

## Written Exam Economics summer 2023

### Financial Markets Microstructure

June 8<sup>th</sup> 2023

This exam question consists of 12 pages in total

Answers only in English.

A take-home exam paper cannot exceed 10 pages – and one page is defined as 2400 keystrokes

***The paper must be uploaded as one PDF document. The PDF document must be named with exam number only (e.g. '1234.pdf') and uploaded to Digital Exam.***

#### **Be careful not to cheat at exams!**

Exam cheating is for example if you:

- Copy other people's texts without making use of quotation marks and source referencing, so that it may appear to be your own text
- Use the ideas or thoughts of others without making use of source referencing, so it may appear to be your own idea or your thoughts
- Reuse parts of a written paper that you have previously submitted and for which you have received a pass grade without making use of quotation marks or source references (self-plagiarism)
- Receive help from others in contrary to the rules in the Faculty of Social Science's common part of the curriculum

You can read more about the rules on exam cheating on your Study Site and in the Faculty of Social Science's common part of the curriculum.

**Exam cheating is always sanctioned by a written warning and expulsion from the exam in question. In most cases, the student will also be expelled from the University for one semester.**

## Final exam

Write up your responses to questions below and submit them to Digital Exam. The deadline to submit the responses is Jun 8, 21:00. No cooperation with other students is permitted.

Be concise, but show your work and explain your answers. Some questions may require you to make additional assumptions beyond those provided in the question; be clear about the assumptions you make. Some questions are open ended in that they may not have a unique correct answer. You are allowed to refer to textbooks, lecture notes, slides, problem sets, etc.

### Problem 1: Estimating spread with informative order flow

Suppose you want to estimate the average spread for a given stock, but only have access to trade data (prices, directions, volumes). You hence decide to use the Roll's model that we have seen in class. At the same time, you find its assumption about the uninformative order flow unrealistic and want to relax it. You believe instead that some traders are informed, and the prices reflect that (as in, e.g., the Glosten-Milgrom world), which leads to  $\mathbb{E}(d_t \epsilon_t) = \rho > 0$  in the Roll's model.

1. Can you estimate  $\rho$  from trade data? If yes, explain in a few words how you would do it (you do not need to spell out the formal estimation procedure). If no, explain why and suggest another way to estimate spread.
2. Assuming you know (or have a good estimate for) the value of  $\rho$ , provide an estimator for spread  $S$ .

### Problem 2: Order splitting

Splitting a large order into multiple smaller orders is an important instrument that traders have for moderating their price impact, but it also has general equilibrium implications for order pricing. This problem explores these implications in the context of the Glosten-Milgrom model.

There is one asset traded in a dealer market with a representative (competitive) risk-neutral dealer, who is tasked with quoting an ask price  $a_1$  and a bid price  $b_1$  for one unit of the asset at all times. The dealer believes that the asset's fundamental value is distributed as  $v \sim U[\mu - \sigma, \mu + \sigma]$ .

The dealer's belief is that any arriving trader is risk-neutral and either informed with probability  $\pi$ , or uninformed with probability  $1 - \pi$ . An informed trader knows  $v$  and selects the profit-maximizing trade given  $v$ . An uninformed (noise) trader wants to buy or sell with equal probabilities, and would like to trade either one (with probability  $1 - \gamma$ ) or two (w.p.  $\gamma$ ) units of the asset. To trade two units, the trader remains in the market after the first trade and submits another order. The dealer observes the trader's identity and can offer different quotes  $a_2$  and  $b_2$  to a repeat trader.

1. Explain why in such a market, an informed trader would never profit by trading more than two units.
2. Calculate the ask price  $a_1$  that a dealer would quote for the first unit.
3. Calculate the ask price for "repeat" purchases,  $a_2$ .
4. Compare these quotes with what would have been offered in a pure limit order book market (without a dealer), according to the Glosten model (with no order display cost). Would the market-order-traders prefer to trade in a dealer market or a LOB market?
5. Now assume instead that the dealer cannot see the trader's identity, so quote  $a_2$  is also "public". This means that it is taken either by the original trader who wanted to trade two units, or by a second trader willing to buy (the dealer's beliefs about the second trader are the same as about the first). Calculate the ask quote  $a_2^O$ . How does it compare to the quote  $a_2$  derived above? Would the traders

prefer their identity to be observable or not?

### Problem 3: The fall of FTX

FTX, a large crypto exchange, has collapsed in the Fall of 2022. You can find the timeline of the collapse in the article from Investopedia attached at the end of this exam.<sup>1</sup> You are to answer the following question:

“How does the fall of FTX affect the other participants of the crypto market?”

1. Consult a chatbot/AI/LLM (hereinafter referred to as LLM) on this issue.<sup>2</sup> Show both your prompt and the response (and mention which LLM you used).

*NOTE: for best results, you may want to phrase your own prompt, rather than just copy the question above.*

2. Discuss the response you got. Does it make sense? Is it applicable to the situation at hand?
3. Is there anything you would like to add to the LLM response, using the knowledge you obtained in the course?

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<sup>1</sup>Original article available at <https://www.investopedia.com/what-went-wrong-with-ftx-6828447>.

<sup>2</sup>For example, you can use openAI's ChatGPT: <https://chat.openai.com>.

# The Collapse of FTX: What Went Wrong with the Crypto Exchange?

*Full Bio*

11–14 minutes

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Cryptocurrency exchange FTX and its founder and former CEO, Sam Bankman-Fried, are intricately entwined. The swift and damaging [collapse of FTX in late 2022](#) will have repercussions on the international crypto community for years to come.

Learn more about what went wrong with FTX.

## Key Takeaways

- FTX collapsed in early November 2022 following a report by CoinDesk highlighting potential leverage and solvency concerns involving FTX-affiliated trading firm Alameda Research.
- FTX's collapse shook the volatile crypto market, which lost billions at the time, falling below a \$1 trillion valuation.
- FTX in November 2022 faced a liquidity crisis and searched for bailout funds; rival exchange Binance considered buying portions of the company but quickly backed out.
- By Nov. 11, 2022, FTX's CEO stepped down and the company filed for bankruptcy.
- In the hours following, FTX experienced a possible hack in which hundreds of millions worth of tokens were stolen.

- FTX founder and ex-CEO Sam Bankman-Fried was arrested in The Bahamas and extradited to the United States in late December. He pleaded innocent to all criminal charges on Jan. 3, 2023.

## What Happened to FTX?

FTX's collapse took place over a 10-day period in November 2022. The catalyst was a Nov. 2 scoop by crypto news site CoinDesk that revealed that Alameda Research, the [quantitative trading](#) firm also run by [Bankman-Fried](#), held a position valued at \$5 billion in FTT, the [native token](#) of FTX.

The report disclosed that Alameda's investment foundation was also in FTT, the token that its sister company had invented, not a [fiat currency](#) or other [cryptocurrency](#).<sup>1</sup> That prompted concern across the cryptocurrency industry regarding Bankman-Fried's companies' undisclosed [leverage](#) and [solvency](#).<sup>2</sup>

## FTX Collapse's Sequence of Events

The following is a recap of the events that led to FTX's failure, bankruptcy filing, and its former CEO's jailing and extradition to the United States to face a series of criminal and civil charges.

### FTX Collapse Timeline—2022

- **Nov. 6:** Rival exchange Binance sells all FTT tokens.
- **Nov. 7:** FTX announces liquidity crisis, seeks bailout from venture capitalists, then Binance.
- **Nov. 8:** Binance says it will buy FTX's non-U.S. business.
- **Nov. 9:** Binance walks away from FTX acquisition after conducting due diligence.

- **Nov. 10:** The Bahamas freezes assets of FTX's subsidiary there; Bankman-Fried admits non-U.S. businesses' liquidity crisis, says affiliate Alameda Research to wind down.
- **Nov. 11:** Bankman-Fried steps down as FTX CEO, is replaced by a court-appointed CEO with restructuring experience. FTX files for Chapter 11 bankruptcy protection.
- **Nov. 12:** FTX reports an alleged hack, suspected to be up to \$477 million, and moves its digital assets to cold storage for security reasons.
- **Nov. 18:** The Bahamas takes control of FTX assets held there.
- **Dec. 12:** Bankman-Fried is arrested by Bahamian authorities. He's later extradited to the U.S.
- **Dec. 22:** Bankman-Fried is released on a \$250 million bond, the largest in history, by a federal judge.

### **Binance Says It Will Sell All Its FTT Tokens**

[Binance](#), the world's biggest crypto exchange, announced on Nov. 6 that it would [sell its entire position in FTT tokens](#)—roughly 23 million FTT tokens valued at about \$529 million. Binance CEO [Changpeng “CZ” Zhao](#) said the decision to [liquidate](#) the exchange's FTT position was based on [risk management](#), following the [collapse of the Terra \(LUNA\)](#) crypto token earlier in 2022.<sup>34</sup>

### **FTX Liquidity Crisis and Binance Deal**

By the next day, FTX was experiencing a [liquidity crisis](#). Bankman-Fried attempted to reassure FTX investors that its assets were stable, but customers demanded withdrawals worth \$6 billion in the days immediately following the CoinDesk report.

Bankman-Fried searched for additional money from venture capitalists before turning to rival Binance. The value of FTT fell by more than 80% in two days.<sup>56</sup>

On Nov. 8, Binance announced that it had reached a nonbinding agreement to buy the non-U.S. business of FTX for an undisclosed sum—effectively the world’s largest cryptocurrency exchange [bailing out](#) its close rival.<sup>7</sup>

## **Binance Cancels Deal to Bail Out FTX**

The promise of a rescue was short-lived, as Binance backed out of the deal a day later. On Nov. 9, the exchange said that it would cancel the FTX deal after corporate [due diligence](#) raised concerns about the mishandling of customer funds, among other issues.<sup>8</sup>

## **FTX Assets Frozen and Other Implications**

On Nov. 10, The Bahamas’ securities regulator froze the assets of FTX Digital Markets, FTX’s Bahamian subsidiary, following news that Bankman-Fried was seeking up to \$8 billion in [capital](#) to bail out the exchange.<sup>9</sup> On the same day, the California Department of Financial Protection and Innovation announced that it had initiated an investigation into FTX.<sup>10</sup>

Bankman-Fried apologized the same day for the liquidity crisis and admitted on Twitter that FTX’s non-U.S. exchange had insufficient funds to meet customer demands. He said that “poor internal labeling” caused FTX to miscalculate leverage and [liquidity](#). In the same Twitter thread, he said Alameda would wind down trading.<sup>11</sup>

## **Bankman-Fried Steps Down as CEO; FTX Files for Bankruptcy**

Bankman-Fried stepped down on Nov. 11 as CEO of FTX, replaced by court-appointed FTX CEO John Ray, who led energy trading firm [Enron](#) through bankruptcy proceedings years before.<sup>12</sup>

FTX filed for [Chapter 11 bankruptcy](#) protection the same day, revealing that roughly 130 other affiliated companies were also part of the proceedings. The bankruptcy filings indicated that FTX had [assets](#) and [liabilities](#) each in the range of \$10 billion to \$50 billion.<sup>13</sup>

Investors and customers have lost billions, and not all of it will be recovered, the new FTX CEO told a U.S. House of Representatives committee hearing on the FTX debacle held on Dec. 13.

### **‘Unauthorized Transactions’ on FTX**

Within hours of filing for bankruptcy, FTX said it was the victim of “unauthorized transactions” and that it would move its digital assets to [cold storage](#) for security purposes.<sup>14</sup> Outside analysts said they suspect that about \$477 million was stolen from FTX in the alleged hack.<sup>15</sup>

### **Lawsuit Against FTX, Celebrity Promoters Filed**

On Nov. 16, [a class-action lawsuit was filed](#) in a Florida federal court, alleging that Bankman-Fried created a fraudulent cryptocurrency scheme designed to take advantage of unsophisticated investors from across the U.S. Others named in the lawsuit include celebrities and professional athletes Steph Curry, Shaquille O’Neal, Shohei Ohtani, Naomi Osaka, Larry David, and Kevin O’Leary, who allegedly helped Bankman-Fried facilitate the plan.<sup>16</sup>



## **The Bahamas Takes Control of FTX Digital Assets**

The Securities Commission of The Bahamas (SCB) [took control](#) of cryptocurrency assets held by bankrupt exchange FTX on Nov. 18. The SCB said it instructed Bankman-Fried to move crypto assets to the regulator's wallet to protect creditors.

## **Arrest, Charges Against Bankman-Fried**

Bahamian authorities arrested Bankman-Fried on Dec. 12, 2022, and jailed him in connection with multiple fraud charges involving FTX, including those stemming from an indictment from the U.S. Attorney of the Southern District of New York. U.S. Attorney Damian Williams said when announcing the charges against the former CEO that it was one of the largest financial crimes in American history. New FTX CEO Ray told the U.S. House committee on Dec. 13 that FTX practiced "no bookkeeping." He added, "It was old-fashioned embezzlement."<sup>17</sup>

Bankman-Fried was extradited to the U.S., then indicted by U.S. District Court in Manhattan on eight counts, including [securities fraud and money laundering](#). Following a court hearing on Dec. 22, a federal judge decided to release Bankman-Fried from custody after his attorneys and federal prosecutors agreed to a \$250 million bond, the largest in history. The 30-year-old former crypto executive will live with his Stanford law professor parents in Palo Alto, Calif., be confined to the Northern California area, and wear an electronic monitoring bracelet.<sup>18</sup>

On Jan. 3, 2023, Bankman-Fried pleaded not guilty to all criminal charges in a federal court in New York. He is set to face trial on eight charges on Oct. 2.<sup>19</sup>

## Future of FTX and Consequences of Collapse

The future of FTX as a cryptocurrency exchange is in serious jeopardy. As of mid-November 2022, withdrawals were disabled and a notice on the FTX website says the company “strongly advise[s] against depositing.”<sup>20</sup>

The broader consequences of the FTX fiasco for the cryptocurrency industry will take time to unfold. As the largest collapse in the short history of cryptocurrencies, FTX may further deter [investors](#), who already are cautious because of concerns about stability and security. Customers on the FTX platform may not recover their assets, potentially triggering legal action. The U.S. [Securities and Exchange Commission \(SEC\)](#) and other regulators may see the collapse of FTX as justification for tightening regulatory scrutiny of cryptocurrencies, and Congress may be more inclined to step in and create new laws governing digital tokens and exchanges.<sup>21</sup>

The stunning collapse of the third-largest crypto exchange by volume will send shock waves through the crypto universe for some time. To date, crypto lender [BlockFi](#) paused client withdrawals on Nov. 11, 2022, and rumors indicate it may have a dicey future. [Crypto.com](#) saw withdrawals increase Nov. 12–13, 2022. [Genesis Global Trading](#) halted customer withdrawals from its crypto lending unit.

### How did FTX fail?

FTX filed for bankruptcy on Nov. 11, 2022, after a surge of customer withdrawals earlier in the month. Then-CEO Sam Bankman-Fried admitted that the company didn’t have sufficient assets [in reserve](#) to meet customer demand.

## **Did FTX get hacked?**

Within hours of filing for bankruptcy, FTX alleged that it was hacked. The exchange noted “unauthorized transactions” that may have stolen close to \$500 million in assets, and that were spotted by Elliptic, a crypto compliance service. The hacker continued to drain wallets for several days, using what analysts called “on-chain spoofing.” The hacker reportedly then invested those funds in Ether (ETH).<sup>22</sup>

## **What happens next to ex-FTX CEO Bankman-Fried?**

Bankman-Fried is set to face trial on eight criminal charges on Oct. 2, 2023. After a court hearing on Dec. 22, 2022, a federal judge decided to release Bankman-Fried from custody after his attorneys and federal prosecutors agreed to a \$250 million bond, the largest ever. He will live with his law professor parents in Palo Alto, Calif., be confined to the Northern California area, and wear an electronic monitoring bracelet.<sup>18</sup> On Jan. 3, 2023, Bankman-Fried pleaded not guilty to all criminal charges in a federal court in New York.

## **The Bottom Line**

The fortunes of FTX and its founder and former CEO, Bankman-Fried, are linked. In November 2022, cryptocurrency exchange FTX collapsed over a period of 10 days. Following a report suggesting potential leverage and solvency concerns, the exchange faced a liquidity crisis and tried to negotiate a bailout by rival Binance that quickly fell through. Its CEO was later arrested, extradited to the U.S., released on a \$250 million bond, and now faces trial in October.

The implications for the future of FTX, and the collapse's impact on the broader cryptocurrency industry, are ongoing and difficult to assess.