The Instability of Crypto-Exchanges and Utility Tokens. *

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Abstract

We investigate the impact of reserve asset management strategies on the stability of cryptocurrency exchanges and the price of their issued utility tokens. Utilizing a global game framework, we explore how exchanges' equity levels, reserve assets, short-term payments, and exposure to Bitcoin price fluctuations affect their susceptibility to runs. Our findings highlight several key dynamics: exchanges with greater capital reserves are more resilient to external shocks and less prone to liquidity crises; the misappropriation of client funds for token investments significantly heightens the risk of a run; high short-term payments may increase the likelihood of runs during market turbulence,exposure to Bitcoin's volatility can both mitigate and exacerbate platform instability depending on market conditions. We also find that platform instability directly leads to instability in token prices. Specifically, higher equity levels are associated with higher token prices. The misappropriation of client funds to purchase self-issued tokens has an ambiguous impact on token prices. Additionally, holding large amounts of Bitcoin amplifies the impact of Bitcoin's price fluctuations on the token price.

Keywords: Cryptocurrency Exchanges; Reserve Asset Management; FTX ; Global Game; Bank-run

JEL Classification: G23, G28, G33

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1 Introduction

In recent years, the cryptocurrency market has witnessed a dramatic surge in trading activity with annual trading volume skyrocketing from a mere $2.1 trillion in 2017 to over $100 trillion by 2022[1]. This exponential growth in demand for cryptocurrency trading has led to the establishment of numerous crypto-exchanges, which, in turn, aggressively expanded their operations in an unregulated environment. However, amid this rapid expansion, scandals and frauds arose in terms of the operation of these cryptocurrency trading platforms. The most prominent example of these scandals is the sudden collapse of FTX, once the world's second-largest cryptocurrency exchange. The precipitous downfall of FTX underscores the risks associated with the misappropriation of client funds and lack of transparency in the exchange's financial statements. This incident has captured widespread media attention, sparking discussions among investors, regulators, and policymakers around the globe [2].

For many crypto-platforms, token issuance has become a common strategy for raising capital by offering investors potential future benefits tied to the platform's performance. FTX, for instance, issued its native token, FTT, to the public in 2019, initially priced at $1 per token. As FTX expanded and gained market share, the price of FTT surged, reaching over $60 at its peak. Just before the exchange's collapse in November 2022, the price of FTT remained above $25. However, between November 2 and November 10, FTX's rapid descent from a multi-billion-dollar exchange to bankruptcy unfolded in just over a week. The catalyst for the crisis came from a CoinDesk report on November 2, revealing that Alameda Research—FTX's sister hedge fund—held vast quantities of FTT in its portfolio and had secretly borrowed billions of dollars from FTX's client funds to

[1]The data for this trading volume summary statistics comes from CoinMarketCap.

[2]The collapse of FTX has been extensively covered by mainstream financial outlets, including Bloomberg, The Economist, Financial Times, Forbes, and the Wall Street Journal, etc. Janet Yellen, the U.S. Treasury Secretary and former Federal Reserve Chair, has suggested that the collapse of FTX can be regarded as a "Lehman moment" for the cryptocurrency market. The impact of FTX's fall on global financial stability was also discussed at the G20 Finance Ministers and Central Bank Governors meeting in April 2023.

finance these holdings. This revelation triggered a mass withdrawal of funds from the exchange, leading to FTX halting withdrawals on November 8, followed by its bankruptcy declaration on November 10. The collapse of FTX ranks among the largest financial scandals in recent history, resulting in multi-billion-dollar losses for clients and investors.

The FTX collapse exposes three key features that may be prevalent among other unregulated crypto-exchanges. First, FTX engaged in widespread misappropriation of client funds, funneling billions of dollars into Alameda's portfolio through aggressive accounting practices and programming strategies[3]. This misappropriation transformed FTX from a typical crypto-exchange into a de facto crypto-bank, with Alameda relying on client funds to maintain its trading positions. The collapse of FTX thus shares similarities with classic bank-run models(Diamond and Dybvig, 1983).

Second, exchanges commonly use utility tokens to incentivize participation and provide liquidity, but these tokens are highly sensitive to market conditions. The value of these tokens can fluctuate dramatically, particularly during market shocks such as significant changes in Bitcoin's price. When an exchange collapses, its utility token's value often follows suit.

Third, like other exchanges that collapsed during the same period, FTX's downfall occurred during the downward trend of Bitcoin prices. The Bitcoin market's volatility undoubtedly played a significant role in exacerbating the platform's instability.

Crypto platforms, especially exchanges, face significant challenges in managing their reserve assets. These challenges include high volatility of Reserve Assets, the liquidity risk of native tokens, lack of transparency, mismanagement of funds, and regulatory arbitrage.

In response to these challenges, in August 2024, the U.S. Securities and Exchange Commission (SEC) introduced revised regulations requiring crypto platforms to disclose detailed information re-

[3]According to the a report by the U.S. Securities and Exchange Commission (SEC), FTX diverted approximately $8 billion of client assets to Alameda without their consent. Additionally, FTX provided undisclosed preferential treatment to Alameda, allowing it to borrow tens of billions of dollars from FTX clients through a virtually unlimited "line of credit" that permitted a negative balance in its account.

garding their reserve assets, including their composition, size, and liquidity risks. However, despite the increasing regulatory pressure, few studies have explored how the reserve asset management strategies of cryptocurrency exchanges impact their stability. Furthermore, the influence of these strategies on the value of the platform's issued tokens remains unclear. This paper employs a global game framework (Carlsson and Van Damme, 1993; Morris and Shin, 1998, 2000) to analyze the impact of reserve asset management on exchange stability. Building on this framework, we further examine how such management practices affect the value of utility tokens issued by the platform.

In our model, clients deposit funds into the exchange for trading convenience, which is influenced by the platform's client base and network effects. The more clients engage with the platform, the greater the trading convenience. When a "run" occurs, where clients rapidly withdraw their funds, the trading convenience for remaining clients diminishes, creating a stronger incentive for others to follow suit. We investigate the equilibrium behavior of clients in such a scenario, where the decision to withdraw or remain on the platform is based on private signals regarding the platform's health.

Exchanges typically issue utility tokens that offer intrinsic benefits to participants. The value of these tokens is closely linked to clients' convenience yield (Sockin and Xiong, 2023). During a run on the platform, the value of the tokens drops precipitously. Unregulated exchanges may misappropriate customer funds to invest in their own tokens or in other cryptocurrencies, such as Bitcoin[4]. Many crypto platforms, including Binance and Coinbase, invest in Bitcoin as part of their reserve assets to safeguard against liquidity crises. However, Bitcoin's price volatility—largely disconnected from underlying fundamentals (Pagnotta, 2022)—presents an additional risk to platform stability .

This study aims to provide insights into how exchange strategies—such as equity levels, re-

[4]As reported by Coindesk, at the time of its collapse, approximately 40% of Alameda's collateral was composed of FTX's self-issued FTT tokens. One of the SEC's charges against FTX involved concealing the risks associated with the platform's exposure to its own illiquid assets, such as FTT.

serve asset management, and short-term payments—affect the likelihood of a run and the resulting volatility in token prices. Our analysis yields several key findings:

First, **Equity and Crisis Mitigation**: Exchanges with greater equity are more resilient to external shocks and are less prone to liquidity crises, effectively stabilizing the platform and maintaining a higher fundamental value for the utility token.

Second, **Bitcoin Exposure's Impact on Stability**: The interplay between Bitcoin's price movements and an exchange's Bitcoin investments plays a crucial role in the platform's overall stability. In a bull market, investments in Bitcoin can help reduce the risk of a run, but excessive exposure during a bear market can exacerbate the risk, as a drop in Bitcoin's price erodes the exchange's capacity to meet customer withdrawals.

Third ,**Risk of Fund Misappropriation**: The misappropriation of client funds to invest in self-issued tokens significantly raises the likelihood of a run, especially when the exchange's financial health is fragile. The value of the utility token is closely tied to the platform's stability, and in times of panic, its price is likely to crash, underscoring the necessity of robust financial practices and transparent token issuance policies.

Fourth, **Impact of High Short-Term Payments**: While high short-term payments may attract more users to deposit funds, they also make the exchange more susceptible to runs during periods of market turbulence. Without fundamental improvements in the platform's stability, offering high short-term payments amplifies the risk of a run.

The framework presented here sheds light on the dynamics between clients behavior, exchange strategies, and market conditions, offering valuable insights into how exchanges can better manage risks and enhance resilience to market shocks.

We make several contributions to the literature. First, we examine the factors influencing the instability of cryptocurrency platforms. A growing body of research has compared the advantages and

disadvantages of issuing tokens. Some studies explore the differences between issuing crypto tokens and traditional equity (Catalini and Gans, 2018; Bakos and Halaburda, 2019; Chod and Lyandres, 2021; Gryglewicz *et al.*, 2021; Malinova and Park, 2023). Lee and Parlour (2022) show that issuing crypto tokens can be efficient. Gan *et al.* (2021) examine the design of asset-backed Initial Coin Offerings (ICOs) to address the shortcomings of ICOs. Goldstein *et al.* (2024) discusse how utility tokens can curb rent-seeking activities in two-sided platforms with market power. Chod and Lyandres (2023) explore the benefits of pricing products in tokens. Chiu and Koeppl (2022) show that using transaction fees to finance mining is costly. Abadi and Brunnermeier (2018) demonstrate that no consensus method can simultaneously achieve fault-tolerance, resource-efficiency, and full transferability. Hinzen *et al.* (2022) present that Bitcoin's limited adoption as an equilibrium.

Many studies address the instability of cryptocurrencies. Klages-Mundt and Minca (2019) identify the possibility of a deleveraging spiral in the crypto market. Cong *et al.* (2021) show network effect amplifies utility token price. Pagnotta (2022) explore how interactions between user networks and miners' investments in network security can intensify Bitcoin price volatility. Sockin and Xiong (2023) show that network effects among users can result in a market failure when token prices are non-neutral . Uhlig (2022) builds a dynamic model to study the crash of the stablecoin Luna. Liu *et al.* (2023) provide empirical evidence that investor doubts about the system's sustainability led to Luna's downfall.

In contrast to these studies, we highlight how the instability of a platform can also affect the price of its utility token. We argue that both platform participants — who may not even use the utility token — and investors influence its token price. Specifically, we explore how the management of platform reserve assets impacts both platform stability and token prices, using the lens of coordination failure. Unlike traditional risk factors, as examined by Liu *et al.* (2022), we focus on the token price dynamics from the perspective of platform instability.

Second, we extend the bank run model (Diamond and Dybvig, 1983; Rochet and Vives, 2004; Goldstein and Pauzner, 2005). Previous research employed the global game framework to study bank runs (Vives, 2014; Liu, 2016; Eisenbach, 2017; Goldstein *et al.*, 2020; Liu, 2023). However, cryptocurrency platforms have huge differences from traditional banks. They also issue their own tokens, and the broader cryptocurrency market exerts a significant influence on these platforms.

The paper is organized as follows. Section 2 provides a model setup. Section 3 characterizes the model equilibrium. Section 4 presents the equilibrium analysis. Section 5 discusses the policy implications. Section 6 concludes our paper.

2 Model

2.1 Setup

Consider a centralized crypto-exchange platform that reduces trading frictions among a pool of clients. To facilitate transactions, clients deposit their funds into the crypto-exchange's wallet. The benefit of depositing in the exchange is the **convenience yield**, which clients' benefit in trading. The convenience yield depends on both the platform's services and trading volume. To expand in the short term, the platform subsidizes consumers. The exchange issues a utility token that helps reduce transaction fees. The value of this utility token is linked to the convenience yield.

The crypto-exchange, however, can misappropriate clients' funds. For example, Coindesk reported that FTX misappropriated billions of dollars in client funds. Some of these funds were invested in risky cryptocurrencies such as Bitcoin, while others were used to purchase the exchange's own utility tokens, inflating their price.

There are three dates in this model ($t = 0, 1, 2$). At date 0, N clients each deposit 1 dollar into the crypto-exchange. The exchange's equity is denoted by \$E\$. At this point, the exchange misappropriates a fraction of the client funds: bN dollars are invested in risky cryptocurrencies such as Bitcoin, while sN dollars are invested in the exchange's self-issued utility tokens.

Each consumer then decides whether to withdraw their funds at date 1, with $a_i \in \{0,1\}$. If a client withdraws at date 1 ($a_i = 1$), they receive a fixed payment of $1 + c_1$ ($c_1 > 0$). This payment is made by the exchange. If the client chooses to wait until date 2 ($a_i = 0$), they receive $1 + \widetilde{R}$, provided the crypto-exchange does not fail. Here, $\widetilde{R}$ represents the stochastic convenience yield, which arises from trading opportunities and platform services.

The stochastic convenience yield depends on the exchange service quality, denoted by $\widetilde{\theta}$, and the number of consumers, N. We use N as a proxy for trading volume. A higher $\widetilde{\theta}$ represents better service, while a larger N provides more trading opportunities due to network effects. We assume that the convenience yield increases with N. If there are no clients, clients prefer to withdrawing at date 1, $E[\widetilde{R}(\widetilde{\theta},0)] < c_1$. Importantly, the crypto-exchange does not directly pay the convenience yield to clients. Since this yield naturally arises over the long term, it is efficient for clients to stay on the platform until date 2. To incentivize clients to wait, we assume that the expected convenience yield, $E[\widetilde{R}(\widetilde{\theta},N)]$, is greater than the fixed payment, c_1, provided that all clients stay on the exchange until date 2. We have the following assumption.

Assumption 1. *The stochastic convenience yield $\widetilde{R}(\widetilde{\theta},N)$ continuously increases with $\widetilde{\theta}$ and N. $E[\widetilde{R}(\widetilde{\theta},N)] > c_1$, $E[\widetilde{R}(\widetilde{\theta},0)] < c_1$.*

If the exchange cannot meet the withdrawal demands of clients at date 1, it fails. Clients who choose to wait until date 2 receive nothing. We assume that clients can always receive the fixed payment $1 + c_1$ if they withdraw at date 1.

The utility differential between withdrawing at date 2 versus date 1 is given by:

$$\begin{cases} u(1+\widetilde{R}(\widetilde{\theta},N-A)) - u(1+c_1), & \text{if} \quad A(1+c_1) \leq E + (1-s-b)*N + bNR^B \\ 0 - u(1+c_1), & \text{if} \quad A(1+c_1) > E + (1-s-b)*N + bNR^B. \end{cases} \tag{1}$$

Here, A is the total number of clients who choose to withdraw at date 1, and R^B denotes the return

of Bitcoin between date 0 and date 1. If $A(1+c_1) \leq E+(1-s-b)*N+bNR^B$, the exchange has enough funds to meet clients' withdrawal requests at date 1. Clients who stay until date 2 receive $1+\widetilde{R}(\widetilde{\theta},N-A)$. If $A(1+c_1) > E+(1-s-b)*N+bNR^B$, the exchange fails and clients receive nothing. We assume that the exchange can sell Bitcoins and the Bitcoin price is not affected by clients withdrawals. However, the exchange cannot sell its utility tokens to meet the demand of withdrawals. The utility token market is illiquid especially in a panic. Clients are also very pessimistic about the value of the tokens issued by the platform. For example, when clients withdraw from the FTX exchange, the exchange cannot sell FTT to pay these clients.

The payoff function has similar properties to the bank run model (Diamond and Dybvig (1983)). The difference is that the network effect plays an important role when clients withdraw from the exchange. Due to network effects, clients receive a reduced convenience yield as more clients withdraw from the exchange. This creates a **strategic complementarity**: clients' incentive to withdraw increases as more others choose to withdraw.

In a complete information scenario, where clients know the exchange service $\widetilde{\theta}$ and the actions of others, there are multiple equilibria. Clients will choose to stay on the exchange until date 2 if they know that all others will do the same. Conversely, they will choose to withdraw their funds at date 1 if they know that all others will withdraw. While the convenience yield arises at date 2, it would be inefficient for clients to withdraw at date 1. In contrast to the bank run, where withdrawals are motivated by fears of other depositors' actions, in the exchange run, client withdrawals harm the exchange's fundamental value due to network effects.

We assume that clients only receive private noisy signals x_i about $\widetilde{\theta}$ at date 1.

$$x_i = \widetilde{\theta} + \varepsilon_i, \tag{2}$$

where ε_i are small error terms that are independently and uniformly distributed over $[-\varepsilon, \varepsilon]$. We

assume that the exchange service $\widetilde{\theta}$, which measures the quality of the exchange, is normally distributed over $N(\mu, \delta)$. The quality of the exchange $\widetilde{\theta}$ is realized at date 1, but is publicly revealed only at date 2. At date 1, clients' decisions depend solely on the signal they observe. A higher signal regarding $\widetilde{\theta}$ not only indicates a higher convenience yield but also suggests that other clients are more likely to receive a similarly high signal. As in the game in Goldstein and Pauzner (2005) andRochet and Vives (2004), when the signal is precise enough, clients will adopt a **threshold strategy** based on their signals.

2.2 Utility Token

Clients are not required to buy the exchange-issued utility tokens, though they do have use value. For instance, the tokens can offset transaction fees. The tokens are tradable on the market, and their value closely tied to the conditions and overall value of the platforms that issue them. A more valuable platform typically has more valuable tokens because the token's value is often linked to the platform's ability to provide utility, liquidity, and network effects.[5] In the token market, we assume that investors are heterogeneous, with the fundamental value of the utility token, v_i, normally distributed over $N(E[\widetilde{R}], \sigma)$. At date 0, there are N^e investors, each deciding whether to buy one token. The total supply of utility tokens is S, and the exchange misappropriates sN dollars to invest in these tokens. Let $X_i = 0$ if the investor purchases the token and $X_i = 0$ if he chooses not to purchase. The decision of whether to buy is given by:

$$\max_{X_i}(p_o - v_i)X_i. \tag{3}$$

[5]For instance, Binance Coin (BNB) is the native utility token of the Binance exchange. The larger the user base and the more active the platform, the higher value for BNB. As FTX provided more trading pairs, derivatives, and leveraged products, the value of FTT rose.

The token demand from investors is given by:

$$N^e(1-\Phi(\frac{p_0-E[\widetilde{R}]}{\sigma})).$$

where Φ is the cumulative distribution function of the standard normal distribution. The demand for tokens increases with the convenience yield $\widetilde{R}$. Market clearing in the token market implies that:

$$sN + p_0 * N^e(1-\Phi(\frac{p_0-E[\widetilde{R}]}{\sigma})) = p_0 * S. \tag{4}$$

The token price is determined by the exchange's misappropriations (s), the distribution of investors (σ), and the expected value of the token, $E[\widetilde{R}]$. Here we do not consider the number of investors N^e and the supply of tokens S. Furthermore, both the value of the exchange service $\widetilde{\theta}$ and the probability of a run on the exchange influence $E[\widetilde{R}]$, as will be discussed in the next section.

The timing of the model is as follows. At date 0, the exchange decides to misappropriate sN dollars to invest in the exchange-issued utility token and bN dollars to invest in Bitcoin. The token price is determined by market clearing. At date 1, after receiving the private signal about the exchange service, x_i, clients decide whether to withdraw their funds or wait until date 2. At date 2, clients who wait late receive the convenience yield from the exchange service. The model is solved backwards.

3 Equilibrium

3.1 Threshold equilibrium

In this section, we derive the equilibrium following Goldstein and Pauzner (2005). We begin by analyzing clients' decisions at date 1 for a given fixed payment c_1. Because clients are unaware of others' decisions at date 0, they must form expectations about others' actions based on their private signals. The higher the exchange service $\widetilde{\theta}$, the greater the stochastic convenience yield,

which strengthens clients' incentives to stay on the exchange until date 2. As more clients wish to stay, the network effect becomes stronger, reinforcing the incentive to stay. Thus, the incentive to remain on the exchange increases continuously with the private signal. The setup leads to a global game problem (Carlsson and Van Damme, 1993; Morris and Shin, 2000). Clients will withdraw at date 1 when the signal is low enough, and will wait until date 2 when the signal is high enough. We consider two extreme regions: one with very poor exchange service and one with very good exchange service, where each client's action depends solely on the realization of their private signal, independent of their beliefs about others' behaviors.

Lower dominance region. When θ is sufficiently low, withdrawing at date 1 is the dominant strategy. After receiving the signal, clients are certain that the expected utility, $E[u(1+\widetilde{R}(\widetilde{\theta},N))]$, will be lower than the utility from withdrawing at date 1, $u(1+c_1)$, even if all clients decide to wait until date 2. We denote by $\underline{\theta}$ the value of θ that solves

$$R(\underline{\theta},N) = c_1. \tag{5}$$

The interval $[-\infty,\underline{\theta}]$ is referred to as the lower dominance region. Each client withdraws at date 1 if their signal x_i is less than $\underline{\theta}-\varepsilon$. When $\widetilde{\theta} < \underline{\theta}-2\varepsilon$, all clients will know that others will also withdraw at date 1.

Upper dominance region. The upper dominance region is $[\overline{\theta},\infty]$, where $\overline{\theta}$ is the value of θ that solves

$$R(\overline{\theta},0) = c_1. \tag{6}$$

If $x_i > \overline{\theta}+\varepsilon$, each client will choose to wait until date 2, regardless of others' actions. When $\widetilde{\theta} > \overline{\theta}+2\varepsilon$, clients know that others' signals are also above $\overline{\theta}$, and thus all clients will choose to wait until date 2.

The intermediate region. When the signal indicates that $\widetilde{\theta}$ falls within the intermediate region $[\underline{\theta}, \overline{\theta}]$, a client's decision to withdraw at date 1 depends not only on their own signal but also on their beliefs regarding others' actions. If a client expects that all other clients will withdraw at date 1, their optimal strategy is to withdraw as well. Similarly, if they expects all other clients to keep their funds deposited in the exchange, their optimal strategy is to wait. This introduces strategic complementarity. The coordination problem among clients is analogous to the bank run problem (Diamond and Dybvig, 1983).

After receiving their private signal x_i, client i must form expectations about other clients' decisions. Their strategy profile is a function of their private signal x_i. The game represents a global game with a continuum of players and binary actions. The equilibrium of the game can be solved by referring to Rochet and Vives (2004) and Morris and Shin (2004). As $\varepsilon \to 0$, there exists a unique equilibrium where a client withdraws at date 1 if and only if their signal is below the threshold θ^*. Clients are indifferent between withdrawing at date 1 and waiting until date 2 when the signal is θ^*.

Proposition 1. *There is a unique equilibrium in which clients withdraw if they observe a signal below the threshold θ^*, and do not withdraw if their signal is above this threshold. As $\varepsilon \to 0$, θ^* satisfies*

$$\int_0^{\hat{A}} u(1+R(\theta^*, N-A)) * \frac{1}{N} dA - u(1+c_1) = 0, \tag{7}$$

where $\hat{A} = \min(\frac{E+(1-s-b)N+bNR^B}{1+c_1}, N)$.

The proposition states that all clients will withdraw from the crypto-exchange at date 1 when the realization of the exchange service $\widetilde{\theta}$ falls below the threshold value θ^*. For $\widetilde{\theta}$ in the range $[-\infty, \underline{\theta}]$, clients will run because they expect the crypto-exchange service to be so poor that running is the dominant strategy. This is referred to as a *fundamental-based run*. For $\widetilde{\theta}$ in the range $[\underline{\theta}, \theta^*]$, clients run because they anticipate that others will withdraw, which reduces their convenience yield. The

runs are classified as *panic-based runs*. Panic-based runs harm market efficiency because clients' panic destroys the benefit of network effects, whereas fundamental-based runs do not.

A key distinction from bank runs is that clients' withdrawal requests undermine the fundamental value of the exchange. In the case of the FTX collapse, for example, the CoinDesk news on November 2 served as the initial negative signal, and panic-stricken clients coordinated on the equilibrium of submitting withdrawal requests. The resulting withdrawals and devaluation of FTT led to a solvency crisis.

3.2 Token Price

At date 0, investors can infer the ex-ante probability of a crypto-exchange run at date 1. Since the fundamental of the exchange $\widetilde{\theta}$ is normally distributed as $N(\mu, \delta)$, the probability of a run is given by

$$q = \Phi(\frac{\theta^* - \mu}{\delta}), \tag{8}$$

where Φ is the cumulative distribution function of the standard normal distribution. The lower the threshold value θ^*, the more stable the exchange is. The probability of a run affects the fundamental value of the utility token. The expected value of the convenience yield is given by

$$E\widetilde{R} = \int_{-\infty}^{\theta^*} R(\theta, 0)\phi(\theta)d\theta + \int_{\theta^*}^{\infty} R(\theta, N)\phi(\theta)d\theta. \tag{9}$$

$\phi(\theta)$ is the probability density function of $\widetilde{\theta}$. Since the convenience yield increases with the number of clients N, a lower threshold θ^* leads to a higher convenience yield. Combined with equation (12), a lower threshold θ^* increases the ex-ante price by raising the expected value of the token.

4 Equilibrium Analysis

4.1 Instability of Crypto-Exchanges

The stability of crypto platforms is vital to crypto industry. The FTX collapse in late 2022 led to the loss of billion of dollars worth of users' assets. Large crypto exchange, such as Binance and Coinbase play a pivotal role in the entire crypto market. If such a platform fails, the ripple effects can affect broader financial system. The collapse of TerraUSD led to market-wide panic.

There are many challenges to crypto platform stability. Many crypto platforms do not have clear governance structures. There is a lack of transparency regarding their financial operations. Security is also a major concern. Many crypto platforms are frequent targets for hackers. Some crypto platforms rely heavily on their utility tokens. If the market for these tokens collapses, the platform will also be in trouble. Besides, cryptocurrencies are inherently volatile assets. During market downturn, exchanges often face liquidity concerns.

In this model, we focus on the impact of exchange management strategies on their stability, as well as the influence of Bitcoin market shocks on exchange stability. The strategies include reserve asset management s and b, equity levels E, and short-term payment c. Proposition 2 shows that all these factors can influence the threshold value θ^*.

In terms of the shock of the Bitcoin market, a higher Bitcoin return R^B increases the exchange's ability to handle consumers' withdrawal demands, leading to a decrease in the threshold θ^*. This makes the exchange less likely to experience a run, which is why cryptocurrency platforms are rarely seen going bankrupt during a Bitcoin bull market. Conversely, during a bear market, the exchange becomes more vulnerable. The effect of the exchange's Bitcoin investment b on the probability of a run depends on the return R^B. In a bull market, a higher investment in Bitcoin reduces the likelihood of a panic run, while in a bear market, excessive Bitcoin investments increase the likelihood of a run.

Misappropriating consumer funds to invest in self-issued tokens, s, increases the threshold value θ^*. When a crypto-exchange issues tokens, these tokens may face a liquidity crisis if consumers panic. In such cases, the exchange cannot sell these tokens to repay withdrawal requests. For instance, when users attempted to withdraw funds from the FTX exchange, FTX was unable to sell its own utility token, FTT, to settle withdrawals. As more consumers withdrew, the fundamental value of FTT decreased, causing its price to plummet to zero. This creates a vicious cycle: the more the exchange invests in its self-issued tokens, the more consumers worry about the exchange's solvency, which drives further withdrawals.

Increasing the payment at date 1, c_1, raises the threshold value θ^*. A higher c_1 makes the payoff from withdrawing at date 1 more attractive compared to the convenience yield at date 2. Increasing c_1 also raises the exchange's burdens, making it more likely to fail if consumers panic. While the exchange may use the short-term payment c_1 to attract more depositors, doing so exacerbates the exchange's instability if its fundamentals do not improve.

The exchange's equity E reduces the threshold value θ^*. A well-capitalized crypto-exchange is less likely to face a liquidity crisis, and consumers are less concerned about the exchange's solvency. This, in turn, reduces the likelihood of a run. In contrast, exchanges with insufficient capital make consumers more likely to withdraw at date 1 due to concerns about the safety of their funds.

Proposition 2. *The threshold θ^* is increasing in s and c_1, $\frac{\partial \theta^*}{\partial s} > 0, \frac{\partial \theta^*}{\partial c_1} > 0$. The threshold θ^* is decreasing in E and R^B, $\frac{\partial \theta^*}{\partial E} < 0, \frac{\partial \theta^*}{\partial R^B} < 0$. If $R^B > 1$, the threshold θ^* is increasing in b, $\frac{\partial \theta^*}{\partial b} > 0$. If $R^B < 1$, the threshold θ^* is decreasing in b, $\frac{\partial \theta^*}{\partial b} < 0$.*

4.2 The Utility Token Price

Assume the supply of the utility tokens is fixed. Both investors' demand and the expected value of the utility tokens influence their price. As shown in equation (11), the expected value

of the token decreases as the probability of a run increases. The instability of the token is thus linked to the instability of the exchange platform. Proposition 3 indicates that the exchange's investment strategy, including its allocations to s and b, payment strategy c_1, and equity holdings E, all influence the token price.

The token price decreases as c_1 increases. A higher payment increases the probability of a run, which in turn raises the likelihood that the fundamental value of the utility token will fall. Conversely, the token price increases with the exchange's equity E. A well-capitalized exchange is more likely to meet consumers' withdrawal demands, and a lower probability of failure leads to a higher token price.

Misappropriating consumer funds to invest in the exchange's self-issued tokens has ambiguous effects on the token price. On the one hand, purchasing the utility token directly boosts its price, especially when the market for the token is not large enough. On the other hand, misappropriating consumer funds increases the probability of a run. Therefore, the token price will be lower if the exchange is more fragile.

Proposition 3. *The equilibrium price p_0 is decreasing in c_1 and increasing in E. Misappropriating consumer funds to invest in utility tokens, s, has an ambiguous effect on its equilibrium price.*

5 Regulation Discussion

Similar to a bank-run model, the clients' withdrawal, which stems from their apprehension regarding the exchange's solvency, is the primary source that drives the failure of a crypto-exchange. However, it's important to underline several distinctions between a bank run and a crypto exchange run. First, in a bank run, the depositors' withdrawal only creates a liquidity mismatch but does not undermine the bank's long-term fundamentals. However, in a crypto exchange run, when clients withdraw their funds, the exchange loses its value, which consequently leads to the depreciation of the tokens it has issued. Second, most crypto exchanges issue their utility tokens and their oper-

ations heavily rely on these tokens. Third, the network effect is vital to the efficiency of resource allocation. Fourth, the banking industry is subject to stringent regulations, whereas the regulatory landscape for the cryptocurrency industry is just beginning to take shape. Based on these differences, we will now discuss the impact of various regulatory policies.

To illustrate the policy effect, we provide a series of numerical examples. We specify the function for the convenience yield. We assume that the stochastic convenience yield is given by:

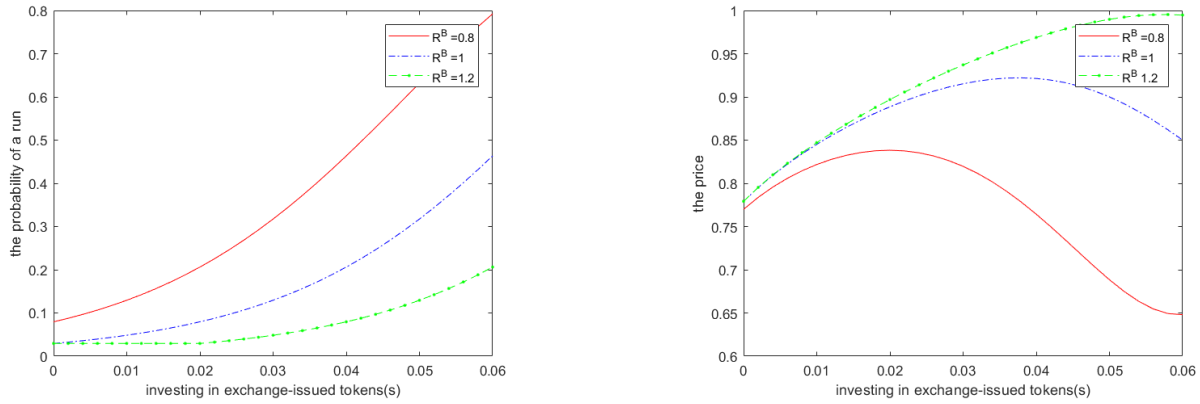
$$\widetilde{R} = \frac{\widetilde{\theta}\beta(1-\alpha^N)}{1-\beta\alpha^N}.$$

where, as stated in Assumption 1, $\widetilde{R}$ is increasing in both $\widetilde{\theta}$ and N. The variable $\widetilde{\theta}$ represents the fundamental value of the exchange service, with a higher $\widetilde{\theta}$ indicating a better service. [6] Assume that consumers have a constant relative risk aversion utility function, $u(c_1) = \frac{c_1^{1-\gamma}}{1-\gamma}$. The parameters are set to better illustrate the properties of our model. Changing parameters does not change our results. Assume $\beta = 0.98, \alpha^N = 0.3679, \gamma = 0.9$, $\widetilde{\theta} \sim N(\mu, \delta)$, where $\mu = 1$ and $\delta = 0.5$.

5.1 Client's Fund Custodian

Custodial management of client funds can significantly reduce the likelihood of a run on the exchange. To better understand the necessity of custodial management, we first explore the impact of exchanges misappropriating client funds to purchase their own issued tokens on the exchange's stability and token price. We assume that $\beta = 0.98, \alpha^N = 0.3679, \gamma = 0.9, \mu = 1, \delta = 0.5, \sigma = 0.2, b = 0.1, c_1 = 0.05, S = 100{,}000, N = 1{,}000{,}000, N^e = 120{,}000$. Figure 1 presents scenarios with Bitcoin returns R^B of 0.8, 1, and 1.2, respectively. As Figure 1a illustrates, misappropriating client funds to buy the exchange's own tokens significantly raises the likelihood of a run on the exchange. When Bitcoin prices decline, this misuse of funds exacerbates the instability of the

[6] Following Rogoff and You (2023) we specify the value of the token as $\widetilde{R} = \beta(1-\alpha^N)\widetilde{\theta} + \beta\alpha^N\widetilde{R}$, where β is the time discount factor and $1-\alpha^N$ is the trading probability. With probability $1-\alpha^N$, consumers receive $\widetilde{\theta}$ from trading. With probability α^N, consumers retain the token.



(a) **(b)**

Figure 1: The Impact of Misappropriating Client Funds to Purchase Tokens

exchange. Therefore, to keep the probability of a run at a lower level, it is particularly important to safeguard client funds during Bitcoin bear markets. However, Figure 1b shows the effect of this fund misappropriation on the exchange's token price. On one hand, buying tokens directly increases the overall market demand, driving up the token price. On the other hand, the increased run probability damages the token's value, leading to a decrease in its price. Thus, without a custodial system, exchanges have an incentive to misappropriate client funds to inflate the token price. The negative side effects of misappropriating client funds on the token price become more severe only when Bitcoin prices fall. Therefore, during Bitcoin bull markets, exchanges are less concerned about misusing client funds.

In practice, policymakers have made some progress in making the custody of client funds an important rule for cryptocurrency exchanges to abide by. For example, the Hong Kong Securities and Futures Commission (SFC) announced *Licensing Handbook for Virtual Asset Trading Platform Operators* and required that a cryptocurrency exchange operator should only hold client assets through an associated entity that should not conduct any business other than that of receiving or holding client assets on behalf of the exchange according to the clause 3.2.22 in the SFC Licensing Handbook.

The new challenge is how to implement an effective custody of clients' crypto-assets in practice.

The reality is that very few reputable traditional banks or financial institutions can provide custodian services under the changing regulatory environment for cryptocurrencies. The blockchain technology grants full control rights of assets to crypto-wallet owners who possess the private keys. If the exchange controls private keys, we further need to audit these custodian wallets and make sure that the exchange cannot swap its clients' crypto-assets into other types of cryptocurrencies without the clients' consent. On the other hand, if a custodian agency manages the private keys, it must bear the burden of handling deposit and withdrawal requests for a very large number of different cryptocurrencies. Furthermore, the custodian may also need to pay gas fees and address additional cybersecurity hacking risks. The sophistication and operation costs are much higher than the custodian service with a conventional bank account — that is why traditional banks exhibit great hesitance to provide crypto custodian services.[7]

5.2 Capital Requirement

As banks are required to maintain capital reserves, crypto exchanges should also have capital requirements. Adequate capital reserves are crucial not only for maintaining the stability of an exchange but also for stabilizing the price of the tokens issued by the platform. Figure 2 illustrates the impact of an exchange's capital reserves on the probability of a run and token price under various scenarios. We assume that $\beta = 0.98, \alpha^N = 0.3679, \gamma = 0.9, \mu = 1, \delta = 0.5, \sigma = 0.2, c_1 = 0.05, S = 100,000, N = 1,000,000, N^e = 120,000$. In Figures 2a and 2b, we assume $b = 0.1$, and we show the effects of equity with Bitcoin returns of 0.8, 1, and 1.2, respectively. The higher the exchange's capital reserves, the lower the probability of a run. During periods of falling Bitcoin prices, maintaining sufficient capital becomes even more important to ensure platform stability. To keep the run probability within a reasonable range during a Bitcoin bear market, exchanges must hold more capital. Furthermore, the more capital the exchange holds, the higher the token price

[7] One possibility is to let the insurance company cover the potential loss in the crypto wallets and guarantee exchange solvency. For example, Hashkey Exchange, a licensed Hong Kong crypto-exchange, collaborates with OneDegree (an insurance provider for digital assets) to obtain crypto wallet insurance.

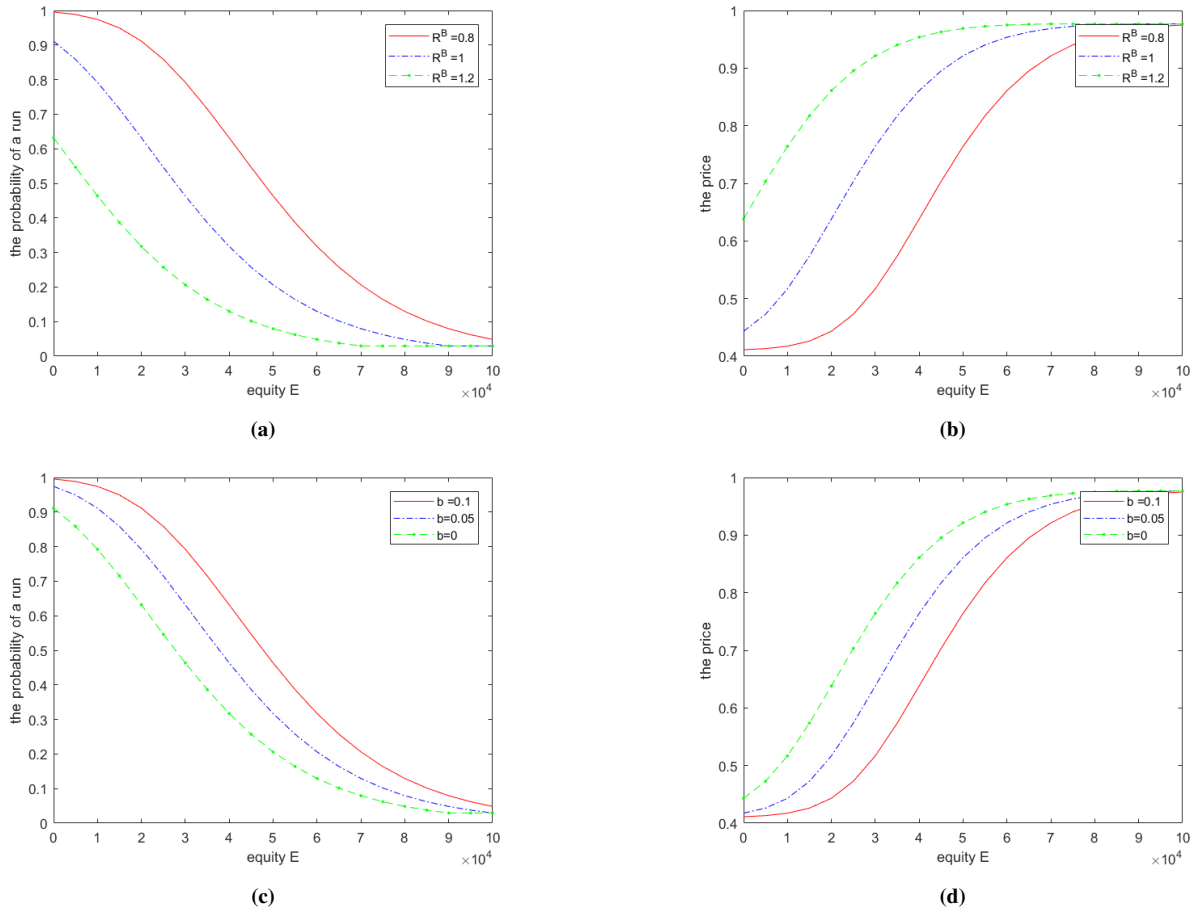


Figure 2: The Impact of Exchange Equity

tends to be. Therefore, maintaining sufficient capital reserves is critical for stabilizing token prices as well. In times of falling Bitcoin prices, platforms must retain more capital to maintain the token price.

Figures 2c and 2d show the impact of exchange capital on platform stability and token price in a Bitcoin bear market. We assume $R^B = 0.8$. The analysis considers exchanges holding different amounts of Bitcoin, with b of 0, 0.05, and 0.1. The more Bitcoin an exchange holds, the higher the capital reserves required to keep the run probability low. To maintain token prices, exchanges need more capital reserves as they hold more Bitcoin. Consequently, regulations should stipulate that the more cryptocurrencies, such as Bitcoin, an exchange holds, the higher its required capital reserves should be.

5.3 Suspension of Convertibility

Suspending client withdrawals can avert a panic-induced run, but the price paid is higher than that of banks suspending withdrawals. The suspension of convertibility can effectively quell a bank run, because it alleviates the concerns among bank depositors that withdrawals of other depositors might lead to bankruptcy and provides sufficient time for long-maturity loans to replenish liquidity. In this model, when θ is in the interval $(\overline{\theta}, \theta^*)$, the run on the exchange is driven by panic because if clients know that others are not withdrawing, they will understand that the convenience yield remains higher than short-term payouts, thus preventing a run. However, since exchange clients have greater demands for liquidity, this inevitably incurs a greater cost. On the other hand, if the token price continues to decline and sparks concerns about the exchange's solvency, halting withdrawals cannot save the exchange. In fact, doing so may further depress the token's value, intensifying client panic.

One feasible option to avert the collapse of FTX was an acquisition by another major crypto-exchange. The endorsement from the acquisition can stop investors from withdrawing their funds from FTX and encourage them to continue their cryptocurrency trading activity on the exchange trading platform. This would help keeping FTX solvent and boost the FTT token prices. As the FTT price rebounds, the crypto-run issue can be addressed endogenously, as FTX would be able to sell its FTT tokens at a more favorable price to satisfy its clients' withdrawal requests. Only through such a combination of both bailout measures and suspension-of-convertibility, the exchange can ensure its survival when confronted with the impending threat of a crypto-run.

5.4 Deposit Insurance

Another commonly-used policy tool to prevent a bank run is deposit insurance. In the context of a crypto-run, introducing a similar insurance policy for the investors' funds deposited in the exchange can serve as a theoretically effective approach to prevent a crypto-run. If investors can

be assured that, regardless of the exchange's solvency status, they are always able to receive their deposited assets back, they will choose to keep their funds in the exchange because they can enjoy the additional convenience yield from the exchange-provided trading service. Consequently, the deposit insurance can address the risk that investors' withdrawals make the exchange insolvent and hence prevent a crypto-run.

Despite the theoretical merits described above, a more important question is who should provide the insurance for the investors on the crypto-exchange in practice. Should a private insurance company assume this role, the insurance premiums could become prohibitively expensive. This predicament arises because private insurers often lack the means to effectively monitor the exchange's business operations, which leaves them unable to prevent potential misappropriations of investors' funds by the exchange. Consequently, this exposes the private insurer to significant moral hazard issues. Facing the dilemma, the private insurance company may be compelled to demand exorbitant premiums to offset such risk, and this will make the private investor-insurance scheme practically infeasible.

In contrast, a public deposit insurance scheme provided by the government may have the virtue that the insurance premium can be reduced by implementing effective oversight of the crypto-exchange. For instance, if a regulator can monitor the exchange's operations, audit its financial statements, and hold exchange operators accountable for any misconduct, the concerns related to moral hazard in insurance provision can be significantly mitigated. This, in turn, leads to more affordable investor insurance costs for the exchange and ultimately lowers the overall expenses incurred by crypto-investors. The example of public insurance scheme illustrated here suggests that well-designed regulatory guidance can actually benefit regulated crypto-exchanges by preventing crypto-run and enabling them to provide a low-cost and safe trading venue for crypto-investors.

6 Conclusion

The collapse of FTX highlighted critical vulnerabilities in the cryptocurrency exchange ecosystem, underscoring the significant risks posed by unregulated platforms, poor reserve asset management, and the misappropriation of client funds. Through our model, we have shown how these factors contribute to exchange instability and token price volatility, offering new insights into the dynamics of cryptocurrency platforms. Specifically, we find that platforms with higher equity reserves are better equipped to weather external shocks, while excessive exposure to volatile assets like Bitcoin can exacerbate instability during market downturns. Moreover, the misallocation of client funds, particularly when used to support illiquid self-issued tokens, increases the likelihood of a "run" on the platform and a subsequent crash in token prices.

Our analysis highlights the role of exchange strategies—such as equity management, reserve diversification, and short-term payment policies—in shaping both platform stability and the value of utility tokens. The interplay between platform health and token price dynamics suggests that participants and investors alike are highly sensitive to signs of instability, which can trigger cascading withdrawals and amplify market volatility. In this context, regulatory interventions such as the SEC's revised disclosure requirements on reserve assets are crucial for enhancing transparency and mitigating risks.

This paper contributes to the growing body of research on cryptocurrency platform instability by extending traditional bank run models to account for the unique characteristics of crypto-exchanges, including their issuance of utility tokens. Future studies should explore the long-term effects of regulatory measures on platform stability, token market behavior, and overall market confidence. Additionally, further work is needed to refine the models of reserve asset management, especially in light of the evolving landscape of global cryptocurrency regulations and the increasing interconnections between crypto-exchanges and the broader financial system.

By providing a theoretical framework for understanding the complex interactions between exchange behavior, asset management, and token dynamics, this study offers practical insights for both market participants and regulators seeking to improve the resilience of cryptocurrency platforms in an increasingly volatile environment.

Appendix

A Proofs

Proof of Proposition 1. The proof follows Goldstein and Pauzner (2005). There is a unique equilibrium in which clients run if and only if the signal they receive is below a common signal θ^*. The fraction n of clients withdrawing at date 1 is equal to the probability of receiving a signal x_i below θ^*, $n = \frac{A}{N}$. Because clients' signals are independent and uniformly distributed over the interval $[\widetilde{\theta} - \varepsilon, \widetilde{\theta} + \varepsilon]$, n satisfies,

$$n(\widetilde{\theta}, \theta^*) = \begin{cases} 1 & \text{if} \quad \widetilde{\theta} \leq \theta^* - \varepsilon \\ \frac{\theta^* - \widetilde{\theta} + \varepsilon}{2\varepsilon} & \text{if} \quad \theta^* - \varepsilon \leq \widetilde{\theta} \leq \theta^* + \varepsilon \\ 0 & \text{if} \quad \widetilde{\theta} \geq \theta^* + \varepsilon \end{cases}$$

When $\widetilde{\theta}$ is below $\theta^* - \varepsilon$, all clients receive a signal below θ^* and run. When $\widetilde{\theta}$ is above $\theta^* + \varepsilon$, all clients wait until date 2. In the intermediate interval, when $\widetilde{\theta}$ is between $\theta^* - \varepsilon$ and $\theta^* + \varepsilon$, the proportion of clients withdrawing at date 1 decreases linearly with $\widetilde{\theta}$. A client who receives the signal θ^* must be indifferent between withdrawing at date 1 and at date 2.

$$\int_0^{\hat{A}} u(1 + R(\theta(A), N - A)) * \frac{1}{N} dA - u(1 + c_1) = 0, \tag{10}$$

where $\hat{A} = \min(\frac{E + (1-s-b)N + bNR^B}{1+c_1}, N)$, $\theta(A) = \theta^* + \varepsilon - 2\varepsilon\frac{A}{N}$. When $\varepsilon \to 0$, $\theta(A) \to \theta^*$. Solving (10) with respect to θ^* gives the threshold.

□

Proof of Proposition 2. We analyze the properties of the threshold θ^*. We denote equation (10) by $F(\theta^*, b, c_1, s, E, R^B)$. By the implicit function,

$$\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial s} = -\frac{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial s}}{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*}}.$$

$\hat{A}$ is non-increasing in s. Because $u(1 + R(\theta(A), N - A)) > 0$, $F(\theta^*, b, c_1, s, E, R^B)$ is increasing in $\hat{A}$. According to the chain rule, we obtain that $\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial s} \leq 0$. Because $R(\theta^*, N - A)$ is increasing in θ^*, $u(1 + R(\theta^*, N - A))$ is increasing in θ^*, we have that $\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*} > 0$. Therefore, $\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial s} \geq 0$.

Similarly,

$$\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial c_1} = -\frac{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial c_1}}{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*}}.$$

Because $\hat{A}$ is non-increasing in c_1, $\int_0^{\hat{A}} u(1 + R(\theta(A), N - A)) * \frac{1}{N} dA$ is non-increasing in c_1. $u(1 + c_1)$ is increasing in c_1. We obtain that $\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial c_1} < 0$. Therefore, $\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial c_1} > 0$.

$$\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial E} = -\frac{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial E}}{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*}}.$$

Because $F(\theta^*, b, c_1, s, E, R^B)$ is increasing in E, $\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial E} < 0$.

$$\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial R^B} = -\frac{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial R^B}}{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*}}.$$

Because $F(\theta^*, b, c_1, s, E, R^B)$ is increasing in R^B, $\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial R^B} < 0$.

$$\frac{\partial \theta^*(b, c_1, s, E, R^B)}{\partial b} = -\frac{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial b}}{\frac{\partial F(\theta^*, b, c_1, s, E, R^B)}{\partial \theta^*}}.$$

When $R^B > 1$, $\hat{A}$ is increasing in b, we obtain that $\frac{\partial F(\theta^*,b,c_1,s,E,R^B)}{\partial b} > 0$. Therefore, $\frac{\partial \theta^*(b,c_1,s,E,R^B)}{\partial b} < 0$. On the contrary, when $R^B < 1$, $\hat{A}$ is decreasing in b, $\frac{\partial F(\theta^*,b,c_1,s,E,R^B)}{\partial b} < 0$. We obtain that $\frac{\partial \theta^*(b,c_1,s,E,R^B)}{\partial b} > 0$. □

Proof of Proposition 3. First, we analyze the property of $E\widetilde{R}$. Because $R(\theta,0) < R(\theta,N)$, from equation

$$E\widetilde{R} = \int_{-\infty}^{\theta^*} R(\theta,0)\phi(\theta)d\theta + \int_{\theta^*}^{\infty} R(\theta,N)\phi(\theta)d\theta, \tag{11}$$

$E\widetilde{R}(\theta^*)$ is decreasing in θ^*. Investors' demand $N^e(1-\Phi(\frac{p_0-E[\widetilde{R}]}{\sigma}))$ is increasing in $E[\widetilde{R}]$. Based on the chain rule, investors' demand $N^e(1-\Phi(\frac{p_0-E[\widetilde{R}]}{\sigma}))$ is decreasing in θ^*.

According to the market clear condition,

$$sN + p_0 * N^e(1-\Phi(\frac{p_0-E[\widetilde{R}]}{\sigma})) = p_0 * S, \tag{12}$$

price p_0 increases with investors' demand. Therefore, token price p_0 decreases with θ^*. Combined with Proposition 2, we obtain that the token price p_0 is increasing in E and R^B and is decreasing in c_1. If $R^B > 1$, the token price p_0 increases in b. If $R^B < 1$, the token price p_0 decreases in b. As for s, on one hand, the increase of sN raises the token price. On the other hand, the decrease of investor demand due to the increase of s decreases the token price. Therefore, the effect of s on the token price is ambiguous.

□

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