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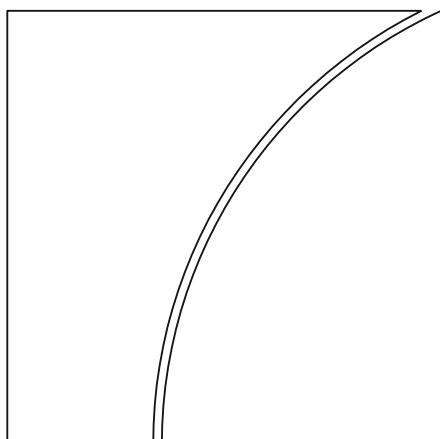
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Public information and stablecoin runs

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Keywords: stablecoins, crypto, global games, bank runs

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Public information and stablecoin runs

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Abstract

We provide a global games framework to study how the promise of par convertibility by various types of stablecoins breaks down. Public information disclosure has an ambiguous effect on run risk: greater transparency can lead to increased (reduced) run risk for sufficiently low (high) stablecoin holders' priors about reserve quality or transaction costs of conversion to fiat. If the distribution of reserve assets is fat-tailed (i.e. reserves are volatile), par convertibility is resilient to small shocks but fails with large negative public shocks, even for high initial reserve values. We find empirical support for the testable implications of the model.

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1 Introduction

Stablecoins (SCs) are crypto tokens that live on distributed ledgers and promise to be always worth a dollar.¹ Various ly likened to banks (Gorton and Zhang, 2023), exchange rate pegs (Levy Yeyati and Katz, 2022) and a combination of money market and exchange traded funds (Ma et al., 2023), the key defining feature of stablecoins is their promise to deliver par convertibility to the sovereign unit of account (Aldasoro et al., 2023). To make that promise credible, stablecoin issuers hold a variety of reserve (collateral) assets, including fiat-denominated money market instruments, Treasuries, bank deposits and other cryptoassets (including other stablecoins).

Public information and perceptions regarding the quality, transparency and volatility of reserves are thus key for stablecoin peg stability. This was evident during the March 2023 US banking turmoil. As stress in Silicon Valley Bank (SVB) mounted, the stablecoin USD Coin (USDC, known to have a yet-undisclosed amount of deposits at SVB) broke par (see Figure 1, red line). The situation deteriorated when Circle, the issuer of USDC, disclosed it held \$3.3 billion of its cash reserve at SVB (first vertical dashed line). This episode illustrates how a negative shock arising from increased *transparency* of reserves led to a shift in the aggregate behavior of coin holders. USDC had served as a stable reserve asset for other stablecoins such as Dai, which shortly thereafter lost its peg as well (solid black line): a negative shock to the perceived *volatility* of reserves that did not affect other (dollar-backed) stablecoins.² The situation only improved when the US government announced a backstop for SVB (third vertical dashed line).

This paper analyzes the effects of collateral disclosure and transparency as well as the perceived quality and volatility of reserve assets on stablecoins' peg stability. We develop a global game model to show that when the portfolio of collateral assets features low volatility, greater transparency can increase run risk if stablecoin holders' priors about collateral quality or transaction costs of conversion to fiat are sufficiently weak. Conversely, when priors about

¹Stablecoins arose from the need for a safe and stable unit of account within the notoriously volatile crypto universe. They witnessed a meteoric rise from \$5 billion market capitalization in early January 2020 to a record \$190 billion in early May 2022, and stood at around \$129 billion as of June 2023. Stablecoins firmly established themselves as the medium of exchange of, and gateway into, crypto. We focus on stablecoins pegged to the US dollar, as they make the lion's share of the market.

²Stablecoins such as Dai provide constant public visibility of the composition of reserves through on-chain mechanisms. Others like Circle do not continually disclose reserve assets and instead publish regular reports and attestations. We refer to *transparency* as relating to the frequency and credibility of this kind of public information, which contrasts with reserve *volatility* – large-scale fluctuations in the dollar value of reserves that may or may not be made transparent to the public.

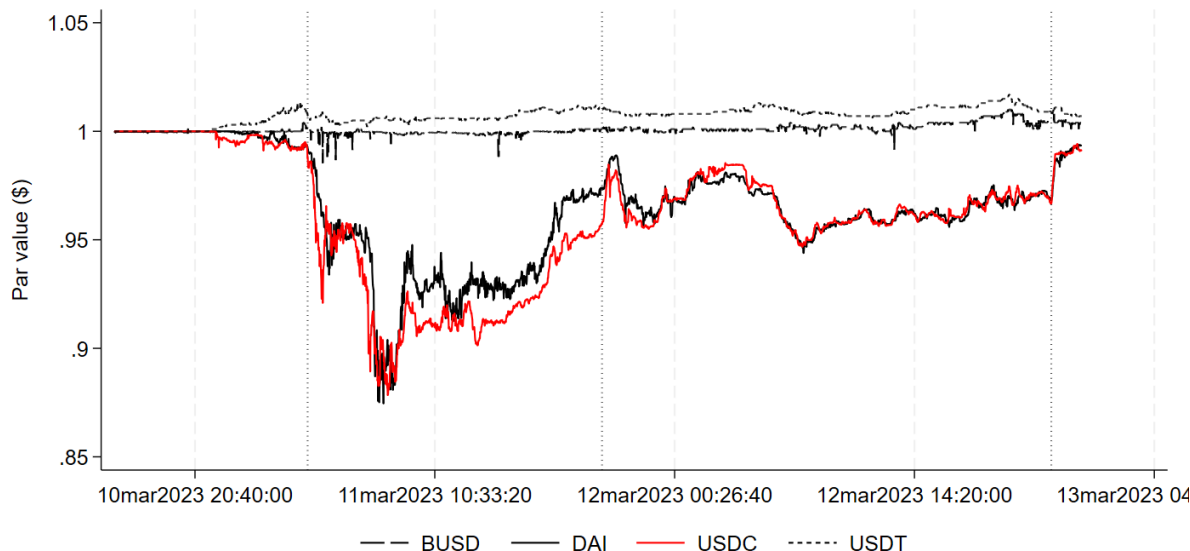


Figure 1: Stablecoin pegs around the run on Silicon Valley Bank.

Notes: Based on minute-by-minute data. The first vertical dashed line denotes Circle’s disclosure that \$3.3 billion of its cash reserve was held at SVB; the second line denotes the announcement by Circle that normal liquidity operations would resume by Monday 13 March; and the third line denotes the announcement of a backstop by the US government. Figure 14 in Appendix B.2 zooms in on the event to highlight more clearly the sequencing (USDC first, then Dai). Figure 15 shows this was a common feature of USDC-backed stablecoins, whereas those backed by other cryptoassets remained stable. Source: Cryptocompare.com.

collateral quality are strong or transaction costs are high, transparency can reduce run risk. We extend the model to show that when collateral assets are highly volatile, their dollar value is characterized by a fat tailed distribution. In such circumstances, par convertibility is resilient to small shocks (a *reversion to mean* effect) but collapses under large negative public shocks, even for high initial collateral values (a *change* effect). Drawing on several case studies and using a synthetic control approach to address endogeneity concerns, we find empirical support for the implications of the model.

We model a run on a stablecoin issuer as a regime change global game (Morris and Shin, 2003).³ This class of models is well suited to the study of stablecoins because, by design, they operate as a unilateral exchange rate peg to a reference asset (usually fiat money). Stablecoin

³Global games have been extensively studied in applications ranging from bank runs (Goldstein and Pauzner, 2005; Rochet and Vives, 2004) and currency crises (Morris and Shin, 1998; Angeletos et al., 2006), to political protests (Edmond, 2013; Little et al., 2015), the emergence of tax havens (Konrad and Stolper, 2016), and financial crises (Bebchuk and Goldstein, 2011). Recent work on stablecoins, discussed in more detail below, also employs global game techniques (e.g. Bertsch, 2023; Ma et al., 2023; d’Avernas et al., 2023; Gorton et al., 2022; Li and Mayer, 2021).

issuers are only able to meet redemption requests when a sufficiently small proportion of stablecoin holders demand conversion. When stablecoin holders have perfect information about the value of reserve assets, and this value enters a “ripe for run” region (i.e., the issuer becomes under-collateralized), there are multiple equilibria. Global games establish the conditions for a unique outcome to emerge under incomplete information, allowing us to derive the probability of a run and study the factors that shape it.

The model extends across two dates. At the initial date, the dollar value of a stablecoin issuer’s collateral is realized and stablecoin holders observe noisy signals about the true value of this collateral. At the final date, stablecoin holders decide whether to withdraw their holdings by demanding conversion to cash, or to roll over their holding. The issuer observes the aggregate size of redemption requests and is not able to defend par whenever the liquidation value of reserve assets is smaller than the value demanded by stablecoin holders. We assume that owing to positive, but small, transaction costs, stablecoin holders prefer to maintain a holding of coins.⁴ But since the issuer may be unable to defend par and collapse altogether, each stablecoin holder may prefer to dash for cash to avoid losing their holdings entirely. The strategic interactions among stablecoin holders depend on their *rank beliefs* – the probability each one assigns to the event that others have more pessimistic signals about the issuer’s ability to meet conversion requests. With small private noise, or when there are large public shocks, rank beliefs approach uniformity, pinning down a uniquely rationalizable action by each stablecoin holder. As a result, the degree of flight risk to which the issuer is exposed depends on the nature of stablecoin holder benefits, transaction costs, and the type of collateral held by the issuer.

Stablecoin issuers vary in the type of reserves they hold. Whereas fiat-, commodity- and certain crypto-backed stablecoins have low volatility in the value of their collateral reserve, algorithmic stablecoins employ policies that increase or decrease the supply of the coin, often using other crypto-assets that feature a large degree of volatility – effectively attempting to guarantee stability by shifting volatility to a paired token. To model these differences, we draw on two generations of global games suited to environments that feature a low degree of fundamental volatility (“first-generation global games”, (Morris and Shin, 1998)) and those that feature high volatility or model uncertainty (“second-generation global games”, (Morris

⁴These holdings yield benefits such as the option value of remaining in the crypto universe using stablecoins as collateral for investment purposes.

and Yildiz, 2019)).⁵

We first examine how run risk is related to the degree of transparency of the issuer’s collateral portfolio. We pin down a (globally) unique stablecoin run equilibrium for stablecoin issuers that hold low-volatility collateral, e.g., Tether (USDT) and USDC.⁶ Increasing the degree of transparency of reserves – through, for example, issuing public broadcasts or portfolio audits on a regular basis – provides stablecoin holders with common knowledge about the quality of the collateral. We find that the effect of public disclosure on run risk is ambiguous. Greater transparency can lead to increased run risk whenever stablecoin holders have sufficiently low priors about the collateral to begin with, or when transaction costs of conversion to fiat are sufficiently low. Conversely, heightened transparency lowers run risk when priors are strong or transaction costs are large. Our results highlight the nuanced but important role that public information has on stablecoin runs.

We then extend the model to introduce fat tails into the perceived distribution of the dollar value of reserve assets, capturing stablecoins that hold highly volatile assets. Prominent examples include TerraUSD (UST) and Frax. Fat tails capture the relatively high probability that stablecoin holders assign to extreme realizations of reserve asset values, generating uncertainty over the issuer’s ability to honour redemption requests. Heightened uncertainty about fundamentals undoes the uniqueness that characterizes traditional global games, leading to local multiplicity when the value of reserve assets enters an intermediate range. We embed the model in a dynamic global game (Chen and Suen, 2016) and appeal to hysteresis equilibrium (Morris and Yildiz, 2019) to form predictions about the effect of such tail risk on the probability of a stablecoin run. Importantly, whereas the thin-tailed global game predicts runs whenever collateral value drops below a threshold *level*, the fat-tailed global game requires both a fall in collateral value below a threshold and a sufficiently large *change* relative to previous periods to make running a uniquely rationalizable response by stablecoin holders.

Our model generates a set of testable implications. For stablecoin arrangements featuring low-volatility collateral and strong priors about collateral quality, pressure on the peg should

⁵While the global game in Morris and Shin (1998) is also a model of regime change, the payoff type in Morris and Yildiz (2019) produces a linear global game. We extend their model by applying the second-generation structure to a regime-change setting and studying how the game is affected by public information revelations.

⁶The mapping between our model variations and specific stablecoins is not written in stone, not least because our second model nests the first one. For example, the event discussed in Figure 1 represents an instance where perceptions about the value and volatility of reserve assets changes suddenly and sharply. Such changes can tip one stablecoin from one model environment to another.

decrease following an announcement about improvements in the quality of collateral assets used in the issuer’s portfolio. Conversely, the broadcasting of public information about reserves when there are doubts over the issuer’s reserve adequacy should lead to greater peg instability. When stablecoin collateral is highly volatile and its value enters a “ripe for run” region, holders pay close attention to past events and peg stability depends on shock size: the par promise is resilient to small negative shocks to collateral value (a *reversion to the mean* effect), but it breaks down in the face of large negative public shocks, even when initial collateral values are relatively high (a *change* effect).

In a first step, we empirically assess the implications of the first variant of our model with two event studies. The events respectively signal improvement and deterioration in collateral quality. The first event study exploits a change in the collateral policy of Dai, which in 2020 began accepting USDC as collateral.⁷ We think of this policy change as a shift in the perceived quality of reserves, given that Dai would no longer be 100% crypto-collateralized but would instead be partly backed by a crypto-based money-like asset (itself backed by off-chain dollar assets). The second event study exploits a series of publicized concerns over Tether’s reserve adequacy in 2018, signaling a reduction in the perceived quality of its reserves. Tether, the largest US dollar stablecoin, temporarily lost its peg of \$1 due to rising concerns that it was not 100% backed by US dollar assets (contrary to repeated claims by the issuer) and the alleged co-mingling of customer funds.

Our model predicts an improvement in Dai’s peg stability and a deterioration in Tether’s following these events, and we find empirical support for both predictions. For each event study we estimate the causal effect of a change in collateral quality (real or perceived) on stablecoin price stability, measured as the average of daily absolute price deviations from \$1 (Lyons and Viswanath-Natraj, 2023). To address endogeneity concerns we employ regression methods inspired by the synthetic control literature to construct counterfactual time series of stablecoin peg deviations that we compare against realized peg deviations before and after each event (Abadie and Gardeazabal, 2003; Doudchenko and Imbens, 2016). Using the pre-event sample, we first estimate dynamic regressions of the treated stablecoin’s peg deviations on a set of control units: measures of cryptoasset and financial market volatility along with the peg deviations of other non-treated stablecoins. We carefully select these control units such that they are likely to impact the price stability of the treated stablecoin

⁷Dai is a stablecoin pegged to the US dollar that was originally backed only by the cryptoasset Ether. It then expanded its reserve to other volatile cryptoassets (see third event study) and, eventually, to stablecoins.

but unlikely to be themselves affected by the policies or conditions of the treated stablecoin. The sequence of post-event counterfactual peg deviations are then generated by applying the regression parameter estimates to the post-event observations of the control units. Our results support the model predictions: Dai’s peg deviations decrease between 33% and up to 91% after the adoption of USDC collateral, whereas Tether’s peg deviations increased 9-fold, or close to 800% relative to the average counterfactual peg deviations after Tether’s reserves came under intense scrutiny.

We then test the predictions of the extended model featuring a fat-tailed distribution of the value of collateral assets. In particular, a third event study considers an early-stage collateral policy change by Dai in November 2018, when the collateral was expanded from just Ether to additional cryptoassets. Such a change represents a diversification of the collateral pool backing the stablecoin. Accordingly, the perceived volatility of Dai’s reserve asset portfolio should decline and peg stability should improve. Consistent with model predictions and following a similar empirical strategy as that in the first two event studies, we find evidence of a significant decline in peg deviations. In particular, following the transition from single- to multi-collateral, Dai’s realized peg deviations were about 69% lower on average than the counterfactual.

Finally, we test further the predictions of the second-generation model by examining the TerraUSD stablecoin. TerraUSD was the largest algorithmic stablecoin and third largest stablecoin overall at its peak before imploding in May 2022.⁸ TerraUSD was backed by Luna, a self-issued and highly volatile cryptoasset. Consistent with the predictions of the model, we find that higher Luna volatility (measured as the conditional standard deviation of Luna’s daily returns – our proxy for large reserve asset shocks) was associated with larger peg deviations in TerraUSD’s price even before its collapse. This link becomes stronger whenever the “equity value” of Terra, defined as the market capitalization of Luna minus that of TerraUSD, is low and hence the stablecoin is more vulnerable to a run (i.e. it is in a “ripe for run” region). These findings help rationalize the May 2021 UST depegging event (i.e. consistent with the *reversion to the mean* effect) as well as the final collapse in May 2022 (i.e. consistent with the *change* effect).

Our paper contributes to the understanding of stablecoins along multiple dimensions. We consider how (i) the quality of issuers’ reserve assets and (ii) public information about these

⁸See Uhlig (2022) for a model of TerraUSD and Liu et al. (2023) for a detailed analysis of the Terra ecosystem and its demise, consistent with our model predictions.

assets change both stablecoin exposure to run risk and the type of global game being played among stablecoin holders. We develop and empirically test theoretical predictions using event studies and a synthetic control approach across various stablecoins. While previous literature situates run risk in the broader stablecoin ecosystem, we study this run risk in detail, providing a richer classification of different types of stablecoins and their distinct run dynamics.

2 Related literature

Our paper contributes to a growing literature on stablecoins.⁹ Arner et al. (2020) provide an early non-technical overview that combines economic and legal perspectives, Mell and Yaga (2022) provide a comprehensive assessment of stablecoins from a technical standpoint, Barthélémy et al. (2023) show how stablecoin issuers' reserve management can spill over to the real economy, and Makarov and Schoar (2022) provide a broader overview of cryptoassets.¹⁰ Lyons and Viswanath-Natraj (2023) highlight arbitrage design as a source of stability for Tether and argue that decentralization of issuance and access to arbitrage trades with the issuing treasury are key for peg stability. While they focus on arbitrage to assess what makes a stablecoin stable, our question is rather what makes them unstable, with a focus on the role of reserve transparency and volatility. Li and Mayer (2021) derive stablecoin management strategies by issuers and agent demand for stablecoins in a dynamic model that focuses on the interplay between the endogenously determined stablecoin price (the exchange rate), reserve management and the issuer's equity shares or governance tokens. Whereas Li and Mayer (2021) shed light on issuer incentives around governance token issuance and debasement to mitigate stablecoin price volatility, we focus on stablecoin holder strategic incentives to maintain holdings for a given level of reserves and issuer equity. d'Avernas et al. (2023) in turn theoretically study stablecoin issuance as a commitment problem, potentially solvable through smart contracts. They consider various protocols for issuance and redemption and zoom in on *ex ante* design.¹¹ Instead, our focus is on how these factors may affect

⁹More broadly, it also relates to, and builds on, an extensive literature on bank runs and currency attacks mentioned above.

¹⁰See also Caramichael and Liao (2022), Eichengreen et al. (2023) and Levy Yeyati and Katz (2022), among others. Klages-Mundt and Minca (2021, 2022) provide early studies of deleveraging spirals and stablecoin runs within the computer science literature.

¹¹Li and Mayer (2021) also explore from a theoretical perspective the different stability strategies implemented by stablecoin issuers.

run dynamics for a given design, explicitly featuring coordination, strategic uncertainty and equilibrium selection. Moreover, their model does not study the transparency of reserves and the volatility of collateral, which is a key component of our analysis.

Closest to our paper are the recent contributions by [Bertsch \(2023\)](#), [Ma et al. \(2023\)](#) and [Gorton et al. \(2022\)](#). [Bertsch \(2023\)](#) uses a first generation regime change global game to capture stablecoin fragility stemming from concerns about the quality of the issuer’s assets, giving rise to run risk; this is the same fragility we are concerned with. [Bertsch \(2023\)](#) endogenizes the liability side of the stablecoin issuer’s balance sheet *ex ante*, before the issuer is exposed to run risk. The issuer faces demand for stablecoins that arises from heterogeneity in preferences by groups of consumers over holding different monies ([Agur et al., 2022](#)), producing heterogeneous payoffs in the global game.¹² The adoption stage both links stablecoin demand to outside options such as bank deposits, and allows [Bertsch \(2023\)](#) to study the relationship between factors that increase adoption and shape stablecoin issuer fragility. We abstract from tensions in the adoption stage, focusing instead on how differences on the asset side of the issuer affect higher-order beliefs and run incentives among a fixed mass of stablecoin holders. Our contribution is to unpack theoretically and test empirically the effect of changes in both the quality of the asset side of the issuer and transparency over these assets on incentives to run on the issuer.

[Ma et al. \(2023\)](#) also features a first generation global game in the spirit of [Goldstein and Pauzner \(2005\)](#), with [Diamond and Dybvig \(1983\)](#) style liquidity shocks. In addition, they include a layer of arbitrageurs as firewalls with the efficiency of the secondary market being an indicator of the fragility of the stablecoin’s price. Their key finding is that higher price volatility comes with lower run risk, and *vice versa*.¹³ Our setup, by contrast, links run risk to the volatility of reserve assets which impacts (i) the issuer’s ability to process redemptions and (ii) the benefits to investors from transacting in the crypto space. Our focus is on how transparency and volatility of reserve assets affect run risk, rather than how the two-layer market infrastructure of stablecoins affects stability of the stablecoin price in terms of market design.¹⁴ Finally, our model allows for a broader class of both private and

¹²In [Bertsch \(2023\)](#), the matching problem that consumers face with sellers who accept each payment instrument with some probability is in the spirit of search-theoretic monetary models ([Kiyotaki and Wright, 1993](#)).

¹³Concentration of arbitrageurs leads to a trade off between price stability and run risk in their model. When there are fewer authorized arbitrageurs, arbitrage is less efficient and therefore price deviations are more frequent. But opening the door to more arbitrageurs increases run risk because it increases the first mover advantage for arbitrageurs.

¹⁴Moreover, in [Ma et al. \(2023\)](#) run risk is driven by a combination of liquidity shocks and private signals,

fundamental distributions, can accommodate non-US dollar backed stablecoins and features a “large shock” result that is absent from first-generation global games.

[Gorton et al. \(2022\)](#) argue that stablecoins are able to fulfill their par promise despite being exposed to run risk and not paying any interest because levered traders (a third agent in their model) provide compensation to stablecoin holders for lending their coins.¹⁵ As in [Bertsch \(2023\)](#), [Gorton et al. \(2022\)](#) model a classic first generation global game with uniform distributions. Therefore, they do not consider how variation in the information structure influences run risk, which is our focus. Moreover, investors in their model may learn about the proportion of safe assets only from issuer disclosures but do not study the implications of this theoretically (rather, it is posed as an empirical challenge). Our contribution is to formalize how opaque portfolios held by issuers influence the beliefs of stablecoin holders (formed by the convolution of various assets) and, thus, contribute to run risk. We discuss when disclosure lowers/heightens run risk and how the magnitude of public shocks (informational or fundamental) are critical in triggering runs.¹⁶

3 Baseline model

In this section, we present our baseline model of stablecoins to analyze how information and the distribution of collateral influence the possibility of a panic-based run. The baseline model has two variants. The first one employs a standard regime change global game ([Morris and Shin, 2003](#)) that allows us to analyze the effects of public expectations of reserve asset values and transparency of public information about reserves on run risk. This model captures the dynamics of fiat-backed stablecoins that dominate the market, such as Tether and USDC. The second variant of the model introduces fat tails into the distribution of the

whereas investor behavior in our model is driven by fundamentals in the crypto universe.

¹⁵Our model abstracts from the role of crypto speculators. However, we indirectly capture the interconnectedness that arises with such speculators by modelling the benefits to stablecoin holders from rolling over their holdings as positively dependent on the dollar value of assets in the crypto space. With this payoff structure, we argue that there is some correlation between the collateral value of the issuer and the expected payoffs to stablecoin holders from transacting in the crypto universe – whether it be via direct speculation or lending to speculators.

¹⁶A further point of departure is that in [Gorton et al. \(2022\)](#), stablecoin holders have uncertainty only about the fraction of early withdrawals that arise from fundamentals (the return on risky assets held by the issuer). By contrast, in our model there is uncertainty both about the fraction of withdrawals linked to the quality of collateral assets and the net benefits from transacting in the crypto space. Technically, this makes stablecoin holders less flighty when they receive optimistic information about issuer collateral and the health of the crypto system, whereas the return on stablecoin holdings is fixed at the time of the redemption decision in [Gorton et al. \(2022\)](#).

value of reserve assets. Fat-tailed distributions could capture, for example, a movement from single- to multi-collateral reserve holdings by a stablecoin issuer that brings about changes in reserve volatility, or fundamental uncertainty over reserve assets. This model, which nests the first one, can better capture the dynamics of crypto-backed stablecoins or algorithmic stablecoins. We draw on [Morris and Yildiz \(2019\)](#) to model the resultant global game and use hysteresis equilibrium to analyze the role of large shocks in triggering runs.

3.1 Model elements

The model features a unit continuum of risk-neutral stablecoin (SC) holders, $i \in [0, 1]$, and a single issuer of stablecoins. One stablecoin is issued to each SC holder.¹⁷ Stablecoins are backed by a vector of reserve assets with a combined dollar value θ , representing an issuer’s per unit collateral or fundamentals. SC holders perceive θ as a random variable drawn from the portfolio-weighted convolution of all reserve asset distributions, with realizations of θ equal to the portfolio-weighted realized values of individual reserve assets (see [Appendix B.1](#) for details).¹⁸

Cash is converted to stablecoins and redeemed at a one-to-one conversion rate, subject to the issuer continuing to operate. The transaction costs collected by the issuer for conversion are denoted by τ , with $0 < \tau < 1$.

The game extends over two stages. In the first stage, Nature selects θ and the issuer observes the dollar value of reserve assets. In the second stage, SC holders decide whether to demand conversion to cash, $a_i = 1$, or to maintain a stablecoin holding, $a_i = 0$. During this stage, the issuer processes aggregate conversion requests, $A \in [0, 1]$, and becomes unable to defend par whenever $A > \theta$, i.e., whenever the conversion value of reserve assets, θ , is smaller than the value of fiat currency demanded. The inability to meet redemptions by relying on the liquidation of reserve assets effectively renders the issuer insolvent. But note that the key problem facing the issuer is one of *liquidity*: what matters is not the value of reserve assets relative to liabilities (i.e. a solvency concern), but rather whether assets can command enough resources to liquidate liabilities.

¹⁷While beyond the scope of our paper, the model can be extended to understand the effect that large players or “whales” have on run risk. See [Corsetti et al. \(2000\)](#) for an example of the effects of large players in a currency crisis setting.

¹⁸Our model can easily accommodate an analysis of the effect of increasing the weight of low-risk asset in the reserve portfolio. Tether’s transition away from commercial paper and towards short-term safe assets is an example of this. The effects are similar to our transparency results: greater weighting on low risk assets decreases run risk.

The interaction between SC holder redemptions and the issuer’s balance sheet produces a tripartite classification of fundamentals (Morris and Shin, 1998). There is a lower threshold, $\theta_L = 0$, such that for all $\theta \in (-\infty, 0)$, the issuer is fundamentally insolvent even if no SC holders demand conversion (i.e., $A = 0$). Similarly, there is an upper threshold, $\theta_U = 1$, such that for all $\theta \in [\theta_U, \infty)$, the issuer is solvent even if all SC holders demand conversion (i.e., $A = 1$). We consider the stablecoin to be in a “ripe for run” region whenever $\theta \in [\theta_L, \theta_U)$.

The payoffs received by SC holders based on their actions for each possible state of the issuer are summarized in Table 1. The payoff per unit accruing to SC holders is captured by $\pi : \mathbb{R} \rightarrow \mathbb{R}$ with $\pi(\theta) \geq 1 - 2\tau$ for all θ .¹⁹ Such a payoff could reflect returns from using stablecoins as collateral in decentralized finance applications, from realizing gains in the crypto space without costly conversion back to fiat currency, or revenue from illicit activities such as tax evasion. The returns depend on fundamentals in the crypto environment, such that $\pi'(\theta) > 0$. In states where the issuer is solvent, SC holders prefer to maintain their holdings, and receive a strictly higher expected payoff from demanding conversion in states where the issuer is rendered insolvent.²⁰ If a SC holder demands conversion and the issuer is rendered insolvent, the SC holder walks away with fiat money converted at the pegged value, net of transaction costs, and receives zero if abstaining from the run. If the issuer remains solvent, SC holders who demand conversion to cash re-enter the market by buying the stablecoin again, maintaining their dollar claim on the issuer but incurring fees on their exit and re-entry, whereas they receive $\pi(\theta)$ if they abstained from demanding conversion.²¹

Under complete information, there are multiple equilibria for all $\theta \in [\theta_L, \theta_U)$. If SC holders anticipate $A > \theta$, it is a best response to demand conversion (since $1 - \tau > 0$). If they anticipate $A \leq \theta$, it is a best response to maintain their holding (since $\pi(\theta) > 1 - 2\tau$).

SC holders, however, do not observe the quality of reserve assets θ directly. Instead,

¹⁹This mapping restricts the image of π to real numbers and ensures that two-sided limit dominance is satisfied for all $\theta \in \mathbb{R}$ and for any arbitrarily small transaction cost τ . An example of a function satisfying this condition is $\pi(\theta) = e^\theta + 1$, which suggests that SC holders receive at least their claim of \$1 plus additional benefits from transacting in the crypto environment. A well-defined dominance region is crucial for the uniqueness of a global game equilibrium, since it relies on iterative deletion of strictly dominated strategies (Milgrom and Roberts, 1990). See Goldstein and Pauzner (2005) for a discussion of one-sided strategic complementarity.

²⁰Formally, our payoff structure ensures both action and state monotonicity. The payoff differential between demanding conversion and maintaining a holding is increasing in A and decreasing in θ .

²¹We abstract from the kind of sequential servicing in Gorton et al. (2022) that discounts the expected payoff from redeeming. We introduce the additional transaction fee from running on a solvent issuer to capture the pecuniary and inconvenience costs from demanding conversion unnecessarily. Including such a constraint and imposing a symmetric transaction fee of τ under both solvency and insolvency would not qualitatively change our results. We also normalize the benefit from holding coins to SC holders to zero with a defunct issuer, as there are currently no resolution procedures in place for stablecoins (see Bains et al. (2022)).

| | Issuer solvent | Issuer insolvent |
|-----------|----------------|------------------|
| $a_i = 1$ | $1 - 2\tau$ | $1 - \tau$ |
| $a_i = 0$ | $\pi(\theta)$ | 0 |

Table 1: Stablecoin holder payoffs. Action $a_i = 1$ denotes demanding conversion; action $a_i = 0$ denotes maintaining a holding.

they receive noisy private signals about θ . We first consider an environment characterized by relatively low volatility in reserve assets and highly precise individual information, before examining the effects of high volatility (fat-tailed) reserves on run dynamics among SC holders.

4 Low-volatility reserve assets

We use the first variation of the model to study the effect of transparency and public information when reserve assets are characterized by a thin-tailed distribution. For a given portfolio of reserve assets $(\theta_1, \dots, \theta_n)$, let the distribution of θ be normal with mean $y > 0$ and variance $\sigma_\theta > 0$, i.e., $\theta \sim \mathcal{N}(y, \sigma_\theta^2)$.

In the second stage of the game, SC holders observe noisy private signals about the quality of reserve assets:

$$x_i = \theta + \sigma_x \varepsilon_i, \quad (1)$$

where $\varepsilon_i \sim \mathcal{N}(0, 1)$ is a noise term that is independently and identically distributed across SC holders with a PDF denoted by $\phi(\varepsilon)$. SC holders' signals are thus drawn from a normal distribution with mean θ and variance σ_x^2 , i.e., $x \sim \mathcal{N}(\theta, \sigma_x^2)$.

Our first result, summarized in Proposition 1, comprises equilibrium thresholds for both SC holders and the SC issuer.²² For all SC holders there is a common signal threshold, x^* , that drives SC behavior and produces consistent higher-order beliefs about the strategies of other SC holders. For the SC issuer there is a fundamental threshold, θ^* , that dictates the point at which the mass of redemption requests becomes so large that the issuer is rendered insolvent. The SC holder of type x^* holds a posterior belief over the probability of issuer failure equal to $\rho(\theta^*) \equiv \frac{\pi(\theta^*) + 2\tau - 1}{\pi(\theta^*) + \tau}$ that renders the SC holder indifferent between demanding conversion and rolling over the holding.

²²Pinning down a unique equilibrium to determine run probability is a standard approach in the global games literature (Morris and Shin, 1998, 2003).

Proposition 1. Fix σ_θ^2 . As idiosyncratic noise becomes sufficiently small, $\sigma_x < \sigma_\theta^2 \sqrt{2\pi}$, there is a unique equilibrium with thresholds (θ^*, x^*) such that the issuer is rendered insolvent if and only if $\theta < \theta^*$ and each SC holder demands conversion if and only if $x_i < x^*$.

Proposition 1 pins down a unique equilibrium in the global game among SC holders and the issuer.²³ SC holders use Bayesian inference to determine the probability that others have equally or more pessimistic signals than their own, allowing them to weigh the expected benefits and costs of early withdrawal. When their signals fall below x^* , they believe that the proportion of others who observe signals that are, at most, equal to their own, is large enough to topple the peg. The threshold x^* represents the signal that renders a SC holder just indifferent between redeeming and rolling over. Accordingly, any SC holders with signals below x^* expect a strictly higher payoff from demanding conversion than from maintaining a holding which, in turn, reinforces other SC holders' decisions to demand conversion. This decision rule among SC holders aggregates into a threshold for the dollar value of collateral such that the issuer experiences a large-scale run that leads to failure whenever $\theta < \theta^*$.

The unique equilibrium establishes two regimes for the issuer that depend on the value of reserve assets, the benefits derived by SC holders, and transaction costs.²⁴ Figure 2 illustrates the equilibrium and the two regimes that emerge. As private signals become sufficiently precise (i.e., as idiosyncratic noise becomes low enough, $\sigma_x^2 < \sigma_\theta^2 \sqrt{2\pi}$, by Proposition 1), there is a unique equilibrium in the coordination game among SC holders. Whenever $\theta < \theta^*$, which happens with probability $F(\theta^*)$, sufficient SC holders demand conversion that the issuer is rendered insolvent. Whenever $\theta \geq \theta^*$, which happens with probability $1 - F(\theta^*)$, the issuer is able to meet conversion requests and remains solvent.

4.1 Reserve transparency and run risk

Does a commitment to transparency by stablecoin issuers in the form of broadcasting reserve portfolios mitigate or aggravate the probability of a run (i.e., $\mathbb{P}[\theta \leq \theta^*]$)? To answer this, we draw on Metz (2002) to analyze the sensitivity of SC holders' switching point x^* , and

²³The restriction, standard in the global games literature, depends on π the mathematical constant, and should not be confused with $\pi(\theta)$ – the payoff from maintaining a stablecoin holding.

²⁴Based on this result, it is possible to form predictions about how these different factors influence both the probability of a run on the stablecoin (i.e., $\mathbb{P}[\theta \leq \theta^*]$), and the expected level of downward pressure on the peg for any realization of fundamentals, (i.e., $\mathbb{P}[x \leq x^* | \theta]$). We report comparative statics on the equilibrium switching points in Appendix A.1.

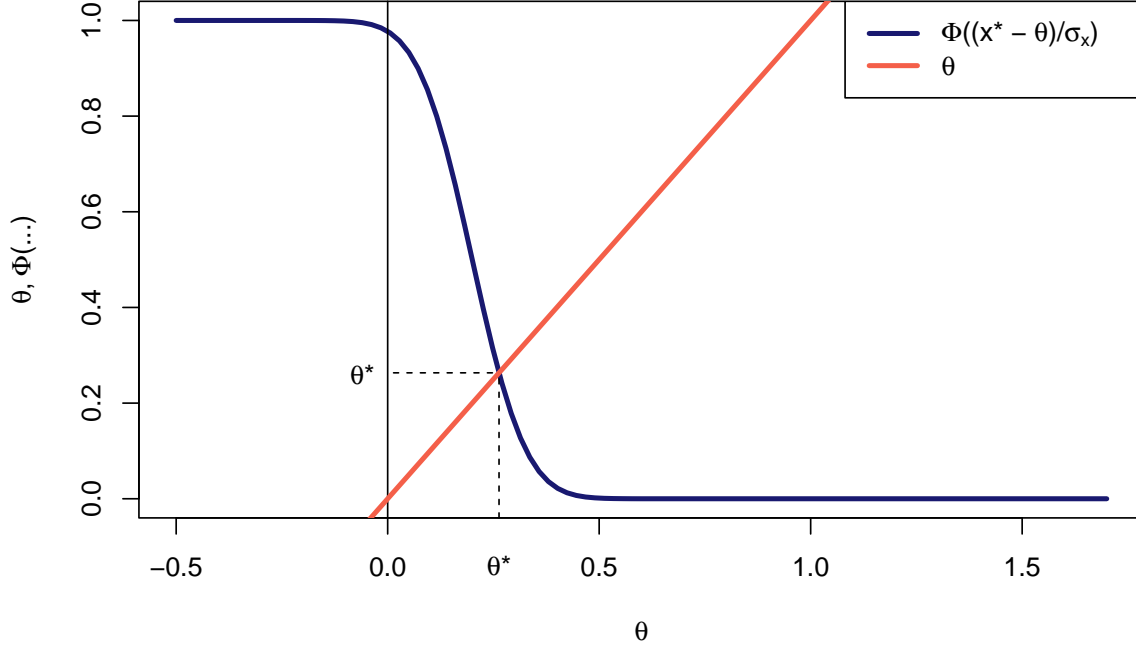


Figure 2: Equilibrium with two regimes.

Notes: As idiosyncratic noise becomes small, there is a unique equilibrium in the coordination game among SC holders. Whenever $\theta < \theta^*$, the proportion of SC holders demanding conversion ($\Phi((x^* - \theta)/\sigma_x)$, blue line) is larger than the dollar value of collateral (θ , red line) and the issuer is rendered insolvent. If $\theta \geq \theta^*$, the issuer can meet the low proportion of conversion requests and remains solvent.

fundamental threshold θ^* , to an increase in the *precision of public information*.²⁵ Let $\alpha \equiv \frac{1}{\sigma_\theta^2}$ denote the precision of public information, and let $\beta \equiv \frac{1}{\sigma_x^2}$ denote the precision of private (idiosyncratic) information.

Our next result, summarized in Proposition 2, applies to forces that improve either *informational precision* or *precision in collateral fundamentals*. A key characteristic of games with self-fulfilling features is the commonly held beliefs about the distribution of fundamentals. For our purposes, a decrease in the variance of fundamentals, σ_θ , can arise either from a portfolio with relatively low volatility (e.g. Treasury bills) or from information that shifts

²⁵The interaction between the precision of public information, or the proportion of well-informed investors, and run risk is well established in the first-generation global game literature (Ahnert and Kakhbod, 2017; Prati and Sbracia, 2010; Szkup and Trevino, 2015). We extend these results to show that the effects of changes in the precision of public and private information are also sensitive to the type of coordination game being played. In later results, we provide comparative statics on signal thresholds that determine SC holder propensity to run when there is tail risk in the distribution of the value of reserve assets.

commonly held uncertainty around the distribution of reserve assets (e.g. the broadcasting of reserve quality).²⁶

Proposition 2. *The precision of public information, α , exerts a positive influence on the probability of a run if $\theta^* > y + \frac{1}{2\sqrt{\alpha+\beta}}\Phi^{-1}(\rho(\theta^*))$, and a (weakly) negative influence on the probability of a run if $\theta^* \leq y + \frac{1}{2\sqrt{\alpha+\beta}}\Phi^{-1}(\rho(\theta^*))$.*

Proposition 2 shows that there are critical levels of the common prior, y , and transaction costs, τ , that determine the sign of $\partial\theta^*/\partial\alpha$. In particular, when either the expected dollar value of reserve assets or transaction costs are relatively low, improving the precision of public information heightens the probability of a run on the SC issuer, while the converse is true for relatively strong expected fundamentals and high transaction costs. Intuitively, a commitment to higher transparency of information about reserves makes relatively smaller pessimistic signals carry greater weight in SC holders' strategic reasoning. Every SC holder anticipates that every other SC holder will be relatively flighty when expected reserve asset values and transaction costs are low. Under these conditions, greater precision of public information amplifies the contagion process that determines the switching point x^* . As a result, the critical dollar value θ^* increases, widening the event space where a run takes place. Such a dynamic was very clearly at play during the breaking of the USDC's peg as stress in SVB mounted (Figure 1): increased transparency effectively lowered the expected value of dollar reserves (i.e. cash held at SVB), in a context in which transaction costs for withdrawing are generally low.

Proposition 2 thus delivers clear testable predictions. In particular, it suggests that, for a given level of fundamentals and relatively high market priors, y , and exchange costs, τ , pressure on the peg should decrease following an improvement in the quality of reserve assets used in the issuer's portfolio. To test this prediction, we analyze the stability of the Dai stablecoin peg following public disclosure about improvements in the quality of the pool of collateral backing the stablecoin in Section 6.3. Proposition 2 also suggests that, for a given level of fundamentals, low priors and low transaction costs, an increase in reserve transparency should lead to heightened pressure on the peg. In Section 6.4, we test

²⁶For example, information about reserves may change commonly held perceptions over asset distributions as SC holders learn from public information. If instead of allowing common knowledge about the parameters of $F(\theta)$, we assume a normally distributed θ but with variance unknown to SC holders and drawn from an inverse χ^2 -distribution then, mechanically, the posterior distribution of θ has fat tails (and is drawn from a t -distribution). However, these tails grow thinner in the number of observations about θ , n , since the degrees of freedom shaping the t -distribution are given by $n - 1$.

this prediction by analysing market responses to the increased public scrutiny over Tether’s reserve portfolio following a June 2018 audit report.

5 High volatility reserves

The analysis we have presented so far is suitable for describing stablecoin environments in which private information is precise and readily available (since we impose $\sigma_x < \sigma_\theta^2 \sqrt{2\pi}$). But it does not explain why markets sometimes remain relatively optimistic even in the face of gradually deteriorating reserve assets, or why events seemingly unrelated to fundamentals can trigger runs. We next examine a broader class of stablecoins to assess how large public shocks affect the probability of a run.

Consider an alternative class of stablecoins that could include both collateralized and algorithmic coins.²⁷ Stablecoin holders perceive that the reserve portfolio of this class of stablecoins is drawn from a distribution with *fat tails* (i.e., with positive excess kurtosis).

As before, let the perceived distribution of portfolio returns approximate a normal distribution with prior $y > 0$ and let $\sigma_\theta = 1$ for simplicity. In this case, however, suppose that SC holders do not know the variance of these returns. Instead, the reciprocal of the variance of θ has a χ^2 distribution. With this variance uncertainty, $\theta = y + \eta$ comprises a commonly known prior, y , and a shock term, η , with distribution $G(\eta; \nu)$, where $G(\cdot; \nu)$ is a t -distribution with ν degrees of freedom proportional to the number of past observations that SC holders have for θ .²⁸

The timing, payoffs and signal structure, x_i , are identical to the low reserve volatility case. However, in the presence of fat tails, SC holders’ beliefs are perturbed in a crucial way. The SC holder signal in Equation (1) can be reformulated as follows

$$x_i = y + z_i, \tag{2}$$

where $z_i = \sigma_x \varepsilon_i + \eta$ is an aggregated noise term that SC holders disentangle to form beliefs over fundamentals and the likelihood that others’ signals are lower than their own.

²⁷Collateralized stablecoins refer to those coins that are backed by either assets denominated in traditional fiat currency or independent digital crypto assets. Algorithmic stablecoins are not backed by reserve assets; instead, they maintain their value through algorithms that adjust supply relative to another paired digital asset forming part of the stablecoin arrangement (Chaudhary and Viswanath-Natraj, 2022).

²⁸With an inverse χ^2 distribution as the conjugate prior, the posterior distribution is a Student’s t distribution.

Let

$$R(z) = Pr[z_j \leq z | z_i = z] = \frac{\int \Phi(\varepsilon) \phi(\varepsilon) g(z - \sigma_x \varepsilon) d\varepsilon}{\int \phi(\varepsilon) g(z - \sigma_x \varepsilon) d\varepsilon}, \quad (3)$$

denote the *rank belief* of SC holder i . Agent i 's rank belief represents the proportion of other SC holders who observe a lower signal than i , conditional on her own signal. Given the variance uncertainty SC holders have over θ , the rank belief function is *non-monotonic* in z and approaches $\frac{1}{2}$ as z grows large in either direction (see Figure 3). Proposition 3 summarizes a first result based on this expanded model.

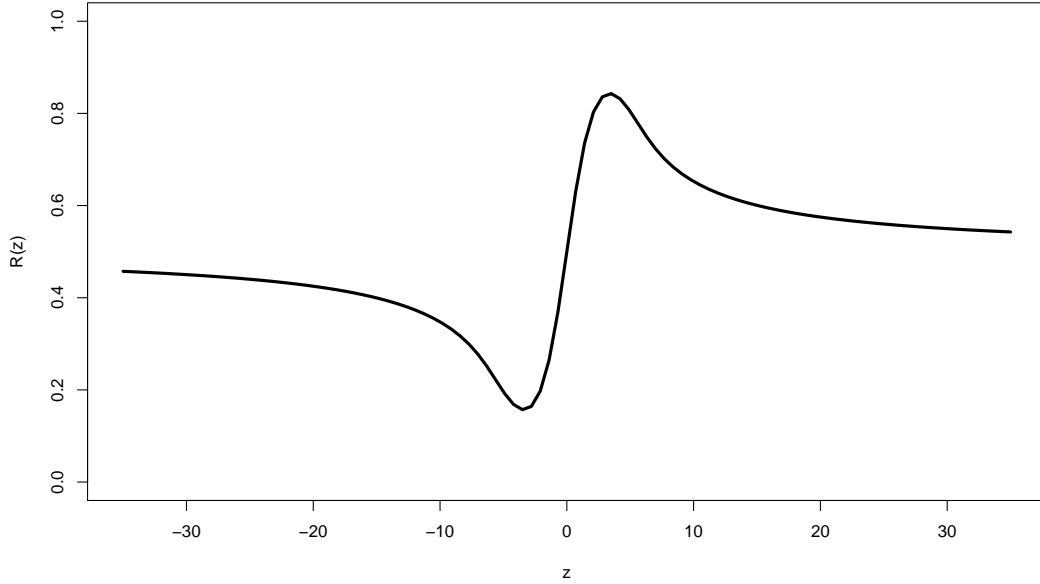


Figure 3: Rank belief function with fat-tailed distribution of reserve assets.

Notes: The rank belief function for SC holders when they perceive tail risk in the reserve portfolio. Rank beliefs represent conditional beliefs about the proportion of other SC holders who observe lower signals. They are non-monotonic and approach uniformity in the limit as $|z|$ (the absolute value of aggregate noise) grows large.

Proposition 3. Fix $\sigma_x^2 > 0$. There are two locally unique thresholds, $\hat{\theta} = y + \hat{\eta}$ and $\hat{\theta} = y + \hat{\eta}$, such that the issuer is rendered insolvent if $\theta < \hat{\theta}$ and remains solvent if $\theta \geq \hat{\theta}$. There are multiple equilibria for all $\theta \in [\hat{\theta}, \hat{\theta})$.

The rationale behind SC holders' decisions is similar to the case of thin-tailed reserve asset distribution.²⁹ In particular, SC holders use posterior beliefs over θ and the likelihood

²⁹We contrast the comparative statics in this type of regime against the low-volatility reserve regime in Appendix A.3.

that others will demand conversion to cash to determine their actions $a_i \in \{0, 1\}$. For $a_i = 1$ (demand conversion) to be uniquely rationalizable, and given a critical portfolio return θ_c , SC holder i must believe with a sufficiently high probability that at least θ_c other SC holders will demand conversion.³⁰ Similarly, for $a_i = 0$ to be uniquely rationalizable, SC holder i must believe with a sufficiently high probability that at most θ_c other SC holders will demand conversion, to justify maintaining her holding.

Stablecoin holders with extremely low (high) signals find it optimal to withdraw (maintain) their holding irrespective of the actions of others. Formally, there exists a lower threshold, \underline{x} such that

$$\mathbb{P}[\theta \leq 0 | x_i = \underline{x}] = \frac{\pi(0) + 2\tau - 1}{\pi(0) + \tau}.$$

When $x_i \leq \underline{x}$, SC holders have an optimal strategy to withdraw even if the anticipated withdrawal mass is zero. There is an analogous upper threshold \bar{x} , where

$$\mathbb{P}[\theta \leq 1 | x_i = \bar{x}] = \frac{\pi(1) + 2\tau - 1}{\pi(1) + \tau},$$

such that when $x_i > \bar{x}$, SC holders always find it optimal to maintain their holding, even if the anticipated withdrawal mass is one.

Extreme beliefs can generate contagion. In particular, these extreme beliefs, even if held by a small proportion of SC holders with very pessimistic or very optimistic signals, ignite a contagion process that extends towards SC holders with more moderate signals (i.e. signals that are closer to the true value of fundamentals, θ). Given that all SC holders who observe $x_i \leq \underline{x}$ will demand conversion, those whose signals are slightly higher than \underline{x} will also find it optimal to demand conversion, since their own beliefs about the likelihood that the issuer survives are low and they anticipate that everyone with even lower signals will definitely run. This, in turn, causes SC holders with even larger signals to follow suit, and so on. The thresholds $\hat{\theta}$ and $\hat{\theta}$ in Proposition 3 are determined by switching signals \hat{x} and \hat{x} respectively, with $\hat{x} \leq x^* \leq \hat{x}$. The thresholds \hat{x} and \hat{x} bound two regions of uniquely rationalizable actions, resulting in determinate outcomes when reserve assets are subject to large positive or negative shocks.³¹ To test whether the effect of public disclosure about

³⁰See Morris et al. (2016) for a detailed discussion of so called (q, p) -beliefs and rationalizability.

³¹The thin-tailed variant of the model in Section 4 is actually an extreme case of Proposition 3. If we take $\nu \rightarrow \infty$, the t -distribution approaches a standard normal distribution, rank beliefs become monotone in z , and as private noise becomes small enough, the thresholds $\hat{\theta}$ and $\hat{\theta}$ converge to the unique equilibrium θ^* (see Duley and Gai (2023)). However, the locally unique thresholds $\hat{\theta}$ and $\hat{\theta}$ are qualitatively different from θ^* , because

improved collateral quality on peg pressure extends to high-volatility stablecoins, we analyze the transition of the Dai stablecoin from single- to multi- (cryptoasset) collateral in Section 6.5.

5.1 Large shocks and equilibrium shifts

We now focus on equilibrium shifts (i.e., when do we expect a run on stablecoin issuers and under what conditions can the peg be re-established?) and the role that sudden, large shocks to collateral play in such shifts. The result of the static global game can be easily transformed towards a dynamic application.³² At the beginning of each period $t \geq 0$, there is an expected dollar value of reserve assets, y_t . Common shocks (η_t) and idiosyncratic shocks (ε_{it}) are independently drawn across SC holders and time, who decide $a_{it} = \{0, 1\}$ (i.e., roll over or withdraw) after observing a signal x_{it} as in the static game above, aggregating to a withdrawal mass A_t . The commonly held prior over the dollar value of reserve assets in the current period, $y_t = Y(\theta_{t-1})$, is determined by a known process, $Y : \mathbb{R} \rightarrow \mathbb{R}$, with $\theta_t = y_t(\theta_{t-1}) + \eta_t$. We denote the sample size of past observations by $|\Theta_t|$ where $\Theta_t \equiv \{\theta_{t-1}, \theta_{t-2}, \dots, \theta_0\}$, that determine the degrees of freedom $\nu_t \propto |\Theta_t|$ in distribution $G(\cdot)$.³³

To address the indeterminacy of outcomes in the presence of multiple equilibria in Proposition 3, we focus on *hysteresis equilibrium*. This equilibrium corresponds to games that exhibit path dependence, so that agents' actions are systematically shaped by the aggregate outcomes or payoff parameters in previous periods.³⁴ With this equilibrium selection method, we resolve the indeterminacy of outcomes for moderate values of θ_t by arguing that agents will play the less aggressive decision rule (i.e., run if $x_{it} < \hat{x}_t$) if their choice was to maintain a holding in the previous period, and will play the more aggressive decision rule

in the fat-tailed environment the individual indifference condition is decoupled from the critical mass condition, with different comparative static results. For these results, we refer the reader to the appendix.

³²To be clear, we do not extend the model into a rich dynamic arrangement of the kind studied in d'Avernas et al. (2023) or Li and Mayer (2021). Instead, we simply re-frame the model as a sequence of plays of the static model, linking a global games framework across two dates $t-1$ and t , along the lines of Morris and Yildiz (2019).

³³That is, common past observations of θ provide public information that SC holders use to learn about the population parameters governing the distribution of reserve assets. The shape of the t distribution is influenced by this sample of past observations. Our approach differs from the dynamic global game application in Angeletos et al. (2007) in which fundamentals do not change over time, but instead players observe a sequence of past plays which helps them learn about the value of fundamentals.

³⁴See Bebchuk and Goldstein (2011), Rajan (1994) and Romero (2015) for similar characteristics of persistence in coordination games.

(i.e., run if $x_{it} < \hat{x}_t$) otherwise.³⁵ Corollary 1 summarizes this.

Corollary 1. *Under hysteresis equilibrium, each SC holder maintains a holding if and only if $x_{it} \geq x_c$ where*

$$x_c = \begin{cases} \hat{x}_t(y_t) & \text{if } t = 0 \text{ or } A_{t-1} < \frac{1}{2} \\ \hat{x}_t(y_t) & \text{otherwise.} \end{cases} \quad (4)$$

This equilibrium formulation suggests *inertia* in majority behavior by SC holders. If the issuer remained solvent in the previous period and a SC holder observes a modest deviation from her prior, maintaining her holding is uniquely rationalizable. Aggregating this behavior, whenever the value of reserve assets experiences small shocks, there is a *reversion to the mean* effect by SC holders and the peg is maintained. However, a large negative shock (i.e., $\theta_t < \hat{x}_t(y_t)$) makes withdrawing uniquely rationalizable for the median SC holder.

Figure 4 illustrates withdrawal dynamics under hysteresis equilibrium. Time is on the horizontal axis, whereas the vertical axis captures a sample path of fundamentals (value of reserve assets) and aggregate behavior of SC holders (determining the stablecoin price). With small variance in idiosyncratic noise, aggregate behavior is always close to one or zero. There are two periods in which the peg is maintained: at the beginning, the majority rolls over their holdings even though there are downward drifts in the value of reserve assets. However, a large enough negative shock in the value of reserve assets, coupled with withdrawing becoming a p -dominant response for the median SC holder, causes a majority of SC holders to run on the stablecoin and its price drops significantly.³⁶ Subsequent increases in the value of reserve assets do not recover the peg as long as withdrawing remains p -dominant for the median SC holder. A large positive shock that exceeds $\hat{x}(y_t)$ near $t = 80$ triggers an optimistic shift in higher-order beliefs for the median SC holder, causing a majority reversion to an equilibrium SC holding close to one.

The hysteresis equilibrium in Corollary 1 gives rise to two predictions, which we test empirically in Section 6.6.

³⁵The nature of the global game is unchanged. We do not alter the timing of the game nor payoff parameters. Instead, we assume the history of past play (as summarized by the observed mass of conversion requests and commonly held belief over reserve asset quality in the previous period) is instructive in resolving multiplicity.

³⁶Demanding conversion is said to be p -dominant whenever it is a best response to the conjecture placing probability p on the event that the issuer is rendered insolvent (Morris et al., 2016). In our formulation, SC holders must believe with probability at least $p(\theta_t) \equiv \frac{\pi(\theta_t)+2\tau-1}{\pi(\theta_t)+\tau}$ that the issuer will fail to make withdrawing a rationalizable response.

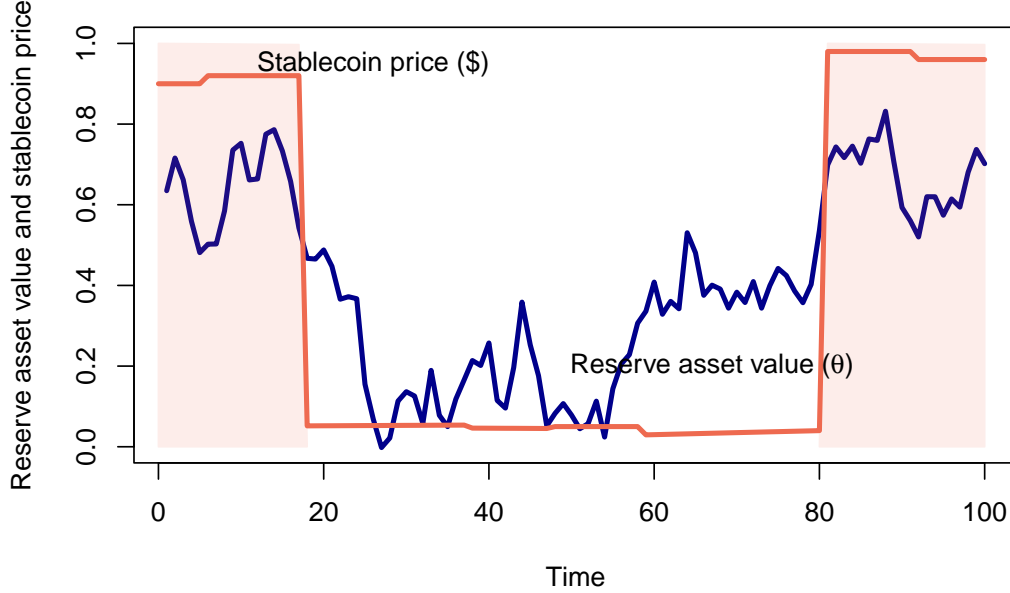


Figure 4: Equilibrium shifts under hysteresis equilibrium.

Notes: The issuer maintains solvency only during the early and final stages (shaded time intervals) for a given path of the dollar value of reserve assets (blue solid line).

Prediction 1. Reversion to mean effect. *When the dollar value of reserve assets enters a region where it is “ripe for a run” (i.e., the dollar value of reserves backing each coin, θ , is between 0 and 1), the SC peg is resilient to small shocks in reserve asset values (i.e., $\theta_t(y_t) \geq \hat{\theta}_t(y_t)$).*

Prediction 2. Change effect. *When the dollar value of reserve assets enters a region where it is “ripe for a run” (i.e., the dollar value of reserves backing each coin, θ , is between 0 and 1), a large negative shock in reserve assets triggers a run on the SC, even if the value was initially close to \$1 (i.e. $\theta_t(y_t) < \hat{\theta}_t(y_t)$). Analogously, after a destabilizing run on the SC, the peg may recover following a large enough positive shock in reserve asset values, even if the value of reserve assets is not \$1 (i.e., when $\theta_t(y_t) \geq \hat{\theta}_t(y_t)$).*

In this environment, an increase in transparency helps to resolve uncertainty among SC holders over the parameters governing the distribution of reserve assets. Both the disclosure of public information about reserve assets in period t and past realizations of the dollar value of reserve assets bring the perceived distribution closer to the true distribution (determined

by the issuer’s reserve asset portfolio). To compare the effects of transparency on run risk with that of issuers holding low volatility reserve assets, we provide a comparative static result on reserve asset value thresholds $\hat{\theta}_t$ and $\hat{\theta}_t$ that correspond with the signal thresholds in Corollary 1 below.

Corollary 2. *The release of public information or a longer time since the issuer’s launch, that increase degrees of freedom (ν_t), lowers $\hat{\theta}_t$ and increases $\hat{\theta}_t$.*

Corollary 2 illustrates the role of transparency and issuer age under hysteresis equilibrium. Increased transparency towards SC holders who believe that reserves are subject to high volatility has a negative influence on the probability of a run if no run occurred in the previous period, and increases the probability of a run continuing if one took place last period. In other words, runs on the issuer become less likely as SC holders receive more precise public information, but recoveries from a run (i.e. SC holders finding it optimal to maintain a holding) also become more difficult once a run is triggered. To the extent that SC holders use past events to learn about the issuer, this result gives theoretical support to evidence that issuers that have been around for longer are subject to less price volatility than their younger counterparts (Kosse et al., 2023).

Corollary 2 also highlights a link between the effects of transparency in the fat-tailed environment and the thin-tailed environment in Proposition 2. A relatively strong realization of θ at $t-1$ produces a high common prior, y_t . Just as a large enough prior ensures that transparency dampens run risk in Proposition 2, so too does a large prior make every SC holder less confident that others will run and the issuer will fail in Corollary 2. However, while the sign of the comparative static in Proposition 2 is also sensitive to transaction costs (τ), the run trigger in Corollary 2 is independent of τ as long as $\hat{\theta}_t < \theta_t^* < \hat{\theta}_t$. The reason for this independence is that the equilibria in Corollary 2 are derived from a focus on the perceived critical mass of redeeming SC holders ($A_t = \theta_t$) rather than individual payoff conditions that are influenced by transactions costs (τ). As a result, the level of transaction costs does not influence how transparency interacts with SC redemption behaviour.³⁷

Summary of model results and implications. Before moving to the empirical application, we take stock of the various results obtained from our two models.

Figure 5 summarizes our results by contrasting both the threshold(s) that characterize

³⁷See the appendix for the formal conditions under which this independence breaks down.

the equilibria of the game and the type of coordination game being played. When an issuer holds reserve assets that are tightly distributed, Proposition 1 shows that the probability of issuer failure due to a run is proportional to the size of the interval $(-\infty, \theta_t^*)$. When an issuer holds reserve assets whose value is drawn from a fat-tailed distribution and a majority of SC holders did not demand conversion in the previous period, Corollary 1 demonstrates that the probability of issuer failure is proportional to the size of the interval $(-\infty, \hat{\theta}_t)$.³⁸ The second interval is smaller than the first. But note that this does not necessarily imply that the probability of issuer failure, defined by $\mathbb{P}[\theta < \hat{\theta}]$, is also smaller than that of an issuer with tightly distributed reserve assets, $\mathbb{P}[\theta < \theta^*]$.³⁹ While transparency influences the size of these intervals by affecting the perceived quality of reserve assets, the true quality of these assets is what matters for the *probability* that an issuer fails. This is what distinguishes the effects of the *volatility* of reserve assets on run risk from *transparency* over the composition of reserve assets. Figure 6 illustrates using Dai, USDC and Tether as examples.⁴⁰

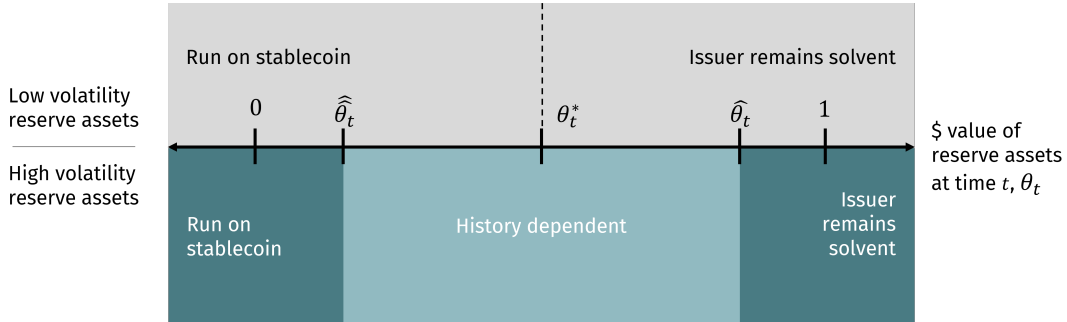


Figure 5: Model summary – switching thresholds in ripe for run region.

Notes: Switching thresholds in the ripe for run region $[0, 1)$ that determine run risk on issuers that hold low and high volatility reserve assets.

The summary in Figure 5 highlights a notable difference between our two model environments. Whereas the thin-tailed environment in Section 4 suggests issuer solvency should teeter precariously around the fundamental threshold θ^* , a stablecoin with high-volatility reserves features runs and recovery of confidence only following *large public shocks*.

This difference may seem surprising as it implies issuers with more volatile reserve assets

³⁸This assumes hysteresis equilibrium with no run in the previous period, and the same prior, idiosyncratic noise and payoff parameters across the two types of issuers.

³⁹Notice, too, that the same inertia that prevents SC holders from running in the first place also prevents a recovery in the event of a run once the dollar value picks up. The interval $[\theta_t^*, \infty)$ over which an issuer recovers the peg, is larger for issuers with tightly distributed reserve assets than those with high volatility assets, for which the interval is $[\hat{\theta}_t, \infty)$. In this way, the heightened strategic uncertainty introduced by fat tails in the perceived distribution of reserve assets acts as a double-edged sword for stablecoin issuers.

⁴⁰The examples in the Figure are meant to illustrate mechanisms in the model.

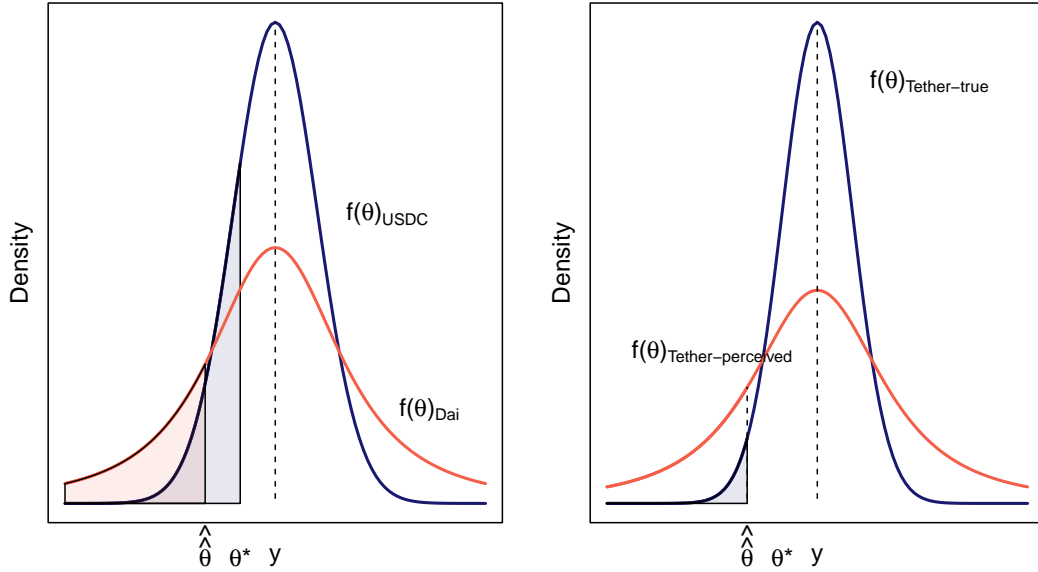


Figure 6: An illustration of reserve quality and transparency.

Notes: The left panel illustrates the reserve quality effect. It plots the probability density functions (PDFs) for a stablecoin with high quality, transparent reserves (USDC) and more volatile, transparent reserves (Dai). The run threshold on the high-volatility reserve coin ($\hat{\theta}$) is lower than the low volatility coin (θ^*), but the probability of issuer failure (orange shaded area) is higher (blue shaded area). The right panel illustrates the reserve transparency effect. It plots the PDFs for a high-quality reserve stablecoin (Tether) with transparent (true) and opaque (perceived) reserve quality respectively. The run threshold ($\hat{\theta}$) is determined by the perceived distribution, but the probability of issuer failure is dependent on the true distribution (blue shaded area).

are more resilient to small shocks, but the inertia has a simple intuition. A SC holder of slightly pessimistic type x_i does not trust that her signal is representative of weak reserve asset values, and believes that others harbor similar doubts about the information recovered from their own signals. This prevents her from running on signals that would induce a run in the unique equilibrium case. By contrast, a signal that is large in absolute terms, such that $x_i < \hat{x}$, causes the SC holder to interpret her signal as a fundamental shock rather than idiosyncratic noise. With these beliefs, she no longer knows where she ranks in the population (i.e., her rank beliefs are diffuse). Because running produces higher payoffs than refraining under such beliefs, she is prompted to demand conversion. In this way, both opacity about the reserve portfolio and volatility in the realized dollar value of reserve assets serve to anchor runs around large, public shocks.

6 Empirical evidence

In this section we take the various predictions from the models to the data. We analyze peg stability around three events, and also study peg stability more broadly in a fourth case study. The first event is the rise of USDC collateral backing Dai in late 2020, which up to that point was only backed by volatile cryptoassets. The second event in turn considers a period of heavy scrutiny over Tether’s collateral adequacy that began in October 2018. These two events allow us to test the predictions of the first-generation models that fit best stablecoins backed relatively low-volatility reserve assets. We then zoom in on events that speak to the predictions of second-generation models that characterize stablecoins with particularly volatile collateral. The third event we study is Dai’s November 2018 policy shift from accepting only a single cryptoasset collateral type, Ether, to accepting multiple volatile cryptoassets as collateral alongside Ether. Finally, we also examine the stability of the now defunct TerraUSD stablecoin and how it related to the volatility of its collateral asset Luna, both in the presence of small and large shocks.

6.1 Identification strategy

A simple pre-post analysis of changes in stablecoins’ peg stability over time faces an important identification challenge. In particular, due to the endogenous nature of stablecoin collateral policy shifts, such an approach may not estimate a causal effect of the event of interest if additional factors that may also drive stablecoin peg stability were changing over the same period.

To overcome this problem, we construct counterfactual values of peg stability in the post-event sample through a synthetic control inspired approach ([Abadie and Gardeazabal, 2003](#); [Doudchenko and Imbens, 2016](#)). Like in the synthetic control literature, we estimate pre-post changes in “synthetic” counterfactual peg stability measures that can then be compared to the actual pre-post change in peg stability in the spirit of a difference-in-difference exercise. But unlike difference-in-differences, which requires multiple treated and control units, synthetic control techniques are designed for settings with just one treated unit such as ours.

However, our approach differs from traditional synthetic controls in two important respects. First, given the limited number of liquid stablecoins in the crypto ecosystem, the number of control units (i.e. other stablecoins) that can be used to estimate the counterfac-

tual is very small – depending on the period considered, even zero. We therefore rely on data beyond stablecoins that are likely to be important determinants of stablecoin variability to estimate our counterfactuals. For example, we consider data on price variability of major cryptoassets like Bitcoin (BTC) and Ether (ETH) to proxy cryptoasset market conditions, as well as indicators of broader financial market conditions.⁴¹ Second, one advantage of our approach is that the relatively small number of covariates used to construct counterfactual predictions implies that the risk of overfitting the counterfactual estimate is much lower compared to a traditional synthetic control exercise, where the number of control units is large and often exceeds the number of observations.

The outcome measure of interest across our empirical analyses is the stability of a stablecoins’ dollar peg. As in [Lyons and Viswanath-Natraj \(2023\)](#), daily stablecoin peg stability is measured in absolute price deviations from \$1:

$$d_t = |1 - p_t^s|, \quad (5)$$

where d_t is the daily price deviation and p_t^s is the closing price of the stablecoin.⁴²

To construct the synthetic control we first estimate a dynamic regression of peg stability as a function of its lagged value and additional variables that shape peg stability over the pre-event sample period:

$$d_t = \alpha + \phi d_{t-1} + \beta \mathbf{X}_t + e_t, \quad (6)$$

where d_t is the absolute peg deviation defined in (5), α captures differential averages between d_t and the estimated counterfactual \hat{d}_t , and \mathbf{X}_t includes control units or covariates that could impact stablecoins through various channels.

We consider covariates that capture both cryptoasset market conditions and broader financial conditions. To proxy for crypto market conditions we use intraday range-based

⁴¹In this sense our approach can be viewed as a hybrid between traditional synthetic control event studies and factor models, as it takes pre-treatment peg stability outcomes as benchmarks when choosing weights for control units and uses correlations between treated and control units to predict treated counterfactuals ([Xu, 2017](#); [Chen, 2023](#)).

⁴²Our set of events examine periods of both upside and downside peg instability: the first event largely features positive price deviations (i.e. prices above \$1) while the second and third feature downward price deviations. Accordingly, restricting the analysis by defining run risk using measures of downside deviations would eliminate variation that is necessary to study the first event. More broadly, upward deviations are also a failure of the promise to deliver par and this is perceived as a bug rather than a feature in practice (e.g., Dai implemented its “price stability mechanism” to stabilize the peg around \$1 after a period of persistent upside deviations).

volatilities of the two largest cryptoassets (Bitcoin and Ether).⁴³ To proxy for broader financial market conditions we rely on indicators from more conventional asset classes.⁴⁴ These include the VIX index (as a proxy for broad financial market risk appetite), the MOVE index for interest rate volatility (which shapes the attractiveness of money-like investments often serving as stablecoin substitutes), option-implied volatility of gold (which serves as a gauge of the riskiness of gold-backed stablecoins), and option-implied volatility of the US dollar-euro exchange rate (capturing international US dollar market conditions and also serving as a global risk barometer).

A threat to identification in our setting arises from the possibility that control units in \mathbf{X}_t are affected by the treated outcome or the policy change specific to the outcome variable. This is also known as a violation of the Stable Unit Treatment Value Assumption (SUTVA). We deal with this threat by carefully selecting variables in \mathbf{X}_t that are unlikely to be impacted by policy changes in the stablecoins studied. Take for instance the two events examining Dai policy changes and peg deviations. In 2022, Dai saw its market capitalization peak at about \$10 billion. It is highly unlikely that the changing dynamics of Dai can materially impact the much larger BTC and ETH markets, let alone conventional financial markets. For our other event study, while Tether is a much larger stablecoin with a market capitalization reaching \$80 billion in 2022, it is still substantially smaller than ETH and BTC (around \$500 billion and \$1 trillion over the same period) and dwarfed by traditional financial markets. Finally, given the large size difference between Tether and Dai and the outsize role played in stablecoin market developments by Tether, we assume that Tether’s peg stability can impact that of Dai but not *vice versa*. We thus include Tether’s absolute peg deviations in \mathbf{X}_t when studying Dai’s peg stability, but not the reverse.

The pre-event sample counterfactual estimate is given simply by the fitted value recovered from (6), $\hat{d}_{t,pre}$. The post-event counterfactual estimate, $\hat{d}_{t,post}$, is in turn given by:

$$\hat{d}_{t,post} = \hat{\alpha} + \hat{\phi}E[d_{t-1,post}|d_{T,pre}, \mathbf{X}_{t-1,post}] + \hat{\beta}\mathbf{X}_{t,post} \quad (7)$$

where $\hat{\alpha}$, $\hat{\phi}$, and $\hat{\beta}$ are estimates of α , ϕ , and β from the pre-event period, respectively. We cannot directly incorporate post-event lagged peg deviations (d_{t-1}) to construct

⁴³These range volatility estimates are defined as: $rv_t^k = \ln p_{t,high}^k - \ln p_{t,low}^k$, where rv_t^k is the time t range volatility of cryptoasset $k \in \{BTC, ETH\}$ measured as the log-difference of the day’s high and low prices given by $p_{t,high}^k$ and $p_{t,low}^k$, respectively.

⁴⁴The main results are largely unchanged when excluding these indicators, suggesting that the risk of overfitting is relatively low.

the counterfactual because those values are ‘treated’. Instead, we recursively estimate the expected value of $d_{t-1,post}$ conditional on the last value of absolute peg deviations from the pre-event sample ($d_{T,pre}$) and lagged (post-event) values of the covariates ($\mathbf{X}_{t-1,post}$). The full counterfactual series of absolute peg deviations that we use to compare against realized peg deviations is then constructed by joining the pre and post event estimates, $[\hat{d}_{t,pre}, \hat{d}_{t,post}]$. This counterfactual path allows us to estimate an average treatment effect in the post sample period using a t -test for the difference in means between $\hat{d}_{t,post}$ and $d_{t,post}$, since the pre-event mean-differences average out to zero by design.

6.2 Data

The empirical analysis relies on daily frequency exchange-level cryptoasset data. Daily prices for Dai, Ether, and Bitcoin are from the Bitfinex exchange, whereas daily Tether prices are from the Kraken exchange. These exchange-level price data are sourced from cryptocompare.com and the choice of exchange is based on coin-level exchange data quality and transparency.⁴⁵ We also make use of daily market capitalization statistics for Dai, Tether, TerraUSD and Luna from coingecko.com. Historical data on collateral underlying the MakerDAO (Dai) protocol are from DefiLlama. Data on conventional financial market variables are from FRED.⁴⁶

6.3 Dai accepts USDC collateral

Our first event study covers Dai, a stablecoin originally fully backed by volatile cryptoassets, first only Ether and then a variety of others. This required over-collateralization in order to help ensure the peg was maintained despite the high volatility of reserve assets.

Dai’s collateral policy changed in 2020 with the acceptance of USDC as collateral. We view this change as an improvement in the quality of the pool of collateral backing Dai. Due to USDC’s 100% US dollar collateral, Dai’s acceptance of USDC effectively meant that Dai would no longer be 100% crypto-collateralized but would have some portion of collateral in US dollars (or dollar equivalents). Moreover, USDC collateral could be posted much more efficiently than crypto collateral as 1 dollar worth of USDC would yield about 1 dollar worth

⁴⁵Figure 16 in Appendix 16 presents figures of the daily price series for the four cryptoassets.

⁴⁶The interest rate, gold, and US dollar-Euro implied volatility indices are derived using the traditional VIX formulation on US Treasury bond, gold ETF, and Euro ETF options, respectively. They are identified by the ticker codes MOVE, GVZ and EVZ.

of Dai issued.

There are three important dates regarding Dai’s collateral during 2020 that help determine our sample (left-hand panel of Figure 7). The official announcement of a change in collateral policy took place in March, but a significant increase in USDC collateral backing Dai did not occur until September (first dashed vertical line). Moreover, in December Dai also introduced its price stability mechanism (PSM) – which allows 1-for-1 exchange between Dai and USDC – to further promote the use of USDC collateral and enhance peg stability (second vertical dashed line). The pre-event sample thus spans September 1, 2019 to September 15, 2020. The cut-off date is based on the sharp increase in USDC collateral, from under 10% to close to 50% of Dai market capitalization.⁴⁷ The post event sample runs from September 16, 2020 to September 1, 2021.

Our model predicts that such improvements in collateral quality should be associated with a more stable peg and reduced run risk. To assess this, we fit the dynamic regression specification described in (6), where Dai’s absolute peg deviations are modeled as a function of their own lag and the set of controls discussed above (including Tether’s absolute peg deviations). The right-hand panel in Figure 7 plots realized peg deviations (in dark blue) against counterfactual peg deviations (in red), before and after the rise of USDC collateral adoption on September 15, 2020.

Dai’s peg deviations decreased markedly following the large adoption of USDC collateral (before the PSM), whereas the counterfactual series remained around the same level. Table 2 reports *t*-statistics on average differences in absolute peg deviations over pre-event and post event periods. Following the acceptance of USDC collateral but before the implementation of the USDC-Dai stability mechanism, average daily peg deviations fell to \$0.008 compared to a pre-event average \$0.011 and a counterfactual post-event average of \$0.012 – a 33.3% reduction in peg deviations immediately following the rise in USDC collateral. After the USDC-Dai price stability mechanism was implemented on December 18, 2020, absolute peg deviations were reduced even further to \$0.001 on average, compared to a counterfactual of \$0.011 – a 91% reduction in average peg deviations. Both post event estimates are highly statistically significant.

⁴⁷One interpretation of the left-hand panel of Figure 7 is the number of US Dollars (in cents) backing each issued Dai token pegged at \$1. Plotting the value of USDC collateral as a percentage of total value locked looks very similar.

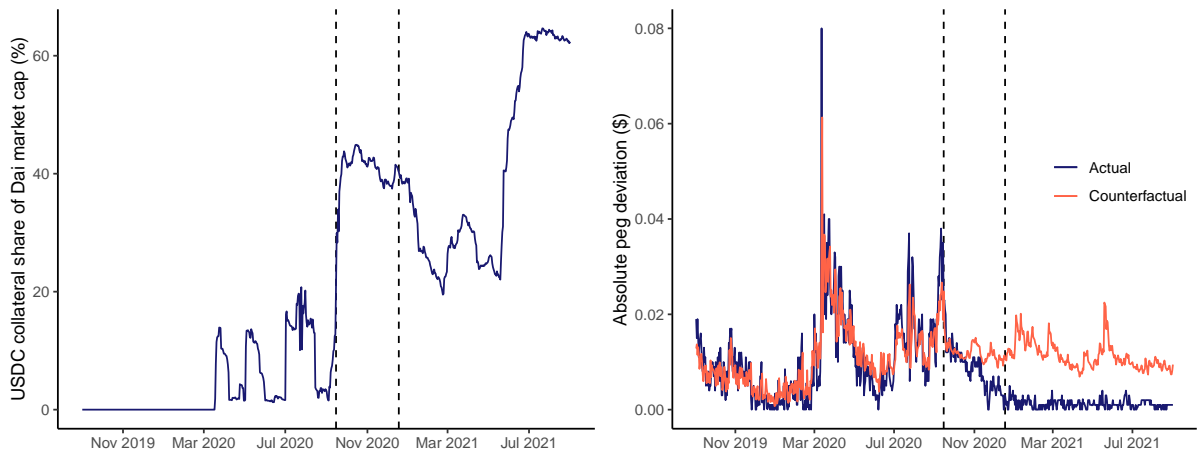


Figure 7: Dai’s shift in collateral policy towards USDC.

Notes: The left panel traces USDC collateral value as a percentage of Dai market capitalization. The right panel plots actual absolute peg deviations of Dai (dark blue) and the counterfactual path (red) estimated from Equations 6 and 7. The first dashed vertical line is September 15, 2020 (rise in USDC collateral). The second dashed vertical line is December 18, 2020 (implementation of the USDC-Dai price stability mechanism).

| Mean absolute peg deviations | Pre event 09-01-2019 to 09-15-2020 | Post event 09-16-2020 to 12-18-2020 | Post event 12-18-2020 to 09-01-2020 |
|------------------------------|------------------------------------|-------------------------------------|-------------------------------------|
| Actual | 0.011 | 0.008 | 0.001 |
| Counterfactual | 0.011 | 0.012 | 0.011 |
| Difference | 0.000 | -0.004*** | -0.010*** |
| <i>t</i> -statistic | 0.030 | -7.033 | -53.767 |
| Observations | 381 | 94 | 257 |

Table 2: Average effect (in \$) of USDC collateral on Dai’s absolute peg deviations, before and after September 15, 2020. Significance at the 10%, 5%, and 1% level given by ‘*’, ‘**’ and ‘***’, respectively.

6.4 Doubts about Tether’s reserve adequacy

Our second event study examines the largest stablecoin, Tether. In particular, we are interested in the period around October 2018, when Tether experienced temporary peg instability connected to worries over its backing. This occurred in the aftermath of a June

2018 audit report that was completed by a law firm rather than a certified accounting firm.⁴⁸ Concerns over whether Tether was 100% backed by US dollars (as claimed) continued to fester for several months and worries also rose regarding Tether’s relationship with Bitfinex and the possible co-mingling of customer funds. These concerns eventually led to a sharp de-pegging on October 15, 2018, followed by a sharp de-pegging in April 2019 when the NY Attorney General announced its lawsuit against iFinex, the parent company of Tether and Bitfinex.⁴⁹

In this event the reserve quality of the stablecoin was called into question, hence we *a priori* we expect to observe greater peg instability. We consider September 30, 2018 our event date as it stands a few days before the sharp de-pegging of Tether in mid October, a short window during which the media increasingly drew attention to Tether’s reserves. The pre-event sample spans February 15, 2018 to September 30, 2018 and the post-event sample spans October 1, 2018 to June 30, 2019. Tether’s market capitalization reached over \$3 billion before the event and by October 2018 it had fallen by \$1 billion, suggesting that these concerns were highly consequential for the stablecoin (left-hand panel of Figure 8).

We employ a similar dynamic regression specification to estimate the synthetic counterfactual path of Tether’s absolute peg deviations before and after the event date. Specifically, we regress absolute peg deviations of Tether on its lagged values, range volatilities of BTC and ETH, and the conventional financial market variables discussed earlier. Because Tether is the largest stablecoin, we do not include variables based on other smaller stablecoins due to the endogeneity concerns mentioned earlier.

The effects of the concerns regarding reserve quality are very clearly visible in terms of (lack of) peg stability in the right-hand panel of Figure 8. This panel plots Tether’s actual absolute peg deviations over the pre and post event periods in dark blue and its corresponding counterfactual path in red (as in the left-hand panel, the vertical line marks September 30, 2018, the beginning of rising concerns over Tether’s reserve adequacy). Actual peg deviations spike in the wake of the event and remain considerably large thereafter, whereas the counterfactual remains stable. We test these differences more formally in Table

⁴⁸The law firm, Free Sporkin and Sullivan, added a disclaimer that, “FSS is not an accounting firm and did not perform the above review and confirmations using Generally Accepted Accounting Principles,” and, “The above confirmation of bank and Tether balances should not be construed as the results of an audit and were not conducted in accordance with Generally Accepted Auditing Standards.”

⁴⁹During the case, Tether’s lawyers stated that as of April 30, just 74% of Tether was backed by US dollar assets, contrary the repeated previous statements by the issuer. The case reached a settlement in 2021.

| Mean absolute peg deviations | Pre event 02-15-2018 to 09-30-2018 | Post event 10-01-2018 to 06-30-2019 |
|------------------------------|------------------------------------|-------------------------------------|
| Actual | 0.011 | 0.009 |
| Counterfactual | 0.011 | 0.001 |
| Difference | 0.000 | 0.008*** |
| <i>t</i> -statistic | 0.101 | 15.042 |
| Observations | 228 | 274 |

Table 3: Average effect (in \$) after rising concerns over Tether’s collateral adequacy, before and after September 30, 2018. Significance at the 10%, 5%, and 1% level given by ‘*’, ‘**’ and ‘***’, respectively.

3, which reports mean absolute peg deviations over the pre and post event samples along with those of the counterfactual estimate. Tether’s realized peg deviations of \$0.009 were significantly larger in the post-event sample compared to the counterfactual mean deviation of \$0.001 (in other words, realized peg deviations were about 9 times, or 800% larger than in the counterfactual).

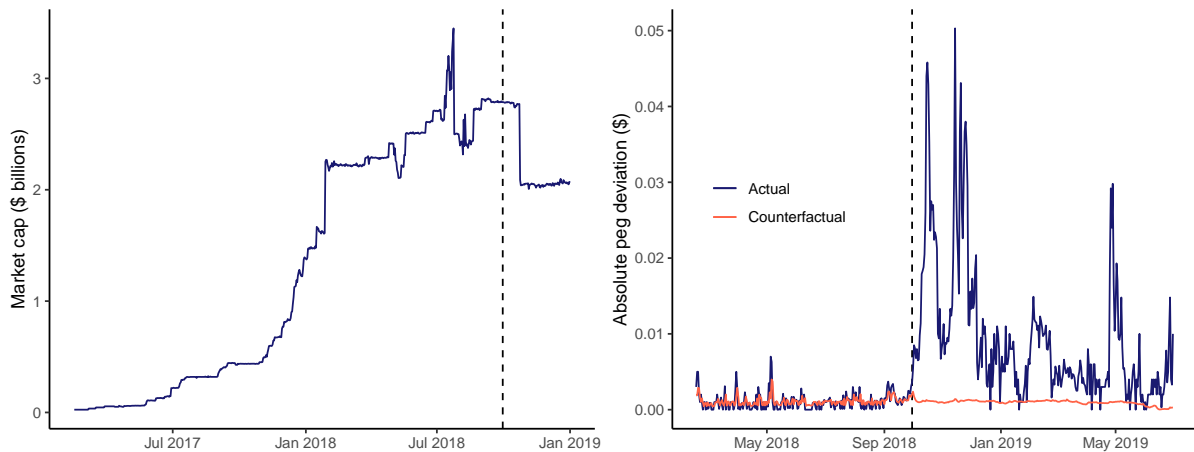


Figure 8: Doubts about Tether’s reserve adequacy.

Notes: The left panel traces the market capitalization of Tether. The right panel plots actual absolute peg deviations of Tether (dark blue) against the counterfactual path (red) estimated from Equations 6 and 7. The dashed vertical line is September 30, 2018, the beginning of concerns over Tether’s reserve adequacy.

6.5 Dai moves from single- to multi-collateral

The third event considers the early-stage collateral policy change by Dai in November 2018, when collateral was expanded from just Ether to additional volatile cryptoassets.⁵⁰ While the accepted collateral remained composed of cryptoassets after this event, the policy shift should imply a reduction in perceptions over reserves volatility, if only via risk diversification in the collateral pool, which is consistent with the second-generation model predictions. Accordingly, the perceived volatility of Dai’s reserve asset portfolio should decline and we thus expect an improvement in Dai’s peg stability.⁵¹

The change in collateral is clearly seen in the data. The left panel of Figure 9 traces the percent total collateral behind Dai accounted for by ETH over the event sample period. The pre-event sample spans November 1, 2018 to November 18, 2019, the day of the policy shift (marked with a vertical dashed line). The post-event sample starts on November 19, 2019 and ends on March 10, 2020 to avoid including the pandemic period. Under single-collateral Dai, ETH naturally made up 100% of collateral. But its share began to decrease once additional cryptoassets were accepted. The ETH share of collateral, however, remained large.

Our results suggest that moving from single to multi-collateral indeed had an improving effect on Dai’s peg stability. This is visible in the right-hand panel of Figure 9 as a divergence between the actual peg deviations (dark blue line) and the counterfactual path obtained from the synthetic control estimation (red line), which begins with the change in policy (vertical dashed line, as in the left-hand panel).⁵² Table 4 complements this visual result with an estimate of the average effect from the policy change on Dai’s peg stability. On average there was a statistically significant reduction in absolute peg deviations after the policy was implemented: average daily peg deviations in the post-event period were \$0.004 while the counterfactual predicted \$0.013, a 69% reduction in average peg deviations relative to the counterfactual. Interestingly, the treatment effect in this event study is considerably smaller than that in the first event study (91% reduction). This suggests that dollar (or dollar-equivalent) collateral is conducive to more peg stability *vis-à-vis* the US dollar than

⁵⁰Technically, the transition from single- to multi-collateral was a new product launch, from Sai (single-collateral) to Dai (multi-collateral).

⁵¹That said, we do not expect an improvement to the same degree as that from Dai accepting USDC collateral, as explored in the first event.

⁵²The covariates (\mathbf{X}_t) included in the synthetic control regression for this event study are the same as those in the first event study also on Dai.

volatile collateral such as cryptoassets.

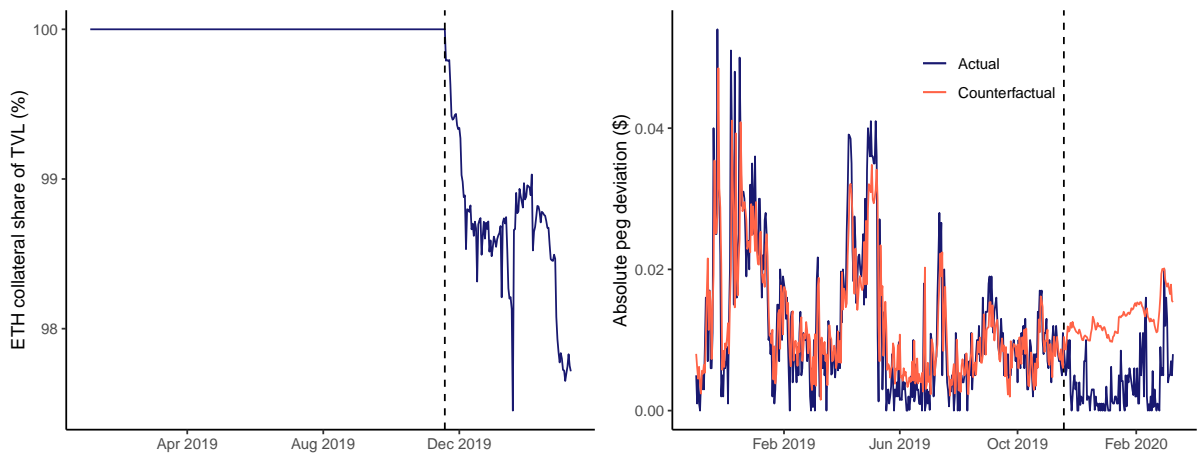


Figure 9: Dai shifts from single to multi-collateral cryptoasset reserves.

Notes: The left panel plots ETH collateral as a percentage of total collateral value (i.e. ‘total value locked’, TVL). The right panel plots the actual absolute peg deviations of Dai (dark blue) against the counterfactual path (red) estimated from Equations 6 and 7. The dashed vertical line is November 18, 2019, the beginning of multi-collateral Dai.

| Mean absolute peg deviations | Pre event 11-01-2018 to 11-18-2019 | Post event 11-19-2019 to 03-10-2020 |
|------------------------------|------------------------------------|-------------------------------------|
| Actual | 0.012 | 0.004 |
| Counterfactual | 0.012 | 0.013 |
| Difference | 0.000 | -0.009*** |
| <i>t</i> -statistic | -0.020 | -20.998 |
| Observations | 383 | 113 |

Table 4: Average effect (in \$) of shifting from single-collateral to multi-collateral on Dai’s absolute peg deviation, before and after November 18, 2019. Significance at the 10%, 5%, and 1% level given by ‘*’, ‘**’ and ‘***’, respectively.

6.6 Reserve volatility and peg stability: TerraUSD and Luna

Lastly, we also test our second-generation model predictions using data on TerraUSD, the now defunct algorithmic stablecoin. This type of second-generation global game model predicts that reserve asset returns are drawn from a distribution with fat tails, such that the variance of the reserve asset returns is unknown and beliefs about it change over time.

The model also predicts that large reserve asset shocks are destabilizing when the stablecoin lies within a “ripe for run” region but not outside this region, whereas small shocks are not destabilizing.

Luna’s market capitalization was indeed volatile. The left panel in Figure 10 shows that Luna’s market capitalization was highly volatile but generally remained well above the value of Terra’s outstanding stablecoin liabilities, except for two periods: May 2021 and May 2022, when TerraUSD permanently de-pegged. During both periods (denoted by grey vertical areas), the market capitalization of Luna approached that of TerraUSD. We define this difference as Terra’s “equity value”.⁵³ For example, the 2021 episode when Terra equity values quickly approached zero was caused by the bursting of the cryptoasset bubble, with the price of Bitcoin falling 40% in a matter of days, bringing Luna’s price down with it. The notion of Terra’s equity value is compelling because if Luna’s market capitalization falls below that of TerraUSD, then there is insufficient Luna available to be sold to cover all TerraUSD liabilities, and therefore Terra as a stablecoin issuer is more likely to become insolvent in the eyes of TerraUSD holders (Liu et al., 2023).

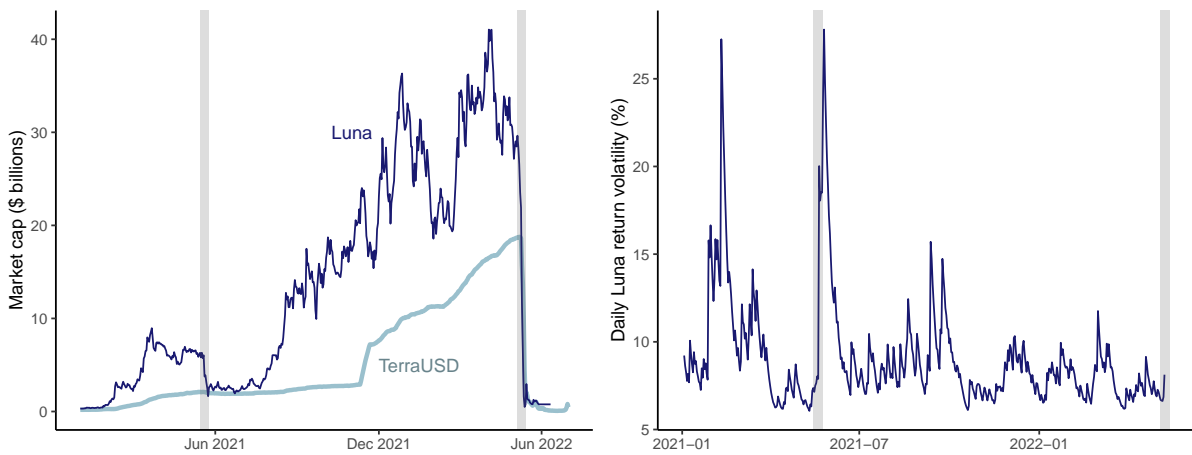


Figure 10: TerraUSD market capitalization, Luna market capitalization and volatility.

Notes: The left-panel plots the market capitalization of TerraUSD (light blue, thick) and Luna (dark blue, thin), including the period of the terminal depegging event. We define the difference between Luna and TerraUSD market capitalization as Terra equity. The right-hand plots the daily return volatility of Luna, estimated under a GARCH(1,1) specification through May 9, 2022 (pre de-pegging event). By May 11 Luna estimated daily volatility reached 50% and exceeded 400% by May 14 (not shown for better visibility). The shaded regions indicate May 15-25, 2021 and May 5-15, 2022, respectively.

As the variance of the reserve asset is unknown under the extended model, we assume

⁵³Concretely, we define it as follows: $Terra\ Equity = Luna\ Market\ Cap - TerraUSD\ Market\ Cap$.

that beliefs over it are formed using observable data on changes in reserve asset prices. As a result, TerraUSD holders’ best guess on the variance of the reserve asset Luna is likely a function of Luna’s price return history, and this estimate can change over time with the arrival of new information. Validating the assumption that variance is not known and non-constant, the right-panel of Figure 10 shows strong evidence of time-varying variance for Luna. Specifically, we use a GARCH(1,1) estimate of the conditional standard deviation of daily returns (i.e. volatility) of Luna through May 9, 2022, right before the permanent de-peg when volatility exploded to over 400%, resulting in a time-series plot that is quite literally off the chart. The non-constant conditional volatility of Luna generates unconditional fat tails in the unconditional distribution of the reserve asset returns, consistent with the second-generation model assumptions and statistical properties of Luna’s price returns.

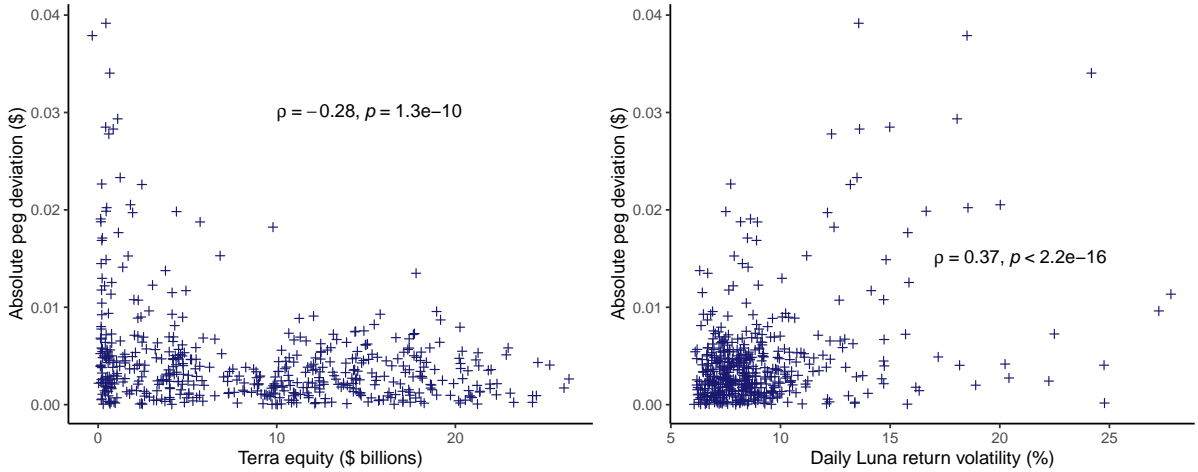


Figure 11: Terra equity, volatility and peg deviations.

Notes: The left panel plots Terra equity (defined as market capitalization of Luna minus that of TerraUSD) versus absolute peg deviations of TerraUSD. The right panel plots the daily return volatility of Luna estimated under a GARCH(1,1) specification versus absolute peg deviations of TerraUSD. Daily data from January 1, 2021 to May 9, 2022.

Our model also implies that when high reserve volatility stablecoins like TerraUSD are in a “ripe for run” region they are susceptible to large shocks toppling them. Here the concept of Terra equity defined above is useful, as it can be seen as a measure that determines vulnerability to a run. In other words, the run region is more likely to be approached as Terra’s equity value approaches zero. Indeed, as Terra’s equity value falls, absolute deviations of TerraUSD’s dollar peg increases and are largest when Terra’s equity value approaches zero (left panel of Figure 11). Without explicitly taking a stance on defining a “ripe for run” threshold, it is possible to simplify to a continuous setting where we can

think of Terra’s run risk, quantified using absolute peg deviations, as decreasing in Terra’s equity value. Luna volatility, in turn, is positively associated with TerraUSD’s absolute peg deviations, as shown in the right panel of Figure 11. In other words, when the range of possible Luna reserve asset returns increases, so do absolute peg deviations of TerraUSD. We interpret large (small) values of Luna return volatility as realizations of large (small) reserve asset shocks.

Taking these stylized facts together help motivate a simple regression analysis to test the implications of the extended model. We test the following two predictions: (i) reserve asset shocks are positively correlated with TerraUSD peg deviations, i.e. large shocks are more destabilizing than small shocks; and (ii) the effect of reserve asset shocks on TerraUSD peg stability are stronger within the “ripe for run” region, i.e. when Terra’s equity value is smaller. A parsimonious regression model to test these predictions can be set up as follows:

$$d_t = \alpha + \phi d_{t-1} + \beta_1 vol_{t-1} + \beta_2 [vol_{t-1} \times equity_{t-1}] + e_t, \quad (8)$$

where variables on the right-hand side are lagged to help reduce the risk of endogeneity arising from simultaneity between TerraUSD and Luna. TerraUSD’s absolute peg deviations are given by d_t , Luna’s GARCH(1,1) conditional volatility is given by vol_t and Terra’s equity value is given by $equity_t$. Daily data from January 1, 2021 to May 9, 2022 are used, so our estimates exclude the final de-peg event of May 2022.⁵⁴

The interpretation of coefficients is as follows. A positive estimate of β_1 suggests that TerraUSD’s peg deviations are larger when reserve asset volatility is higher (larger shocks). A negative estimate of β_2 in turn indicates that for any given level of Luna volatility, its impact on TerraUSD’s peg stability is weaker when Terra’s equity value is larger. Our specification is motivated by the interpolated surface plot shown in Figure 12 which uses local linear smoothing to fit a surface relating Terra’s equity and Luna’s volatility to TerraUSD’s peg deviations. Empirically, it can be seen that even prior to the permanent de-peg that occurred in May 2022, peg deviations were largest when both Luna’s volatility was high and Terra’s equity value was low.

Regression results support the two predictions (Table 5). Indeed as suggested by Figures 11 and 12, as reserve asset volatility rises, so do absolute peg deviations. However, the impact

⁵⁴Results are not sensitive to the choice of using logged or non-logged volatility, nor the choice to include or exclude a lagged dependent variable.

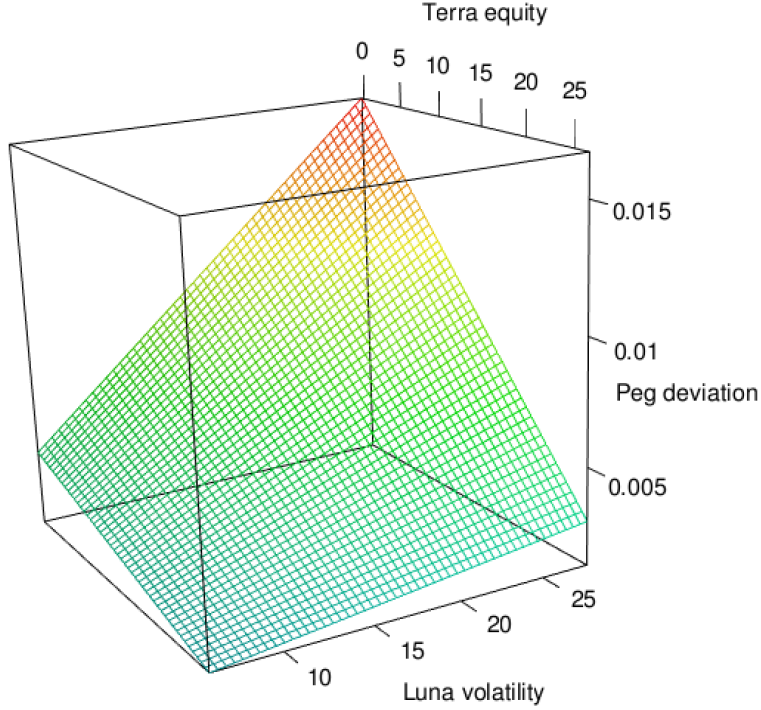


Figure 12: Terra equity, Luna volatility and TerraUSD absolute peg deviations.

Notes: Terra equity is defined as the market capitalization of Luna minus the market capitalization of TerraUSD. Luna volatility corresponds to the daily conditional return volatility estimated from a GARCH(1,1) model. The surface is interpolated via a locally estimated scatter plot smoothing regression with degree of 1 and span of 0.95.

of higher reserve asset volatility on peg deviations depends significantly on the equity value of Terra. When equity is low (i.e. when approaching the “ripe for run” region), the same level of Luna volatility has a substantially larger impact on TerraUSD’s peg stability.

| Covariate | Estimate | SE |
|---------------------------------|------------|----------|
| Intercept | 0.0013 | (0.0007) |
| d_{t-1} | 0.4978*** | (0.0403) |
| vol_{t-1} | 0.0186* | (0.0067) |
| $vol_{t-1} \times equity_{t-1}$ | -0.0011*** | (0.0003) |

Table 5: Regression estimates from Equation 8 where the dependent variable is d_t , TerraUSD absolute peg deviations. Significance at the 10%, 5%, and 1% level given by ‘*’, ‘**’ and ‘***’, respectively. Standard errors adjusted for heteroskedasticity and autocorrelation. Estimates and standard errors (SE) on vol_{t-1} and $[vol_{t-1} \times equity_{t-1}]$ are multiplied by 100. The sample runs from from January 1, 2021 to May 9, 2022, and includes 492 observations.

To interpret the results, let us consider a scenario where Luna daily volatility rises to from 5% to 15%. Under an equity value of \$15 billion, TerraUSD’s peg deviations would

increase from \$0.00013 to \$0.0004.⁵⁵ However, under an equity value of just \$1 billion, TerraUSD peg deviations would rise from \$0.0009 to \$0.0026, a 29-fold increase. On May 12, 2020, TerraUSD broke its peg and fell from \$1 to roughly \$0.78 and Terra’s equity value was wiped out. By May 14, TerraUSD crashed to roughly \$0.12 and Luna volatility rose sharply, exceeding 400%. Our simple linear model estimated on data before the de-peg qualitatively captures the peg stability risk of Terra that eventually became realized, although unsurprisingly non-linearities would likely need to be considered to quantitatively match the nature of Terra’s final de-pegging event.

7 Conclusion

Stablecoins were designed to provide a stable unit of account within the crypto universe. Yet despite the various strategies used to defend their promise of par convertibility to the sovereign unit of account, that promise was broken on multiple occasions. Besides the notorious failure of the algorithmic stablecoin TerraUSD, the March 2023 banking crisis simultaneously highlighted the key role of reserve transparency and volatility.

In this paper, we analyze the various ways in which information (in the form of public broadcasts and learning from past observation) shapes the risk of coordination failure by stablecoin holders through their beliefs about peg stability. Using global games to model the strategic interactions among stablecoin holders and issuers, we argue that the effect of public disclosure and large shocks on run risk is ambiguous. Greater transparency can lead to greater run risk when market expectations are pessimistic or when transacting in and out of the coins is easy; conversely, transparency strengthens a stablecoin peg when priors are strong and conversion is costly. When collateral is particularly volatile (for example, when stablecoins are backed by other crypto assets), we predict inertia in aggregate behavior by stablecoin holders. Individuals pay close attention to past events, and small public shocks to fundamentals induce a reversion to historical outcomes, while large negative (positive) shocks trigger wide-spread runs (recoveries). Our assessment of the effect of recent publicized changes to collateral holdings by prominent stablecoin issuers on stablecoin price stability provides strong support to the model’s predictions.

Our paper points to interesting avenues for future work. For example, future research

⁵⁵TerraUSD absolute peg deviations, d_t , have a standard deviation of \$0.0052 from January 1, 2021 to May 9, 2022.

could consider the interplay between conflicting public messages about the quality of stablecoin issuer collateral, and how public information interacts with shocks to idiosyncratic noise that, together, shape run risk. The first issue pertains to instances where, for example, public audits reveal information that contradicts disclosure by the issuer. The second issue involves the impact of informational sources such as social media on the idiosyncratic beliefs of market participants. Such work may be facilitated by the continuous development of stablecoins with an increasingly diverse range of reserves and collateral policies. Recent developments in the US banking sector and an evolving regulatory landscape should also provide a rich environment that yields additional insights into the relationship between collateral quality, transparency and stablecoin risk.

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A Derivations and proofs

A.1 Proof of Proposition 1

We work backwards, first analyzing the behavior of the issuer for any mass of early withdrawals before solving the equilibrium strategies of SC holders.

For a given mass of redemption requests, A , the issuer is able to process withdrawals by selling down reserve assets at a unit value θ per stablecoin. Whenever $A > \theta$, the issuer is rendered insolvent. Therefore, conditional on $A = \theta_c$, where θ_c is some critical level at which withdrawal requests are just equal to the value of reserve assets, it is in every SC holder's best interest to demand conversion in the hope of reclaiming funds before the issuer becomes insolvent (i.e., to run on the stablecoin).

SC holders use Bayesian updating to form beliefs about the value of fundamentals, θ . Conditional on x_i , the density over θ is normal with mean

$$\frac{\sigma_x^2 y + \sigma_\theta^2 x_i}{\sigma_x^2 + \sigma_\theta^2}, \quad (9)$$

and variance

$$\frac{(\sigma_x \sigma_\theta)^2}{\sigma_x^2 + \sigma_\theta^2}. \quad (10)$$

Under this posterior, and given some critical threshold θ_c , SC holders assign the following probability to the event that $\theta < \theta_c$:

$$F(\theta_c | x_i) = \Phi \left(\frac{\sqrt{\sigma_x^2 + \sigma_\theta^2}}{\sigma_x \sigma_\theta} \left[\theta_c - \frac{\sigma_x^2 y + \sigma_\theta^2 x_i}{\sigma_x^2 + \sigma_\theta^2} \right] \right). \quad (11)$$

This posterior determines the critical SC holder's indifference condition (of type x^*) where the expected payoff from demanding conversion is exactly equal to the expected payoff from maintaining a stablecoin holding, i.e.,

$$F(\theta_c | x^*)(1 - \tau) + [1 - F(\theta_c | x^)](1 - 2\tau) = [1 - F(\theta_c | x^)]\pi(\theta_c). \quad (12)$$

Conditional on θ , SC holder signals are normally distributed. The proportion of SC holders with signal below x^* is given by

$$A = \Phi \left(\frac{x^* - \theta}{\sigma_x} \right). \quad (13)$$

This determines the aggregate mass of SC holders that demand conversion in equilibrium. At the critical level of fundamentals, θ_c , the value of conversion requests is exactly equal to the value of reserve assets, i.e.,

$$\theta_c = \Phi\left(\frac{x^* - \theta_c}{\sigma_x}\right) \iff \theta_c = x^* - \sigma_x \Phi^{-1}(\theta_c). \quad (14)$$

This expression can be substituted into the SC holder posterior in (11), rearranged, and evaluated at the indifference condition:

$$\Phi\left(\frac{\sqrt{\sigma_x^2 + \sigma_\theta^2}}{\sigma_\theta} [-\Phi^{-1}(\theta_c)] + \frac{\sigma_x}{\sigma_\theta \sqrt{\sigma_x^2 + \sigma_\theta^2}} (y - x^*)\right) = \frac{\pi(\theta_c) + 2\tau - 1}{\pi(\theta_c) + \tau} \equiv \rho(\theta_c). \quad (15)$$

Equation (15) does not necessarily have a unique solution. By continuity of both the left-hand side and the right-hand side of (15), a sufficient condition that grants uniqueness is if the derivative of the left-hand side of (15) with respect to x^* is less than zero, since the right-hand side is increasing implicitly in x^* . The derivative of this posterior in (11) is negative if

$$\frac{\sqrt{\sigma_x^2 + \sigma_\theta^2}}{\sigma_x \sigma_\theta} \left(\frac{d\theta_c}{dx^*} - \frac{\sigma_\theta^2}{\sigma_x^2 + \sigma_\theta^2} \right) \phi\left(\frac{\sqrt{\sigma_x^2 + \sigma_\theta^2}}{\sigma_x \sigma_\theta} \left[\theta_c - \frac{\sigma_x^2 y + \sigma_\theta^2 x_i}{\sigma_x^2 + \sigma_\theta^2} \right]\right) < 0, \quad (16)$$

and this requires that

$$\frac{d\theta_c}{dx^*} - \frac{\sigma_\theta^2}{\sigma_x^2 + \sigma_\theta^2} < 0. \quad (17)$$

By the implicit function theorem and using the aggregate condition (14), we can substitute in for $d\theta_c/dx^*$ into (17) as follows:

$$\frac{\phi\left(\frac{x^* - \theta_c}{\sigma_x}\right)}{\sigma_x + \phi\left(\frac{x^* - \theta_c}{\sigma_x}\right)} - \frac{\sigma_\theta^2}{\sigma_x^2 + \sigma_\theta^2}, \quad (18)$$

which is negative if

$$\sigma_x < \frac{\sigma_\theta^2}{\phi(\cdot)}. \quad (19)$$

Noting that the maximum of $\phi(\cdot)$ is $1/\sqrt{2\pi}$, where π here refers to the mathematical constant, a sufficient condition for uniqueness is

$$\sigma_x < \sigma_\theta^2 \sqrt{2\pi}. \quad (20)$$

When this condition holds, the posterior mass of SC holders who are expected to observe lower signals is approximately $\frac{1}{2}$, producing consistent higher-order beliefs that each SC holder considers herself the median type.⁵⁶ These uniform rank beliefs, together with the continuity of SC holder payoffs, action and state monotonicity, and limit dominance ensure that through iterative deletion of strongly dominated strategies (Milgrom and Roberts, 1990), switching point, x^* defined in condition (15) forms the unique switching strategy surviving iterative deletion which, in turn, determines the aggregate threshold $\theta_c = \theta^*$.

Equilibrium thresholds are then given by the unique solutions to the following system of equations:

$$\begin{aligned} \int_{-\infty}^{\theta^*} f(\theta|x^*)d\theta - \rho(\theta^*) &= 0, \\ \Phi\left(\frac{x^* - \theta^*}{\sigma_x}\right) &= \theta^*. \end{aligned} \quad (21)$$

Comparative statics

First, we consider the effect of market expectations of fundamentals, y . By differentiating the system in (21) with respect to y , we obtain

$$\begin{aligned} \frac{\sqrt{\sigma_x^2 + \sigma_\theta^2}}{\sigma_x \sigma_\theta} \phi(\cdot) \left\{ \frac{d\theta^*}{dy} - \frac{\sigma_x^2}{\sigma_x^2 + \sigma_\theta^2} - \frac{\sigma_\theta^2}{\sigma_x^2 + \sigma_\theta^2} \frac{dx^*}{dy} \right\} - \rho'(\cdot) \frac{d\theta^*}{dy} &= 0 \\ \frac{1}{\sigma_x} \phi\left(\frac{x^* - \theta^*}{\sigma_x}\right) \left[\frac{dx^*}{dy} - \frac{d\theta^*}{dy} \right] - \frac{d\theta^*}{dy} &= 0. \end{aligned} \quad (22)$$

Solving by substitution, we get:

$$\frac{dx^*}{dy} = \frac{d\theta^*}{dy} \left(\frac{\sigma_x}{\phi(\sigma_x^{-1}(x^* - \theta^*))} + 1 \right) < 0 \quad (23)$$

$$\frac{d\theta^*}{dy} = \frac{\sigma_x^2}{\sigma_x^2 + \sigma_\theta^2} \left(\frac{\sigma_x}{\sigma_x^2 + \sigma_\theta^2} \left[\sigma_x - \frac{\sigma_\theta^2}{\phi(\sigma_x^{-1}(x^* - \theta^*))} \right] - \frac{\sigma_x \sigma_\theta}{\sqrt{\sigma_x^2 + \sigma_\theta^2}} \frac{\rho'(\cdot)}{\phi(\cdot)} \right)^{-1} < 0, \quad (24)$$

where $\phi(\cdot)$ is positive for all reals and obtains a maximum of $1/\sqrt{2\pi}$. The expression in square brackets in (24) is negative when $\sigma_x < \sigma_\theta^2 \sqrt{2\pi}$, which holds by our equilibrium characterization in Proposition 1 and the second term is negative since $\rho'(\cdot) > 0$. Given $\frac{d\theta^*}{dy} < 0$, it follows that $\frac{dx^*}{dy} < 0$ by (23).

Therefore, an increase in the common prior, y , causes a downward shift in both x^* and θ^* ,

⁵⁶See Morris et al. (2016) on why approximate common knowledge of approximately uniform rank beliefs (i.e., the posterior mass of types lower than type i) is sufficient to ensure uniquely rationalizable behaviour in global games.

which lowers the fragility of the stablecoin as measured by $\mathbb{P}[\theta < \theta^*]$. Intuitively, as market sentiment about the dollar value of reserve assets generally improves, there is a direct and indirect effect on stablecoin run dynamics. The direct effect is that the expected dollar value of reserve assets is higher, which makes the issuer better equipped, in expectation, to face a given mass of conversion requests. The indirect effect is that a stronger prior makes every SC holder less confident that others are willing to run on the issuer, which in turn dampens each individual's incentives to run. Both these effects serve to lower the fragility of the stablecoin.

We next consider the effect of transaction costs on the probability of a run. Using the indifference condition in (15) and by the implicit function theorem, the effect of a change in τ is given by

$$\frac{\partial x^*}{\partial \tau} = \frac{-[\pi(\theta^*) + 1]}{\frac{\sigma_x}{\sigma_\theta \sqrt{\sigma_x^2 + \sigma_\theta^2}} \phi(\cdot)} < 0. \quad (25)$$

Aggregate conversion requests are decreasing in transaction costs, τ . The reason is that the indifference condition for the posterior probability that the issuer becomes insolvent ($\rho(\theta)$) is increasing in τ , resulting in an intersection between $F(\theta_c|x)$ and $\rho(\theta_c)$ at a lower signal type x^* . To examine the effect on the probability of issuer insolvency using failure condition (14), we have

$$\frac{\partial \theta^*}{\partial x^*} = \frac{-1}{1 + \frac{1}{\sigma} \phi(\cdot)} (-\phi(\cdot)) > 0. \quad (26)$$

Therefore, the probability of issuer failure due to a stablecoin run is also decreasing in τ , since $\partial x^*/\partial \tau < 0$. Increasing transaction costs cause each SC holder to be less flighty, as it becomes more costly to run on a solvent issuer. Moreover, each SC holder believes that others are less likely to run, which dampens her own propensity to demand conversion due to strategic complementarities. Together, these effects lower the fragility of the stablecoin and $\mathbb{P}[\theta < \theta^*]$ falls.

A.2 Proof of Proposition 2

Since the solvency of the SC issuer is dependent on the aggregate mass of conversion requests by SC holders, we first evaluate the effect of an increase in α on switching point x^* before assessing the total effect on θ^* .

Using the precision parameters and rearranging Equation (15) at the critical level of

fundamentals θ^* , we have that

$$x^* = \frac{\alpha + \beta}{\beta} \theta^* - \frac{\alpha}{\beta} y - \frac{\sqrt{\alpha + \beta}}{\beta} \Phi^{-1}(\rho(\theta^*)). \quad (27)$$

The effect of a marginal increase in the precision of public information, α , on switching point x^* is given by

$$\frac{\partial x^*}{\partial \alpha} = \frac{\theta^*}{\beta} - \frac{y}{\beta} - \frac{1}{2\beta\sqrt{\alpha + \beta}} \phi^{-1}(\rho(\theta^*)). \quad (28)$$

The sign of (28) is ambiguous. In particular, the equilibrium switching point, which indicates the propensity of SC holders to demand conversion for a given level of fundamentals, is increasing in the precision of public information if

$$\theta^* > y + \frac{1}{2\sqrt{\alpha + \beta}} \Phi^{-1}(\rho(\theta^*)). \quad (29)$$

Using the aggregate equilibrium condition (14), and by the implicit function theorem, the effect of a change in x^* on θ^* is given by

$$\frac{\partial \theta^*}{\partial x^*} = \frac{-1}{1 + \sqrt{\beta} \phi(\cdot)} (-\phi(\cdot)) > 0, \quad (30)$$

since $\phi(\cdot)$ is weakly positive for all reals. This means that if the propensity of SC holders to demand conversion increases in response to an increase in the precision of public information, then so too does the overall probability of a run since $\mathbb{P}[\theta \leq \theta^*]$ is increasing in θ^* .

A.3 Proof of Proposition 3

Given some critical reserve asset value θ_c , let \mathcal{P} be the set of all signals associated with a non-negative expected payoff from demanding conversion, so that

$$\mathcal{P} \equiv \left\{ x \left| G(\theta_c|x)(1 - \tau) + \int_{\theta_c}^{\infty} (1 - 2\tau - \pi(\theta)) dG(\theta|x) > 0 \right. \right\}. \quad (31)$$

We say that demanding conversion is p -dominant for SC holder i whenever $x_i \in \mathcal{P}$, and maintaining a holding is p -dominant whenever $x_i \in \mathcal{P}'$ (the complement of \mathcal{P}). Since the left-hand side of the expression in (31) is strictly decreasing in x , by the intermediate value theorem, for any θ_c , there is a corresponding indifference condition characterized by unique signal x_c such that the expected payoff differential is exactly zero.

To derive the critical threshold θ_c , SC holders must also appeal to higher order reasoning to justify the decision to withdraw their holding. Let \mathcal{Q} be the set of all signals associated with rank beliefs that exceed the expected value of reserve assets, so that

$$\mathcal{Q} \equiv \left\{ x \left| R(z_j) > y + \mathbb{E}[\eta|x_j] \quad \forall x_j \leq x \right. \right\}. \quad (32)$$

Whenever $x_i \in \mathcal{Q}$, SC holder i believes that at least $q = y + \mathbb{E}[\eta|x]$ will withdraw early, where $\mathbb{E}[\eta|x_j]$ is defined as the expected shock to fundamentals conditional on observing x_j :

$$\mathbb{E}[\eta|x_j] = \frac{\int \eta g(\eta) \phi(z_j - \eta) d\eta}{\int g(s) \phi(z_j - s) ds}. \quad (33)$$

This mass will be sufficient to render the issuer insolvent and, crucially, anyone with a more pessimistic signal has a belief at least as strong as i 's that the issuer will become insolvent. This is because the rank belief function provides i 's expected mass of withdrawals conditional on i 's signal being the switching point x_c . Denoting the complement of \mathcal{Q} by \mathcal{Q}' , SC holder i believes that too few others will withdraw to cause the issuer to fail whenever $x_i \in \mathcal{Q}'$.

Together, conditions $x \in \mathcal{P}$ and $x \in \mathcal{Q}$ are necessary and sufficient to make withdrawing uniquely rationalizable at signal x .⁵⁷ Owing to supermodularity of the game among SC holders, there exists a greatest and least Nash equilibrium that bound all rationalizable strategies (Van Zandt and Vives, 2007). The least equilibrium switching point, \hat{x} , is the unique solution

$$\hat{x} = \sup_x \{x \in \mathcal{P} \cap \mathcal{Q}\}. \quad (34)$$

The greatest equilibrium switching point, \hat{x} , is the unique solution

$$\hat{x} = \inf_x \{x \in \mathcal{P}' \cap \mathcal{Q}'\}. \quad (35)$$

Since x and θ are stochastically affiliated, we have $\hat{x} \leq \hat{x}$, and the thresholds converge to overlap at x^* whenever $\sigma_x < \sqrt{2\pi}$.

For each equilibrium switching point, \hat{x} and \hat{x} , there is a corresponding critical dollar

⁵⁷Analogously, $x \in \mathcal{P}'$ and $x \in \mathcal{Q}'$ is necessary and sufficient to make maintaining a holding uniquely rationalizable at x .

value of reserve assets, $\hat{\theta}$ and $\hat{\hat{\theta}}$ respectively, given by the unique solution to

$$\theta = \Phi \left(\frac{x - \theta}{\sigma_x} \right). \quad (36)$$

The issuer always becomes insolvent when $\theta < \hat{\hat{\theta}}$, always survives when $\theta \geq \hat{\theta}$, and faces an indeterminate outcome whenever $\hat{\hat{\theta}} \leq \theta < \hat{\theta}$.

Comparative statics

For a given critical value of fundamentals, θ_c , the continuity of $G(\theta_c|x)$ and $\int_{\theta_c}^{\infty} \pi(\theta) dG(\theta|x)$ guarantees that there is a unique p -dominance threshold x_c , at which a stablecoin holder is indifferent between demanding conversion and maintaining a holding. Fix model parameters such that $\bar{x}_Q > x_c > \underline{x}_Q$, where \underline{x}_Q is the lowest, and \bar{x}_Q is the greatest of the solutions to

$$R(z) = y + \mathbb{E}[\eta|x_j]. \quad (37)$$

In this case, it is *beliefs about aggregate behavior* rather than individual payoff parameters that are crucial in determining the probability of issuer insolvency. As such, using the implicit function theorem, changes in market expectations about reserve quality, y , produce the following effects on switching strategies:

$$\begin{aligned} \frac{\partial \hat{x}(z)}{\partial y} &= \frac{1}{R'(z) - \mathbb{E}'[\eta|x]} < 0 \\ \frac{\partial \hat{\hat{x}}(z)}{\partial y} &= \frac{1}{R'(z) - \mathbb{E}'[\eta|x]} < 0, \end{aligned} \quad (38)$$

where we have used the definition for switching point \hat{x} from (35). The sign of (38) is negative since $R'(z) < 0$ and $\mathbb{E}'(\cdot) > 0$ at both \hat{x} and $\hat{\hat{x}}$.⁵⁸ By affiliation of x and θ in (36), the fundamental thresholds are also decreasing in y .

Note that the solutions to (37) are independent of the transaction cost τ . Therefore, as long as $\bar{x}_Q > x_c > \underline{x}_Q$ holds, increases in transaction costs *do not affect switching strategies* defined by \hat{x} and $\hat{\hat{x}}$, and so the fundamental thresholds $\hat{\theta}$ and $\hat{\hat{\theta}}$ are also invariant to small increases in transaction costs.

⁵⁸To see this consider: $\frac{\partial R(z)}{\partial z} = \frac{\phi * g(z) \cdot \Phi \phi * \frac{\partial g}{\partial z}(z) - \Phi \phi * g(z) \cdot \phi * \frac{\partial g}{\partial z}(z)}{(\phi * g(z))^2}$. First, $\hat{z} \leq \bar{z}(\underline{R}) < 0$ as per the proof of Proposition 4 by Morris and Yildiz (2019), where \underline{R} is the minimum rank belief, given distributions g and ϕ . Further, by the definition of \underline{R} and the uniform limit rank beliefs property, $\partial R(z)/\partial z \leq 0$ for all $z \leq \bar{z}(\underline{R})$. By symmetry, the same properties hold at \hat{z} .

However, since we have shown in the proof of Proposition 1 that both x^* and θ^* are decreasing in τ , it follows that a sufficiently large increase in transaction costs could lead to a case where $x_c < \underline{x}_Q < \bar{x}_Q$. When this happens, by the same mechanism in the comparative statics presented in Appendix A.1, we have $\partial \hat{x} / \partial \tau < 0$ and, hence, $\partial \hat{\theta} / \partial \tau < 0$. When the condition $\bar{x}_Q > x_c > \underline{x}_Q$ no longer holds, the lower switching strategy, \hat{x} is defined by the p -dominance threshold x_c , rather than \underline{x}_Q . In this case, by condition (31), an increase in τ has the following effect on the lower threshold:

$$\frac{\partial \hat{x}}{\partial \tau} = \frac{-[G(\theta_c|x) - 2]}{\frac{\partial G(\theta_c|x)}{\partial x}(1 - \tau) - \int_{\theta_c}^{\infty} g'(\cdot)[\pi(\theta) - (1 - 2\tau)]d\theta} < 0, \quad (39)$$

where $G(\theta_c|x)$ is decreasing in x by stochastic affiliation of θ_c and x , and $g'(\cdot) \geq 0$ at the lower threshold since $\hat{x} \leq \hat{\theta}$.

Therefore, while the common prior has the same dampening effect on the flightiness of SC holders as in the low-volatility regime, transaction costs are only effective at staving off a stablecoin run when they are raised by a sufficiently large degree, or when the equilibrium behavior of SC holders is driven primarily by individual payoffs, rather than aggregate beliefs (i.e., when $x_c \leq \underline{x}_Q < \bar{x}_Q$).

A.4 Proof of Corollary 1

Equilibrium shifts to majority redemption if and only if withdrawing early is uniquely rationalizable for the median SC holder. Since signals are symmetric around the mean, this type is $x_{it} = \theta_t$. Using the results in Proposition 3, maintaining a holding is uniquely rationalizable for this type whenever $\theta_t \geq \hat{x}_t(y_t)$ given a new issuance or that there was not a run in the previous period. Otherwise, maintaining a holding continues to be uniquely rationalizable provided $\theta_t \geq \hat{x}_t(y_t)$.

A.5 Proof of Corollary 2

From the proof of Proposition 3 and Corollary 1, we have that $\hat{\theta}_t$ is defined implicitly by

$$\hat{\theta}_t = \Phi \left(\frac{\hat{x}_t - \hat{\theta}_t}{\sigma_x} \right), \quad (40)$$

and that $\hat{\theta}_t$ is defined implicitly by

$$\hat{\theta}_t = \Phi \left(\frac{\hat{x}_t - \hat{\theta}_t}{\sigma_x} \right), \quad (41)$$

given thresholds $\hat{\hat{x}}_t$ and \hat{x}_t respectively. Equations (40) and (41) show that $\hat{\theta}_t$ ($\hat{\theta}_t$) is increasing in $\hat{\hat{x}}_t$ (\hat{x}_t).

By the implicit function theorem, it suffices to examine the effect of an increase in transparency on the equilibrium condition.⁵⁹ The partial derivative of (37) with respect to ν_t is given by:

$$\frac{\partial R(z_t)}{\partial \nu_t} - \frac{\partial \mathbb{E}[\eta_t | x_{jt}]}{\partial \nu_t}. \quad (42)$$

The term $\partial R(z_t)/\partial \nu_t$ causes a ‘widening’ of the rank belief function as follows:

$$\frac{\partial R}{\partial \nu_t} = \frac{\Phi \phi * \frac{\partial g}{\partial \nu_t}(z_t) \phi * g(z_t) - \Phi \phi * g(z_t) \phi * \frac{\partial g}{\partial \nu_t}(z_t)}{[\phi * g(z_t)]^2}. \quad (43)$$

By symmetry of $G(\eta_t; \nu_t)$ around 0, and since an increase in ν_t causes a reduction in the density of the tails of the distribution, the expression in (43) is negative at $\hat{\hat{x}}_t$ and is positive at \hat{x}_t .

The effect on the second term in (42) is given by:

$$\begin{aligned} \frac{\partial \mathbb{E}[\eta_t | x_{jt}]}{\partial \nu_t} = \frac{1}{(\phi * g(z_t))^2} & \left\{ \int g(s) \phi(z_t - s) ds \cdot \int \eta_t \frac{\partial g}{\partial \nu_t}(\eta_t) \phi(z_t - \eta_t) d\eta_t \right. \\ & \left. - \int \eta_t g(\eta_t) \phi(z_t - \eta_t) d\eta_t \cdot \int \frac{\partial g}{\partial \nu_t}(s) \phi(z_t - s) ds \right\}. \end{aligned} \quad (44)$$

Define $\hat{\hat{z}}_t = \hat{\hat{x}}_t - y_t$ and $\hat{z}_t = \hat{x}_t - y_t$. By affiliation of η_t and z_t , and since $\hat{\hat{z}}_t < 0 < \hat{z}_t$, $\partial \mathbb{E}(\cdot)/\partial \nu_t > 0$ at $\hat{\hat{z}}_t$, while $\partial \mathbb{E}(\cdot)/\partial \nu_t < 0$ at \hat{z}_t . Together, the signs in (43) and (44) make the expression in (42) negative at $\hat{\hat{x}}_t$ and positive at \hat{x}_t . We thus have that $\hat{\hat{x}}_t$ is decreasing in ν_t and \hat{x}_t is increasing in ν_t . By equations (40) and (41), $\hat{\hat{\theta}}_t$ is decreasing in ν_t and $\hat{\theta}_t$ is increasing in ν_t .

⁵⁹This is because $R'(z) < 0$ and $\mathbb{E}'(\cdot) > 0$ at both $\hat{\hat{x}}_t$ and \hat{x}_t , and so the partial derivative of the equilibrium condition (37) with respect to x is negative.

B Additional material

B.1 Reserve assets as a portfolio-weighted convolution

In the context of our model, stablecoins are backed by a vector of reserve assets that have a combined dollar value captured by θ . Stablecoin holders perceive θ to be a random variable drawn from the portfolio-weighted convolution of all component reserve asset distributions, with realizations of θ equal to the portfolio-weighted realized values of individual reserve assets used in the reserve portfolio, $\theta = \omega_1\theta_1 + \omega_2\theta_2 + \dots + \omega_n\theta_n$, where ω_j denotes the share of the portfolio allocated to asset j .

To fix ideas, think of a portfolio with three reserve assets. In this case, the joint probability density function (PDF) $f(\theta)$ is given by

$$f(\theta) = (f_1 * (f_2 * f_3))(\theta),$$

where $f_1(\cdot)$, $f_2(\cdot)$ and $f_3(\cdot)$ are the PDFs of collateral assets θ_1 , θ_2 and θ_3 respectively. Figure 13 illustrates this example for a given calibration of individual PDFs and equal portfolio weights. We define the convolution $f_1 * (f_2 * f_3)$ of f_1 , f_2 , and f_3 as follows:

$$\begin{aligned} f(\theta) &= (f_1 * (f_2 * f_3))(\theta) \\ &= \int_{\mathbb{T}} f_1(\omega_1\theta_1) \left[\int_{\mathbb{T}} f_2(\omega_2\theta_2) f_3(\omega_3[\theta - \omega_1\theta_1 - \omega_2\theta_2]) d\theta_2 \right] d\theta_1. \end{aligned}$$

The PDF $f(\theta)$ thus summarizes the portfolio of reserve assets. The model can easily be used to assess the effect of increasing the weight of any asset in the reserve portfolio. For example, Tether's transition away from commercial paper and towards short-term safe assets is an example of an increase of low-risk assets in the portfolio. The effects are similar to the transparency results discussed in the paper: greater weighting on low-risk assets decreases run risk.

B.2 Additional graphs

Figure 14 takes a closer look at March 2023 depegging event by zooming in the early stages. This helps to more clearly highlight the sequencing, with USDC moving first and Dai moving later. The co-movement USDC between Dai and USDC may also partly reflect the price stability mechanism set up by Dai that enables par exchange between the two stablecoins.

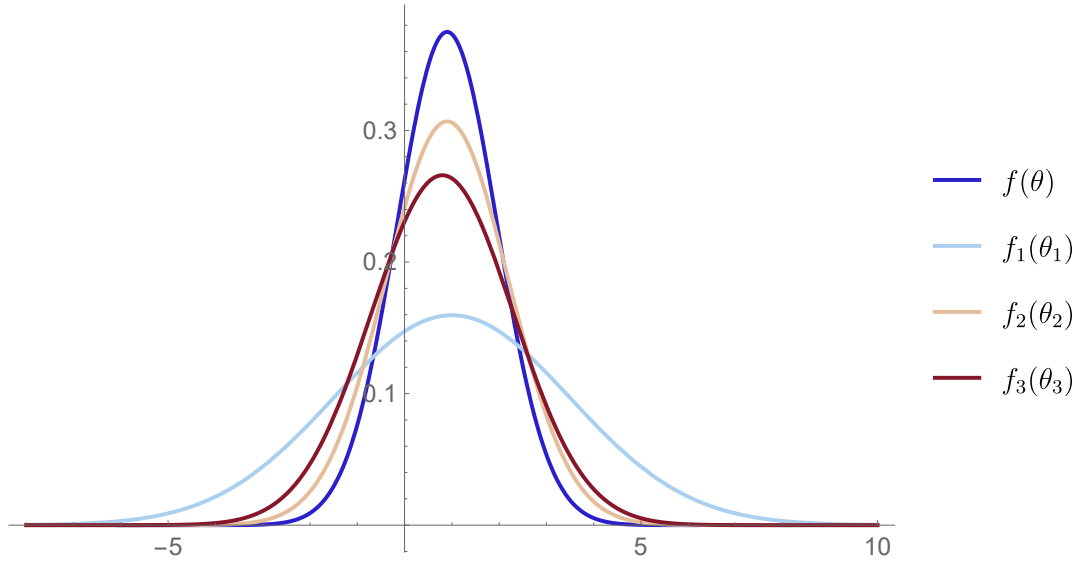


Figure 13: Probability density function of the value of reserve assets (θ) as a convolution of the distribution of assets in the portfolio ($\theta_1, \theta_2, \theta_3$). In this example, $\theta_1 \sim \mathcal{N}(1, 2.5)$; $\theta_2 \sim \mathcal{N}(0.9, 1)$; $\theta_3 \sim \mathcal{N}(0.8, 1.5)$, with equal portfolio weights for each asset.

However, the price stability mechanism is unlikely to be the sole driver of the co-movement between the two stablecoins in the wake of turmoil at SVB, as Figure 15 shows that other stablecoins backed by USDC but without such mechanisms in place also depegged, whereas stablecoins backed by other cryptoassets remained stable during this period.

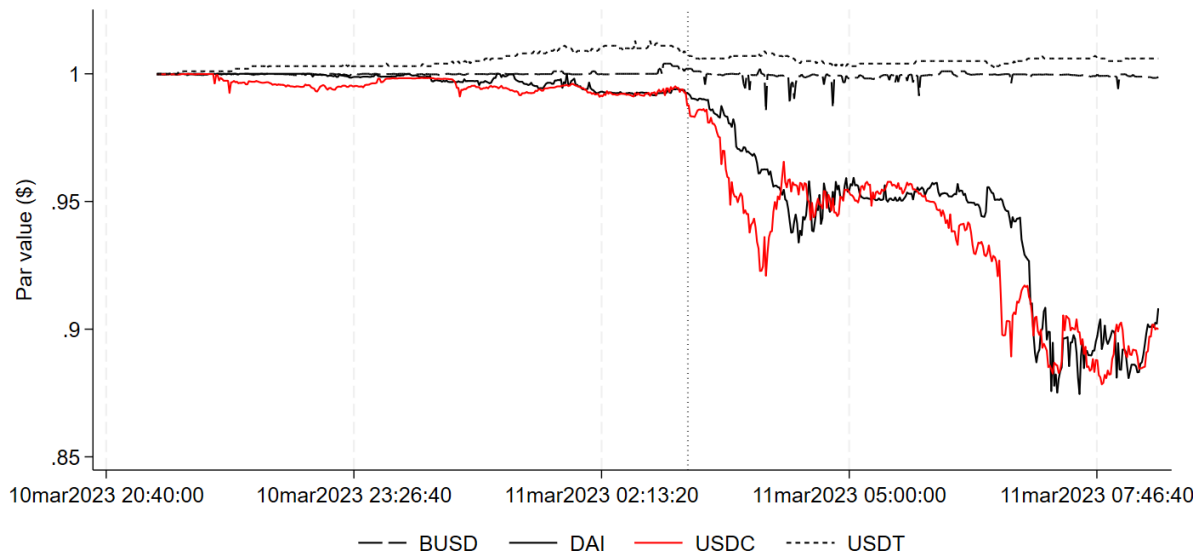


Figure 14: Stablecoin pegs around the run on Silicon Valley Bank under the microscope.
 Notes: Based on minute-by-minute data. The vertical dashed line denotes the disclosure by Circle that \$3.3 billion of its cash reserve was held at SVB. Source: Cryptocompare.com.

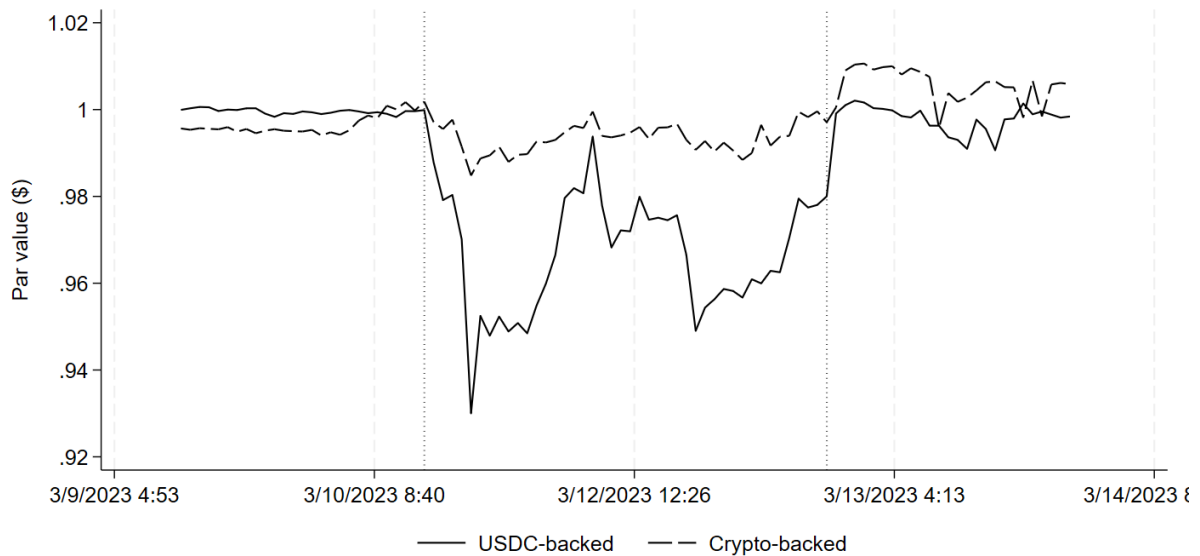


Figure 15: Stablecoin pegs around the run on SVB: USDC-backed versus crypto-backed.
 Notes: Based on hourly data. USDC-backed is a simple average of the value of Dai, Frax and Origin Dollar (OUSD). Crypto-backed is a simple average of the value of CeloUSD, Liquity (LUSD), Tron’s USDD and sUSD. The first vertical dashed line denotes the disclosure by Circle that \$3.3 billion of its cash reserve was held at SVB; the second vertical line denotes the announcement of a backstop by the U.S. government. Source: Cryptocompare.com.

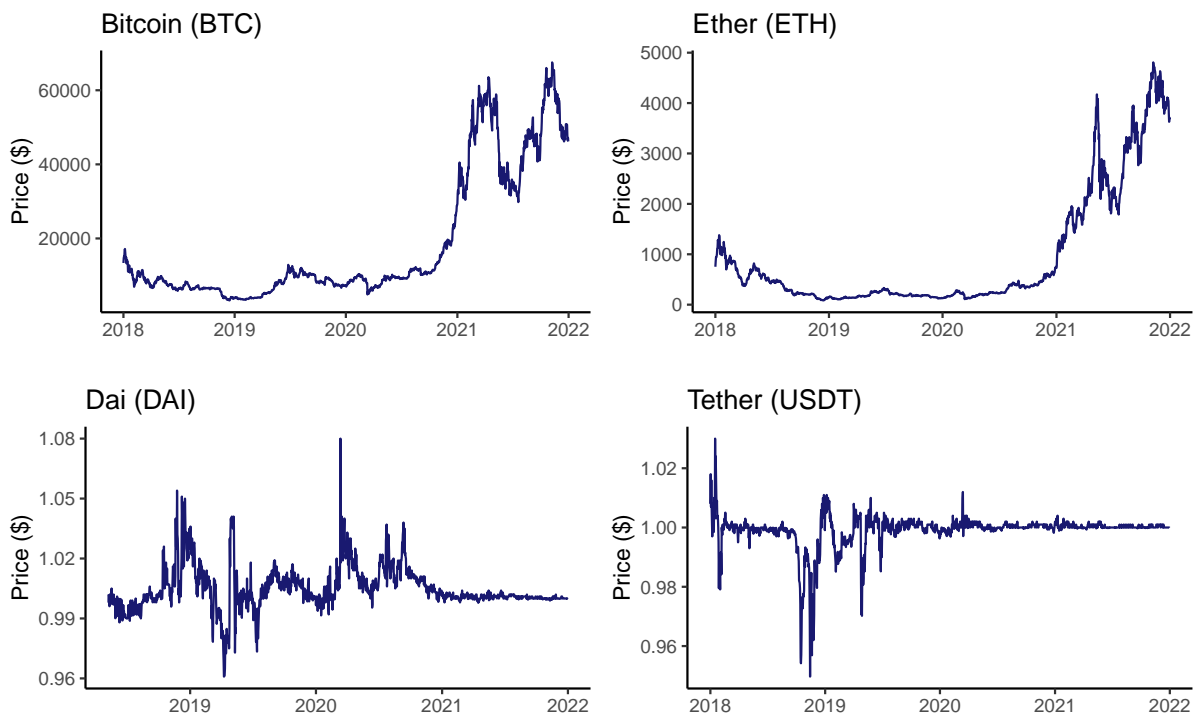


Figure 16: Cryptoasset prices.

Notes: Daily time series of cryptoasset prices from January 1, 2018 to December 31, 2021. Dai series does not begin until May 9, 2018. Source: Cryptocompare.com.

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