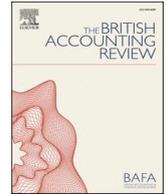




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## Research Note

## The collapse of the FTX exchange: The end of cryptocurrency's age of innocence

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## ABSTRACT

The sudden collapse of the FTX exchange appears to have unearthed several fundamental ethical, regulatory, and policy-based flaws, inherently damaging the cryptocurrency industry at large. The following research outlines the key events that led to the bankruptcy of FTX while examining industry-wide implications as a consequence of an acute risk management failure. Results indicate severe risk and liquidity imbalances between the assets and liabilities of FTX, which contributed to the collapse of the exchange and subsequently led to contagion effects across a range of financial market products. The insolvency of FTX should serve as a significant warning to policymakers and regulators, specifically surrounding the valuation, reserving, and corporate usage of permissionless, privately-issued cryptocurrencies.

## 1. Introduction

While cryptocurrency has long been considered an asset class and industry broadly containing substantial risk, events surrounding FTX, the Bahama-based cryptocurrency exchange founded in 2019 and which filed for bankruptcy protection in 2022, provide a noteworthy illustration of risk management failure. FTX's risk exposures were due to its heavy balance sheet reliance upon the value of permissionless, privately-issued cryptocurrencies, namely FTT Token (FTT) and Serum (SER), two tokens created by those involved with the creation of FTX, and related companies such as Alameda Research. Therefore, the balance sheet reserves of these companies were, as a result, directly influenced by internally created, permissionless, theoretically valueless tokens created and traded by FTX and dependent companies, through which the subsequent collapse has brought much of the industry into disrepute.

This research sets out to quantify the levels of risk and liquidity associated with the reported FTX balance sheet prior to the start of the events leading to the default of the exchange. Evidence of imbalances in risk and liquidity would be symptomatic of the potential for corporate failure, as indicated in previous corporate collapses [Haswell & Evans, 2018; Chen et al., 2014]. We then set out to establish not only the contagion effects of the downfall of FTX and related tokens upon the cryptocurrency industry but also to determine whether such contagion effects are potentially manifested in traditional financial markets. To test for such effects, this research applies a GARCH(1,1) framework to test for high-frequency effects stemming from a severe failure of risk management and corporate governance within a company once valued at \$32 billion. While contagion effects to traditional financial assets verify the continued development and growing maturity of cryptocurrency markets as an asset class, the potential for a collapse in

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privately-issued tokens to manifest in such considerable financial turmoil should act as a stark warning to regulators and policymakers as to the deep-rooted risks inherent within these products.

The sequence of events leading to the collapse of FTX is presented in Table 1. Beginning on 2 November, it was reported that Alameda Research had \$14.6 billion FTT Tokens in possession as of late-June 2022. This news was alarming since FTT was inherently an internal corporate creation, with both companies directly linked. Similar governance concerns have been observed in previous crises [Keys et al., 2009; Gorton & Metrick, 2012; Shiller, 2012]. The actions<sup>1</sup> of Binance founder Mr Zhao, who used social media on 6 November to state “Due to recent revelations that have come to light, we have decided to liquidate any remaining FTT on our books”, further exacerbated the negative pressures upon FTT. This led to Mr Bankman-Fried stating in a now-deleted social media release, that “A competitor is trying to go after us with false rumors. FTX is fine. Assets are fine.”

On November 2, Alameda CEO Ms Caroline Ellison (@carolinecapital) then attempted to restore market confidence, as outlined in Table 1, by guaranteeing FTT Tokens at \$22. On 8 November, as FTT prices sharply collapsed, Binance announced its intention to buy FTX. Less than 24 h later, however, Binance withdrew from the deal, manifesting in a withdrawal surge from the FTX exchange. On 10 November, Mr Bankman-Fried announced the winding down of Alameda Research before The Securities Commission of The Bahamas froze related corporate assets. On 11 November, FTX, FTX-US, and Alameda formally filed for voluntary Chapter 11 bankruptcy protection in the United States.

In the following research, we focus on the risk imbalances and sectoral contagion effects that were evident during these key phases during the collapse of FTX. Specifically, we offer significant insights surrounding cryptocurrency market maturity and the deep-rooted fragility evident therein. Results indicate a severe asset-liability mismatch, both in terms of the relative risk levels of the reported FTX assets and liabilities and their related liquidity. The analysis reveals the vulnerability of digital assets to market sentiment and the pronounced contagion effects following the collapse of key players like FTX. The crucial role of unregulated tokens in the downfall of FTX and the lack of transparency in reserves underscores the pressing need for robust regulatory measures. Furthermore, our study has identified troubling parallels between the cryptocurrency industry’s marketing strategies and the tactics deployed in Ponzi schemes. As FTX’s financial situation deteriorated, evidence of transmission to traditional assets was also identified, indicating that this severe corporate collapse had a broad-reaching influence. Much of FTX’s reserves were accounted for by permissionless, privately-issued cryptocurrencies, where the collapse in the value of these two tokens was one of the primary factors leading to the subsequent collapse of the FTX exchange. Both tokens were largely outside the scope of regulatory authorities, with the potential for their asset value to be easily manipulated by forces outside and, most importantly, inside of FTX. The events outlined should present a stark warning and provide support for firm internationally-coordinated regulation, given the limited risk governance and disclosure requirements. The findings shed light on the gradual convergence of the cryptocurrency industry towards central banking principles, further motivating the urgent need for internationally-coordinated regulation to safeguard financial stability in this rapidly evolving digital landscape [Ocampo et al., 2023].

The rest of this paper proceeds as follows: Section 2 develops the specific research hypotheses examined in the following research, building on previous empirical research. Section 3 presents an overview of the data utilised, while Section 4 describes the empirical methodology and presents the empirical results. Section 5 presents a detailed discussion surrounding the results presented, along with several directions for future research, while Section 6 concludes.

## 2. Hypotheses development

Our study examines risk characteristics of the FTX exchange prior to filing for bankruptcy in November 2022, along with the contagion effects around this period. Specifically, we consider the issue of risk mismatches at a balance sheet level, particularly the extent to which any mismatches are accounted for by permissionless, theoretically worthless tokens. Cryptocurrency exchanges differ from traditional securities exchanges, with the latter not directly holding customer assets. Instead, investors act through a custodian bank (or a broker-dealer) who holds the client’s cash and trades on their behalf on the exchange. In contrast, customers trading on FTX had to transfer cash or cryptocurrencies to the exchange to allow them to trade. In this sense, FTX had characteristics common to broker-dealers, which are subject to considerable regulation owing to multiple historic failures [Altman & Loris, 1976].

In the US, broker-dealers are required to register with the Securities and Exchange Commission (SEC) and are required to meet a series of financial responsibility requirements.<sup>2</sup> These include maintaining a minimum amount of liquid assets, pre-declared procedures in the handling of customer balances, and rules preventing a broker-dealer from using customer funds to finance its business. Many broker-dealers are also banks, which hold long-term illiquid assets financed by short-term liquid liabilities, leading to potential insolvency in times of financial distress [Walther, 2016; Bai et al., 2018; Silva, 2019; Rivero Leiva & Rodríguez Mendizábal, 2019; Gu et al., 2023]. This analogy with broker-dealers motivates our study of the asset-liability mismatch at FTX. Specifically, we hypothesise that a mismatch in the risk and liquidity of the assets held to meet customer liabilities contributed to the collapse of FTX.

To assess this hypothesis, we perform a series of analyses using back-testing techniques commonly employed in banking [Conlon & Cotter, 2014; Escanciano & Olmo, 2010; Wong, 2008]. Specifically, we assess portfolio discrepancies between the assets and liabilities reported by FTX on October 31, 2022, over the previous one-year period. Then, we estimate the tail risk of the assets and liabilities held

<sup>1</sup> The relationship between both owners had been reported to have soured after a series of professional issues, inclusive of a deal where Mr Bankman-Fried bought back Mr Changpeng Zhao’s 20% stake in FTX in June 2021 for approximately \$2 billion, a position that had been purchased for approximately \$100 million.

<sup>2</sup> The full requirements to register with the SEC as a broker-dealer may be found here.

**Table 1**

Key events during the decline and bankruptcy of FTX.

Dummy	Date	Time	Event	Source
$d_1$	02/11/2022	14:44	CoinDesk publishes exclusive revealing key balance-sheet details of Sam Bankman-Fried's Alameda Research trading firm, showing it's heavily invested in the FTX exchange's FTT token.	Available here
$d_2$	06/11/2022	15:47	Binance CEO Changpeng "CZ" Zhao says he's selling his remaining FTT tokens. However, minutes later, Caroline Ellison, CEO of Alameda Research, tweets that Alameda will buy Zhao's FTT tokens for \$22 each.	Available here
$d_3$	07/11/2022	12:38	Bankman-Fried tweets "A competitor is trying to go after us with false rumors. FTX is fine. Assets are fine." Subsequently, at 01:28 on 08/11/2022 it is reported that several reports become available that @SBF.FTX has initiated a process to delete many highly relevant tweets (for example here)	Since deleted, but remains available here
$d_4$	08/11/2022	02:49	The FTT token price falls below \$22. This acts as a critical price barrier given the commitments provided by Caroline Ellis, CEO.	See Fig. 1
$d_5$	08/11/2022	16:03	Binance announces non-binding letter of intent to buy FTX, subject to due diligence, easing the industry panic.	Available here
$d_6$	09/11/2022	15:32	Article on CoinDesk released titled: "Binance Is Strongly Leaning Toward Scrapping FTX Rescue Takeover After First Glance at Books: Source". At 20:50, Binance formally walks away from any deal to acquire FTX. At 14:13 on 10/11/2022, Bankman-Fried says Alameda Research is being wound down, stating: "They aren't doing any of the weird things that I see on Twitter—and nothing large at all. And one way or another, soon they won't be trading on FTX anymore.	Available here and here
$d_7$	10/11/2022	22:56	The Securities Commission of The Bahamas froze the assets of FTX Digital Markets and related parties.	Available here
$d_8$	11/11/2022	15:23	FTX, FTX US, and Alameda formally files for voluntary Chapter 11 bankruptcy protection in US	Available here

Note: All times converted to GMT.

by FTX, looking for discrepancies which might indicate potential balance sheet weaknesses. The quantification of tail risks is a mature branch of financial research, with multiple proposed approaches to estimate the potential for catastrophic loss proposed [Bredin et al., 2017; You & Daigler, 2010]. We investigate the presence of mismatches in tail-risk within the FTX balance sheet, potentially a consequence of volatile and illiquid assets like privately-issued cryptocurrencies, which may serve as a significant precursor to its failure.

Evidence for a contagion effect between distinct financial markets during periods of crisis has been well documented [James et al., 2012; Chan et al., 2011]. Within cryptocurrency markets, there is much evidence for contagion effects between cryptocurrencies during times of systemic market crisis [Caporale et al., 2021; Antonakakis et al., 2019]. While it might be no surprise to find contagion within cryptocurrencies during times of crisis, there is less evidence for contagion effects from cryptocurrency-related events to traditional markets such as foreign exchange. Our research builds upon the previous research by quantifying the extent to which the collapse of FTX impacted cryptocurrency returns. In contrast to the previous research, our research explores how the failure of a single entity, such as FTX, can affect traditional markets. Such work builds on methodological processes used by [Katsiampa et al., 2019a, Katsiampa et al., 2019b, Conlon & McGee, 2020, Hu et al., 2021, Akyildirim et al., 2023, Kyriazis et al., 2023]. We hypothesise that the collapse of FTX led to a wider financial market instability, extending both within and beyond the cryptocurrency market, which we aim to quantify and qualify.

To corroborate this hypothesis, we explore the specific dynamics of contagion within the cryptocurrency market and its potential spillover into traditional markets. Existing literature has indicated that the interconnectedness of these markets might facilitate the transmission of shocks from the cryptocurrency market to traditional financial markets [Corbet et al., 2020]. Our hypothesis posits that the collapse of FTX might have triggered such contagion effects, significantly influencing the returns of not only FTT and SRM tokens but also non-crypto assets. These hypotheses are pivotal to our research, providing a robust framework for understanding the multifaceted reasons behind the collapse of FTX, the subsequent contagion effects, and potential preventive measures to support future market stability.

### 3. Data

In Table 1, key events relating to the decline of the FTX exchange are presented, where data is collated, along with the exact time and specific source from news wire searches on Bloomberg, Thomson Reuters Eikon, and LexisNexis. The FTX balance sheet dated Thursday, November 10, is obtained from that reported by the Financial Times, with additional information from the Voluntary Petition for Non-Individuals Filing for Bankruptcy submitted by FTX.

The FTX balance sheet is presented in Table 2, with associated one-week changes in valuation before the formal filing for voluntary Chapter 11 bankruptcy protection in the United States for FTX, FTX US, and Alameda Research. Data related to each of the examined assets are obtained hourly for the period midnight 1 January 2022 through midnight on 14 November 2022 from Thomson Reuters Eikon, providing a total of 7632 observations. The price series associated with FTT, the FTX token, over this period, is plotted in Fig. 1. A steep decline in the price of FTT can be observed, especially after November 2nd. Data relating to the market capitalisation, traded volume and supply of assets are obtained from CoinMarketCap.

**Table 2**

FTX balance sheet dated to Thursday, November 10, as reported by the Financial Times, USD\$.

Ticker (Description)	Liabilities	Assets	Est 1-week $\Delta$ pre-Chap.11
LayerZero (LayerZero/WBNB)	45,000,000	-	
EUR (EUR/USD)	114,536,254	-	
Genesis	200,000,000	-	
BlockFi	215,000,000	-	
USDT (Tether)	796,482,404	-	
ETH (Ethereum)	671,542,668	-	
BTC (Bitcoin)	1,412,738,406	-	
USD (USD/GBP)	5,135,280,129	-	
Other	268,462,711	-	
		Described as a "Liquid Asset"	
HOOD (Robinhood)	-	472,291,833	-18.46%
USD <sup>#</sup> (USD/GBP)	-	200,000,000	0.00%
USDB (USD Bancor)	-	73,001,646	-0.30%
DAI (Dai)	-	28,491,686	0.10%
DOT (Polkadot)	-	28,384,450	-12.72%
PAXG (Pax Gold)	-	23,767,062	2.25%
JPY (JPY/USD)	-	21,758,186	-1.01%
TUSD (TrueUSD)	-	15,991,381	-0.27%
EURT (TetherEURT)	-	12,117,879	2.28%
BRZ (Brazilian Digital Token)	-	-9,049,093	3.91%
BRL (Borealis)	-	7,017,295	3.91%
WXR (Wrapped XRP)	-	6,987,896	-24.85%
PAX (PAX Dollar)	-	1,000,714	-0.16%
		Described as a "Less Liquid Asset"	
FTT (FTX Token)	-	-553,903,773	-90.62%
SRM (Serum)	-	2,187,876,172	-59.71%
SOL (Solana)	-	981,902,267	-56.27%
MAPS (MAPS)	-	616,372,827	-28.77%
Locked USDT (Locked Tether)	-	500,000,000	0.00%
OXY (Oxygen)	-	54,008,094	-46.05%
STG (Stargate Finance)	-	45,511,034	-31.56%
ETHE (ETHEKing)	-	53,155,549	-17.49%
FIDA (Bonafida)	-	36,492,962	-41.26%
MSOL (Marinade Staked SOL)	-	-26,558,417	-56.03%
ASD (ASD)	-	33,946,248	-32.06%
BITW (Bitwise 10 Crypto Ind.)	-	26,527,697	-16.95%
Others	-	17,860,159	-38.64%
GBTC (Grayscale Bitcoin Trust)	-	3,304,945	-24.67%
APT (Aptos)	-	312,092,943	116,525.79%
		Described as a "Illiquid Asset"	
Other Ventures	-	1,475,000,000	0.00%
GDA	-	1,150,000,000	0.00%
Anthropic	-	500,000,000	0.00%
PYTH (PythNetwork)	-	63,766,000	0.00%
TWTR (Twitter Tok. Stock FTX)	-	43,293,943	23.74%
TRUMPLOSE (TRUMPLOSE)	-	7,394,877	0.00%
Total	Est. Liabilities	Est. Assets	
	9,588,827,028	8,859,042,572	

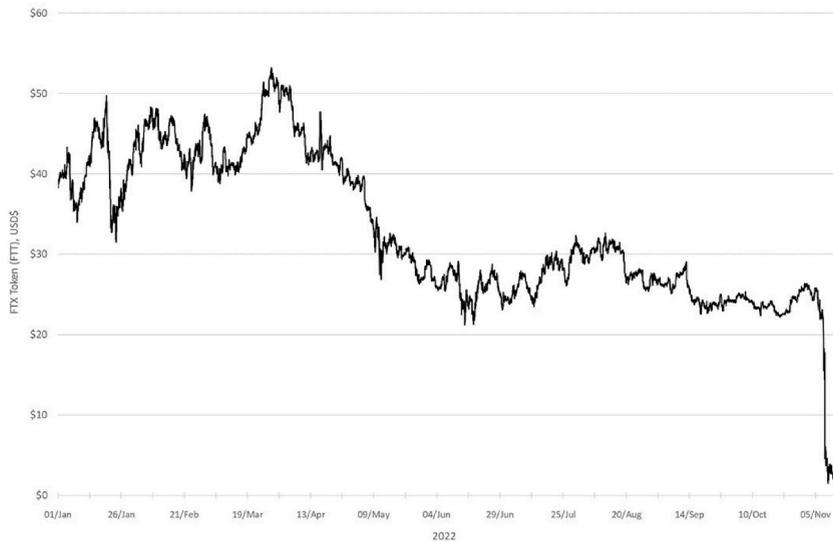
Note: The above data was shared with prospective investors before eventual bankruptcy, outlining the specific position that FTX had found itself regarding assets they held on the exchange." The figures and document provided are reported to have been generated by Mr Sam Bankman-Fried. <sup>#</sup> indicates that this USD holding was in a related company named Ledger Prime.

## 4. Empirical approach and results

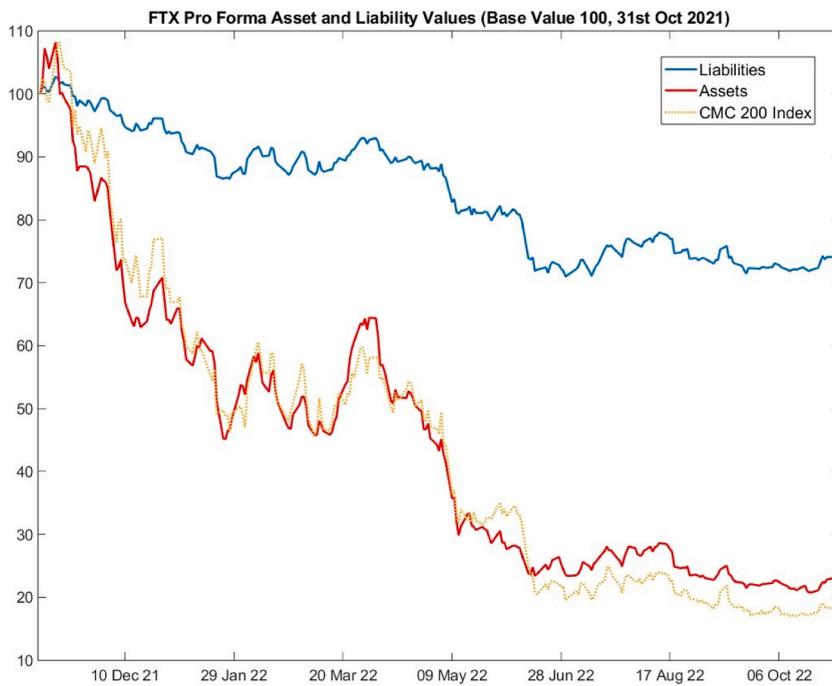
### 4.1. Balance sheet imbalances

In this section, we explore the statistical and economic imbalances evident in the FTX balance sheet described above. The focus here is on the market values of the assets held, along with the implied asset and liability weights. For both assets and liabilities, a pro forma portfolio is constructed, where the weights are assumed to equal those found in the reported FTX balance sheet before the sharp decrease in the prices of FTT and SER. While these pro forma portfolios will not reflect any changes in the positions held by FTX over the previous year, they act as an indicator of the risk levels associated with the portfolio of assets and liabilities reported.

Fig. 2 provides the indicative performance of the pro forma portfolios associated with the assets and liabilities held by FTX before the statement from CoinDesk regarding the key balance sheet details. Portfolio values are indexed at 100 on 31st October 2021. Over the following year, a very considerable divergence is evident. The liabilities, dominated by a USD cash obligation of \$5.1 billion and smaller liabilities of Bitcoin and Ethereum, decrease in value by 26% over the one-year period considered. A more severe decrease is



**Fig. 1.** FTX Token (FTT) Price Performance Note: Data is obtained from Thomson Reuters Eikon from the period midnight 1 January 2022 through to midnight on 14 November 2022.



**Fig. 2.** Pro forma portfolio of FTX Assets and Liabilities, November 2021–October 2022. Note: This figure shows the value of a pro forma portfolio of assets and liabilities held by FTX as of 31st October 2022, over the previous one-year period. Portfolios are fixed at 100 on 31st October 2021. The value of the CMC 200, a cryptocurrency index, is provided for relative evaluation purposes.

associated with the portfolio of assets, which dropped by 77% over the same period. The performance of the FTX assets is analogous to the CMC 200 cryptocurrency index over the same horizon. While not intended to quantify the value of the actual FTX portfolio, these results act as an indicator of the potential risk imbalance between assets and liabilities held by the exchange.

Next, we assess the risk characteristics associated with the assets and liabilities held by FTX using data from 1st November 2021 to 31st October 2022. Table 3 provides daily summary statistics and tail risk measures for the portfolios of assets and liabilities. The asset portfolio had more negative average returns and substantially higher standard deviations over the period examined. The portfolio of liabilities is more negatively skewed and exhibits higher kurtosis, pointing to potential tail risks associated with the liabilities. In panel (ii), lower and upper tail risk measures are contrasted between liabilities and assets using historical simulation value at risk (VaR) and

**Table 3**  
FTX balance sheet statistics and estimated risk.

(i) Summary Statistics					
	Liabilities		Assets		
Mean	−0.11		−0.52		
Standard Deviation	1.15		3.54		
Skewness	−1.21		−0.60		
Kurtosis	7.21		1.09		
(ii) Historical Simulation Downside Risk Estimates					
Lower Tail Measures	Liabilities	Assets	Upper Tail Measures	Liabilities	Assets
VaR 99%	−3.18	−11.18	VaR 1%	2.64	6.59
VaR 95%	−1.74	−6.06	VaR 5%	1.41	4.79
CVaR 99%	−5.11	−12.38	CVaR 1%	2.92	7.04
CVaR 95%	−2.99	−9.23	CVaR 5%	2.20	5.87
(iii) Cornish Fisher Downside Risk Estimates					
Lower Tail Measures	Liabilities	Assets	Upper Tail Measures	Liabilities	Assets
VaR 99%	−5.05	−10.72	VaR 1%	2.79	6.54
VaR 95%	−2.20	−6.86	VaR 5%	1.18	4.61
CVaR 99%	−7.29	−13.02	CVaR 1%	4.22	7.60
CVaR 95%	−3.98	−9.23	CVaR 5%	2.20	5.79

Note: This table uses historical data from 1st November 2021 through 31st October 2022 to estimate summary statistics and risk characteristics associated with the assets and liabilities held by FTX as of 31st October 2022. Historical simulation is a non-parametric approach using historical data, while Cornish Fisher is a parametric approach to estimating downside risk measures. VaR is value-at-risk, while CVaR is conditional value-at-risk or expected shortfall. Each tail measure is multiplied by minus one for clarity.

conditional value at risk (CVaR or expected shortfall), [Conlon & Cotter, 2013; Linsmeier & Pearson, 2000]. VaR is the maximum expected loss on a portfolio over a given time period and is represented as,

$$VaR(1 - \alpha) = \mu - \sigma z(\alpha) \quad (1)$$

where  $z(\alpha)$  is the  $\alpha$  quantile of the standardised distribution,  $\mu$  and  $\sigma$  are the estimated mean and standard deviation of returns, and  $\alpha$  is the confidence level considered. CVaR is calculated by taking the expectation of the distribution beyond the confidence level.

For both a 99% (1%) and 95% (5%) confidence level, results are emphatic for downside (upside risk). Taking downside risk at a 99% level, the VaR of liabilities is −3.18%, while that of assets is −11.18%, more than 3.5 times larger, with analogous results for CVAR. Findings for the upper tails are similar. Considering upside risk at a 1% level, CVaR for assets is more than 2.4 times that of the liabilities held. Robustness results are provided in panel (iii) using the Cornish Fisher expansion to estimate parametric tail risk measures, accounting for higher-order moments of the returns distribution.<sup>3</sup> The four-moment VaR, proposed by Favre and Galeano [2002], is an approximation for the quantile of the distribution, cut off at the fourth moment, and estimated using:

$$\tilde{Z}(\alpha, S_p, K_p) = z(\alpha) \frac{1}{6} (z(\alpha)^2 - 1) S_p + \frac{1}{24} (z(\alpha)^3 - 3z(\alpha)) K_p - \frac{1}{36} (2z(\alpha)^3 - 5z(\alpha)) S_p^2, \quad (2)$$

where  $S_p$  and  $K_p$  are the skewness and kurtosis of portfolio  $P$  and  $z(\alpha)$  is the  $\alpha$  quantile of the standard normal distribution. Four-moment modified VaR is then given by:

$$MVaR_p(1 - \alpha) = \mu_p - \sigma_p \tilde{Z}(\alpha, S_p, K_p). \quad (3)$$

This adjusts the two-moment VaR to account for tail characteristics commonly associated with financial time series. Therefore, empirical findings are akin to those found using historical simulation tail risk, pointing towards a substantially greater probability of a large change in the value of the assets held by FTX compared to the liabilities.

These findings point to a severe risk imbalance between the assets and liabilities held by FTX. A substantial proportion of the Liabilities (58%) were USD, followed by Bitcoin (16%) and Ethereum (7.68%), but the balance sheet asymmetry is highlighted by only 1% USD and an absence of Bitcoin and Ethereum listed as assets. While a direct comparison with other exchanges is impractical due to

<sup>3</sup> The Cornish-Fisher expansion is an adjustment to the quantiles of the distribution to account for higher-order moments related to skewness and excess kurtosis.

a paucity of reported balance sheet information, in [Appendix A](#) we provide a similar analysis using data from Coinbase, the NASDAQ listed exchange, as reported on 31<sup>st</sup> December 2022.<sup>4</sup> As highlighted in [Table A1](#) of the Appendix, the acute risk imbalances evident for FTX are absent for Coinbase. For example, taking historical simulation VaR at a 99% level, the downside risk of liabilities is 95% of that found for assets. In contrast, for FTX, this ratio is 352%. Similar findings are evident for all risk measures and confidence levels examined. This suggests that for the Coinbase exchange, the probability of large price moves is similar for both assets and liabilities, implying a reduced chance of risk imbalances.

This evidence for greater risk imbalances for the privately held exchange FTX adds to the debate surrounding disclosure for cryptocurrency exchanges. Coinbase, as a publicly listed US company, is obliged to make regulatory filings, including a 10-k annual report highlighting its balance sheet exposures.<sup>5</sup> FTX, in contrast, had no obligation to disclose their holdings, offering them the opportunity to invest in high-risk assets with limited liquidity. This emphasises the importance of disclosure in allowing cryptocurrency investors to select exchanges which best meet their risk tolerance.

Finally, in [Table 4](#), we examine the liquidity characteristics of the “less liquid assets” held by FTX. Just three tokens, FTT, SRM and SOL, account for 69% of all assets held by FTX. In the case of FTT and SRM, the attributed value on the balance sheet is greater than the associated market capitalisation of the asset. This points to two possible implications; the asset value documented in the FTX balance sheet was illusory and could not be realised in the open market. The second inference is that FTX, also behind the issuance of FTT and SRM, was accounting on their internal balance sheet for the uncirculated supply of these assets, implying that the free float associated with the market capitalisation is much smaller. The second implication is supported by the traded volume of FTT and SRM, which amounted to 1.7% of the market capitalisation for the former and just 0.37% for the latter, respectively, on October 31st, 2022. These “less liquid assets” were, in fact, very illiquid, and any attempt to sell the vast proportions held by FTX to meet asset withdrawal demands would likely have resulted in further price impact. Although a much smaller component of the overall FTX assets, similar shortcomings are observed for MAPS, OXY, FIDA and MSOL, where the market capitalisation of these assets is also less than that indicated as the value attributed to them on the FTX balance sheet. With the exception of USDT, the attributed value on the FTX balance sheet also accounts for a substantial proportion of the market cap for the remaining tokens.

One explanation for these findings is the stark difference between circulating and maximum supply. For SRM, for example, the circulating supply is about 2.63% of the maximum supply. Similar proportions are evident for MAPS, OXY and FIDA. Moreover, further evidence for the limited liquidity available in these assets is provided by the proportions held by the top 10 holders, found to be over 85% for six of the tokens examined.

While perfect comparisons with other exchanges are impeded by a lack of reported data and no issuance of native tokens (Coinbase), the native token of Binance, BNB, provides some guidance. On November 11, 2022, Binance shared details of the assets held by their hot and cold wallets. At this time, Binance held 58 million BNB, which would have had a market value of \$18.975 billion dollars as of October 31, 2022. This compares with a market capitalisation on that date of \$53.416 billion, accounting for 35.5% of the total. These reported data may, however, be obfuscated by holdings of BNB by other corporate entities such as BAM trading or BAM management.<sup>6</sup> Considering liquidity of BNB, similar findings emerge with 3.03% of the total BNB market capitalisation trading on October 31st 2022 and 0.97% per day over the month of October. This highlights that the Binance native token is also very illiquid, and any attempt to sell large volumes would have a market impact.

These analyses point to severe imbalances in the balance sheet reported by FTX. The majority of asset value is attributed to a small number of privately-issued tokens. Given the limited availability of liquidity in these assets, there appears to be a dislocation between the valuations placed on these assets by FTX and the realisable market value. Similarities with BNB also highlight the prevailing vulnerability of native tokens and the potential for fraudulent activities in relation to these self-issued securities.<sup>7</sup> While similar issues have not emerged at any scale in other exchanges, the dangers outlined, taken alongside the risk imbalances reported earlier, provide a wake-up call for regulation of the cryptocurrency industry, as current levels of opacity and risk culture present dangers for investors, and many endanger financial stability. We next explore the implications of the collapse in the market value of the FTT token on financial contagion.

#### 4.2. Contagion effects

In this section, we examine GARCH-estimated return exposures for a series of traditional and cryptocurrency assets to key FTX events, presented in [Table 1](#), taking the methodological form:

<sup>4</sup> Balance sheet data for Coinbase are extracted from the 2022 10k report. In contrast to FTX, Coinbase’s list matched ‘customer crypto assets’ and ‘customer crypto liabilities’, and the composition of these is identical regarding the cryptocurrency weightings. In [Table A1](#) of the Appendix, the risk of current assets, including customer assets and cash held, along with liabilities, are reported.

<sup>5</sup> While Coinbase provides some level of disclosure, there are other outstanding concerns, including an ongoing SEC charge for operating as an unregistered securities exchange.

<sup>6</sup> According to SEC documents, Binance stated in the white paper that it would reserve 40% of all BNB for its founding team, along with 10% for angel investors who purchased BNB before ICO.

<sup>7</sup> These fraudulent activities are highlighted by the charges brought against Ms Caroline Ellison and Mr Zixiao (Gary) Wang, alleging “that, by manipulating the price of FTT, Bankman-Fried and Ellison caused the valuation of Alameda’s FTT holdings to be inflated, which in turn caused the value of collateral on Alameda’s balance sheet to be overstated, and misled investors about FTX’s risk exposure”.

**Table 4**

FTX 'less liquid' assets - market capitalisation and volume analysis.

	Attributed Value	Asset		Market	Volume 1d	Volume Avg 30d	Top 10	Total Unique	Circulating	Max
	Balance Sheet	Weight	Price	Capitalisation	(31st Oct 2022)	(October 2022)	Holder	Addresses	Supply	Supply
FTT	5,905,299,356	30.04%	26.11	3,476,092,574	102,509,275	56,710,626	93%	21,249	133,132,615	345,000,000
SRM	5,430,110,335	27.62%	0.77	202,369,389	19,920,902	18,036,736	85%	10,311	263,227,613	10,000,000,000
SOL	2,245,516,953	11.42%	32.61	11,700,034,113	1,174,404,933	774,847,932	N/A	N/A	358,786,695	489,000,000
MAPS	865,376,279	4.40%	0.14	6,328,142	253,589	248,594	98%	772	45,526,201	10,000,000,000
Locked USDT	500,000,000	2.54%	1.00	69,416,268,972	67,168,423,338	42,712,794,508	31%	4,488,226	69,423,211,293	N/A
OXY	100,105,976	0.51%	0.04	1,751,407	332,553	331,471	97%	1014	39,304,466	10,000,000,000
STG	66,499,913	0.34%	0.50	70,370,367	14,238,046	14,921,437	96%	12,451	140,656,340	1,000,000,000
FIDA	62,127,831	0.32%	0.41	18,017,341	1,051,663	3,783,578	N/A	N/A	44,192,644	1,000,000,000
MSOL	60,394,582	0.31%	35.20	17,489,175	8,912,531	6,544,827	N/A	N/A	496,852	498,000
ASD	49,967,401	0.25%	0.11	69,731,557	1,848,903	1,878,634	100%	741	664,110,067	780,615,274

Note: This table details the balance sheet exposure of FTX 'Less Liquid Assets' along with the asset weight and details on market capitalisation and traded volume. The attributed value balance sheet corresponds to the value 'before this week' on the FTX balance sheet. Asset weight is the proportion of total assets represented by that asset. Price and market capitalisation are as of October 31st, 2022. Volume 1d and volume avg are the traded volume on 31st October 2022 and over the month of October, respectively. The top 10 and total unique addresses represent the proportion of coins held by the ten largest addresses and the total number of unique addresses that hold the asset. Circulating supply and max supply represent the number of coins in the market, while total supply is the max supply that will ever exist. N/A indicates that data is not available.

$$r_t = a_0 + \sum_{j=1}^n b_j r_{t-j} + \varphi d_t + \varepsilon_t, \quad (4)$$

$$\varepsilon_t | \Omega_t \sim i.i.d. N(0, h_t), \quad (5)$$

$$h_t = \omega + \alpha_1 h_{t-1} + \beta_1 u_{t-1}^2, \quad (6)$$

where  $r_t$  corresponds to the subsequent market response in each of the assets to the events listed in Table 1, and  $r_{t-j}$  represents the lagged value of each respective asset analysed. Further,  $j$  represents the number of hourly periods before  $r_t$  is observed.  $\varphi d_t$  is included in the mean equation. Bollerslev [1986] argued for restrictions on the parameters for positivity,  $\omega > 0$ ,  $\alpha \geq 0$  and  $\beta \geq 0$ , and the wide-sense stationarity condition,  $\alpha + \beta < 1$ . The GARCH(1,1) process is uniquely stationary if  $E[\log(\beta + \alpha e^2)] < 0$ .<sup>8</sup> To estimate the response of  $r_t$  to previous events, listed in 1, associated with the collapse of FTX, we use event dummies corresponding to 6-h and 12-h periods after the announcements listed in Table 1.<sup>9</sup>

Results, presented in Table 5, highlight the immediacy of the response of both FTT and SRM to the key events that had taken place relating to FTX. Both permissionless, privately issued tokens exhibit periods of severe depreciation, further evidencing their role as primary propellants of the rapid demise in the balance sheet assets of FTX. Several other significant results are also of interest. First, while many specific cryptocurrency-related interactions are particularly prevalent during the demise of FTX, it is also notable that EUR/USD, USD/GBP, and USD/JPY exhibit significant, albeit brief negative effects. For example, in a 6-h window following the CoinDesk article indicating that Binance might pull out of the proposed deal to acquire FTX, the USD/JPY rate fell by  $-1.5\%$ . Secondly, while Bitcoin, as the largest cryptocurrency, does not initially respond to events, it becomes significantly responsive as conditions deteriorate. The magnitude of the coefficients, using hourly data, are considerable, with a maximum coefficient of  $-3.3\%$  corresponding to the decrease in FTT below \$22. Further, a significant response is identified between FTT and Robinhood<sup>10</sup> (HOOD) as FTT fell below \$22, and again during the failed takeover attempt of FTX by Binance. The short-term (6-h) effect sizes are large, with price drops of between  $-0.7\%$  and  $-1.5\%$ . The interactions between brokerage firms should be observed as representative of FTX's relationship with risk and a direct avenue through which the collapse of FTX could have serious detrimental effects on the portfolios of non-cryptocurrency investors.

Furthermore, the results from our study stress the importance of creating robust policies to protect investors from the potential fallout of cryptocurrency market collapses. Given the observed contagion effects following the collapse of FTX, regulations should be designed to mitigate risk and ensure the safety of investors' portfolios, including those of non-cryptocurrency investors. These measures could encompass various initiatives, from reinforcing transparency and accountability among privately-issued cryptocurrencies to monitoring and limiting their interactions with traditional asset markets. Our research aligns with the emerging literature advocating for such policies, reinforcing the importance of regulatory progress in the evolving cryptocurrency landscape.

## 5. Discussion and directions for future research

### 5.1. Policy and regulatory implications

Our research underscores the urgency for regulators to understand the complexity and risks associated with privately-issued cryptocurrencies and with cryptocurrency exchanges effectively acting as broker-dealers. Such tokens, given their lack of traditional oversight, have been pivotal in the collapse of FTX and subsequent contagion effects. Policymakers should consider these findings as they seek to develop regulatory frameworks suitable for this new asset class, recognising their potential impact on financial stability. Additionally, the finding that the collapse of FTX had notable implications for traditional asset classes suggests that existing regulatory parameters need to be urgently expanded. As more research continues to identify the expanding and deepening interconnectivity between cryptocurrency markets and traditional financial markets, policymakers might be best to prepare urgent mitigation plans to address associated contagion risks. This underscores the need for holistic, rather than segmented, regulatory oversight.

The presence of liquidity mismatch and tail risk in FTX's operation indicates the potential for cryptocurrency exchanges to face similar risks as broker-dealers, many of whom operate within the confines of traditional banks and financial institutions. As such, there may be lessons to learn from existing banking regulations that could be applied to cryptocurrency exchanges. For instance, capital adequacy requirements and liquidity coverage ratios, widely used in banking regulation, could be adapted for the context of cryptocurrencies. While cryptocurrency-specific prudential regulatory guidelines have been proposed for banks [Basel Committee on Banking Supervision, 2022], no coherent framework has been proposed to safeguard investors. Regulators should consider specific

<sup>8</sup> Bollerslev [1986] also proved that if the fourth order moment exists, then the model can handle leptokurtosis. Bonferroni adjusted results are presented in this analysis. To deal with the multiple hypothesis problem, we adjust the significance level using the Bonferroni correction, leading to a significance level of 0.1%. This procedure has the advantage of being robust to the hypothesis tests' dependence structure.

<sup>9</sup> Extended results along with associated robustness testing procedures are omitted for brevity of presentation and are available from the authors upon request. Only results surrounding the periods [0,+6] and [0,+12] are presented hereafter. Other models tested included EGARCH, TGARCH, Asymmetric Power ARCH (APARCH), Component GARCH (CGARCH) and the Asymmetric Component GARCH (ACGARCH). The optimal model is chosen according to three information criteria, namely the Akaike (AIC), Bayesian (BIC) and Hannan-Quinn (HQ).

<sup>10</sup> Robinhood is a brokerage firm that played a significant role during the r/wallstreetbets attempt to organise coordinated targeting of financial markets [Corbet et al., 2022].

**Table 5**  
Selected GARCH results based on selected FTX bankruptcy events.

	6- hour GARCH-estimated connectedness differential						12-h GARCH-estimated connectedness differential					
	EUR	BTC	USD	USDT	ETH	JPY	EUR	BTC	USD	USDT	ETH	JPY
$\varphi d_1$	-0.001*	-0.001	-0.002***	0.000	-0.002	0.001	-0.001***	0.000	-0.001***	0.000	-0.001	0.000
$\varphi d_2$	-0.004***	0.000	-0.001***	0.000	-0.002	0.000	-0.004***	-0.001	-0.001***	0.000	-0.003**	0.000
$\varphi d_3$	0.001	-0.002	0.001	0.000	0.001	0.000	0.000	-0.004	0.001*	0.000	0.000	0.000
$\varphi d_4$	0.000	-0.033***	-0.001***	0.000	-0.013	0.000	-0.001***	-0.031***	0.000	0.000	-0.014***	0.000
$\varphi d_5$	0.003***	-0.023***	0.001	0.000	-0.009	0.000	0.001***	-0.024***	0.000	0.000	-0.006**	0.000
$\varphi d_6$	0.001	-0.015***	0.001	0.000	-0.001	-0.015***	0.000	-0.020***	0.000	0.000	-0.003	-0.008*
$\varphi d_7$	0.000	-0.008***	0.000	0.000	-0.011	-0.002*	0.001	-0.001***	0.001	0.000	-0.002	-0.001*
$\varphi d_8$	0.001	-0.015***	0.001	0.000	-0.001	-0.001**	0.000	-0.017***	0.000	0.000	0.000	0.000
	<u>HOOD</u>	<u>FTT</u>	<u>DOT</u>	<u>PAX</u>	<u>BRZ</u>	<u>MAPS</u>	<u>HOOD</u>	<u>FTT</u>	<u>DOT</u>	<u>PAX</u>	<u>BRZ</u>	<u>MAPS</u>
$\varphi d_1$	-0.001	-0.004*	-0.001	0.000	0.000	0.000	-0.001	-0.002	0.000	0.000	0.000	-0.001
$\varphi d_2$	0.000	-0.069***	-0.001	0.000	0.000	-0.003	0.000	-0.040***	-0.002	-0.001	0.000	-0.002
$\varphi d_3$	0.002	-0.050***	0.010**	0.000	-0.003***	-0.001	0.001	-0.035***	0.005	0.000	-0.002***	-0.005***
$\varphi d_4$	-0.007***	-0.168***	-0.010***	-0.010***	-0.001	-0.016***	-0.016***	-0.115***	-0.008***	-0.005***	-0.002***	-0.021***
$\varphi d_5$	-0.015***	-0.112*	-0.009	-0.001	-0.013***	0.049***	-0.002	-0.034***	-0.014	-0.001	0.012***	0.049***
$\varphi d_6$	-0.014***	-0.037	-0.003	0.009***	0.005	0.124***	0.003	-0.011	-0.004***	0.009***	0.001	0.123***
$\varphi d_7$	0.001	-0.058	-0.008	0.000	-0.001	0.069	0.000	-0.060	-0.003	0.001	0.020***	0.119***
$\varphi d_8$	0.022	-0.031	-0.007	0.001*	-0.072***	-0.024	0.000	-0.022	-0.001**	0.001**	0.053***	-0.014
	<u>SOL</u>	<u>SRM</u>	<u>STG</u>	<u>ASD</u>	<u>BITW</u>	<u>GBTC</u>	<u>SOL</u>	<u>SRM</u>	<u>STG</u>	<u>ASD</u>	<u>BITW</u>	<u>GBTC</u>
$\varphi d_1$	-0.003	-0.007	0.001	0.000	0.001	-0.003	-0.001	-0.003	0.003	0.000	0.000	-0.001
$\varphi d_2$	-0.008	-0.113***	-0.004	0.000	0.000	0.000	-0.007	-0.101***	-0.007	0.000	0.000	0.000
$\varphi d_3$	0.008*	-0.069***	-0.005	0.001	-0.004	-0.003	0.001	-0.041***	-0.001	0.000	-0.002	-0.001
$\varphi d_4$	-0.024***	-0.095***	-0.021	-0.003**	0.007	-0.014*	-0.020***	-0.094***	-0.017	-0.003*	0.001	0.000
$\varphi d_5$	-0.057**	-0.078***	-0.022***	-0.037***	-0.009**	-0.017***	-0.004	-0.074***	-0.008	0.035***	-0.003	-0.003
$\varphi d_6$	0.008	-0.022***	0.067**	-0.029***	-0.006***	-0.012**	0.003	0.017***	-0.016***	0.032	-0.011***	-0.002
$\varphi d_7$	-0.017	0.031***	0.056***	0.035	-0.015***	0.013***	-0.001	0.027***	-0.026***	0.002	-0.009***	0.003
$\varphi d_8$	-0.012	-0.032***	-0.001	-0.029	-0.143***	-0.059***	-0.007	0.011**	-0.001	0.004	-0.143***	-0.082***

Note: In the above table, we develop upon GARCH methodology of the form:  $r_t = a_0 + \sum_{j=1}^n b_j r_{t-j} + \varphi d_t + \varepsilon_t$ , where  $r_{t-j}$  represents the lagged value of each respective asset analysed, while  $j$  represents the number of hourly periods before  $r_t$  is observed.  $d_t$  is included in the mean equation to estimate the subsequent 6-h and 12-h market response. Extended results and associated robustness testing procedures are omitted for brevity of presentation and are available from the authors upon request. In our selection, other competitive models included EGARCH, TGARCH, Asymmetric Power ARCH (APARCH), Component GARCH (CGARCH) and the Asymmetric Component GARCH (ACGARCH). The optimal model is chosen according to three information criteria, namely the Akaike (AIC), Bayesian (BIC) and Hannan-Quinn (HQ). \*\*\*, \*\* and \* denote significance at the 1%, 5% and 10% levels, respectively.

requirements related to the valuation, possession, and corporate usage of self-issued tokens to prevent similar scenarios from recurring, necessitating a holistic perspective of the industry rather than being observed in silos. This can be achieved by extending current financial protection frameworks to encompass cryptocurrencies, considering their increasingly prominent role in the financial ecosystem. Lastly, the formation of an industry recovery fund by Binance after FTX's collapse signals an attempt to self-regulate within the cryptocurrency industry. Policymakers could, perhaps, interpret this as a call to foster a collaborative relationship with industry stakeholders; however, the fact that such an event has occurred could be observed as a signal that the sector is perhaps unable to apply and comply with such ambitions. Engaging with these stakeholders could allow regulators to understand the industry's intricacies, develop tailored regulatory responses, and encourage the industry to adopt best practices.

## 5.2. Directions for future research

Our analysis specifically revealed a strong interconnection between the downfall of FTX and the value of FTT and Serum tokens. Future research should seek to quantify this relationship in a more nuanced manner, using higher-frequency financial market data and perhaps trade-level data. This could help us specifically understand the exogenous effect of shocks to privately-issued cryptocurrencies and their issuing platforms more deeply, including the regional and investor-level aspects of this relationship. The financial contagion from FTX to traditional assets uncovered in this study prompts several avenues for future research. One could be to examine the extent to which these contagion effects permeate other segments of traditional finance, including bonds, commodities, and derivatives markets. This can offer a more comprehensive understanding of how cryptocurrency market dynamics can spill over into the broader financial ecosystem.

The bankruptcy of FTX sheds light on liquidity and balance sheet risks in the cryptocurrency industry. Future studies could explore stress testing and scenario analysis to assess the resilience of cryptocurrency exchanges and other related entities to liquidity shocks. This would also potentially identify the triggers of such shocks and their probable cascading effects. The bankruptcy of FTX has notably unveiled the possible balance sheet risks inherent within the cryptocurrency industry. Further exploration based on the triggers and amplification mechanisms of such shocks, including network effects, market sentiment, and regulatory announcements, could also prove beneficial. In particular, research focusing on 'black swan' events and their cascading effects across cryptocurrency products would contribute significantly to our understanding of systemic risk in this domain. Additionally, understanding the mechanisms and pathways through which shocks propagate could shed light on potential points of intervention to mitigate negative impacts. Such models could incorporate elements of behavioural finance, given the industry's susceptibility to investor sentiment, and elements of network theory, given the interconnected nature of the crypto markets. Overall, these investigations would not only further our understanding of the cryptocurrency industry but also aid regulators and policymakers in designing more robust risk management frameworks and effective preventive measures.

Our work indicated an emerging trend of self-regulation in the cryptocurrency industry. Subsequent research can delve deeper into the effectiveness of such initiatives, their potential drawbacks, and how they can be integrated into a broader regulatory framework. This could inform the development of a balanced regulatory approach that respects the unique ethos of the cryptocurrency industry while ensuring financial stability. These proposed directions enrich the cryptocurrency research landscape and provide a roadmap for uncovering more intricate aspects of the industry's operations and its relationship with traditional finance.

## 6. Concluding comments

The results of this work indicate that the risk and liquidity position of FTX, especially in relation to the privately-issued cryptocurrencies, FTT and Serum, was linked to the collapse of FTX and subsequent contagion effects. Increased interconnectivity with traditional assets could manifest in far more broad-reaching negative scenarios. The central role of such unregulated tokens in the demise of FTX, and the lack of transparency in reserves held, should serve as a strong warning as to the immaturity of the cryptocurrency industry and how much industry control rests in the hands of so few. Particular emphasis must be placed upon specific regulatory requirements surrounding the valuation, possession, and corporate usage of permissionless, privately-issued cryptocurrencies. The events outlined should present a stark warning and provide support for firm internationally coordinated regulation.

Recently, the cryptocurrency industry has experienced the collapse of Luna, the liquidation of Three Arrows Capital, the collapse of NFTs, and the bankruptcy of FTX. These individual cases have together generated a watershed moment. First, the incredible growth of cryptocurrency marketing and celebrity endorsement should be considered a significant red flag, particularly due to tactical similarities with Ponzi schemes. Second, during the May depegging of terraUSD and the subsequent collapse of Luna, one proposed mechanism to restore confidence was using an external bailout. Third, Mr Changpeng "CZ" Zhao, CEO of Binance, stated on 14 November 2022 that "*Binance is forming an industry recovery fund, to help projects who are otherwise strong but in a liquidity crisis.*" The cryptocurrency industry set out to be independent and decentralised. It appears that some cryptocurrency market participants are re-inventing central banking step-by-step but on their terms.

Lastly, the issues uncovered in our study open up multiple avenues for future research. One potential direction could involve the development of a regulatory framework that can effectively manage the risks posed by privately-issued cryptocurrencies without stifling their innovation potential. Another could explore the interplay between traditional and cryptocurrency markets, with an emphasis on how risk can be transmitted between the two. These prospective research areas could further illuminate the complexities of the cryptocurrency industry, providing policymakers with additional insights to enhance their regulatory strategies.

The collapse of FTX and the ensuing contagion effects underscore the inherent risks associated with privately-issued cryptocurrencies. Specifically, the dynamics surrounding risk and liquidity positions in such entities emerged as areas of substantial concern.

Our findings suggest the urgent need for regulatory action to enforce transparency and due diligence in the valuation, possession, and corporate usage of such digital assets. The prevailing lack of transparency in reserves and the opacity in accumulating positions highlight loopholes that can catalyse financial instability. As such, regulatory efforts should emphasise the development and enforcement of stringent disclosure requirements to ensure greater transparency.

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### Data availability

The authors do not have permission to share data.

### Appendix A

**Table A1**  
Coinbase Balance Sheet Statistics and Estimated Risk

(i) Summary Statistics					
	Liabilities		Assets		
Mean		-0.41			-0.39
Standard Deviation		4.06			3.84
Skewness		-1.27			-1.27
Kurtosis		6.55			6.55
(ii) Historical Simulation Downside Risk Estimates					
Lower Tail Measures	Liabilities	Assets	Upper Tail Measures	Liabilities	Assets
VaR 99%	-12.72	-12.02	VaR 1%	9.15	9.21
VaR 95%	-6.58	-6.21	VaR 5%	5.40	5.16
CVaR 99%	-18.62	-17.59	CVaR 1%	9.99	9.44
CVaR 95%	-10.69	-10.10	CVaR 5%	7.41	7.00
(iii) Cornish Fisher Downside Risk Estimates					
Lower Tail Measures	Liabilities	Assets	Upper Tail Measures	Liabilities	Assets
VaR 99%	-17.28	-16.32	VaR 1%	8.93	8.44
VaR 95%	-7.91	-7.47	VaR 5%	4.17	3.94
CVaR 99%	-24.44	-23.08	CVaR 1%	13.08	12.36
CVaR 95%	-13.74	-12.98	CVaR 5%	7.17	6.77

Note: This table uses historical data over the period 1st November 2021 through 31st October 2022 to estimate summary statistics and risk characteristics associated with the current assets and current liabilities held by Coinbase as of 31st December 2022. Historical simulation is a non-parametric approach using historical data, while Cornish Fisher is a parametric approach to estimating downside risk measures. VaR is value-at-risk, while CVaR is conditional value-at-risk or expected shortfall. Each tail measure is multiplied by minus one for clarity.

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