the "fully diluted" market capitalization was around $8 billion. The huge difference between these values seems to reflect that approximately $5 billion of FTT was not tradeable on the market. Sometimes, fully diluted market capitalizations reflect cryptocurrency which is not yet mined but will be. For example, On December 6, 2022, at 11:30 PM UTC, Bitcoin had a market capitalization of $328,018,046,774 and a fully diluted market capitalization of $357,604,219,672 which reflects the fact that 19,226,200.00 Bitcoin out of a total supply of 21 million were currently circulating at that time. In the case of FTT, it appears that FTX was benefiting by keeping large portions of the token that it had created off the market, but pricing those reserve tokens as if they were freely tradeable at market prices.

4. Data and methods

We use proprietary tick-by-tick trades and quotes (TAQ) data for some of the most liquid and popular cryptocurrencies - Bitcoin, Ethereum, Dogecoin, and Litecoin - available to trade on the FTX exchange. In addition, the dataset also includes the FTX Token and the Binance Token for comparison across the two major exchange-created tokens. The sample spans an 8-day period extending from November 4, 2022, to November 12, 2022, and covers a symmetrical pre- and post-period of 4 days around the FTX withdrawals being halted on November 8, 2022. We collect data from the FTX exchange and Binance, supplied by Refinitiv. Data are sourced from the Refinitiv Tick History (RTH) database. The final dataset consists of 100,816,148 and 22,199,534 trade prices and best bid and ask quotes and associated volumes observations from Binance and FTX, respectively.[12]

We use the 6:37 AM media announcement on the 8^{th} of November 2022 disclosing the last outgoing transaction from FTX on the Ethereum blockchain[13] as the starting point of the withdrawal halt period. Corresponding cryptocurrency pairs traded on Binance serve as a control sample for the natural experiment, although it is possible for such a catastrophic event to spread contagion across other exchanges. Consistent with empirical research in microstructure (e.g.,Frino et al., 2022, we then carry out a standard *t*-test on the difference in liquidity measures between the pre- and post-period on the null hypothesis of whether the means are equal in the two periods. We follow the mainstream literature in market microstructure (e.g.,Aitken et al., 2017; Benenchia et al., 2024 to compute liquidity for digital asset i at time t (expressed in nanoseconds) as:

$$Spread_{it} = ask_{it} - bid_{it};$$

$$MarketDepth_{it} = askprice_{it} * asksize_{it} + bidprice_{it} * bidsize_{it};$$

$$EffectiveSpread_{it} = 2 * tradesign_{it} * (price_{it} - midpoint_{it})/midpoint_{it};$$

$$PriceImpact_{it} = 2 * tradesign_{it} * (midpoint_{it+20} - midpoint_{it})/midpoint_{it};$$

$$RealizedSpread_{it} = EffectiveSpread_{it} - PriceImpact_{it}.$$

For the sake of completeness and consistent with Galati, 2024, in tests not included in this study, we computed both the relative (in percentage terms) and weighted versions of the above liquidity measures following the literature (e.g.,Brauneis et al., 2021; Hagströmer, 2021, respectively), which produced qualitatively similar results.

Finally, for the purpose of the price slippage analysis, we use an extended time period to look at what happened one month before the time surrounding the exchange collapse. The analysis focuses on price data of the major cryptocurrencies mentioned above to compare market behavior on the bankrupted exchange and the leading cryptocurrency exchange, Binance, serving as a proxy of the

[9] See information source at https://www.reuters.com/technology/exclusive-behind-ftxs-fall-battling-billionaires-failed-bid-save-crypto-2022–11-10/

[10] CNBC Host Jim Cramer called SBF the "J.P Morgan of this generation." One month before the collapse, Shark Tank host Kevin O'Leary said "if there's ever a place I could be that I'm not going to get in trouble, it's gonna be at FTX." SBF also appeared in the social media posts of football star Tom Brady, testified before the US Congress, and appeared on the covers of multiple major magazines, including Forbes and Fortune.

[11] A "burn" refers to the destruction of cryptocurrency tokens, with an intended effect similar to a stock buyback.

[12] We further exclude potential transaction record errors by eliminating observations where the best ask price was smaller than the best bid price and transactions within the nanoseconds from 23:59:59 to 00:00:00 (included) because of updates on the Refinitiv data collection side.

[13] See news at https://www.theblock.co/post/184176/ftx-appears-to-have-stopped-processing-withdrawals-on-chain-data-show

Table 1
FTT price and volume history. Price is expressed in US Dollars, while volumes are in million dollars. Time is shown according to the standard UTC time zone.

FTT Price ($US)	Volume $ (Millions)	Time (UTC)
24.35	103.07	12 AM, Nov 4, 2022
24.97	96.26	12 AM, Nov 5, 2022
25.49	92.48	12 AM, Nov 6, 2022
23.06	277.98	12 AM, Nov 7, 2022
22.57	774.5	12 AM, Nov 8, 2022
17.36	1420	12 AM, Nov 9, 2022
4.54	3310	12 AM, Nov 10, 2022
2.75	986.69	12 AM, Nov 11, 2022

market. With regards to the last analysis, we use publicly available on-chain data from the Ethereum blockchain and downloaded from Etherscan.io at https://etherscan.io/address/0×2faf487a4414fe77e2327f0bf4ae2a264a776ad2. The dataset consists of 14,826 anonymized transactions of an FTX-owned wallet from November 8 to 12, 2022, allowing an examination of in-flows and out-flows transactions during the withdrawals halt period. This second dataset contains rich information on all the trades that occurred on the largest wallet of the exchange that did not necessarily appear on the centralized exchange and consists of investors' wallet addresses, token value and turnover, the address of the smart contract and timestamp to the nearest second.

5. Empirical findings

5.1. Liquidity of cryptocurrency markets around frozen funds withdrawals

Table 2 reports the t-tests on the difference in liquidity between the pre- and post-halt of funds withdrawals for the six cryptocurrency pairs analyzed on FTX in Panel A and on Binance in Panel B. Binance is the control sample for the natural experiment. There is no statistical significance in the t-test results in panel B, meaning that the statistically significant changes seen on FTX can be separated and are the direct effect of the shock we are analyzing. The exceptions are Bitcoin and Ethereum, which are the two most traded cryptocurrencies, and also the market depth for all the digital assets analyzed.

Panel A shows that market depth decreased for every cryptocurrency pair except FTT where market depth increases five-fold. It shows that all of the various measures of liquidity increased (i.e., deteriorated) sharply during the stranded assets period on FTX. Panel B shows that market depth increased for both FTT and ETH and the effective spread decreased for FTT traded on the Binance exchange. Table 2 clearly illustrates that overall the magnitude of the liquidity deterioration on FTX was massive compared to the market. Dogecoin seems an exception for its non-significance given the small magnitude of liquidity effects.

The widening of the spread measures in the aftermath of FTX's withdrawal halt draws upon foundational principles of market microstructure theory. This posits that in times of increased uncertainty and risk, such as during the FTX withdrawal halt, liquidity providers (i.e., market makers) face heightened operational risks. Consequently, these actors adjust their pricing models to account for the elevated risk, manifesting in wider bid-ask spreads as they seek to hedge against potential losses. As highlighted by Mishra et al. (2020), in times of economic downturns and market crises, markets may experience one-sided dynamics as a result of either an abundance of asset supply or a surge in demand for funding. Throughout these tumultuous periods, the liquidity of stocks tends to decline, intensifying the risks associated with assets and collateral, and further worsening overall market liquidity. This heightened risk concerning assets and collateral exacerbates funding liquidity challenges for investors and market makers (Brunnermeier & Pedersen, 2009; Brunnermeier, 2009.

The results of Table 2 are depicted in Figures 1a to 2b. The two events shown in the middle of the two sub-periods within the charts are the first announcements of the FTX insolvency[14] and the re-opening of withdrawals in the Bahamas,[15] respectively. Figure 1a shows market depth and the bid-ask spread (depicted in blue and yellow, respectively) for the six studied cryptocurrency pairs traded on the FTX before and during the withdrawals halt period, while figure 1b shows liquidity on Binance. Note the large-scale difference in scale between the two sets of figures given the size of market liquidity on the FTX during the stranded assets period. For instance, the effective spread for BNBUSDT on FTX is vastly higher than on Binance, with the data differing so much, that the FTX chart requires a scale 25 times larger.

BTC and ETH experienced a drastic decrease in market depth and therefore liquidity, suggesting holders of these high-quality assets did not want to trade them, showing evidence of a desire for safety among investors. On the other hand, the other digital asset[redacted]al. saw a significant increase in limit orders, showing fear within the market possibly due to investors' eagerness to engage in a flight to quality. Figures 1a and 1b show a massive increase in the bid-ask spread for all cryptocurrencies analyzed across both Binance and FTX, even though only FTX had halted withdrawals. This provides evidence of spillover effects across exchanges, even when one of the exchanges has frozen withdrawals. Such correlated spikes took place before and after FTX's announcement that Bahamian withdrawals were once again permitted, although the exact moment that such withdrawals actually occurred is unknown.

[14] See news at https://twitter.com/du09btc/status/1589135270103773184?lang=en
[15] See news at https://twitter.com/FTX_Official/status/1590783569471115264

Table 2
Liquidity around the FTX withdrawal halt. The table shows the results of t-tests on the difference in various liquidity measures around the period when funds were frozen on the FTX. We compute liquidity for digital asset i at time t (expressed in nanoseconds) as: $Spread_{it} = ask_{it} - bid_{it}$, $MarketDepth_{it} = askprice_{it}{*}asksize_{it} + bidprice_{it}{*}bidsize_{it}$, $EffectiveSpread_{it} = 2 * tradesign_{it} * (price_{it} - midpoint_{it})/midpoint_{it}$, $PriceImpact_{it} = 2 * tradesign_{it} * (midpoint_{it+20} - midpoint_{it})/midpoint_{it}$, $RealizedSpread_{it} = EffectiveSpread_{it} - PriceImpact_{it}$. * **, * *, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

		Liquidity Measures										
		Absolute Spread		Market Depth			Effective Spread		Price Impact		Realized Spread		
		mean	t-test	mean	t-test	n	mean	t-test	mean	t-test	mean	t-test	n
Panel A: FTX													
BNB	pre	0.1378		16.3931		772,024	0.1462		–0.1557		0.3019		45,057
	post	2.8571		11.4189		1,076,106	3.6663		–1.094		4.7503		102,547
	difference	–2.7193	–36.46 * **	4.9741	15.03 * **	1,848,130	–3.5201	–14.90 * **	0.9382	5.30 * **	–4.4484	–15.10 * **	147,604
BTC	pre	1.3275		2.3656		1,603,918	2.1608		–3.6797		5.8405		138,073
	post	31.8699		0.9198		1,709,694	29.6403		–4.7099		34.3502		269,145
	difference	–30.5424	–588.92 * **	1.4458	17.43 * **	3,313,612	–27.4795	–47.84 * **	1.0302	2.74 * **	–28.5097	–41.58 * **	407,218
DOGE	pre	0.0001		20626.1625		1,009,686	0.0001		–0.0001		0.0002		49,595
	post	0.0003		16367.4299		1,211,160	0.0003		–0.0001		0.0004		46,499
	difference	–0.0002	–0.1575	4258.7326	389.92 * **	2,220,846	–0.0002	–0.0359	0.0000	–0.004	–0.0001	–0.0239	96,094
ETH	pre	0.1633		13.1526		1,548,487	0.3214		–0.4814		0.8028		183,173
	post	2.9951		5.8436		1,649,326	3.6153		–0.7089		4.3242		366,230
	difference	–2.8318	–38.62 * **	7.309	35.98 * **	3,197,813	–3.2938	–19.42 * **	0.2276	2.01 * *	–3.5214	–17.31 * **	549,403
FTT	pre	0.0193		113.6533		857,281	0.0164		–0.0124		0.0287		107,204
	post	0.035		700.704		2,211,045	0.0288		–0.009		0.0378		309,619
	difference	–0.0156	–1.42 *	–587.0506	–461.89 * **	3,068,326	–0.0124	–0.4916	–0.0034	–0.1634	–0.0091	–0.2779	416,823
LTC	pre	0.051		43.2824		878,942	0.0329		–0.0686		0.1015		17,484
	post	0.4201		25.8754		383,544	0.248		–0.0865		0.3345		14,005
	difference	–0.3692	–6.6 * **	17.407	26.38 * **	1,262,486	–0.2152	–1.44 *	0.0179	0.1377	–0.233	–1.1824	31,489
Panel B: Binance													
BNB	pre	0.1011		214.227		2,239,776	0.1074		0.0065		0.1009		954,333
	post	0.1092		90.1653		3,797,477	0.1235		0.0162		0.1073		1,162,637
	difference	–0.0081	–0.515	124.0618	194.70 * **	6,037,253	–0.0161	–0.6158	–0.0097	–1.2141	–0.0064	–0.255	2,116,970
BTC	pre	0.6546		0.1453		1,7765,671	1.2995		0.1154		1.1841		22,014,259
	post	1.7539		0.2357		26,783,442	2.4913		–0.2356		2.7269		23,388,597
	difference	–1.0992	–58.94 * **	–0.0904	–11.82 * **	44,549,113	–1.1918	–53.03 * **	0.351	47.50 * **	–1.5428	–67.42 * **	45,402,856
DOGE	pre	0.0001		50541.6961		3,727,040	0.0000		0.0000		0.0000		1,549,206
	post	0.0000		43965.769		5,162,672	0.0000		0.0000		0.0001		1,344,803
	difference	0.0001	0.6373	6575.9271	759.00 * **	8,889,712	0.0000	–0.0134	0.0000	0.0094	0.0000	–0.0162	2,894,009
ETH	pre	0.0149		93.339		3,417,265	0.1483		–0.054		0.2024		1,991,188
	post	0.0785		22.3091		8,184,406	0.2863		–0.0785		0.3648		3,818,546
	difference	–0.0636	–9.12 * **	71.0299	220.70 * **	11,601,671	–0.138	–6.44 * **	0.0245	2.12 * *	–0.1625	–6.68 * **	5,809,734
FTT	pre	0.0108		526.9074		1,386,100	0.0109		–0.0041		0.015		529,806
	post	0.0068		643.0944		7,065,271	0.0082		–0.0016		0.0098		2,717,315
	difference	0.0041	0.7475	–116.187	–94.09 * **	8,451,371	0.0028	0.3199	–0.0025	–0.4241	0.0053	0.5035	3,247,121
LTC	pre	0.0114		101.4891		1,699,788	0.0227		–0.0137		0.0364		537,479
	post	0.0197		59.1027		2,817,579	0.03		–0.0123		0.0423		560,249
	difference	–0.0083	–1.2192	42.3864	79.97 * **	4,517,367	–0.0073	–0.4253	–0.0014	–0.1153	–0.0059	–0.2796	1,097,728

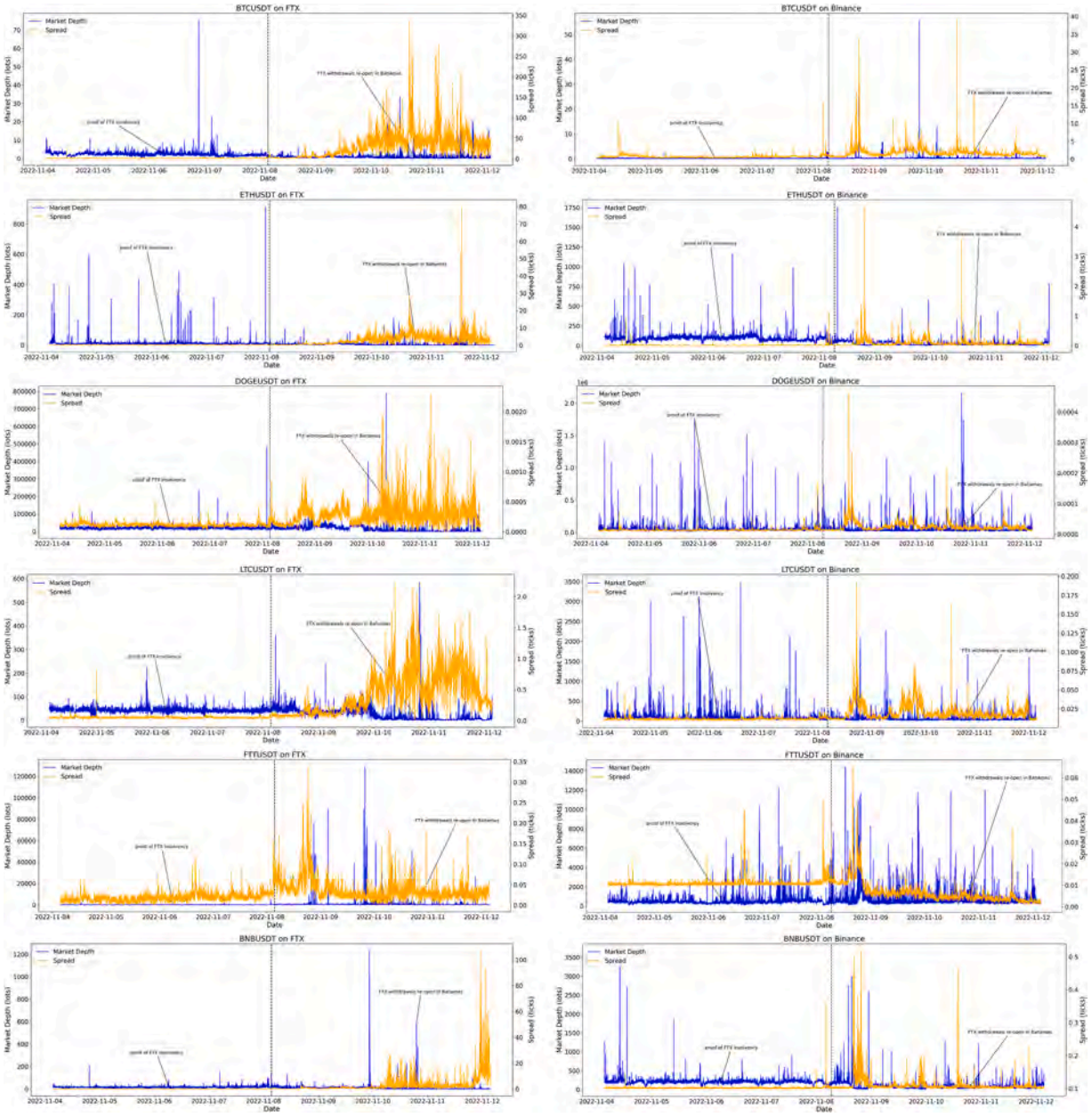

Fig. 1. Bid-ask spread and market depth around frozen digital funds withdrawals.

Figure 2a and 2b illustrate the effective spread, price impact, and realized spread for the digital assets analyzed, respectively, on FTX and Binance. Both adverse selection (price impact) and transaction (effective spread) costs increased on a larger scale on FTX compared to the market. As a direct consequence of the above widened bid-ask spread demanding higher compensation for liquidity provision, the liquidity makers' revenues (realized spread) also increased sharply. Those spread measures were almost stable and economically insignificant on Binance.

Perhaps most interestingly, FTT saw improved liquidity on Binance through tighter bid-ask spreads even as its issuing exchange was collapsing. This goes against the results of all the other digital assets analyzed and may indicate speculative activity by traders betting on whether FTX would recover.

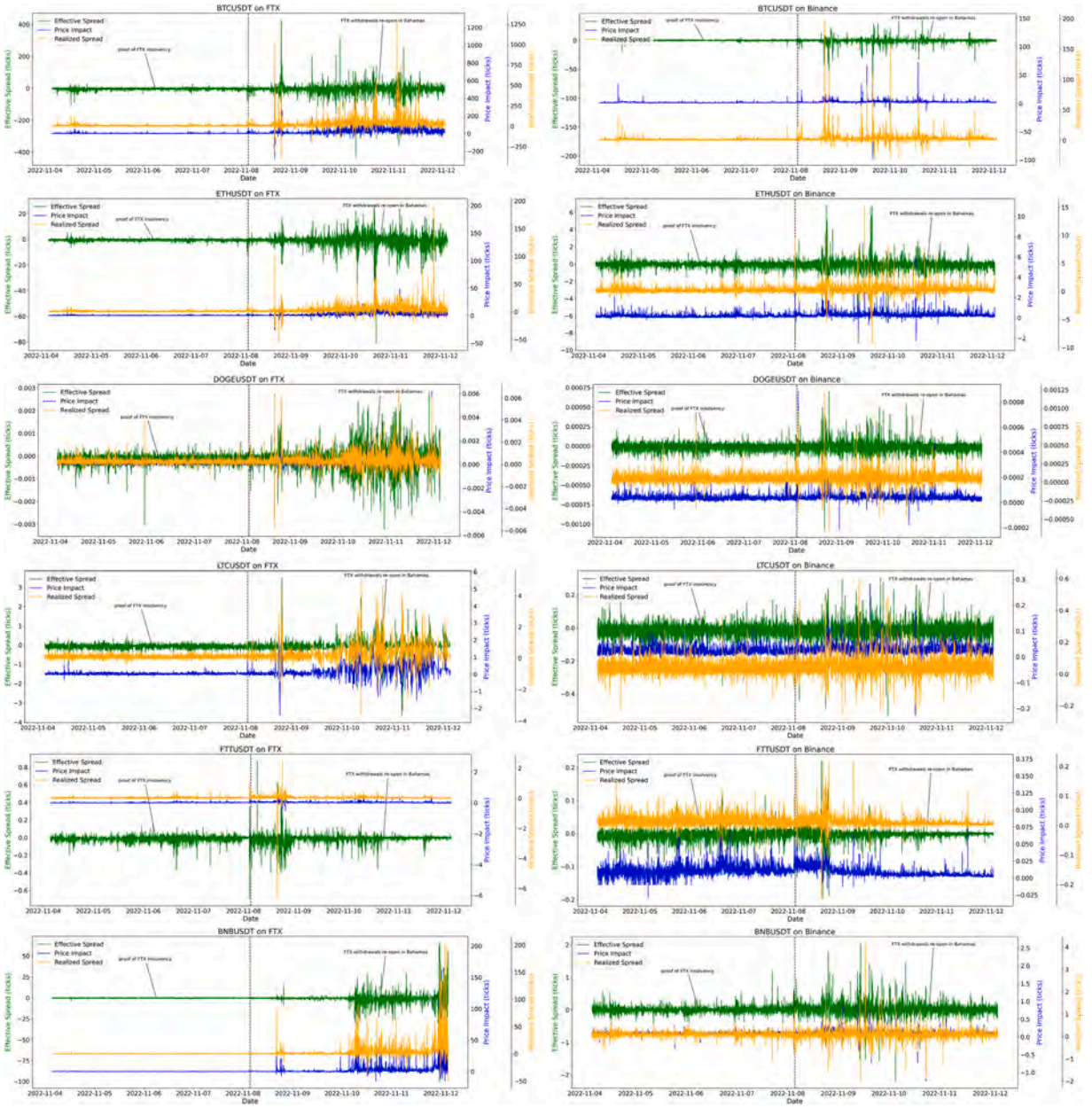

Fig. 2. Transaction and adverse selection costs around frozen digital funds withdrawals.

5.2. *Trading stranded assets on FTX*

The analysis shows trading volume before and during the stranded assets period for the digital assets against Tether (USDT).[16] FTX trading activity for all studied assets except for FTT peaked on November 8th and declined sharply afterwards. FTT, however, saw trading increase substantially throughout the withdrawal halt period. We also find significant price deviations of digital assets traded on FTX from the market price when withdrawals were halted. Moreover, the decline in trading activity for the other six digital assets is relatively smooth. Interestingly, trading in FTT on the FTX peaked at 5:55 p.m. UTC on November 11, 2022.

Figure 3a and 3b illustrate the total turnover in millions of dollars in both pairs against USDT and the USD, respectively. Major increases are apparent in the turnover of stablecoins like DAI and Tether, with a relatively muted increase in the turnover of Bitcoin, one about half as large as a previous spike in October. The spike in the turnover of stablecoins suggests a flight to relative safety within

[16] We exclude the Maker Dao coin (DAI) as per the missing quotes data from the database.

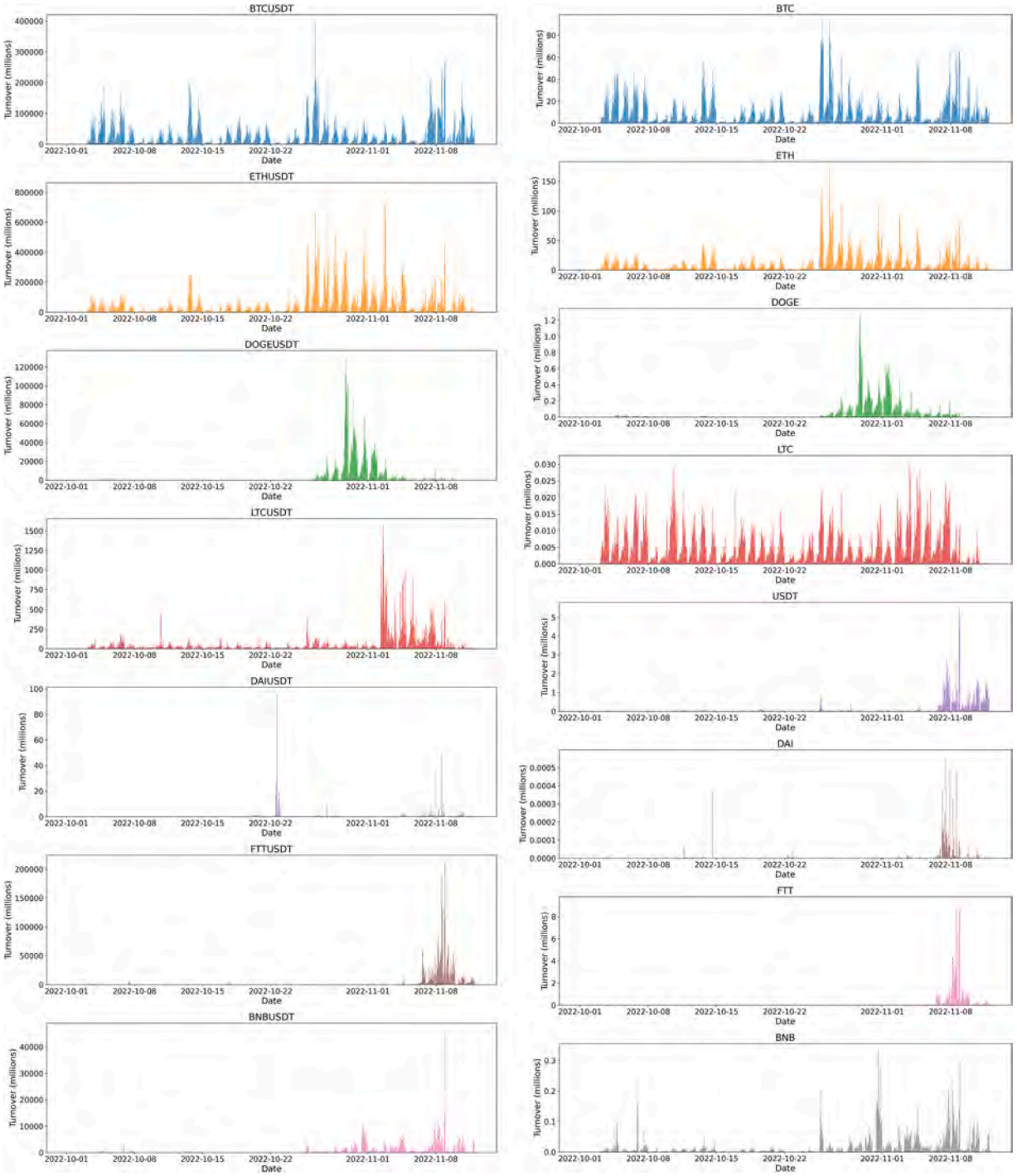

Fig. 3. Turnover of major cryptocurrencies on FTX.

FTX, which is symmetric for FTT and BNB as well. It may have been part of a strategy to have a defined asset pool with an easily equivalent US dollar amount. The large increase in the turnover of DOGE around 1 November 2022 correlates with a period where the cryptocurrency saw its price triple across exchanges, making it unlikely that this is related to the collapse of FTX. This, again, is left for further investigation. Interestingly, turnover for the BNB coin against the US Dollar spiked well before the first announcement of FTX being insolvent, suggesting possible informed transactions anticipating the market crash and speculating against uninformed traders. A similar comment might be made for some major cryptocurrencies given the high turnover for all cryptocurrency pairs against USDT observed during the week preceding the collapse of FTX. We nevertheless leave this avenue for future research.

Our data set also includes information on whether a transaction was initiated by a buyer or a seller. We examine the buy and sell pressure of cryptocurrencies against Tether on FTX during the withdrawal halt. Figure 4a, for pairs against Tether, and 4b, for pairs against the dollar, show major increases in selling pressure across cryptocurrencies during the collapse and trading halt at FTX. Selling pressure in DAI is particularly pronounced when compared to Tether, showing traders' strong preference for Tether, a larger and more popular stablecoin, over the less popular DAI. Perhaps unsurprisingly, this stablecoin deviated significantly from its market price, at one point trading at a steep discount, approximately 30%, on its 1 peg. That is, traders preferred to sell their cryptocurrencies for Tether. This may be because Tether avoids the US banking system or is seen as easier to transfer to other exchanges.

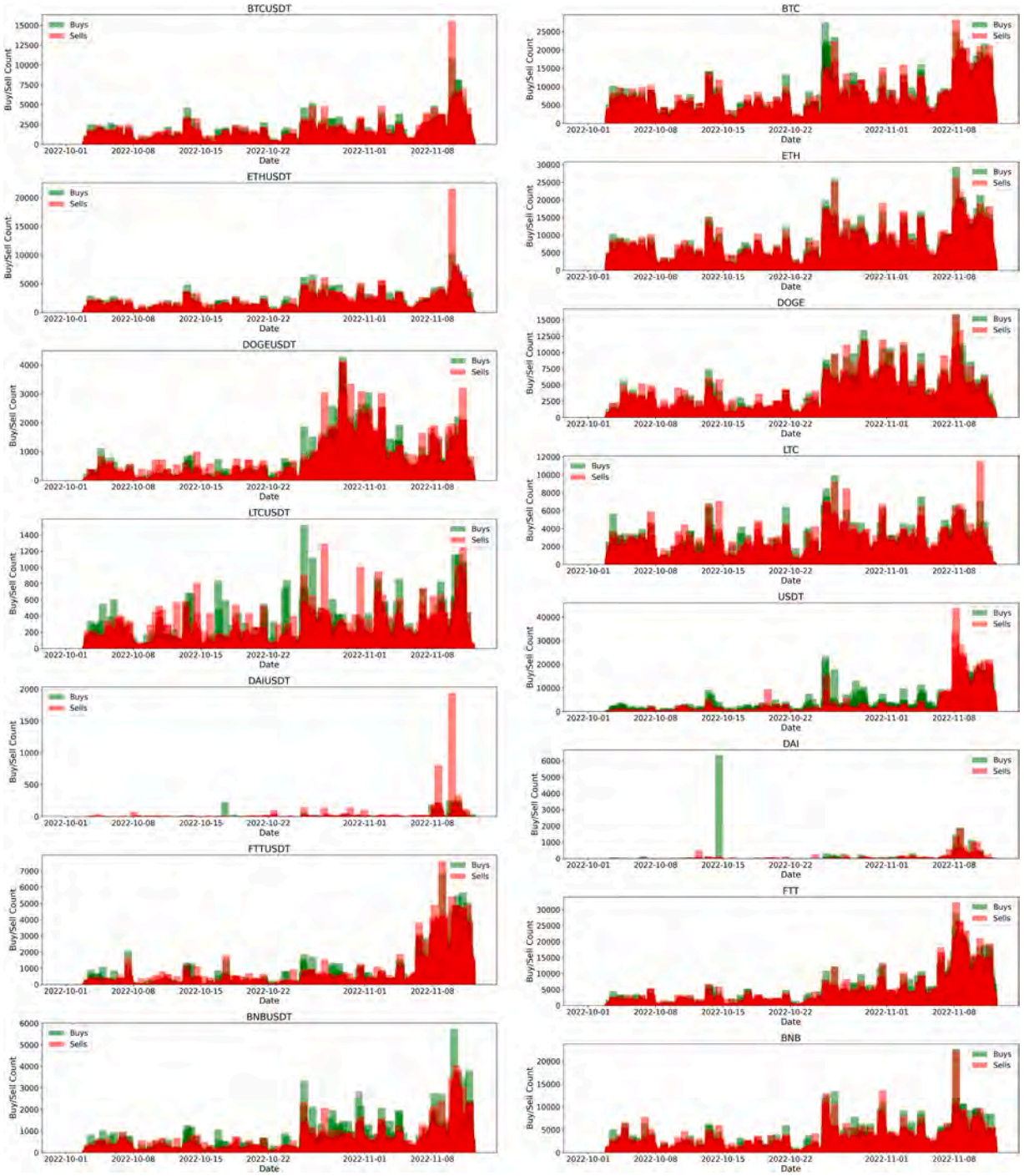

Fig. 4. Buy/sell initiated transactions of major cryptocurrencies on FTX.

Although Tether is a cryptocurrency pegged to the US dollar and is theoretically backed 1:1 by reserves, transactions in it occur outside the U.S. banking system. This characteristic allows traders to bypass traditional banking channels, which might introduce delays or restrictions, especially during times of market stress or regulatory uncertainty. Additionally, some observers argue that Tether's blockchain-based nature enables faster and more seamless transfers compared to traditional fiat currencies. Therefore, traders may perceive Tether as a more reliable and efficient medium of exchange, particularly in situations where access to traditional banking services is limited or uncertain.

Although asset withdrawals were halted on FTX, some traders may have hoped they would resume, allowing the quick transfer of

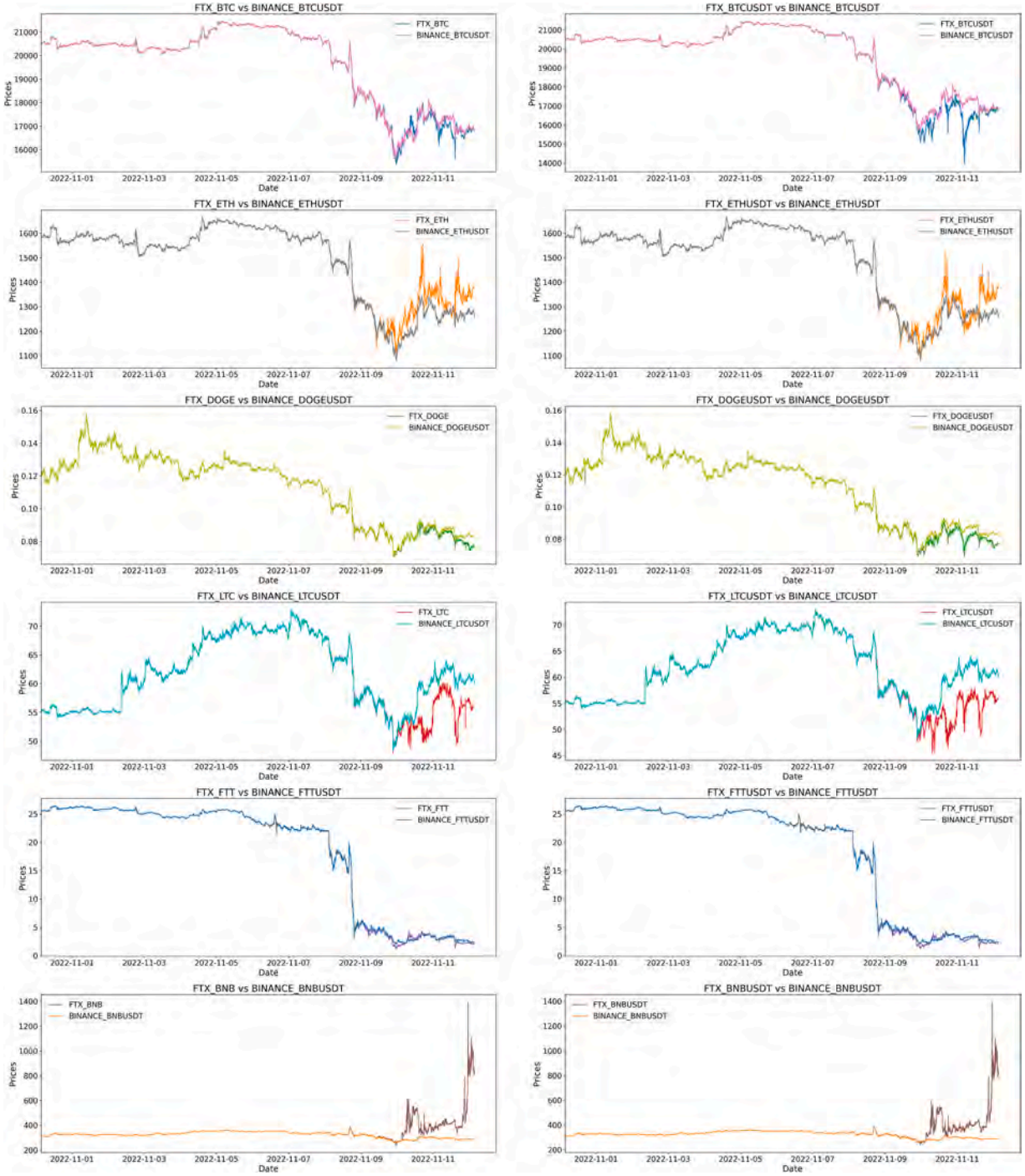

Fig. 5. Price slippage of major cryptocurrencies between FTX and Binance.

Tether. Some traders were therefore rushing to buy "safer" digital assets as demonstrated by the persistent selling pressure in all major cryptocurrencies, tokens, and stablecoins against the USDT, implying that Tether is seen as a comparatively safe haven in some turbulent periods and is used in flight to quality strategies to re-balance the composition of portfolios. Tether's liquidity and ease of exchangeability for the dollar certainly contribute to this perceived safety, especially during volatile market conditions. Selling pressure on FTX for all cryptocurrency pairs against the US dollar provides further evidence of investors preferring to exit the cryptocurrency market.

Finally, we examine the price action of assets on Binance and FTX priced in USDT to look for any price divergence, also referred to as price slippage. Figure 5a, for pairs against USDT, and 5b, for pairs against the US Dollar, present the price comparison between all the digital assets analyzed in this study traded on the FTX exchange, and the same traded on Binance. We chose Binance as a market indicator, as it is the largest and most liquid cryptocurrency exchange, accounting for the vast majority of transactions in these markets. From 06:37 a.m. UTC on November 8, 2022, to 3:28 a.m. UTC on November 12, 2022, FTX allowed trading but would generally not allow cryptocurrency withdrawals. At the beginning of this period, we find assets on FTX traded at approximately the market price before beginning to diverge after approximately 24 h. By 11^{th} most of the assets in our study had begun to seriously diverge from the market price. This evidence is consistent for both pairs against USDT and USD.

Perhaps surprisingly, compared to other assets, Bitcoin did not diverge from the market price. Despite its status as the first and most popular cryptocurrency, traders did not pay a premium for Bitcoin on FTX during the halt on asset withdrawals. By contrast, Ethereum, sometimes seen as Bitcoin's main rival, traded at a premium. The most surprising result is the extreme outperformance of BNB, which traded on FTX at a premium of over 400% to its market price. Although Binance briefly agreed to buy FTX, the action happened after the deal had fallen through, making the popularity of BNB on FTX during the withdrawal halt an interesting question for future researchers. At the same time, coins with less popularity (e.g., Litecoin) or associated with memes and jokes (e.g., Dogecoin) traded at a discount to the market price. Despite the halt on asset withdrawals, questions of solvency, and the likelihood of years of legal battles over repayment for creditors, the price of FTT on FTX seemed to deviate from the market price by only around 10%.

5.3. *Who traded during the stranded assets period?*

The question naturally arises as to who would trade during a stranded asset period. Traders may have looked to previous exchange collapses. For instance, Bitcoin holders at Mt. Gox, a failed Japanese cryptocurrency exchange, lost most of their cryptocurrency yet saw the price of Bitcoin rise so much during the drawn-out bankruptcy process that, in dollar terms, they likely came out ahead. This may have spurred traders to move to higher-quality cryptocurrencies, an effect we show some evidence of in the previous section. Barber & Odean (2024) argue that active trading is wealth-reducing in part because of transaction costs. This would suggest that rational investors would not trade or trade less during stranded asset periods as transaction costs are higher. Given the volatility of the asset prices observed during the stranded asset period, there may be a clue in the existing literature on who trades on days when stock prices have large price moves up or down and whether they exacerbate the price move by doing so. Namely, Dennis & Strickland show that institutional investors exacerbate the price moves in US equities on days with large price moves. In contrast, Tian et al. (2018) show the opposite is true for Chinese equities on days with large price moves. The literature remains thus inconclusive.

While we do not have individual trader IDs or even trader category IDs (i.e., retail or institutional investor identification), for individual trades, we are able to infer who may be trading from the size of trades. Although large traders may engage in stealth trading by breaking up large trades into a series of smaller trades, small traders are unable to piece together a potential series of small trades into a large trade. Consequently, large trades are more likely to reflect trades by institutions than individuals. Table 3 provides suggestive clues about who might have traded during this period by showing large amounts of average trade sizes and traded volumes per day during the withdrawal halt.

Table 3
Trading Activity during the FTX Withdrawal Halt on an Ethereum Wallet associated with FTX.

Date	No. of Transactions	Volumes in USD Value	Avg. Trade Size
Panel A: Overall on-chain transactions			
November 08, 2022	11,670	671,411,852.27	57,533.15
November 09, 2022	776	2753,539.48	3548.38
November 10, 2022	662	26,295,483.12	39,721.27
November 11, 2022	405	32,502,381.53	80,252.79
November 12, 2022	1313	529,645,450.04	403,385.72
Panel B: Outflow on-chain transactions			
November 08, 2022	9031	365,310,207.90	40,450.69
November 09, 2022	0	0.00	0.00
November 10, 2022	277	11,878,423.71	42,882.40
November 11, 2022	167	31,361,295.49	187,792.19
November 12, 2022	1284	529,645,421.18	412,496.43
Panel C: Inflow on-chain transactions			
November 08, 2022	2639	306,101,644.37	115,991.53
November 09, 2022	776	2753,539.48	3548.38
November 10, 2022	385	14,417,059.41	37,446.91
November 11, 2022	238	1141,086.04	4794.48
November 12, 2022	29	28.86	1.00

The amount transferred to Bahamian (or other) accounts during the withdrawal halt period is unknown but is likely small compared to the amount transferred in and out during normal trading. We examine the transaction records of an Ethereum wallet associated with FTX, finding 11,670 transactions on the 8^{th} of November 2022, which had an estimated USD value of $671,411,852.27. $365,310,207.9 of that figure were outgoing transactions, with $306,101,644.37 incoming. Given the turmoil around the exchange it is unlikely inflows were new customer money, and likely represent movement from other FTX entities.

Consistent with the withdrawal halt, the same address processed 776 transactions, all of which were inflows, on November 9, 2022, with an estimated USD value on the day of the transaction of $2753,539.48. There were 662 transactions during the entire day on November 10, 2022, with a USD value of $26,295,483.12–$11,878,423.71 of which were outflows, possibly to Bahamian customers. November 11, 2022, saw a total of 405 transactions with a value of $32,502,381.53, nearly all of which ($31,361,295.49) were outflows. November 12, 2022, saw a total of 1313 transactions with a whopping $529,645,450.04 of estimated value. Before the halt of trading, $218,224,057.10 was transferred out of the FTX wallet. This almost certainly *did not* represent large withdrawals to customers, as nearly all ($218,212,384.10) of this sum was transferred to a single wallet (which features a warning on Etherscan.io). Ultimately, the on-chain data show limited withdrawals to customers.

These transactions include both in and out transactions to the wallet. All of these transactions are time-stamped *after* trading on FTX has been halted. However, transactions with an estimated value of $218,224,057.1 took place just before the halt of trading, from 2:23 AM to 2:43 AM, representing a 20-minute period where an estimated $200 million dollars was moved through this account. This is shown in Table 3, which lists the average trade sizes, number of transactions, and total dollar value traded for each token for each day of the stranded assets period.[17] The amounts and details around these transactions clearly deserve further study, although they are beyond the scope of this paper.

6. Conclusions

This study examines market liquidity, trading activity, and price action in cryptocurrency markets around the FTX collapse. Evidence shows that traders are sensitive to the asset allocation of their cryptocurrency portfolios even when there is little practical chance of retrieving those assets anytime soon and it is costly to transact. We find that liquidity significantly deteriorated on FTX, and largely more than what happened on Binance, as the bid-ask spread, transaction and adverse selection costs increased sharply. Nonetheless, there is substantial trading during the stranded asset period, especially for the FTT token. However, much of the trading volume during the stranded assets period for cryptocurrency pairs other than FTT comes soon after the prohibition of withdrawals is imposed. Trading volume declines sharply for these assets long before the stranded assets period comes to an end.[18]

This study also looks at how cryptocurrency markets react to the halt of withdrawals on a major cryptocurrency exchange. It uses FTX, Binance, and on-chain data from an FTX-controlled Ethereum wallet to analyze market, trader, and exchange behaviour during this period. On the FTX exchange, we find evidence of substantial trading even though most traders could not realistically hope to withdraw their assets from the exchange. Some of this activity may have been traders moving into assets they expected to appreciate if FTX filed for bankruptcy protection and while FTX was in administration, but further analysis is needed to analyze trader incentives and motives. We find evidence of spillover effects from FTX to Binance, despite Binance's much larger size and the fact that traders could not withdraw assets from FTX and transfer to Binance. Analysis of on-chain data aligns with a withdrawal halt for nearly all traders and shows activity approximately aligned with the effective spread and other liquidity measures analyzed; that is, there was not only lower activity on FTX's exchange but also lower activity on the wallet back-end of at least one of FTX's wallets.

Analyzing on-chain data was crucial, especially regarding FTX, amidst suspicions that the exchange might have disseminated inaccurate information or engaged in fraudulent activities. However, the situation becomes more complex upon observing significant withdrawals on November 12, coinciding with the trading halt—an occurrence some attribute to a hack. Ultimately, this study shows how traders, a failing exchange, and a rival exchange acted during what is arguably the cryptocurrency market's largest crisis to date. Future studies may further examine the withdrawal halt period, as well as how other cryptocurrencies reacted during the crisis period. Future research may also examine the source of inflows and outflows to the FTX wallet, as well as the Bahamian withdrawals in further detail as relevant data becomes available.

The importance of studying the topic of cryptocurrency market behavior, especially in the context of a major exchange like FTX allowing trading but halting withdrawals during a collapse, is multifaceted. Firstly, it offers insights into the resilience and liquidity of cryptocurrency markets under stress, providing valuable data for policymakers to safeguard decentralized market stability and investor interests in digital assets. Secondly, for investors, understanding the market dynamics during such events can inform risk management and investment strategies, highlighting the importance of regulatory frameworks and exchange policies to protect assets in extreme market conditions. This study, therefore, has significant implications for enhancing market stability, investors' confidence, and informing the development of robust regulatory policies to safeguard against future market disruptions.

One of the oddities of the stranded assets period is the Bahamian exception to asset withdrawals. Our examination of one of FTX's Ethereum wallets shows activity approximately aligned with the effective spread and other liquidity measures analyzed; that is, there was not only lower activity on FTX's exchange but also lower activity on the wallet back-end of at least one of FTX's wallets. Additional analysis is needed to determine where the money went in FTX's final hours, especially as the amount passing through the analyzed

[17] The tokens transacted on the FTX's Ethereum wallet are not limited to the major crypto assets analyzed in the next section.

[18] FTX filed for bankruptcy protection sometime during the morning of November 11, 2024. Reuters filed a report at 08:15 ET –although the filing was likely earlier. This means that there was about a day when FTX clients could trade knowing that bankruptcy was certain.

wallet is extensive (around $500 million on November 12, 2022) alone. That most of these transactions (worth around $300 million) took place after FTX had filed for bankruptcy protection and halted trading only adds to the many questions that remain about the collapse of the exchange.

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CRediT authorship contribution statement

Luca Galati: Conceptualization; Methodology; Software; Formal analysis; Investigation; Data curation; Writing - Original draft; Writing - Review & Editing; Visualization; Validation; Project administration; Funding acquisition. **Alexander Webb:** Conceptualization; Data curation; Writing - Original Draft; Writing - Review & Editing. **Robert I. Webb:** Writing - Original Draft; Writing - Review & Editing; Supervision.

Data Availability

The data that support the findings of this study are available from Refinitiv but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Refinitiv and Rozetta.

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Appendix A. Timeline of events

In November 2017, Alameda Research, a cryptocurrency trading firm sometimes described as a hedge fund, was founded by Sam Bankman-Fried, who, in May 2019, co-founded FTX with Gary Wang.

In August 2022, FTX was issued with a cease-and-desist order by the Federal Deposit Insurance Corporation (FDIC) after several tweets seemed to imply customer funds were backed by FDIC insurance. On September 14, 2022, Bloomberg published an article noting the close ties between Alameda Research and FTX, noting that traditional regulatory oversight would not allow such an arrangement in the equities market. On November 2 at 2:44 pm UTC, Coindesk published an article describing the close relationship between Alameda Research and FTX, noting the large portion of Alameda's balance sheet which was made up of FTT. According to the article, as of June 30, 2022 Alameda Research had over $6 billion in FTT-related assets. $3.66 billion of this was "unlocked FTT", with a further $2.16 billion in "FTT collateral" as well as $292 million in 'locked FTT'. The same article noted that the total value of all FTT tokens in circulation was $5.1 billion.

At 12:51 PM on 5 November 2022, Binance founder Changpeng Zhao (CZ) tweeted: "Crypto is high risk". This tweet came less than two hours before over half a billion dollars in FTT was moved by Binance. On Saturday, 05 Nov 2022 at 14:08:59 UTC, a transfer of 22,999,999 FTT ($585,070,132 USD) was made, which is reported on Twitter by 'Whale Alert', (a group that reports large trades in the cryptocurrency markets) almost immediately after the transaction took place. whale_alert wrote "22,999,999 FTT (584,818,174 USD) transferred from unknown wallet to Binance". CZ confirmed this transaction publicly on Twitter at 6:49 PM on November 6, 2022.

At 5:59 AM on November 6th, sources on Twitter speculated that FTX was insolvent. User DU09BTC writes: "FTX is insolvent and we got proof. FTX Exchange and Alameda Research hold 8bil in FTT value which is illiquid against a real mcap of 3bil. That is 5 bil of magic money they report on their balance sheet. Sam feeling the heat. Any sell pressure will crash that mcap fast!". At 2:32 PM on November 6th, Caroline Ellison (head of Alameda Research) tweets "A few notes on the balance sheet info that has been circulating recently: - that specific balance sheet is for a subset of our corporate entities, we have more than $10b of assets that aren't reflected there". This was retweeted by SBF. At 3:47 PM on November 6th, 2022, CZ begins to tweet a thread with four tweets: .

1. "As part of Binance's exit from FTX equity last year, Binance received roughly $2.1 billion USD equivalent in cash (BUSD and FTT). Due to recent revelations that have come to light, we have decided to liquidate any remaining FTT on our books".
2. "We will try to do so in a way that minimizes market impact. Due to market conditions and limited liquidity, we expect this will take a few months to complete".
3. "Binance always encourages collaboration between industry players. Regarding any speculation as to whether this is a move against a competitor, it is not. Our industry is in its nascence and every time a project publicly fails it hurts every user and every platform".
4. "We typically hold tokens for the long term. And we have held on to this token for this long. We stay transparent with our actions".

At 6:49 PM on November 6, 2022, CZ tweeted: “Yes, this is part of it”, confirming the 22,999,999 FTT transaction publicly on Twitter. At 9:49 PM, CZ tweeted: “Liquidating our FTT is just post-exit risk management, learning from LUNA. We gave support before, but we won’t pretend to make love after divorce. We are not against anyone. But we won’t support people who lobby against other industry players behind their backs. Onwards”. On 7 November 2022, SBF tweeted: “A competitor is trying to go after us with false rumors. FTX is fine. Assets are fine”. This tweet was later deleted. On November 8, 2022, at 11:37 AM FTX appears to stop processing withdrawals, and Binance agreed to purchase FTX pending due diligence.

By midnight on November 9, 2022 FTT trades at $17.36 with a volume of $1.42 billion. On November 9, at 9 PM 2022 Binance publicly announces on Twitter that they have pulled out of the deal. By midnight on November 10, 2022, FTT’s price has collapsed to $4.54 with a trading volume of 3.31 billion. At 7:08 PM on November 10, FTX tweeted: .

- “Per our Bahamian HQ’s regulation and regulators, we have begun to facilitate withdrawals of Bahamian funds. As such, you may have seen some withdrawals processed by FTX recently as we complied with the regulators”;
- “The amounts withdrawn comprise a small fraction of the assets we currently hold on hand and we are actively working on additional routes to enable withdrawals for the rest of our userbase. We are also actively investigating what we can and should do across the world”.

On 11 November 2022, FTX filed for Bankruptcy Protection under Chapter 11 in the United States.

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