Stablecoin Runs and the Centralization of Arbitrage*

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Abstract

We analyze the run risk of USD-backed stablecoins. Stablecoin issuers aim to keep the stablecoin price at $1 by holding a portfolio of US dollar assets like bank deposits, Treasuries, and corporate bonds while promising to exchange stablecoins for $1 in cash with arbitrageurs. We show that asset illiquidity coupled with fixed redemption values reinstates panic runs among investors that only trade stablecoins in secondary markets with flexible prices. Importantly, run risk is exacerbated by more efficient arbitrage, implying a tradeoff between financial stability and run risk. This is why stablecoin issuers only authorize a concentrated set of arbitrageurs despite the cost to price stability. Our findings are based on a model calibrated with a novel dataset on stablecoin arbitrage and trading activity. Our model predicts economically significant run risk for Tether (USDT) due to its liquidity transformation. But run risk is also sizeable for Circle (USDC) due to its less concentrated arbitrage. Finally, we show that issuing dividends to investors would effectively reduce run risk at both USDT and USDC, which points to a potential benefit of regulating stablecoins as securities.

1 Introduction

Stablecoins are blockchain assets whose value is claimed to be stable at $1. The largest stablecoins are fiat-backed. They attempt to achieve price stability by promising to back each stablecoin token with at least $1 in US dollar-denominated assets, which range from bank deposits and Treasuries to corporate bonds and loans. The potential for stablecoins to become a safe asset and a means of payment has contributed to their meteoric rise. The six largest US dollar-backed stablecoins have grown from $5.6 billion in asset size at the beginning of 2020 to exceed $130 billion at the beginning of 2022.

The rapid expansion of fiat-backed stablecoins has raised financial stability concerns because of the potential spillover effects on the traditional financial system.[1] In March 2023, for example, Circle's USDC, the second largest fiat-backed stablecoin, saw its price plummet by more than 15% within a few hours amid the collapse of Silicon Valley Bank. Distinct from defaults of other crypto assets, a run on fiat-backed stablecoins like USDC would not only lead to losses for stablecoin investors but may also strain important asset markets for deposit funding, Treasuries, and corporate bonds. These ramifications have led to widespread discussions about how stablecoins should be regulated.

In this paper, we analyze the economics of US dollar fiat-backed stablecoins to understand whether runs could materialize in the future and what design features of stablecoins could affect their occurrence. Stablecoins have features of both money market funds (MMFs) and exchange-traded funds (ETFs). The majority of stablecoin investors can only buy and sell stablecoins in competitive secondary markets, similar to investors trading ETF shares on exchanges. Only a small set of arbitrageurs are also approved to redeem and create stablecoins with the issuer in primary markets. Like MMFs, stablecoin issuers meet arbitrageurs' redemption requests with $1 in cash, which is raised from selling the underlying reserve assets. For example, if selling pressure from investors pushes stablecoin prices below $1, arbitrageurs can buy stablecoins in secondary markets and redeem them for $1. Efficient arbitrage is thus key to maintaining stablecoins' price stability in secondary markets.

[1] For example, see, G7 Working Group and others, 2019, "Investigating the Impact of Global Stablecoins"; ECB, 2020, "Stablecoins: Implications for monetary policy, financial stability, market infrastructure and payments, and banking supervision in the euro area"; BIS, 2020, "Stablecoins: potential, risks and regulation"; and IMF, 2021, "The Crypto Ecosystem and Financial Stability Challenges".

Although arbitrage is conducive to price stability, we discover that stablecoin issuers maintain a surprisingly concentrated arbitrage sector. This is because efficient arbitrage exacerbates run risk. Stablecoins remain vulnerable to panic runs despite their tradability in competitive secondary markets. The fixed \$1 redemption price in the primary market reinstates run incentives among secondary market investors, who fear that arbitrageurs will retract from providing liquidity to them if the stablecoin issuer can no longer honor the \$1 redemption value. When arbitrage is more efficient, the same selling or buying pressure would have a smaller price impact. However, precisely because sellers in secondary markets would receive better prices, they are more incentivized to sell during a run. In other words, approving more arbitrageurs for more efficient arbitrage would improve price stability at the cost of higher run risk, and thus lower financial stability.

We further show that regulation may affect the run risk and price stability of stablecoins. Stablecoin issuers currently do not distribute dividends to investors, in part because doing so would likely lead stablecoins to be classified as securities. We show that allowing positive dividend payments could effectively reduce run risk and improve price stability for USDT and USDC. Thus, providing stablecoins a path to registering as securities and paying out dividends may have benefits for financial stability.

Our empirical findings are based on a novel dataset of fiat-backed stablecoins. From the Ethereum, Avalanche, and Tron blockchains, we collect transaction-level data on each stablecoin creation and redemption event for the 6 largest fiat-backed stablecoins: Tether (USDT), Circle USD Coin (USDC), Binance USD (BUSD), Paxos (USDP), TrueUSD (TUSD), and Gemini dollar (GUSD). We obtain this data from each blockchain by converting transaction-level blockchain data into a usable format. For each stablecoin, we also extract average trading prices in secondary markets from the main exchanges. Further, we obtain the composition of reserve assets for USDT and USDC, which reported these breakdowns at various points in 2021 and 2022.

From our novel data, we observe that the concentration of arbitrageurs in the primary market, where stablecoins are directly redeemed and created with issuers, varies across stablecoins. For example, USDT only has 6 arbitrageurs redeeming tokens during the average month, and the largest arbitrageur accounts for 66% of the total redemption activity. In contrast, arbitrage at USDC is more competitive with 521 redeeming arbitrageurs in an average month. We also find that trading prices in the secondary market frequently deviate from \$1. We note that these price deviations are not analogous to MMFs' "breaking the buck" nor are they an indicator of runs. Rather, stablecoin prices fall below $1 when selling pressure in the secondary market is not fully absorbed by arbitrageurs. Similarly, stablecoin prices could exceed $1 if buying pressure is not fully absorbed by arbitrageurs. In this sense, stablecoin price fluctuations resemble ETF shares trading at a premium or discount to their NAVs.[2]

Stablecoins with fewer arbitrageurs have higher average price deviations in secondary markets. For example, the average price deviation at USDT is 41.9 bps, while the average price deviation at USDC is only 1.7 bps. At the same time, USDT also has more illiquid assets, like corporate bonds and loans, as part of their reserve assets than USDC. These observations leave open the question of how stablecoin issuers choose the arbitrage concentration they allow, and how their choice relates to the liquidity of their reserve asset portfolios. After all, if approving more arbitrageurs improves price stability in secondary markets, why don't all stablecoin issuers allow for free entry and perfectly efficient arbitrage?

We develop a model to show how the issuer's choice of arbitrage efficiency reflects an inherent tradeoff between financial stability and price stability. There are four types of agents: stablecoin investors, arbitrageurs, noise traders, and a stablecoin issuer. Investors decide whether to stablecoins by comparing their expected benefits and costs. Holding stablecoins becomes less attractive when price fluctuations induced by noise traders are larger, and when there is a greater probability of runs that destroy the long-term benefit and recovery value of stablecoins. Investors can also prematurely sell the stablecoins they hold in the secondary market, but they cannot directly redeem stablecoins from the issuer. Instead, they sell to arbitrageurs, who can redeem and create stablecoins with the issuer in the primary market at a fixed price of $1. Arbitrageurs trade stablecoins in the direction of equalizing prices in primary and secondary markets, but leave a wedge depending on their inventory costs. The issuer meets arbitrageur redemptions by prematurely liquidating illiquid reserve assets at a discount, until the point at which the issuer defaults.

Our model shows that panic runs by investors on stablecoins can occur. Stablecoin investors are limited to selling in the secondary exchange at market prices like investors trading ETF shares. The conventional view may imply that they are less runnable like ETF shares because the trading price in

[2]The parallel to "breaking the buck" at money market funds would be a failure by stablecoin issuers to honor the $1 redemption value in primary markets, which has not yet materialized thus far.

secondary markets falls as more investors sell, creating a natural strategic substitutability. However, in the case of stablecoins, arbitrageurs are promised a fixed redemption price by the issuer. As a result, investors who hold stablecoins may end up with less valuable stablecoins in the future due to the costs from the issuer's forced sales of illiquid assets to meet arbitrageurs' redemptions at $1. Consequently, stablecoins' fixed primary market price reintroduces strategic complementarity among secondary market investors.

Endogenizing the probability of runs using a global games approach, we arrive at our core result that decreasing the efficiency of arbitrage can actually lower run risk. This is because more efficient arbitrage lowers the price impact for investors who sell in the secondary market. A more favorable selling price incentivizes selling and amplifies investors' first-mover advantage when they expect others to sell. In contrast, more concentrated arbitrage increases price impact in secondary markets, discourages panic selling, and mitigates run risk. Nevertheless, this mitigation of run risk comes at the expense of secondary market price stability, which suggests that arbitrage concentration is a double-edged sword. Since stablecoin investors care about both run risk and price stability, the stablecoin issuer optimally chooses arbitrage efficiency to trade off its benefits for price stability with its costs for run risk.

Further, our model shows that distributing some of the reserve asset returns to investors as dividends could impact both run risk and price stability. The prospect of receiving dividends discourages investors from selling in the short run and thereby reduces run risk. The reduced incentive to sell also allows the issuer to opt for arbitrage efficiency to improve price stability. At the same time, however, the stablecoin issuer has less skin in the game to prevent runs after distributing some of their revenue to investors. This channel further encourages efficient arbitrage but counteracts the reduction in run risk from investors. Thus, dividend payments unambiguously improve stablecoin price stability while their overall effect on financial stability remains an empirical question.

We then calibrate our model to quantify the run risk of the two largest stablecoins, USDT and USDC. We first measure the overall illiquidity of USDT and USDC's reserve portfolios using collateral haircuts. On average, the reserve assets of USDT are more illiquid than those of USDC, but both shift towards holding more liquid assets over time. We then estimate the probability at which the reserve asset payoff does not materialize using CDS spreads. We further proxy for the long-term benefit of holding the stablecoin using the return to lending out the stablecoin. This lending rate captures the compensation to investors for not being able to use the stablecoin while it is on loan. Finally, we obtain the remaining two parameters using moment matching. Specifically, we choose the slope of investors' stablecoin demand and the cost of price variance to most closely match the slope of investors' demand and the slope of arbitrageurs' demand, K, in the data. Intuitively, when the cost of price instability is high, the stablecoin issuer chooses a more efficient arbitrage sector, i.e., a lower K, to better arbitrage away price fluctuations. In the data, the K estimate for USDT is larger than that for USDC, consistent with USDT maintaining a more concentrated arbitrage sector.

Our model estimates imply an economically significant risk of runs at both USDT and USDC. USDT's fragility stems from its higher liquidity transformation, while USDC is vulnerable due to less concentrated arbitrage. USDC is also exposed to default risk in the banking sector because of its concentrated deposit holdings. The run risk at both stablecoins has decreased over our sample period. Nevertheless, they remain elevated at 3.927% in March 2022 for USDT and 3.336% in October 2021 for USDC.

Our calibrated model further shows that the run risk at both USDT and USDC could be meaningfully reduced if they started paying dividends to investors. As dividends increase from 0% to 4%, for example, we estimate that run probabilities would be lowered by 1.81% and 1.63%, respectively. The stabilizing effect of dividend payments for US dollar stablecoins is thus amplified in a high-interest-rate environment where the higher yields of reserve assets could be distributed to investors. At the same time, the cost from price instability decreases, as issuers increase the efficiency of arbitrage in response to lower run risk. Thus, changes in regulation that make it easier for stablecoin issuers to pay out dividends to investors could contribute to improving the financial stability and price stability of the two largest fiat-backed stablecoins going forward.

Our paper contributes to a large literature on bank runs and liquidity transformation (e.g., Diamond and Dybvig, 1983, Allen and Gale, 1998, Bernardo and Welch, 2004, Goldstein and Pauzner, 2005). It has also been shown that MMFs are subject to panic runs because their shares are redeemed by investors at a fixed price (Kacperczyk and Schnabl, 2013, Parlatore, 2016, Schmidt, Timmermann and Wermers, 2016), while closed-end funds and ETFs are typically viewed as less runnable because their shares are tradable at market prices without direct liquidation of the underlying assets (Jacklin, 1987, Allen and Gale, 2004, Koont, Ma, Pastor and Zeng, 2021). By carefully modeling the unique combination of

ETFs and MMFs in the design of stablecoins, we show that panic runs may still happen despite their trading on competitive secondary markets and investors' inability to access primary markets.

Our focus on arbitrage capacity for stablecoins is related to the limits to arbitrage literature (e.g., Shleifer and Vishny, 1997, Gromb and Vayanos, 2002). Several papers have shown that non-competitive arbitrage hurts price efficiency (e.g., Oehmke, 2010, Du and Zhu, 2017, Davila, Graves and Parlatore, 2022). Our work generalizes this finding to the stablecoin context, where a more concentrated arbitrage sector hurts stablecoins' price stability. We further find the novel result that arbitrage concentration can be a double-edged sword: arbitrage concentration hurts price stability, but is beneficial for improving financial stability.

We also contribute to the fast-growing stablecoin literature by analyzing and quantifying the run risk of US dollar reserve-backed stablecoins. Closely related to us is Gorton, Klee, Ross, Ross, and Vardoulakis (2023), who also focus on the run risk of reserve-backed stablecoins. They show that the use of stablecoins in facilitating leveraged trading of other crypto-assets can help maintain stablecoins' price stability despite the run risk. We also examine stablecoin run risk and price stability but focus on how arbitrage capacity determines an inherent tradeoff between the two and how the tradeoff can be eased by distributing dividends to investors. Our model captures the interaction between the primary and secondary markets for stablecoins to show that they resemble a combination between ETFs and MMFs. Relatedly, Frost, Shin, Wierts (2020), Gorton and Zhang (2021), and Gorton, Ross and Ross (2022) compare stablecoins to deposits issued by the banking sector pre-deposit-insurance. Stablecoin price stability has also been compared to exchange rate pegs by Lyons and Viswanath-Natraj (2021), who show that USDT's creation and redemption activity respond to secondary market price deviations. More generally, several recent papers explore runs on algorithmic stablecoins after the Terra-Luna crash in 2022 (e.g., Adams and Ibert, 2022, Uhlig, 2022, Liu, Makarov and Schoar, 2023) and Kozhan and Viswanath-Natraj (2021) analyze DAI, which is a stablecoin overcollateralized by risky crypto assets.

Several other papers have explored the financial stability risks associated with stablecoins other than panic runs. Li and Mayer (2021) develop a dynamic model to characterize the endogenous transition between stable and unstable price regimes, focusing on the feedback between debasement and the collapse of demand for stablecoins as money. d'Avernas, Maurin, and Vandeweyer (2022) provide a framework to analyze how price stability can be maintained depending on the issuer's commitment to stablecoin supply. Routledge and Zetlin-Jones (2022) consider the design of exchange rate policies in maintaining price stability. Barthelemy, Gardin and Nguyen (2021), Liao and Caramichael (2022), and Kim (2022) analyze the potential impact of fiat-backed stablecoin activities on the real economy, while Baughman and Flemming (2023) argue that the competitive pressure of stablecoins on USD assets is limited. Complementary to these papers, we focus on stablecoins as financial intermediaries engaged in liquidity transformation, the arbitrage efficiency between primary and secondary markets, and the resulting run risks.

Our paper also fits more broadly into the literature on cryptocurrencies and decentralized finance, discussed and surveyed in Harvey, Ramachandran and Santoro (2021), John, Kogan and Saleh (2022), and Makarov and Schoar (2022).

The rest of the paper proceeds as follows. Section 2 describes institutional details of the stablecoin market and Section 3 explains the data we use. Section 4 documents several empirical facts that motivate our model in Section 5. Section 6 explains the model calibration and results. Section 7 shows the counterfactual results of issuing dividends to investors. Finally, Section 8 concludes.

2 Institutional Details

Stablecoins are blockchain assets whose value is claimed to be stable at $1. Blockchain assets can be self-custodial: a user can use crypto wallet software, such as Metamask, to hold, send, and receive stablecoins directly. These tokens are not stored with any trusted intermediary: rather, a "private key" – a long numeric code, generally kept only on the user's hardware device – is used to prove to the blockchain network that the user owns her tokens, and to direct the network to take actions such as transferring tokens to other wallets. Others have no access to individuals' private keys so they have no ability to take funds from individuals' wallets.

Relative to other blockchain assets like bitcoins, the defining feature of stablecoins is (relative) price stability. The largest stablecoin issuers attempt to achieve price stability by promising to back each stablecoin token by at least $1 in off-blockchain US dollar assets. These fiat-backed stablecoins have experienced a rapid expansion over the last few years. Within two years , the total asset size of the six largest fiat-biased stablecoins has grown from $5.6 billion at the beginning of 2020 to exceed $130 billion at the beginning of 2022 (Figure 3). The largest stablecoin is Tether (USDT), which made up more than 50% of the total market size at $76.4 billion in January 2022. Circle USD Coin (USDC) and Binance USD (BUSD) are second and third at $37.7 and $14.4 billion. Paxos, (PUSD), TrueUSD (TUSD), and Gemini dollar (GUSD) are significantly smaller with a market size of around or below $1 billion. The asset size of fiat-backed stablecoins has experienced ups and downs in 2022 but remains high at $136 billion in June 2022.

2.1 Uses of Stablecoins

Stablecoins are a fairly low-cost way to transact and hold US-dollar assets. Suppose, for example, a sender in country A wishes to send funds to a receiver in country B. The sender can purchase stablecoins on a crypto exchange using fiat currency in country A, withdraw these stablecoins to her personal crypto wallet, and send them to the wallet of the receiver in country B. The receiver can then deposit these funds to a crypto exchange in her country, sell the stablecoins for fiat, and then withdraw the fiat currency. The first and third steps in this process may incur fees and delays from converting fiat to and from crypto using local crypto exchanges, which may vary across exchanges and countries. However, the second step – sending stablecoins from one crypto wallet to another – is relatively fast and low-cost. As of January 2023, sending tokens on the Ethereum blockchain finalize in under a minute and cost around $1 USD per transaction, independent of the amount of stablecoins sent. Stablecoins can also be used as a store of value; to this end, stablecoins can be held in crypto wallets indefinitely at no cost.

As a result, while stablecoins are costlier to use than well-functioning banking services in developed countries, they are competitive when traditional financial infrastructure functions poorly. For example, stablecoins are being used in settings where transactions must cross national borders, capital controls and financial repression are prevalent, inflation is high, or trust in financial intermediaries is low.[3]

[3] Humanitarian organizations have used stablecoins to make cross-border remittance payments, circumventing banking fees and regulatory frictions. See Fortune.com. Some firms in Africa have begun using stablecoins for international payments to suppliers in Asia. See Rest Of World. In settings with high inflation, such as Lebanon and Argentina, individuals have begun storing value and transacting using stablecoins. See Rest Of World for a discussion of the case of Africa, CNBC and Rest Of World for the case of Lebanon, and Coindesk, EconTalk, and Memo for the case of Argentina. Some merchants in these areas have begun accepting stablecoins as a form of payment. For example, the Unicorn Coffee House in Beirut, Lebanon accepts USDT (Tether) as a form of payment.

Stablecoins are also used to transact with other blockchain smart contracts within the space of "decentralized finance." For example, market participants can use stablecoin tokens to purchase other blockchain tokens, such as ETH, MKR, or UNI, using an automated market maker protocol such as Uniswap. Market participants can also lend stablecoin tokens on lending and borrowing protocols, such as Aave and Maker, allowing them to receive positive interest rates, and also to use these assets as collateral to borrow other assets. In a way, stablecoins provide a safe store of value and a medium of exchange resemble for the blockchain ecosystem.

2.2 Market Structure

Stablecoin tokens are created ("minted") or redeemed ("burned") in the primary market with US dollar cash as shown on the left-hand side of Figure 4. To create a stablecoin token, an arbitrageur sends $1 to the issuer, and the issuer then sends a stablecoin token into the market participant's crypto wallet. Analogously, to redeem a stablecoin token, for each stablecoin token that the market participant sends to the issuer's crypto wallet, the issuer sends $1, for example through a bank transfer, into the market participant's bank account. The primary market for stablecoins resembles a money market fund in the traditional financial system. Please see Appendix A for further details.

Importantly, not all market participants can freely become arbitrageurs to participate in the redemption and creation of stablecoin tokens in the primary market. Stablecoin issuers differ in how easily and costly market participants can access primary markets. According to market participants, USDC allows general businesses to register as arbitrageurs, while USDT requires a lengthy due-diligence process and imposes restrictions on where arbitrageurs can be domiciled. Further, USDT imposes a minimum transaction size of $100,000, and charges the greater of 0.1% and $1000 per redemption. USDT also requires a lengthy due-diligence process and imposes restrictions on where arbitrageurs can be domiciled.

The majority of market participants trade existing stablecoins for fiat currencies in secondary markets, as shown on the right-hand side of Figure 4. Crypto exchanges allow investors to make US dollar deposits, and then trade US dollars for stablecoins with other market participants.[4] The price of stable-

[4]Please see Appendix A for details regarding the use of different crypto exchanges.

coin tokens in the secondary market is thus driven by the demand from stablecoin buyers and the supply from stablecoin sellers. When there is a surge in stablecoin sales on the secondary market, secondary market prices will drop, but the closed-ended nature of stablecoins implies that sales do not directly cause liquidations of reserve assets. In this way, the buying and selling of stablecoins on secondary markets resemble the trading of ETF shares on competitive exchanges.

Selling pressure in the secondary market for stablecoins can spill over to affect the primary market through arbitrageurs. When investor selling pressure in the secondary market depresses stablecoin prices to be below $1, arbitrageurs can profit from purchasing stablecoin tokens for below $1 in secondary markets, and redeeming them one-for-one for $1 with the stablecoin issuer in primary markets, as long as the issuer does not default. Analogously, if positive demand shocks in secondary markets causes stablecoins to trade above $1, arbitrageurs could profit from creating stablecoin tokens in primary markets and then selling them at higher prices in secondary markets. Thus, the $1 redemption value of stablecoins in primary markets pulls the trading price of stablecoins towards $1 in secondary markets through the trading incentive of arbitrageurs.

At the same time, this arbitrage process implies that investor selling pressure in secondary markets eventually triggers sales of reserve assets when stablecoin issuers liquidate reserves to meet arbitrageurs' $1 redemption in cash. These fire sales can be especially costly if illiquid reserve assets can only be converted to cash at a discount.

2.3 Dividend Payments to Investors

For fiat-backed stablecoins, returns from reserve assets are fully accrued to the issuer and no dividends are issued to investors holding stablecoins. One potential reason why stablecoin issuers currently do not retain and attract investors by distributing dividends is regulation. US regulators have deemed many programs which take funds from users, and return funds with dividend or interest payments, to be securities that fall under the SEC's jurisdiction. For example, the June 2023 SEC case against Coinbase argued that Coinbase's Staking Program is a security. The June 2023 SEC case against Binance argued that Binance's BNB Vault and Simple Earn programs, and the BAM Trading Staking Program, constituted securities under US law. In our conversations with market participants, many believed that a stablecoin that offered to pay accrued interest on reserves as dividends would be classified as securities.[5] Nevertheless, there could be other reasons for not paying dividends to investors. For example, stablecoins issuers could simply have enough monopoly power to maximize their own profits without paying anything to investors. In the counterfactual analysis, we will analyze the hypothetical scenario in which issuers pay dividends to investors and demonstrate the effect on price and financial stability.

3 Data

We compile a novel and comprehensive dataset that sheds light on stablecoins' on-chain primary market activity, secondary market prices, and reserve assets.

3.1 Primary Market Data

The core dataset used in our analysis is data on each stablecoin creation and redemption event for the 6 largest fiat-backed stablecoins: Tether (USDT), Circle USD Coin (USDC), Binance USD (BUSD), Paxos (USDP), TrueUSD (TUSD), and Gemini dollar (GUSD), on the Ethereum, Avalanche, and Tron blockchains. We obtain this data from each blockchain based on "chain explorer" websites, which process transaction-level blockchain data into a usable format. We use Etherscan for Ethereum, Snowtrace for Avalanche, and Tronscan for Tron.

As described in Section 2, there are two ways that stablecoin tokens can be minted or redeemed. First, the stablecoin's "mint" or "burn" functions can be called directly to the primary market participant's wallet. To capture this category of actions, we query Etherscan for all cases in which the "mint" and "burn" functions are called for each stablecoin. Second, the stablecoin issuer can send or receive stablecoins from their "treasury" address. To capture this category, we identify the treasury address or addresses for each stablecoin, and then query Etherscan for every send or receive transaction involving the treasury address. Logistically, some issuers, such as Tether, tend to mint a large quantity of stablecoin tokens into "treasury" addresses they control, then issue tokens to market participants simply

[5] A number of online sources concur with this opinion. Web3 University states: "If you want to organize payouts to your token holders, it is safer to structure them as bonus points instead of paying out what could be considered dividends." Unblock states: "In the U.S. dividend-bearing cryptocurrencies are classified as securities."

by transferring tokens out of their treasury wallet; whereas other issuers, such as TrueUSD, occasionally directly mint stablecoin tokens into the wallet addresses of market participants. On the other hand, most issuers handle redemptions by having market participants send tokens to a treasury wallet address. If the treasury wallet has a large balance of redeemed stablecoins, the issuer will occasionally "burn" quantities of the stablecoin, removing them from the technical outstanding balance of the token.[6]

Using our data extraction process, we see, for each stablecoin creation and redemption event, the precise timestamp of the event; the amount of the stablecoin redeemed or created; and the wallet address of the entity involved in stablecoin creation or redemptions. We also observe the "gas" fee – that is, the transaction fee paid to Ethereum miners for including the transaction in the blockchain – paid for each transaction. Some wallet addresses are tagged on Etherscan, as they are known to belong to large entities such as crypto exchanges. Using Etherscan wallet tags, we can group some wallets that are known to belong to the same economic entity.

We calculate the total issued market capitalization of a given stablecoin at any point in time, as the total technical market capitalization of the stablecoin, minus the amount of the stablecoin held in "treasury" addresses. This is because tokens held in treasury wallets need not be backed one-to-one by US dollars, and thus should not count as part of the total market capitalization of stablecoins in circulation.

3.2 Secondary Market Data

For each of the 6 stablecoins in our data, we extract the hourly closing prices for trades from a number of large exchanges, including Binance, Bitfinex, Bitstamp, Bittrex, Gemini, Kraken, Coinbase, Alterdice, Bequant, and Cexio. In our main analysis, we calculate daily prices for each stablecoin as the weighted average of hourly closing prices across these exchanges, where the weights are by trading volume. Differences in stablecoin prices across the main exchanges are generally negligible, hence the price series are not substantially affected by the weights we put on different exchanges.

[6]The exception to this rule is that TrueUSD occasionally handles redemptions by "burning" tokens directly from market participants' wallets, rather than the treasury.

3.3 Reserves

We use the breakdowns of reserve assets that USDT and USDC report at various points in 2021 and 2022 as part of their balance sheets posted online. The other four stablecoins have not released breakdowns of their reserve asset composition but state the broad categories of their reserves. We note that reserve assets are not recorded on the blockchain so we cannot independently verify the reported information. Griffin and Shams (2020), for example, have pointed out that USDT at times issues tokens insufficiently backed by reserve assets. We think of the reported reserve asset information as the most optimistic estimate of the actual reserve assets that stablecoins hold. Thus, our estimates of run risk may be interpreted as a best-case scenario.

4 Facts

In this section, we present a set of new facts about stablecoins, which informs our model and calibration to quantify the run risk of stablecoins.

4.1 Secondary Market Prices

Fact 1. *The trading price of stablecoins in the secondary market commonly deviates from $1. This price deviation per se does not constitute a run by investors.*

Figure 5 shows the price at which different stablecoins trade on the secondary market over time. We observe that the secondary market price rarely stays fixed at $1. Rather, stablecoins trade at a discount to $1 27.2% to 41.6% of the time and trade at a premium to $1 57.3% to 72.8% of the time for our sample of stablecoins (see Table 2).

The extent of these price deviations varies by stablecoin. While the average discount at USDT is 55bps, the average discount at USDC is only 1bps. The average discounts of BUSD, TUSD, and USDP are also below that of USDT at 1bps, 11bps, and 18bps, respectively, while that of GUSD is the highest at 78bps. The median discounts are generally smaller in magnitude than the average discounts, but the variation in the cross-section remains similar. The average and median premia also show significant variation in the cross-section.

The trading of stablecoins at a discount to \$1 has been commonly associated with “breaking the buck” as in the case of money market funds and even as evidence for panic runs.[7] We note that these are misconceptions. Stablecoins maintaining a “stable value” of \$1 refers to the amount that primary market participants receive or pay when they redeem existing stablecoins or create new stablecoins with the stablecoin issuer. The notion of “breaking the buck” thus corresponds to primary market participants not receiving a full \$1. This scenario has not yet occurred at any of the stablecoins in our sample despite their secondary market price frequently deviating below \$1. The secondary market price is the trading price of stablecoins on exchanges. It is essentially the share price of a closed-end fund and analogous to the share price of an ETF. Just like ETF prices can deviate from the NAV of the underlying portfolio, stablecoin prices can deviate from \$1. This stablecoin price falling below \$1 simply captures the selling pressure of stablecoins in the secondary market and is not a direct indicator of “breaking the buck” or panic runs.

4.2 Primary Market Concentration

Fact 2. *The redemption and creation of stablecoins in the primary market is performed by a set of arbitrageurs, whose concentration varies by stablecoin.*

Table 3 shows the characteristics of daily primary market redemption and creation activity on the Ethereum blockchain for different stablecoins. We observe that on an average day, USDT only has 1 arbitrageur engaged in redemptions, whereas USDC has 33. The concentration of arbitrageurs' market shares also varies. The largest arbitrageur at USDT performs 94% of all redemption activity, while the largest arbitrageur at USDC performs 54%. There are relatively more creations than redemptions and creations have slightly more arbitrageurs, but the trends across stablecoins and the high arbitrage concentration remain.

[7] For example, see https://www.nytimes.com/2022/06/17/technology/tether-stablecoin-cryptocurrency.html and https://www.cnbc.com/2022/05/17/tether-usdt-redemptions-fuel-fears-about-stablecoins-backing.html

We repeat the analysis at the monthly level in Table 4. The monthly snapshot may better capture the market structure of the primary market than the daily snapshot if not all arbitrageurs are active every day. Indeed, we observe that the number of arbitrageurs is larger at the monthly level. However, the arbitrageur market remains highly concentrated for USDT, with only 6 arbitrageurs redeeming shares during the average month and the largest arbitrageur accounting for 64% of the total redemption activity. In contrast, USDC has 521 active redeeming arbitrageurs in an average month but the top 1 and top 5 arbitrageurs make up 45% and 85% of all redemption activity. As before, there is a larger volume of creations and relatively more arbitrageurs engaged in creations but the trends across stablecoins and the arbitrage concentration remain similar.

In terms of transaction volumes, notice that in the average month, the volume of redemptions at USDT is $577 million, while that at USDC is $2976 million. In comparison, the total volume of outstanding tokens at USDT was 1.5 to 2 times that of USDC. Thus, the larger number and lower concentration of arbitrageurs at USDC are correlated with a higher volume of redemptions relative to the total asset size as well.

In comparison, most other stablecoins lie between USDT and USDC in terms of the number of arbitrageurs and arbitrageur concentration. One exception is GUSD, which has the most concentrated arbitrageur market for redemptions. In Appendix Tables 7 to 10, we repeat Tables 3 and 4 for the Tron and Avalanche blockchains and obtain similar variations in arbitrageur concentration across stablecoins.

4.3 Secondary Market Price and Primary Market Concentration

Fact 3. *Stablecoins with a more concentrated set of arbitrageurs experience more pronounced price deviations in the secondary market.*

We proceed to analyze the potential effects of arbitrageur concentration. We calculate the average monthly price deviation from one and the average monthly number of arbitrageurs for each stablecoin and plot them in Figure 6a. A clear negative trend emerges: stablecoins with fewer arbitrageurs, like USDT, have higher average price deviations from one in their secondary market prices than stablecoins with more arbitrageurs, like USDC. Another way to capture arbitrageur concentration is through the market share of the largest arbitrageurs. In Figure 6b, we repeat the analysis with the market share of the top 5 arbitrageurs. The relationship is positive. Stablecoins whose top 5 arbitrageurs consistently perform a larger share of total redemptions and creations have higher average price deviations than other stablecoins with lower arbitrageur concentration. In other words, it seems that higher arbitrage competition is associated with reduced price dislocations in secondary markets.

One question arising from this trend is why some stablecoins choose to have a more concentrated arbitrageur sector. If arbitrageur competition can indeed stabilize secondary market prices, all stablecoins should be incentivized to open up arbitrageur access and encourage the entry of new arbitrageurs. In our model, we show that a counteracting force is the presence of panic runs by investors, which are more likely with a more competitive arbitrageur sector.

4.4 Liquidity Transformation

Fact 4. *Stablecoins engage in varying degrees of liquidity transformation by investing in illiquid assets.*

Stablecoins are not literally backed by US dollars in the form of cash. Rather, stablecoin issuers hold USD-denominated assets with varying degrees of illiquidity as reserves. Table 1 shows the composition of reserve assets for USDT and USDC on reporting dates. Overall, reserve assets of both USDT and USDC are far from being fully liquid, with those of USDT being more illiquid.

A significant portion of reserve assets is in the form of deposits and money market instruments. In June 2021, these two asset classes took up 60.7% and 59.5% of reserve assets at USDT and USDC, respectively. Money market instruments include commercial paper and certificates of deposits. For USDT, deposits include "cash deposits at financial institutions and call deposits, i.e., deposits that may be withdrawn with two days' notice or less; fiduciary deposits, i.e., deposits made by banks on behalf of and for the benefit of members of the consolidated group; and, term deposits, i.e., deposits placed by members of the consolidated group at its banks for a fixed term." For USDC, deposits include "US dollar deposits at banks and short-term, highly liquid investments that are readily convertible to known amounts of cash and have a maturity of less than or equal to 90 days from purchase." Thus, except for deposits in checking accounts, money market instruments and other types of deposits are not fully liquid, i.e., they can not be freely converted to cash at short notice. For example, time deposits and certificates of deposit experience a discount when demanded before their maturity date.

USDT also holds a significant portion of reserves in the form of Treasury bills, which increased from 24.3% in June to 47.6% in March 2022. In contrast, USDC reduced its Treasury holdings from 15.0% in July 2021 to 0% in August 2021. USDC states that their Treasuries include "US government treasury bills, notes and bonds with a maximum maturity of 3 years". While Treasuries are generally liquid and safe security, the extent of their liquidity varies by type and over time. For example, on-the-run Treasuries and Treasury bills are much more liquid than off-the-run Treasuries and non-bills.

The remaining reserve assets are comprised of more illiquid assets, including municipal and agency securities, foreign securities, corporate bonds, corporate loans, and other securities. USDT still held a sizable amount of these illiquid assets in March 2022, with 4.5%, 3.8%, and 6.0% in corporate bonds, corporate loans, and other assets, respectively. While the exact identity of other assets is not disclosed, it is mentioned that they do include crypto investments. In June 2021, USDC held 0.4%, 15.9%, and 9.5% in municipal and agency securities, foreign securities, and corporate bonds respectively. USDC's holding of these assets is reported to have dropped to zero starting in September 2021, with all assets held in the form of the deposits described above.

The other four stablecoins report that their assets are limited to deposits, Treasuries, and money market instruments. For example, a statement issued by BUSD and USDP in July 2021 claims that they hold 96% of cash equivalents and 4% of Treasury bills. GUSD states that their reserves are "held and maintained at State Street Bank and Trust Company, Signature Bank, and within a money market fund managed by Goldman Sachs Asset Management, invested only in U.S. Treasury Obligations." TUSD also claims that their US dollar balance is held by "U.S. depository institutions and Hong Kong depository institutions" and that they "include US dollar cash and cash equivalents that include short-term, highly liquid investments of sufficient credit quality that are readily convertible to know amounts of cash."

5 Model

We build a model to analyze the potential for runs in the context of the bifurcated primary-secondary market structure of fiat-backed stablecoins. We first show how run risk is linked to the level of liquidity transformation performed and the concentration of the arbitrage sector. We then analyze how the stablecoin issuer's choice of efficient arbitrage faces an inherent tradeoff between price stability and financial stability. Finally, we analyze the issuers' incentives in choosing arbitrage efficiency to maximize profits and the effect of distributing dividends to investors.

5.1 Setup

The economy has four dates, $t = 0, 1, 2, 3$, with no time discounting. There are four groups of risk-neutral players, 1) a competitive group of infinitesimal investors indexed by i, 2) noise traders, 3) a sector of n arbitrageurs, and 4) a stablecoin issuer. There are two types of assets: 1) the dollar, which is riskless, liquid, and serves as the numeraire, and 2) an illiquid and potentially productive reserve asset.

At $t = 0$, the stablecoin issuer designs the primary market. Specifically, the issuer chooses n at $t = 0$, that is, how concentrated it primary market is, to maximize its expected profit. The issuer also holds the stablecoin that is initially backed by the reserve asset. The initial value of the reserve asset is normalized to one dollar.

At $t = 0$, investors also make participation decisions. If an investor chooses to participate in the stablecoin market, she incurs a cost of c_i, which follows a distribution function $G(c)$, and receives one stablecoin. The investor, therefore, participates only when her participation cost is smaller than the expected utility from participation, which will be determined in equilibrium and specified below. Noise traders are automatically endowed with a stablecoin. We will formalize investors' participation decision and issuer's profit maximization in Section 5.3. Until then, we take n as exogenous and normalize the population of participating investors to one.

In stage $t = 1$ of our model, noise traders trade stablecoins, creating variance in stablecoin prices, which lowers convenience yields to investors. At $t = 1$, with equal probability, noise traders either buy a fraction δ of the total stablecoin market cap, and then resell them at the end of $t = 1$; or sell a fraction

δ of stablecoin market cap, and then rebuy them at the end of the period. Hence, letting ω denote order flow from noise traders, ω is equal to δ or $-\delta$ with equal probability. Intuitively, we can think of noise traders as individuals who attempt to use stablecoins for remittances. As we describe in Subsection 2.1, this involves buying stablecoins with fiat, sending stablecoins, and then selling stablecoins. The specification that noise trader order flow perfectly reverts is convenient because, as we will show, it implies that noise trading ω affects stablecoin price but does not directly generate fire sales by the issuer. This allows us to focus on the trade-off in price and financial stability in stablecoin design while ruling out the uninteresting case of noise trading itself leading to runs. Consistent with the observations in Section 4, we assume noise traders cannot directly trade with the issuer; instead, they exchange fiat for stablecoins by trading with arbitrageurs in secondary markets.

Also at $t = 1$, n arbitragers trade stablecoins in secondary and primary markets to profit from price deviations. We assume arbitrageurs cannot hold net inventory, so they must on net redeem as much on primary markets as they purchase in secondary markets. Arbitrageurs face quadratic inventory costs for arbitrage: arbitrageur j incurs a cost $\frac{z_j^2}{2\chi}$ for arbitraging z_j units of the asset from secondary to primary markets, where χ scales proportionally with the stablecoin's market cap. The parameter χ can be thought of as capturing arbitrageurs' balance sheet capacity: when χ is higher, inventory costs are lower. Arbitrageurs submit bid curves in secondary markets to trade stablecoins in a uniform-price multi-unit double auction. We characterize the solution to the double auction in Appendix B. Essentially, arbitrageurs' bids produce a downwards-sloping demand curve in secondary markets for the stablecoin; the slope of demand is higher, so stablecoin sales have less price impact, when n is larger and there are more arbitrageurs, and when χ is larger so arbitrageurs have more balance sheet capacity.

Also at $t = 1$, arbitrageurs can redeem or create the stablecoins with the issuer in the primary market at a fixed price of one dollar per stablecoin if the issuer is solvent. Expecting the amount of dollars to be redeemed from or to be delivered to the issuer, the n arbitrageurs bid in a double auction (e.g., in the manner of Kyle (1989) and Du and Zhu (2017)) to absorb the ω stablecoin orders from noise traders, determining p_1. As standard in the double auction literature, we let each arbitrageur's balance sheet capacity be χ, where χ scales with the stablecoin market cap. The reciprocal of χ can be understood as a given arbitrageur's per unit balance sheet cost. When the arbitrageurs are better-capitalized or when the stablecoin sector is bigger, χ will be larger. Consistent with the observations in Section 4, noise traders cannot directly trade with the issuer. Appendix B provides a more detailed description of the double auction and its solution.

Fluctuations in the stablecoin price p_1 induced by noise trader order flow matter because they lower stablecoin investors' convenience yields from holding stablecoins. Following Gorton and Pennacchi (1990), we let investors enjoy a short-term convenience of $-\alpha Var(p_1)$ per stablecoin at $t = 1$, where $\alpha > 0$. This captures the idea that stablecoins are less valuable to users, both as a transaction medium and as a store of value, if their prices are more volatile.

In stages $t = 2$ and $t = 3$, investors decide whether to liquidate stablecoins early, potentially leading to runs, or hold stablecoins to maturity to capture convenience yields. At $t = 2$, investors can choose to sell their stablecoins; we use λ to denote the fraction of investors that sell their stablecoins at the market price p_2. This selling of stablecoins can be interpreted as investors deciding to permanently de-invest in stablecoins in exchange for dollars, or other unmodeled assets. Like noise traders, investors cannot directly redeem stablecoins from the issuer; instead, they liquidate by selling stablecoins to arbitrageurs in the secondary market, who subsequently redeem stablecoins for cash from the issuer. Arbitrageurs, considering the amount they expect to be able to redeem from the issuer, bid in a double auction to determine the price p_2 at which investors' sales of λ stablecoins occur.

The issuer, in turn, meets arbitrageur redemptions in cash by liquidating the illiquid reserve asset. This involves a liquidation cost of $\phi \in (0, 1]$, i.e., liquidating one unit of the asset yields $1 - \phi$ dollars. Economically, ϕ captures the level of liquidity transformation as well as the various costs incurred when transacting illiquid assets (see Duffie, 2010, for a review). Note that the issuer is solvent if and only if $\lambda < 1 - \phi$. When $\lambda \geq 1 - \phi$, the issuer defaults, and arbitrageurs receive the liquidation value of $(1 - \phi)/\lambda$ per stablecoin redeemed.

In deciding whether to liquidate their stablecoins early, investors receive private information a $t = 2$ about the fundamentals of the economy at $t = 3$. Following the global games literature, each investor i obtains a private signal $\theta_i = \theta + \varepsilon_i$ at $t = 2$, where the noise term ε_i are independently and uniformly distributed over $[-\varepsilon, \varepsilon]$. As usual in the literature (e.g., as in Goldstein and Pauzner (2005)), we focus on arbitrarily small noise in the sense that $\varepsilon \to 0$, but the model results also hold beyond the limit case.[8]

Fundamentals θ reflect the level of aggregate risk and determine the stablecoin's long-term value at $t = 3$. With probability $1 - \pi(\theta)$, the economy enters a bad state: the reserve asset fails and investors do not receive any nominal return nor any long-term benefits from holding the stablecoin backed by assets of no value. Essentially, this is when the stablecoin ceases to exist as a means of payment in transactions. With probability $\pi(\theta)$, the economy enters a good state: the reserve asset yields a positive value of $R(\phi) \geq 1$ dollar, the stablecoin continues to operate, and the remaining $1 - \lambda$ investors consume a long-term benefit $\eta > 0$ per stablecoin and the initial value of 1 per unit of the remaining reserve asset. η can be understood as the benefits derived from holding and using the stablecoin in the long run. In the baseline model, we consider stablecoins that do not issue dividends to investors, consistent with the current state of USD stablecoins in our discussion in Section 2. In this case, the net maturing gain of the reserve asset in the good state, $R(\phi) - 1$, is accrued to the stablecoin issuer but not the investors. $R(\phi)$ increases with asset illiquidity $R(\phi)$ to reflect the liquidity risk premium. In Section 5.2, we consider the counterfactual case where the stablecoin issuer distributes some of the asset returns as dividends to investors.

Taken together, our model setup can parsimoniously capture the concepts of price stability and financial stability by combining features of the Gorton and Pennacchi (1990) and Diamond and Dybvig (1983) models. At $t = 1$, the stablecoin is used for transactional purposes but its price fluctuations lead to transaction costs that hurt its convenience. Between $t = 2$ and $t = 3$, investors consider whether to sell their stablecoins early considering economic fundamentals and the decision of other investors. This is where the illiquidity of reserve assets may give rise to a first-mover advantage in liquidating the stablecoin despite the selling price being flexible on the secondary market. This setup thus allows us to formulate the tension between price and financial stability in the optimal design of stablecoins.[9]

[8]Note that we do not impose any restrictions on the distributions of π, θ, or the increasing function $\pi(\theta)$, which allows us to map the model to any empirical distribution of fundamentals. Also note that the standard assumption in the global games literature that investors obtain a private signal about fundamentals is relatively plausible for the stablecoin market because of its opacity: essentially no stablecoin issuers disclose asset-level information about their reserves, and investors and arbitrageurs infer stablecoins' value using their private information.

[9]We note that the separation between $t = 1$ and $t = 2$ is not crucial for the model; it simplifies the model by ruling out the uninteresting case that noise trading itself may lead to fire sales or render the stablecoin issuer default. Considering that would complicate the model without new economic insights.

We solve the model by backward induction: we first analyze investors' run decisions at $t = 2$, and link the run risk to the concentration of arbitrage in Section 5.2. Then in Section 5.3, we analyze how the choice of arbitrage concentration at $t = 0$ in turn affects stablecoin price and investors' convenience at $t = 1$.

5.2 Stablecoin Runs and the Centralization of Arbitrage

To start, we first consider p_2, the price an investor receives from liquidating the stablecoin early:

Lemma 1. *The stablecoin's secondary-market price at $t = 2$ is given by*

$$p_2(\lambda) = \begin{cases} 1 - K\lambda & \lambda \leq 1 - \phi\,, \\ \dfrac{1-\phi}{\lambda} - K\lambda & \lambda > 1 - \phi\,, \end{cases} \tag{5.1}$$

where

$$K = \frac{1}{\chi}\frac{n-1}{n(n-2)}\,. \tag{5.2}$$

Lemma 1 shows that p_2 crucially depends on K, which captures the slope of arbitrageurs' demand. Specifically, p_2 is decreasing in K and thereby increasing in χ and n. Intuitively, a higher arbitrageur balance sheet capacity χ implies a lower cost for arbitrageurs to bid to absorb the selling pressure, leading to a more elastic market and supporting a higher p_2. A less concentrated arbitrageur sector, that is, a larger n, implies that the auction becomes more competitive in the sense that it is harder for any individual arbitrageur to win the auction. At the same time, more arbitragers also mean that the total size of the arbitrage sector's balance sheet becomes larger, potentially absorbing higher selling pressure. Taken together, arbitrageurs bid more competitively with a larger total balance sheet, resulting in a more elastic market and a higher p_2.

Viewing p_2 as a function of λ, we note that p_2 is strictly decreasing in λ everywhere due to the standard effect of excess supply depressing price. Different from classic bank run models (e.g., Diamond and Dybvig, 1983) in which depositors get a fixed deposit value, this feature of $p_2(\lambda)$ points to strategic substitutability present in many exchange-based financial markets: the more investors sell, the lower the price is, making an investor less likely to sell. All else equal, this feature would thus mitigate any potential run risk.

We then consider v_3, the long-term value an investor may get at $t = 3$ if λ other investors choose to liquidate early. It is given by

$$v_3(\lambda) = \begin{cases} \pi(\theta)\left(\dfrac{1-\phi-\lambda}{(1-\phi)(1-\lambda)} + \eta\right) & \lambda \leq 1-\phi\,, \\ 0 & \lambda > 1-\phi\,. \end{cases} \tag{5.3}$$

To see why this is the case, notice that the issuer needs to liquidate

$$l(\lambda) = \begin{cases} \dfrac{\lambda}{1-\phi} & \lambda \leq 1-\phi\,, \\ 1 & \lambda > 1-\phi\,. \end{cases} \tag{5.4}$$

units of the reserve asset to meet arbitrageur redemptions at $t = 2$, and only $1 - l(\lambda)$ units remain at $t = 3$, whose value will be shared by the remaining $1 - \lambda$ late investors. Combining this financial value and the long-term benefit of the stablecoin thus yields (5.3).

An important observation from (5.4) is that more investors selling (i.e., larger λ) and a higher level of liquidity transformation (i.e., larger ϕ) result in more costly liquidations of the reserve asset (i.e., larger $l(\lambda)$). Fundamentally, this arises from the fact that the stablecoin issuer, if solvent, has to meet stablecoin redemptions at a fixed cash value of one dollar. As we show shortly below, this force eventually dominates the strategic substitutability shown in (5.1) when λ becomes large, leading to potential runs.

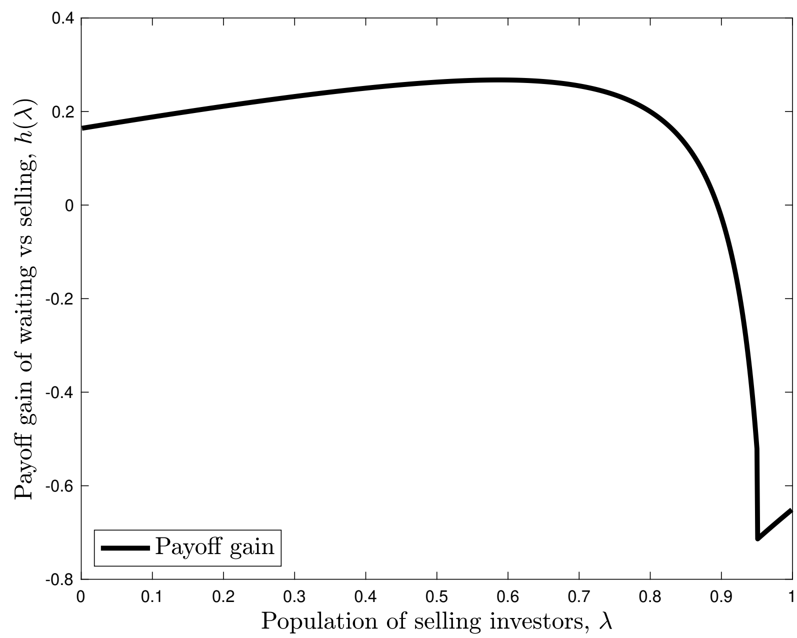
To pin down an investor's run incentive at $t = 2$, we compare the date-3 stablecoin value (5.3) to the date-2 secondary-market stablecoin price (5.1). Formally, we define a late investor's payoff gain from waiting until $t = 3$ versus selling at $t = 2$ as

$$h(\lambda) = v_3(\lambda) - p_2(\lambda) = \begin{cases} \pi(\theta)\left(\dfrac{1-\phi-\lambda}{(1-\phi)(1-\lambda)} + \eta\right) - 1 + K\lambda & \lambda \leq 1-\phi\,, \\ -\dfrac{1-\phi}{\lambda} + K\lambda & \lambda > 1-\phi\,. \end{cases} \tag{5.5}$$

It is easy to see that $h(0) \geq 0$ when $\pi(\theta)$ is sufficiently large while $h(1) < 0$, implying that the model has multiple equilibria when θ is sufficiently large and if θ is common knowledge.

Figure 1 plots the payoff gain function $h(\lambda)$. Observe that $h(\lambda)$ first increases in λ, then decreases, and then increases in λ again. The first region where $h(\lambda)$ increases reflects strategic substitutability arising from the secondary market of stablecoins, as shown in (5.1). Because selling investors' price impact depresses the secondary-market price, an investor may find it less appealing to sell at $t = 2$ if other investors also sell. However, the cost that waiting investors bear increases as more and more investors choose to sell, issuers' liquidation costs increase, and arbitrageurs continue to redeem from the issuer at a fixed price of \$1, as shown in (5.3). This force grows as λ becomes larger, counteracting the secondary-market strategic substitutability and leading to a decreasing $h(\lambda)$. Eventually, the cost from waiting dominates as λ becomes sufficiently large, pushing $h(\lambda)$ to be negative and reinstalling the first-mover advantage that leads to runs in equilibrium.

Figure 1: Investors' Payoff Gain from Waiting versus Selling Early



This figure shows an investor's payoff gain from waiting until $t = 3$ relative to selling early at $t = 2$. Parameters: $\pi(\theta) = 0.97, \eta = 0.2, \phi = 0.05, K = 0.3$.

Under the global games framework, we have the following result:

Proposition 1. *There exists a unique threshold equilibrium in which investors sell the stablecoins if they obtain a signal below threshold* θ^* *and do not sell otherwise.*

Proposition 1 implies that the model with investors' private and noisy signals has a unique threshold equilibrium. An investor's liquidation decision is uniquely determined by her signal: she sells the stablecoin at $t = 2$ if and only if her signal is below a certain threshold. Given the existence of the unique run threshold, we can show that it satisfies the following Laplace equation:

$$\int_0^{1-\phi} (1 - K\lambda)\, d\lambda + \int_{1-\phi}^{1} \left(\frac{1-\phi}{\lambda} - K\lambda \right) d\lambda = \int_0^{1-\phi} \pi(\theta^*) \left(\frac{1-\phi-\lambda}{(1-\phi)(1-\lambda)} + \eta \right) d\lambda \,. \tag{5.6}$$

Solving the Laplace equation gives an analytical solution of the run threshold and presents intuitive comparative statics about stablecoin run risk:

Proposition 2. *The run threshold is given by*

$$\pi(\theta^*) = \frac{(1-\phi)(2 - 2\phi - 2(1-\phi)\ln(1-\phi) - K)}{2\left((1 + \eta(1-\phi))(1-\phi) + \phi \ln \phi\right)} \,. \tag{5.7}$$

which satisfies the following properties:

i). The run threshold, that is, run risk, is increasing in ϕ *if and only if* $g(\phi) > K$*, where* $g(\phi)$ *is continuous and strictly decreasing in* ϕ*, and satisfies* $\lim_{\phi \to 0} g(\phi) > 0$.[10]

ii). The run threshold, that is, run risk, is decreasing in K *(that is, increasing in* n *and increasing in* χ*).*

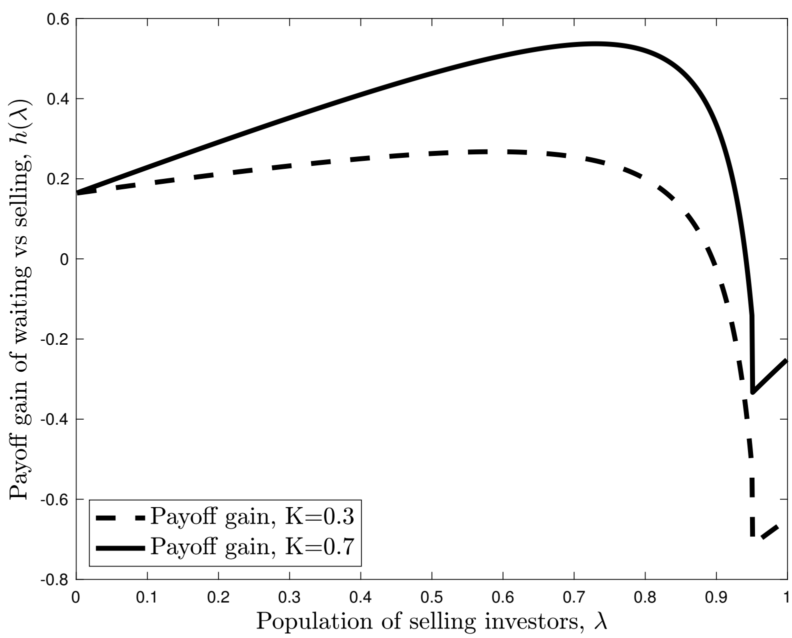
Part i) of Proposition 2 shows that a higher level of stablecoin liquidity transformation leads to a higher run risk when $g(\phi) > K$. This condition may be satisfied when ϕ is not too large for a given K. Intuitively, when the stablecoin holds more illiquid reserve assets, the first-mover advantage among investors increases because an investor who chooses not to sell would have to involuntarily bear a higher liquidation cost induced by selling investors. However, when the reserve asset is too illiquid, run risk could be dampened. The intuition can be understood from equation (5.5): investors enjoy the first-mover advantage only when $\lambda \leq 1 - \phi$, that is, only when $h(\lambda)$ takes the value in the first line of (5.5);

[10]The function $g(\phi)$ can be solved in closed form and is given in the proof.

otherwise, too high a ϕ shrinks the region in which the first-mover advantage can be realized. Thus, further increasing the level of liquidity transformation when $g(\phi) < K$ reduces run risk. In Section 6, we confirm that $g(\phi) > K$ applies for the major stablecoins during our sample period, suggesting that increasing liquidity transformation will increase their run risk in practice.

Part ii) of Proposition 2 shows that more efficient arbitrage in terms of a larger number of arbitrageurs with better balance sheet capacity exacerbates run risk. This surprising result is an implication of the way that stablecoin primary and secondary markets are connected. When arbitrage is more efficient, stablecoin sales have a lower price impact. Thus, investors get higher payoffs from selling early, whereas their payoffs from holding to maturity are unchanged. Investors' incentives to sell early is increased, exacerbating run risk. Conversely, when arbitrage is inefficient, sales have more price impact, and investors are discouraged to sell early. Imperfect arbitrage thus reduces run risk essentially by behaving like a tax on investor redemptions, which is increasing in the number of others that redeem. Figure 2 illustrates how investors' payoff gain from waiting increases as the secondary market becomes less efficient.

Figure 2: Investors' Payoff Gain from Waiting versus Selling Early: Comparative Statics with respect to K



This figure shows an investor's payoff gain from waiting until $t = 3$ versus selling at $t = 2$. Parameters: $\pi(\theta) = 0.97, \eta = 0.2, \phi = 0.05, K = 0.3$ and $K = 0.7$.

In addition, the analytical solution given in Proposition 2 allows us to calibrate the model to the data to quantify run risk in Section 6. To this end, we translate the run threshold into an ex-ante run probability with the distribution of fundamentals $F(\theta)$. Formally,

Definition 1. *The ex-ante run probability of a stablecoin is given by*

$$\rho = \int_{\pi(\theta)<\pi(\theta^*)} dF(\theta)\,, \tag{5.8}$$

where $\pi(\theta^*)$ *is given by* (5.7) *and* $F(\theta)$ *is the prior distribution of the fundamentals.*

Before proceeding, we make two comments about the notion of stablecoin runs in our framework. We purposefully follow the framework of Diamond and Dybvig (1983) to focus on liquidity transformation and the resulting first-mover advantage and coordination failure in liquidation. Other conceptions of coordination motives, and thus other modeling choices, are possible. One possibility is to follow the idea in the new monetarism framework of Kiyotaki and Wright (1989) and Rocheteau and Wright (2005), which shows that an agent adopts a good as a medium of exchange only if other agents adopt and thus accept the same good in transactions. In other words, the value of a medium of exchange becomes higher when more investors adopt it. Although this approach more explicitly highlights the payment role and network-good feature of stablecoins, it does not capture liquidity transformation. In fact, that approach applies to any form of money that is not necessarily backed by dollar reserves. Several recent papers that consider general forms of stablecoins adopt this approach (e.g., Li and Mayer, 2021, Baughman and Flemming, 2023, Bertsch, 2023). In contrast, given our focus on reserve-backed stablecoins as a financial intermediary, as well as the financial stability implications for real dollar asset markets, we view Diamond and Dybvig (1983) as the preferred building block for our model. At the same time, we also capture the payment role of stablecoins by modeling its convenience and linking it to stablecoin price fluctuations, consistent with the micro-foundation provided by Gorton and Pennacchi (1990).

Another possibility for modeling coordination and runs is to follow the idea of market runs in Bernardo and Welch (2004). There, if an illiquid asset market features a downward-sloping demand curve, investors fearing future liquidity shocks will have an incentive to front-run each other, fire selling the asset earlier to get a higher price. Similarly, Bernardo and Welch (2004) do not feature an intermediary or liquidity transformation, which is the focus of our paper.

5.3 Price Stability and Optimal Stablecoin Design

Having analyzed the run risk of stablecoins and its relationship with arbitrage concentration, we now reason backward to analyze how arbitrage affects the stablecoin's price stability at $t = 1$, which determines its convenience value to investors and the issuer's optimal design choices.

Consider p_1 and its variance, which determines the convenience that investors enjoy at $t = 1$:

Lemma 2. *The stablecoin's secondary-market price at* $t = 1$ *is given by*

$$p_1 = \begin{cases} 1 - \delta K & \omega = \delta\,, \\ 1 + \delta K & \omega = -\delta\,, \end{cases} \tag{5.9}$$

where K *is given in* (5.2). *The stablecoin's convenience at* $t = 1$ *is thus given by* $-\alpha\delta^2 K^2$, *which is decreasing in* K, *that is, increasing in* n *and* χ.

Lemma 2 shows that the stablecoin's convenience is decreasing in K. This is intuitive because as arbitrage becomes less efficient, the secondary market becomes less elastic and noise trading induces larger fluctuations in the secondary market price p_1. Investors thus enjoy a lower convenience, reminiscent of the idea of information sensitivity in Gorton and Pennacchi (1990).

Taken together, Proposition 2 and Lemma 2 point to the trade-off between price and financial stability of the stablecoin. To formulate this trade-off, we now consider the stablecoin issuer's design decision at $t = 0$. It involves one key choice variable that determines the elasticity of the stablecoin secondary market: the number of arbitrageurs n that are allowed to perform primary-market redemptions and creations.[11] We suppose that the stablecoin issuer chooses n to maximize its expected revenues at $t = 0$, which in turn depends on how many investors participate at $t = 0$. We also assume that the magnitude of noise trading and the total balance sheet capacity of the arbitrage sector grow proportionally to the

[11] Arbitrage capacity χ also affects arbitrage efficiency, but stablecoin issuers are unlikely to have control over the balance sheet costs and budget constraints of arbitrageurs, which is why we let the issuer choose n for a given χ.

population of investors, capturing the idea that investor growth reflects a growth of the entire stablecoin sector. The issuer's objective function is thus given by

$$\max_{n} E[\Pi] = \underbrace{G(E[W])}_{\substack{\text{population of} \\ \text{participating investors}}} \underbrace{\int_{\pi(\theta)\geq\pi(\theta^*)} \pi(\theta)(R(\phi)-1)dF(\theta)}_{\substack{\text{expected issuer revenue per} \\ \text{participating investor}}}, \tag{5.10}$$

where each investor's expected utility of participation is

$$E[W] = \underbrace{-\alpha\delta^2K^2}_{\text{short-term convenience}} + \underbrace{\int_{\pi(\theta)<\pi(\theta^*)} (1-\phi-K)\, dF(\theta)}_{\text{short-term payoff if runs}} + \underbrace{\int_{\pi(\theta)\geq\pi(\theta^*)} \pi(\theta)(1+\eta)\, dF(\theta)}_{\text{long-term payoff if no runs}}, \tag{5.11}$$

in which $\pi(\theta^*)$ is given by (5.7) in Proposition 2.

The stablecoin issuer's objective function (5.10) captures its revenue base. Absent a panic run, the issuer obtains the expected net long-term return of the remaining reserve asset. At the same time, a larger population of participating investors allows the issuer to scale up its investment in reserve assets. Investors' participation is in turn driven by their expected utility $E[W]$, which is comprised of three components as shown in (5.11). The first term denotes investors' expected convenience loss due to stablecoin price fluctuations. The second term denotes their expected payoff when a panic run happens, while the third term corresponds to their expected payoff without a run.

Solving the stablecoin issuer's problem (5.10), we have the following result about the stablecoin issuer's optimal choice of arbitrageur concentration:

Proposition 3. *When the stablecoin engages in a higher level of liquidity transformation, the stablecoin issuer optimally designs a more concentrated arbitrageur sector, that is, n^* decreases in ϕ when ϕ is not too large and the cumulative distribution function G is close to linear.*

Proposition 3 stems from the trade-off between price stability and financial stability of stablecoins. Intuitively, when an investor values the convenience of the stablecoin, she prefers smaller price fluctuations as captured by the first term in (5.11). Further, she would like to receive a higher price when she decides to liquidate the stablecoin for dollars. For both reasons, the stablecoin issuer would like to maintain an efficient and elastic secondary market to keep the price stable. However, a more elastic secondary market at the same time leads to higher run risks, as captured by the second and third terms in (5.11). This hurts investors' expected utility and thus their participation incentive as captured by the first term in (5.10). Further, a higher run risk also cuts into the stablecoin issuer's expected revenue per participating investor it only obtains the net long-term return of the reserve asset when no run happens, as captured by the second term in (5.10). Thus, the issuer accepts some level of price fluctuations to avoid runs. In particular, when asset illiquidity makes runs more likely, the issuer optimally chooses a more concentrated arbitrageur sector to reduce the first-mover advantage among investors, as illustrated in Figure 2.

Finally, we consider a policy counterfactual in which the stablecoin issuer pays dividends to its long-term investors at $t = 3$. Recall that under the baseline model, stablecoin investors do not receive any nominal returns from the reserve asset. In practice, it is perceived that stablecoins do so in part to avoid being regulates as a security. The choice of paying dividends is particularly relevant given that many stablecoins engage in liquidity transformation by holding illiquid reserve assets, which earn higher long-term returns than liquid assets.

To understand the implications of distributing dividends to investors, we formulate a notion of stablecoin dividends under our framework. Suppose in the good state of the world, the stablecoin issuer shares τ out of its net long-term value with investors. Each investor's value at $t = 3$ thus becomes:

$$v_3(\lambda;\tau) = \begin{cases} \pi(\theta)\left(\dfrac{1-\phi-\lambda}{(1-\phi)(1-\lambda)}(1+\tau)+\eta\right) & \lambda \leq 1-\phi\,, \\ 0 & \lambda > 1-\phi\,, \end{cases} \tag{5.12}$$

which nests (5.3) as a special case of $\tau = 0$. Accordingly, the stablecoin issuer's objective function becomes:

$$\max_n E[\Pi] = G(E[W]) \int_{\pi(\theta)\geq\pi(\theta^*)} \pi(\theta)\,(R(\phi)-1-\tau)\,dF(\theta)\,, \tag{5.13}$$

which similarly nests (5.10) as a special case. We have the following result:

Proposition 4. *Suppose ϕ is not too large. When the stablecoin issuer distributes a positive dividend τ to its long-term investors, the stablecoin issuer optimally designs a less concentrated arbitrageur sector, that is, $n_{\tau}^{*} > n^{*}$, resulting in higher price stability of the stablecoin.*

Proposition 4 arises from two economic forces. First, a higher dividend payment would encourage investors to hold the stablecoin in the long-term rather than liquidating them in the short-term, which can be observed from (5.12). This reduction in investors' run incentives allows the issuer to choose a more efficient arbitrage sector without incurring a high run risk. Second, the stablecoin issuer's expected revenue per each participating investor decreases after distributing some of her returns as dividends, as illustrated in (5.13) compared to (5.10). This channel reduces the issuer's incentive to prevent runs for a given level of investor participation, which further encourages more efficient arbitrage. Thus, both forces lead to a less concentrated arbitrage sector and improved price stability when dividends are paid out, unambiguously benefitting investors' convenience value.

Interestingly, the financial stability implication of dividend payouts is ambiguous in the model. This is because the aforementioned two forces counteract each other in affecting run risk. The first force reduces run risk because stablecoin investors expecting dividends are less runnable. The second force, however, increases run risk because the lower revenue to the issuer reduces her skin in the game to reduce run risk. Which of the two forces dominates in equilibrium is thus an empirical question. In Section 5.3, we analyze the effect of issuing dividends on the run risk of USDT and USDC using our calibrated model.

6 Model Calibration and Results

In this section, we calibrate our model to estimate run probability as defined in Definition 1. Intuitively, our estimation relies on calculating the global games' prediction of a unique run threshold that lets fundamentals coordinate investors selling decision on the secondary market.

We focus our analysis on the largest two fiat-backed stablecoins, USDT and USDC, because of the availability of their reserve asset breakdowns. We first estimate asset illiquidity ϕ, the distribution of $p(\theta)$, and the long-term benefit η from the data. Using these parameters, we can calculate run thresholds for any given value of K, and then investor welfare and issuers' profits given investor demand $G(\cdot)$. Second, we choose the investor risk parameter $\alpha\delta^2$ and investor demand elasticity to match the model-predicted K and investor demand elasticity in the data.

6.1 Empirical Moments ϕ, $p(\theta)$, and η

Asset Illiquidity ϕ. We proxy asset illiquidity with haircuts following Bai, Krishnamurthy and Weymuller (2018) and Ma, Xiao and Zeng (2021). These haircuts measure the discount incurred when illiquid assets are converted into cash at short notice.[12] More liquid assets are more readily pledged to obtain cash while more illiquid assets incur a higher discount.

To measure the overall illiquidity of USDT and USDC's reserve portfolios, we calculate the average discounts of their reserve assets weighted by their portfolio weights. One challenge is that we do not know the exact liquidity of their deposits, which include both demandable deposits and time deposits and CDs. In the baseline estimate, we assume that half of the deposits are fully liquid while the other half is subject to the money market discount. The results are shown in Table 5. Overall, reserve assets of USDT are more illiquid than those of USDC, but both of them shift towards holding more liquid assets over the sample period.

Distribution of $p(\theta)$. Our model also requires us to take a stance on the distribution of $p(\theta)$, which is the signal of how likely the risky asset held in the issuer's portfolio is to pay nothing. To estimate p empirically, we use historical CDS prices to evaluate the daily recovery value of each portfolio component and then take a weighted average to obtain the daily expected recovery value of the reserve portfolio. We construct a distribution of expected recovery values, i.e., CDS spreads, using daily data from 2008 to 2022 from Markit, calculate the mean and variance of the distributions, and fit a beta distribution with the same mean and variance for each coin-month. We adjust for the extent of collateralization for each coin based on their reported asset and liability values. The fitted beta distribution parameters, as well as the mean and variance of the implied beta distributions, are shown in Appendix Table 11. Please see Appendix E.1 for more details about our construction.

[12] The New York Fed publishes haircuts on different securities when pledged as collateral in repo loans.

Long-term Benefit η. To proxy for investors' long-term benefit from holding and using the stablecoin, we follow Gorton, Klee, Ross, Ross, and Vardoulakis (2023) to use investors' return from lending out the stablecoin. Specifically, we focus on the Aave secondary lending market, using data from aavescan.com. Aave is a smart contract lending platform, which allows market participants to lend cryptoassets for interest, overcollateralized by other cryptoassets. Intuitively, this lending rate captures the compensation to the investor for not being able to use the stablecoin herself while it is on loan to another investor. Table 5 shows the return from lending out USDT and USDC in each reporting period.

6.2 Estimating $\alpha\delta^2$ and $G(\cdot)$ using K and $\frac{\partial \log G(E[W])}{\partial \eta}$

Having obtained asset illiquidity ϕ, the distribution of fundamentals $p(\theta)$, and the long-term benefit η from the data, the remaining model parameters are $\alpha\delta^2$, the utility cost to investors cost of noise trading, and $G(\cdot)$, investors' demand function for the stablecoin. We will estimate $\alpha\delta^2$ as a single parameter, based essentially on how much weight issuers' optimality condition appears to put on lowering K and thus decreasing price variance. This approach jointly estimates risk aversion α and the size of noise trading shocks δ.

We parametrize $G(\cdot)$ as:

$$G(EW) = 1 - \gamma (1 - EW).$$

That is, the issuer has a unit mass of consumers if she produces $EW = 1$. For any gap between 1 and EW, the issuer loses γ consumers. Thus, γ is simply the elasticity of investor demand. We let the demand elasticities for USDC and USDT be γ_{Circle} and γ_{Tether}, respectively, accounting for their different investor bases.[13]

We then estimate $\alpha\delta^2$ and $G(\cdot)$ through moment matching. For each choice of $\alpha\delta^2, \gamma_{Circle}, \gamma_{Tether}$ and each coin-month combination in our data, we calculate the optimal value of K, by solving the issuer's optimization problem (5.10). At the optimal K, we then numerically compute the partial

[13] We do not let the unobserved $\alpha\delta^2$ vary across USDT and USDC to avoid allowing for too many degrees of freedom in moment matching.

elasticity of investors' demand with respect to η in the model:

$$\frac{\partial \log G\left(E\left[W\right]\right)}{\partial \eta}.$$

For each choice of $\alpha\delta^2$ and γ, this procedure gives us a model-predicted value of K and $\frac{\partial \log G(E[W])}{\partial \eta}$ for each month. We then choose parameters to minimize the sum of squared distances between model-predicted log values of K and $\frac{\partial \log G(E[W])}{\partial \eta}$, averaged across months for each coin, and their counterparts in the data across all reporting periods of USDC and USDT.

To obtain K from the data, we regress daily price deviations against daily redemption or creation volume for each stablecoin:

$$Deviation_t = \beta Redemption/Creation_t + FE_y, \tag{6.1}$$

where $Deviation_t$ is one minus the lowest observed secondary market price on redemption days and the highest observed secondary market price minus one on creation days, $Redemption/Creation_t$ is the volume of redemptions or creations divided by the total outstanding volume of tokens on day t. We use the lowest and highest secondary market prices on each day to capture the extent of price dislocations that demand arbitrage rather than the price dislocations resulting from arbitrage. We normalize the volume of redemptions and creations by the total outstanding volume of tokens to consider the difference in market sizes across stablecoins. Finally, we include a year fixed effect to capture potential structural shifts in the arbitrageur sector for each stablecoin. For example, the number and constraints of arbitrageurs may evolve after some time with the growth of stablecoins. From the results in Table 6, we observe that the estimated K for USDT is larger in absolute magnitude than for USDC, which is consistent with the higher arbitrageur concentration of USDT constraining redemption volume to be less sensitive to price dislocations. That is, a larger price dislocation is required to induce the same amount of redemptions for USDT than for USDC. Magnitude-wise, a 10 percentage point higher redemption/creation volume as a fraction of the total volume outstanding corresponds to a 2.09 cent larger price deviation USDT and a 1.56 cent larger price deviation at USDC. For more detailed regression results, please refer to Table 12.

To obtain $\frac{\partial \log G(E[W])}{\partial \eta}$ from the data, we regress the monthly log change in the number of shares outstanding against the beginning-of-month long-term benefit, i.e., the lending rate. The results in Table 6 show that the demand for USDC is more responsive to a given change in the long-term benefit than the demand for USDT.

The parameter estimates are shown in the first two columns of Table 5. We estimate $\alpha\delta^2$ to be 12.74 and γ to be 0.38 for Tether and 0.65 for Circle. As is standard in structural models, both parameters contribute to variation in both moments; however, the intuition behind the identification of model parameters is as follows. When $\alpha\delta^2$ is high, the cost of price variance is high. Thus, issuers will tend to choose lower values of K, trading off slightly increased run probabilities for lower price variance and thus lower costs of noise trading. Hence, the level of K in the data, relative to fundamentals, contributes to identifying $\alpha\delta^2$. The parameter γ controls investors' elasticity of demand; when γ is higher, the stablecoin market size will increase more for any given increase in η.

The fit of our model to the targeted moments is shown in Table 6. The model-predicted arbitrageur demand slopes K are in the same range but slightly higher than those in the data.[14] Note that we are able to match the stylized fact that the optimal K is higher for USDT than USDC, with approximately the same magnitude as in the data. In terms of the second moment, we are able to match the elasticity of investors' demand for stablecoins fairly well, on average over time within coins. The mapping from moments to parameters is intuitive: we estimate investors' demand elasticity to be somewhat higher for USDC than USDT, which is why we find that γ is slightly higher for USDC.

6.3 Run Probability

Table 5 shows that the implied run probabilities from our estimation range from 3.336% to 7.459%. Run probabilities depend on input parameters in an intuitive way. For example, USDC substantially de-risked its asset holdings over 2021, causing illiquidity ϕ to decline. At the same time, the long-term benefit η trended up. Both forces contributed to a decline in run probabilities over time from 5.713% in May 2021 to 3.336% in October 2021. Notice that the run risk of USDC remains substantial even

[14]Technically, the reason for this mismatch is that, under our estimates, K values in the data would imply overly high run probabilities for Circle, which could not be consistent with issuer optimization under any parameter settings.

without holding illiquid assets like corporate bonds and corporate loans as USDT. This is because of USDC's concentrated exposure to bank deposits, which incur a higher default risk than Treasuries in the case of uninsured deposits and retain some illiquidity in the case of time deposits. For USDT, both illiquidity ϕ and the long-term benefit η display less variation over time, resulting in relatively stable run risk over the reporting period from 4.592% in June 2021 to 3.927% in March 2022.

Our estimates of stablecoin run probability complement the findings in Egan, Hortacsu and Matvos (2017) and Albertazzi, Burlon, Jankauskas, and Pavanini (2022), who build dynamic structural models to estimate the run probability of commercial banks. Their focus is on the feedback loop between a bank's credit risk and uninsured depositor outflows. We estimate run probabilities derived from a global games model that captures the unique interaction between the primary and secondary markets of stablecoins. In this sense, our approach provides a complementary way to quantify the run risk of tradable assets that are also involved in liquidity transformation.

7 Effect of Dividend Issuance

Finally, we use the estimated model to quantify the effect of dividend payments for different values of τ. Specifically, we solve the model under different τ and examine the changes to consumer welfare, firm profits, issuer's choice of K, price stability, and run probabilities.

The results are shown in Figure 7 for the September 2021 reporting period of USDT and USDC. Results for other reporting periods follow a similar trend and are shown in Appendix Figure 8. Consistent with our model predictions, panel (a) shows that issuers optimally choose a lower K to make arbitrage more efficient. As a result, the cost of price variance $\alpha\delta^2 K^2$ is decreased by 43.91% and 68.97%, for USDT and USDC respectively, relative to the costs at $\tau = 0$, as panel (b) shows.

Importantly, we find that the probability of runs declines with the issuance of dividends for both USDT and USDC. This means that the reduction in investors' run incentives when dividends make it more attractive to hold stablecoins dominates the increase in run risk from more efficient arbitrage. Quantitatively, as dividend issuance increases from 0 to 4%, the run probabilities of USDC and USDT are lowered by 1.81% and 1.63%, respectively, as panel (c) shows. Taken together, dividend payments would be beneficial both for lowering run risk and improving price stability at USDT and USDC.

Our findings on dividend issuance shed light on the broader question of how the design of financial intermediaries engaged in liquidity transformation can improve their stability. For mitigating bank runs, Davila and Goldstein (2023) and Kashyap, Tsomocos, and Vardoulakis (2023) explore the optimal design of deposit insurance and banking regulation, respectively. Empirically, Demirguc-Kunt and Detragiache (2002) and Iyer and Puri (2012) show that deposit insurance indeed mitigates run risks by changing the behavior of banks and depositors. In the context of non-banks, Jin, Kacperczyk, Kahraman and Suntheim (2022) and Ma, Xiao and Zeng (2021) show that swing pricing can prevent panic-driven runs at open-ended mutual funds. Our results complement these papers by showing that issuing dividends can also reduce fragility in the context of stablecoins.

8 Conclusion

In this paper, we analyzed the possibility of panic runs on stablecoins. At a high level, stablecoin runs arise from liquidity transformation. Stablecoin issuers hold illiquid assets while offering arbitrageurs the option to redeem stablecoins for a fixed $1 in the primary market. This liquidity mismatch spills over from the primary market to trigger the possibility of runs among investors on the secondary market despite exchange-trading.

We show, however, that stablecoin run risk is mediated by the market structure of the arbitrageur sector, which serves as a "firewall" between the secondary and primary markets. When the arbitrageur sector is more efficient, shocks in the secondary market transmit more effectively to the primary market. The price stability of stablecoins is thus improved, but the first-mover advantage for sellers is also higher, increasing run risk. If the arbitrageur sector is less efficient, shocks in secondary markets transmit less effectively. Price stability suffers, but run risk actually decreases, as the price impact of stablecoin trades in secondary markets discourages market participants from panic selling. Calibrating the model to data, we find that the two leading fiat-backed stablecoins by market cap, USDT and USDC, have significant run risk. We also showed how requiring stablecoin issuers to pay dividends to token holders could simultaneously decrease run risk and increase price stability.

Our results have implications for understanding stablecoin issuers' behavior. Some industry participants currently view the difficulty of becoming a stablecoin arbitrageur as essentially a bureaucratic oversight on behalf of issuers. We posit instead that issuers may be purposefully limiting the efficiency of primary-secondary market arbitrage, in response to the tension between price stability and run risks inherent in the design of fiat-backed stablecoins. Our results also have implications for policymakers: increased regulatory certainty around the legality of paying dividends to investors has the potential to simultaneously increase price stability and financial stability in the market for fiat-backed stablecoins.

References

ADAMS, AUSTIN and MARKUS IBERT (2022). "Runs on Algorithmic Stablecoins: Evidence from Iron, Titan, and Steel." Working Paper.

Albertazzi, Ugo, Lorenzo Burlon, Tomas Jankauskas, and Nicola Pavanini. "The shadow value of unconventional monetary policy." (2022).

ALBERTAZZI, BURLON, LORENZO BURLON, TOMAS JANKAUSKASA, and NICOLA PAVANINI (2022). "The Shadow Value of Unconventional Monetary Policy" Working Paper.

ALLEN, FRANKLIN and DOUGLAS GALE (1998). "Optimal Financial Crises." *Journal of Finance*, 53: 1245-1284.

ALLEN, FRANKLIN and DOUGLAS GALE (2004). "Financial Intermediaries and Markets." *Econometrica*, 72.4: 1023-1061.

AUER, RAPHAEL, JON FROST, LEONARDO GAMBACORTA, CYRIL MONNET, TARA RICE, and HYUN SONG SHIN (2022). "Central Bank Digital Currencies: Motives, Economic Implications, and the Research Frontier." *Annual Review of Economics*, 14: 697-721.

BAI, JENNIE, ARVIND KRISHNAMURTHY and CHARLES-HENRI WEYMULLER (2018). "Measuring Liquidity Mismatch in the Banking Sector." *Journal of Finance*, 73: 51-93.

BARTHELEMY, JEAN, PAUL GARDIN and BENOÎT NGUYEN (2018). "Stablecoins and the real economy." Working Paper.

BAUGHMAN, GARTH and JEAN FLEMMING (2023). "Global Demand for Basket-Backed Stablecoins." *Review of Economic Dynamics*, 48: 244-264.

BERNARDO, ANTONIO and IVO WELCH (2004). "Liquidity and Financial Market Runs." *Quarterly Journal of Economics*, 119: 135-158.

BERTSCH, CHRISTOPH (2023). "Stablecoins: Adoption and Fragility." Working Paper.

Brunnermeier, Markus, Harold James, and Jean-Pierre Landau. 2019. The Digitalization of Money. Working Paper.

COOPER, RUSSELL and THOMAS ROSS (1998). "Bank Runs: Liquidity Costs and Investment Distortions." *Journal of Financial Economics*, 41: 27-38.

DAVILA, EDUARDO and ITAY GOLDSTEIN (2023). "Optimal Deposit Insurance." *Journal of Political Economy*, forthcoming.

DAVILA, EDUARDO, DANIEL GRAVES and CECILIA PARLATORE (2022). "The Value of Arbitrage." Working Paper.

D'AVERNAS, ADRIEN, VINCENT MAURIN, and QUENTIN VANDEWEYER (2022). "Can Stablecoins be Stable?" Working Paper.

DEMIRGUC-KUNT, ASLI and ENRICA DETRAGIACHE (2002). "Does Deposit Insurance Increase Banking System Stability? An Empirical Investigation." *Journal of Monetary Economics*, 49: 1373-1406.

DIAMOND, DOUGLAS and PHILIP DYBVIG (1983). "Bank Runs, Deposit Insurance, and Liquidity." *Journal of Political Economy*, 91: 401-419.

DU, SONGZI and HAOXIANG ZHU (2017). "What is the Optimal Trading Frequency in Financial Markets?" *Review of Economic Studies*, 84: 1606-1651.

DUFFIE, DARRELL (2010). "Presidential Address: Asset Price Dynamics with Slow-Moving Capital." *Journal of Finance*, 65: 1237-1267.

DUFFIE, DARRELL (2019). "Digital Currencies and Fast Payment Systems: Disruption is Coming." Working Paper.

EGAN, MARK, ALI HORTACSU and GREGOR MATVOS (2017). "Deposit Competition and Financial Fragility: Evidence from the US Banking Sector." *American Economic Review*, 107: 169-216.

FROST, JON, HYUN SONG SHIN, and PETER WIERTS 2020. An early stablecoin? The Bank of Amsterdam and the governance of money. Working Paper.

GORTON, GARY, ELIZABETH C. KLEE, CHASE ROSS, SHARON ROSS, and ALEXANDROS P. VARDOULAKIS (2023). "Leverage and Stablecoin Pegs." Working Paper.

GORTON, GARY, CHASE ROSS and SHARON ROSS (2022). "Making Money." Working Paper.

GORTON, GARY and JEFFERY ZHANG (2021). "Taming Wildcat Stablecoins." Working Paper.

GORTON, GARY and GEORGE PENNACCHI (1990). "Financial Intermediaries and Liquidity Creation." *Journal of Finance*, 45: 49-71.

GOLDSTEIN, ITAY and ADY PAUZNER (2005). “Demand Deposit Contracts and the Probability of Bank Runs.” *Journal of Finance*, 60: 1293-1328.

GRIFFIN, JOHN and AMIN SHAMS (2020). “Is Bitcoin really untethered?” *Journal of Finance*, 75: 1913-1964.

GROMB, DENIS and DIMITRI VAYANOS (2002). “Equilibrium and Welfare in Markets with Financially Constrained Arbitrageurs.” *Journal of Financial Economics*, 66: 361-407.

HARVEY, CAMPBELL, ASHWIN RAMACHANDRAN, and JOEY SANTORO (2021). *DeFi and the Future of Finance*, 2021, John Wiley & Sons.

HE, ZHIGUO and WEI XIONG (2012). “Rollover Risk and Credit Risk.” *Journal of Finance*, 67: 391-430.

IYER, RAJKAMAL and MANJU PURI (2012). ”Understanding Bank Runs: The Importance of Depositor-Bank Relationships and Networks.” *American Economic Review*, 102: 1414-1445.

JACKLIN, CHARLES (1987). “Demand Deposits, Trading Restrictions and Risk Sharing.” in: Prescott, E. D., Wallace, N. (Eds.), *Contractual Arrangements for Intertemporal Trade*. Minnesota: University of Minnesota Press.

JOHN, KOSE, LEONID KOGAN and FAHAD SALEH (2022). “Smart Contracts and Decentralized Finance.” Working Paper.

JIN, DUNHONG, MARCIN KACPERCZYK, BIGE KAHRAMAN and FELIX SUNTHEIM (2022). “Swing Pricing and Fragility in Open-end Mutual Funds.” *Review of Financial Studies*, 35: 1-50.

KACPERCZYK, MARCIN and PHILIPP SCHNABL (2013). “How Safe Are Money Market Funds?” *Quarterly Journal of Economics*, 128: 1073-1122.

KASHYAP, ANIL, DIMITRIOS TSOMOCOS, and ALEXANDROS VARDOULAKIS (2023). “Optimal Bank Regulation in the Presence of Credit and Run-Risk.” *Journal of Political Economy*, forthcoming.

KIYOTAKI, NOBUHIRO and RANDALL WRIGHT (1983). “On Money as A Medium of Exchange.” *Journal of Political Economy*, 97: 927-954.

KOONT, NAZ, YIMING MA, LUBOS PASTOR and YAO ZENG (2022). “Steering a Ship in Illiquid Waters: Active Management of Passive Funds.” Working Paper.

KOZHAN, ROMAN and GANESH VISWANATH-NATRAJ (2021). “Decentralized Stablecoins and Collateral Risk.” Working Paper.

KYLE, ALBERT (1989). “Informed Speculation with Imperfect Competition.” *Review of Economic Studies*, 56: 317-355.

LI, YE and SIMON MAYER (2021). “Money creation in decentralized finance: A dynamic model of stablecoin and crypto shadow banking.” Working Paper.

LIU, JIAGENG, IGOR MAKAROV and ANTOINETTE SCHOAR (2023). “Anatomy of a Run: The Terra Luna Crash.” Working Paper.

LIAO, GORDON and JOHN CARAMICHAEL (2021). “Stablecoins: Growth Potential and Impact on Banking.” Working Paper.

LYONS, RICHARD and GANESH VISWANATH-NATRAJ (2021). “What Keeps Stablecoins Stable?” Working Paper.

KIM, SANG RAE (2022). “How the Cryptocurrency Market is Connected to the Financial Market.” Working Paper.

MA, YIMING, KAIRONG XIAO and YAO ZENG (2021). “Mutual Fund Liquidity Transformation and Reverse Flight to Liquidity.” *Review of Financial Studies*, forthcoming.

MAKAROV, IGOR and ANTOINETTE SCHOAR (2022). “Cryptocurrencies and Decentralized Finance (DeFi).” *Brookings Papers on Economic Activity*, Spring 2022: 1-71.

MORRIS, STEPHEN and HYUN SHIN (1998). “Unique Equilibrium in a Model of Self-fulfilling Currency Attacks.” *American Economic Review*, 88: 587-597.

MORRIS, STEPHEN and HYUN SHIN (2003). “Global Games: Theory and Applications.” in Mathias Dewatripont, Lars Peter Hansen and Stephen J. Turnovsky (eds), *Advances in Economics and Econometrics (Proceedings of the Eighth Congress of the Econometric Society)*, 3: 56-114.

OEHMKE, MARTIN (2010). “Gradual Arbitrage.” Working Paper.

PARLATORE, CECILIA (2016). “Fragility in Money Market Funds: Sponsor Support and Regulation.” *Journal of Financial Economics*, 121: 595-623.

ROCHETEAU, GUILLAUME and RANDALL WRIGHT (2005). “Money in Search Equilibrium, in Competitive Equilibrium, and in Competitive Search Equilibrium.” *Econometrica*, 73: 175–202.

ROUTLEDGE, BRYAN and ARIEL ZETLIN-JONES (2022). "Currency Stability Using Blockchain Technology." *Journal of Economic Dynamics and Control*, 142: 104-155.

SCHMIDT, LAWRENCE, ALLAN TIMMERMANN and RUSS WERMERS (2016). "Runs on Money Market Mutual Funds." *American Economic Review*, 106: 2625-2657.

SHLEIFER, ANDREI and ROBERT VISHNY (1997). "The Limits of Arbitrage." *Journal of Finance*, 52: 35-55.

UHLIG, HARALD (2022). "A Lunatic Stablecoin Crash." Working Paper.

ZHANG, ANTHONY LEE (2022). "Competition and Manipulation in Derivative Contract Markets." *Journal of Financial Economics*, 144: 396-413.

Figure 3: Asset Size of Fiat-backed Stablecoins

This figure shows the asset size of the six largest fiat-backed stablecoins over time.

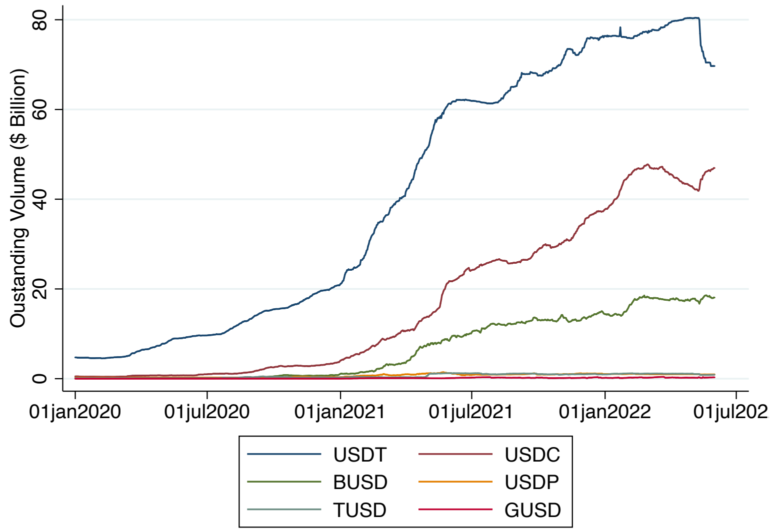


Figure 4: The Design of Fiat-backed Stablecoins

This figure illustrates the design of fiat-backed stablecoins.

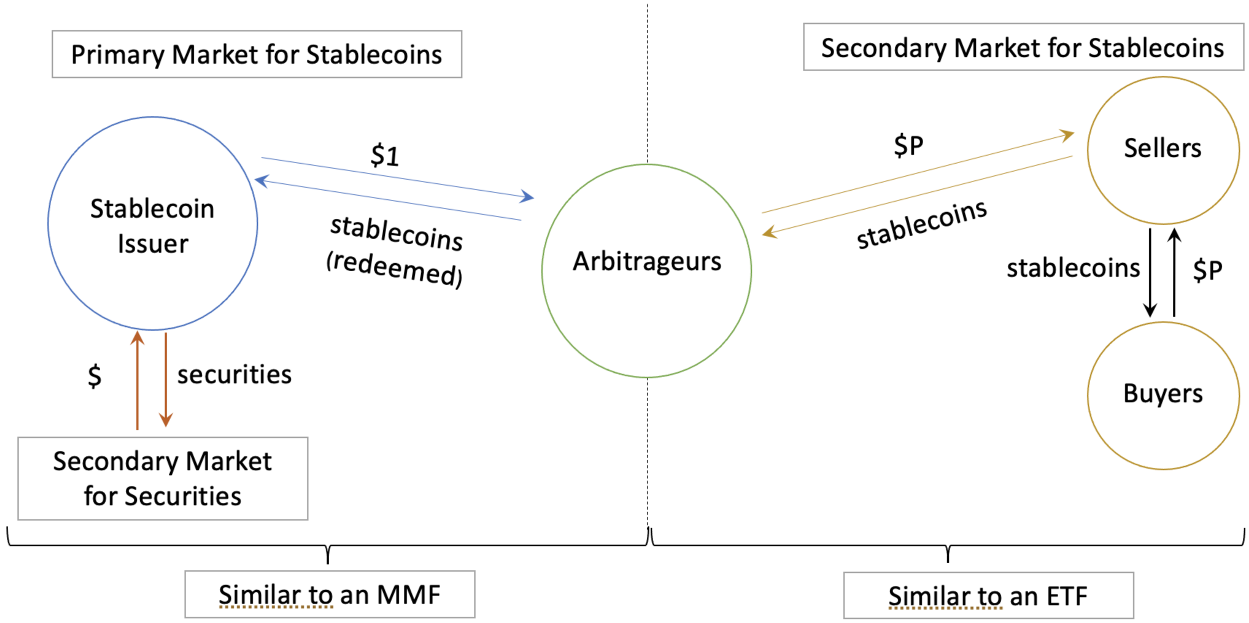


Figure 5: Secondary Market Trading Price

Panels (a) to (f) show the daily secondary market trading price of USDT, USDC, BUSD, USDP, TUSD, and GUSD, respectively. Secondary market prices are volume-weighted averages of trading prices from the exchanges listed in Section 2.

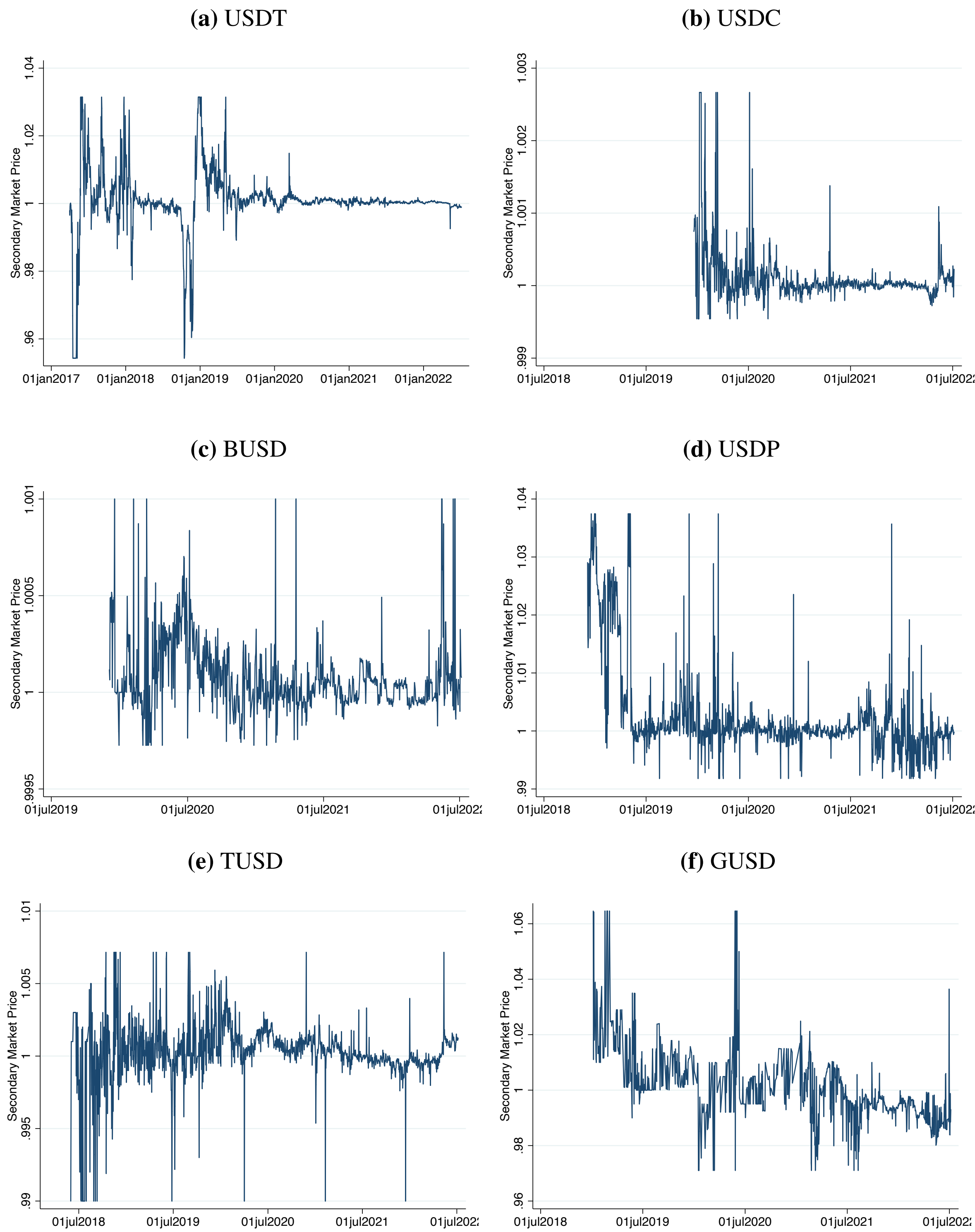


Figure 6: Secondary Market Price Dislocations and Primary Market Structure

This figure shows the relationship between secondary market price dislocations and primary market structure. In panel (a), each dot indicates the average secondary market price deviation and the average number of arbitrageurs in a month for a given stablecoin. In panel (b), each dot indicates the average secondary market price deviation and the average market share of the top five arbitrageurs in a month for a given stablecoin. We first calculate monthly secondary market price deviations for a given stablecoin by averaging over the absolute values of daily price deviations from one in a given month. We then average over months to obtain the average secondary market price deviation for that stablecoin. Similarly, we count the number of unique arbitrageurs and calculate the market share of the largest five arbitrageurs in each month and then average over time for each coin. For the ease of presentation, we take the number of arbitrageurs for USDC, which exceeds 5000.

(a) Number of Arbitrageurs **(b)** Market Share of Top 5 Arbitrageurs

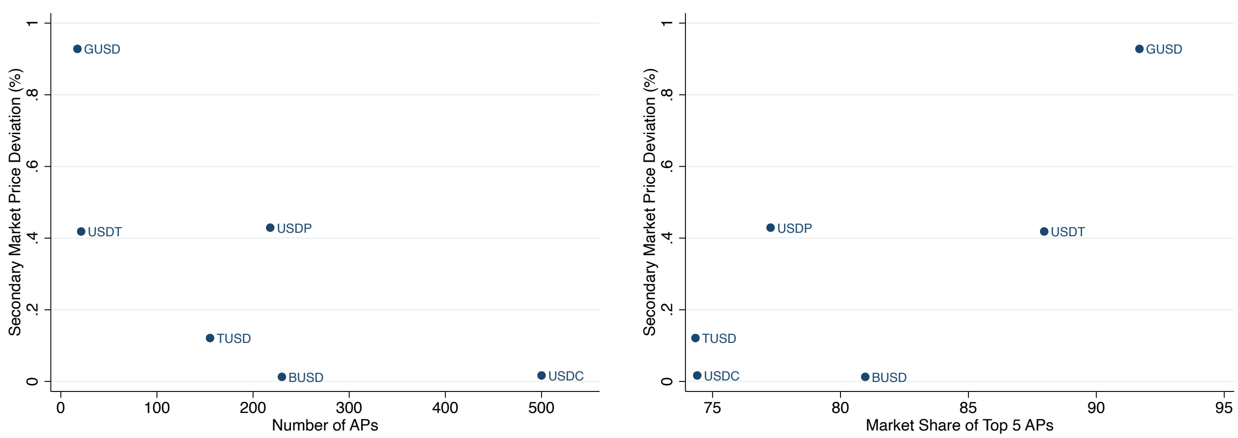
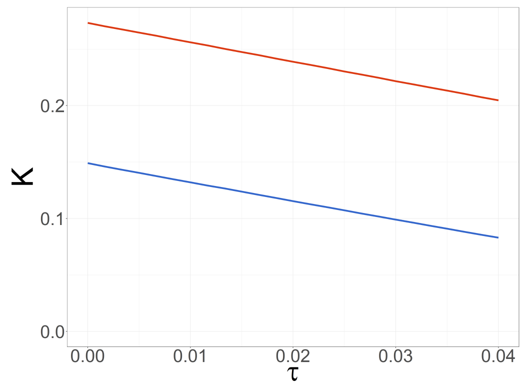


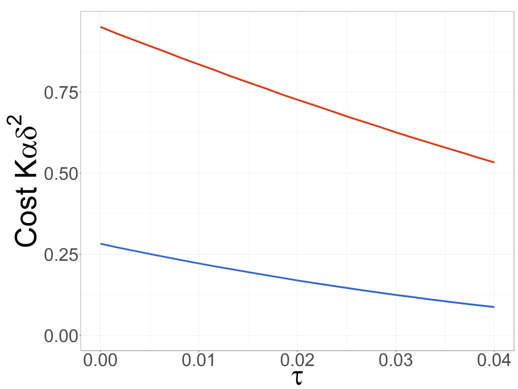
Figure 7: Effect of Dividend Payments

This figure shows the predicted effect of dividend payments to investors on the issuer's choice of K, the cost of price variance $K\alpha\delta^2$, and run probability.

(a) Elasticity K



(b) Price Variance Cost



(c) Run Probability

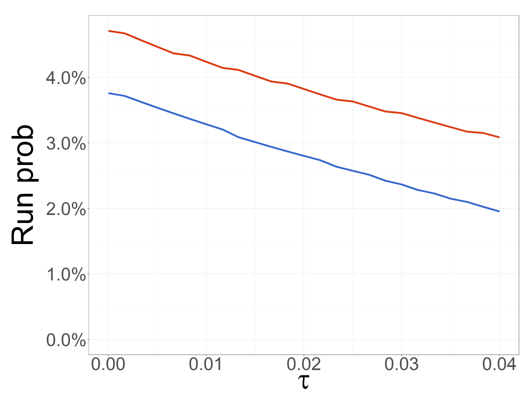


Table 1: Asset Composition

This table shows the breakdown of reserves by asset class for USDT and USDC. Data are available for the dates on which reserve breakdowns are published by USDT and USDC. For USDT, the "Deposit" category includes bank deposits, while for USDC, the "Deposit" category includes US dollar deposits at banks and short-term, highly liquid investments.

(a) USDT

	Deposits	Treas	Muni	MM	Corp	Loans	Others
2021/06	10.0	24.3	0.0	50.7	7.7	4.0	3.3
2021/09	10.5	28.1	0.0	45.7	5.2	5.0	5.5
2021/12	5.3	43.9	0.0	34.5	4.6	5.3	6.4
2022/03	5.0	47.6	0.0	32.8	4.5	3.8	6.4

(b) USDC

	Deposits	Treas	Muni	MM	Corp	Loans	Others
2021/05	60.4	12.2	0.5	22.1	5.0	0.0	0.0
2021/06	46.4	13.1	0.4	24.2	15.9	0.0	0.0
2021/07	47.4	12.4	0.7	23.0	16.4	0.0	0.0
2021/08	92.0	0.0	0.0	6.5	1.5	0.0	0.0
2021/09	100.0	0.0	0.0	0.0	0.0	0.0	0.0
2021/10	100.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2: Secondary Market Price and Volume

This table provides statistics about secondary market trading, including the average daily trading volume, the proportion of days with discounts and premiums, the average discount and premium, and the median discount and premium.

	USDT	USDC	BUSD	TUSD	USDP	GUSD
Average Daily Volume	16.4	15.4	13.5	11.4	10.5	7.3
Proportion of Discount Days (%)	30.5	27.2	34.9	38.2	41.6	39.7
Proportion of Premium Days (%)	69.5	72.8	64.4	61.4	57.3	58.9
Average Discount (%)	0.54	0.01	0.01	0.11	0.18	0.78
Average Premium (%)	0.36	0.02	0.02	0.13	0.64	1.17
Median Discount (%)	0.11	0.00	0.00	0.05	0.09	0.63
Median Premium (%)	0.11	0.01	0.01	0.10	0.18	0.82

Table 3: Primary Market Daily Redemption and Creation Activity

Panels (a) to (f) provide statistics about daily primary market redemption and creation activity on the Ethereum blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across days in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	1	1	1	2
RD Top 1 Share	94	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	57	2	12	60
CR AP Num	3	1	2	4
CR Top 1 Share	80	60	91	100
CR Top 5 Share	99	100	100	100
CR Vol (mil)	77	3	15	65

(b) USDC

	mean	p25	p50	p75
RD AP Num	33	8	14	28
RD Top 1 Share	54	45	50	59
RD Top 5 Share	96	95	98	100
RD Vol (mil)	103	2	15	134
CR AP Num	236	11	29	137
CR Top 1 Share	61	41	58	83
CR Top 5 Share	92	87	96	100
CR Vol (mil)	135	3	24	210

(c) BUSD

	mean	p25	p50	p75
RD AP Num	21	8	15	28
RD Top 1 Share	59	40	56	76
RD Top 5 Share	94	90	96	100
RD Vol (mil)	62	8	27	82
CR AP Num	3	2	2	3
CR Top 1 Share	75	57	76	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	80	9	30	115

(d) USDP

	mean	p25	p50	p75
RD AP Num	18	8	17	27
RD Top 1 Share	55	37	52	73
RD Top 5 Share	90	85	95	100
RD Vol (mil)	12	3	6	13
CR AP Num	4	2	2	4
CR Top 1 Share	75	59	75	94
CR Top 5 Share	99	100	100	100
CR Vol (mil)	11	2	5	12

(e) TUSD

	mean	p25	p50	p75
RD AP Num	6	3	6	8
RD Top 1 Share	72	54	73	91
RD Top 5 Share	99	99	100	100
RD Vol (mil)	6	1	2	5
CR AP Num	10	3	9	16
CR Top 1 Share	68	49	67	88
CR Top 5 Share	97	96	99	100
CR Vol (mil)	7	1	3	7

(f) GUSD

	mean	p25	p50	p75
RD AP Num	1	1	1	1
RD Top 1 Share	100	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	6	0	1	3
CR AP Num	2	1	1	2
CR Top 1 Share	86	72	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	6	0	2	7

Table 4: Primary Market Monthly Redemption and Creation Activity

Panels (a) to (f) provide statistics about monthly primary market redemption and creation activity on the Ethereum blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across months in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	6	3	6	8
RD Top 1 Share	66	42	61	89
RD Top 5 Share	97	98	100	100
RD Vol (mil)	577	46	123	763
CR AP Num	18	9	17	26
CR Top 1 Share	59	35	57	77
CR Top 5 Share	90	84	93	99
CR Vol (mil)	1271	101	470	1800

(b) USDC

	mean	p25	p50	p75
RD AP Num	521	114	168	262
RD Top 1 Share	45	38	49	50
RD Top 5 Share	85	81	85	90
RD Vol (mil)	2976	160	460	4965
CR AP Num	5067	284	406	13112
CR Top 1 Share	45	31	44	51
CR Top 5 Share	81	70	84	92
CR Vol (mil)	3953	184	680	7448

(c) BUSD

	mean	p25	p50	p75
RD AP Num	214	157	202	274
RD Top 1 Share	48	30	50	62
RD Top 5 Share	81	74	82	87
RD Vol (mil)	1596	233	1498	2720
CR AP Num	16	8	11	19
CR Top 1 Share	65	53	68	82
CR Top 5 Share	98	97	99	100
CR Vol (mil)	2116	290	1628	3739

(d) USDP

	mean	p25	p50	p75
RD AP Num	178	71	174	284
RD Top 1 Share	41	24	37	54
RD Top 5 Share	74	62	77	88
RD Vol (mil)	260	94	174	262
CR AP Num	41	5	8	67
CR Top 1 Share	58	48	61	70
CR Top 5 Share	93	94	99	100
CR Vol (mil)	279	107	170	341

(e) TUSD

	mean	p25	p50	p75
RD AP Num	66	49	74	85
RD Top 1 Share	50	36	46	64
RD Top 5 Share	86	79	91	94
RD Vol (mil)	154	31	85	260
CR AP Num	92	53	106	130
CR Top 1 Share	50	33	46	65
CR Top 5 Share	87	83	87	92
CR Vol (mil)	164	30	77	259

(f) GUSD

	mean	p25	p50	p75
RD AP Num	1	1	1	1
RD Top 1 Share	100	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	113	7	17	164
CR AP Num	17	1	12	19
CR Top 1 Share	55	29	40	100
CR Top 5 Share	85	72	82	100
CR Vol (mil)	117	4	13	155

Table 5: Parameter Estimates

Parameters for asset illiquidity ϕ and the long-term benefit η are estimated as described in Section 6.1. Parameters for the price variance cost $\alpha\delta^2$ and the elasticity of demand γ, η, ϕ are estimated as described in Section 6.2. Run prob is the run probability at the issuer's optimal choice of K.

Coin	Month	$\alpha\delta^2$	γ	η	ϕ	Run Prob
USDC	2021m5	12.74	0.65	0.0301	0.0310	5.713%
USDC	2021m6			0.0198	0.0343	7.459%
USDC	2021m7			0.0221	0.0341	7.077%
USDC	2021m8			0.0575	0.0270	3.372%
USDC	2021m9			0.0443	0.0250	3.761%
USDC	2021m10			0.0525	0.0250	3.336%
USDT	2021m6		0.38	0.0301	0.0441	4.592%
USDT	2021m9			0.0292	0.0447	4.711%
USDT	2021m12			0.0250	0.0418	4.594%
USDT	2022m3			0.0365	0.0400	3.927%

Table 6: Model Fit

Target K is the slope of arbitrageur demand for the stablecoin, estimated from the data, from (6.1). Model K is the model-predicted slope of arbitrageur demand. Target elas. is the partial elasticity of investors' demand for the stablecoin with respect to the long-term benefit η , as described in Subsection (6.2). Model elas. is the model partial elasticity of investors' demand for the stablecoin with respect to η.

Coin	Month	Target K	Model K	Target elas.	Model elas.
USDC	2021m5	0.156	0.202	2.486	2.726
USDC	2021m6	0.156	0.235	2.486	4.443
USDC	2021m7	0.156	0.230	2.486	4.071
USDC	2021m8	0.156	0.137	2.486	1.345
USDC	2021m9	0.156	0.149	2.486	1.481
USDC	2021m10	0.156	0.135	2.486	1.312
USDT	2021m6	0.209	0.270	1.600	1.746
USDT	2021m9	0.209	0.273	1.600	1.820
USDT	2021m12	0.209	0.268	1.600	1.714
USDT	2022m3	0.209	0.240	1.600	1.319

A Additional Institutional Details

A.1 Minting of Stablecoins

Technically, stablecoins on Ethereum are ERC-20 tokens, and stablecoins on other blockchains are implemented as similar token "smart contracts." The stablecoin "smart contract," that is, the blockchain code that governs the behavior of the stablecoin, gives the stablecoin issuer the arbitrary right to create, or "mint", new stablecoin tokens, into arbitrary wallet addresses. Stablecoin issuers adopt technically slightly different strategies to issue and redeem stablecoins in primary markets. Some, like USDC, directly "mint" new coins using the token smart contract into customers' wallets. Others, like Tether, occasionally mint large amounts of stablecoin tokens to "treasury" wallets under their own control, and then issue stablecoins in primary markets by sending tokens from the "treasury" address to customers' wallets.[15]

A.2 Trading on Crypto Exchanges

There are a number of ways individuals can purchase stablecoins with local fiat currency. One method is to deposit fiat on a custodial centralized crypto exchange (CEX), such as Binance or Coinbase. Centralized exchanges, like stock brokerages, keep custody of fiat and crypto assets on behalf of users, and allow users to purchase or sell crypto assets using fiat currencies. After purchasing stablecoins on a CEX, the user can then "withdraw" the stablecoins, instructing the CEX to send her stablecoins to a wallet address of her choosing, to self-custody the purchased stablecoins. Another approach is to use peer-to-peer exchanges, such as Paxful. On these platforms, users list offers to buy or sell stablecoins or other crypto tokens for other forms of payment. Accepted forms of payment in the US include Zelle, Paypal, Western Union, ApplePay, and many others. The exchange platform plays an escrow, insurance, and mediation role in these transactions. When a user buys a stablecoin, she sends funds to the exchange's escrow account and the stablecoin seller sends stablecoins to an address of the buyer's choosing. Once the buyer confirms receipt of the stablecoins, the exchange sends funds from

[15] Treasury address tokens technically count towards the market cap of any given stablecoin, but they are not economically meaningful as part of the market cap, since Tether does not have to hold US dollar assets against tokens it holds in its treasury. Thus, we will not count tokens held in treasury addresses as part of the stablecoin supply in circulation.

the escrow account to the seller's account. In this process, purchased stablecoins are sent directly to the user's self-custodial wallet.

B Double Auction

We follow Kyle (1989) and Du and Zhu (2017) to model the arbitrage sector as a double auction. At $t = 1$ and $t = 2$, there are n symmetric arbitrageurs indexed by j. At any given period, arbitrageurs bid to buy or sell stablecoins from investors and noise traders, incur a per-perid inventory cost if winning the auction, and then create or redeem the stablecoin at the fixed price of one dollar if the issuer is solvent. Thus, arbitrageurs always hold zero inventory at the beginning and the end of each period. Specifically, at any given period, the winning arbitrageurs incur a per-period inventory cost $z_j^2/2\chi$ of arbitraging z_j of the stablecoin, where χ is a parameter. Hence, the expected profit, conditional on winning the auction, for arbitraging z_j of the stablecoin at price p is:

$$z_j\left(1-p\right)-\frac{z_j^2}{2\chi}\,.$$

In the auction, arbitrageurs submit a bid curve, $z_{Bj}\left(p\right)$, of the amount of stablecoins they are willing to arbitrage if the secondary-market price is p. We seek an equilibrium in which residual supply facing any individual arbitrageur j is linear in price:

$$z_{RSj}\left(p\right)=d\left(p-\psi\right)+\eta_j\,,$$

where d and ψ are constants and η_j is a full-support random intercept. Conditional on η_j, arbitrageur j picks her favorite point on $z_{RSj}\left(p\right)$.

According to Proposition 1 in Zhang (2022), the solution to the optimal bidding problem above is given by:

$$z_{Bj}\left(p\right)=\frac{\chi d}{d+\chi}\left(1-p\right)\,. \tag{B.1}$$

On the other hand, by symmetry, we must also have that the residual supply slope in equilibrium, that is, d, is $(n-1)$ times the individual demand slope as given in (B.1):

$$d = (n-1)\,\frac{\chi d}{d+\chi}\,. \tag{B.2}$$

The solution to (B.1) and (B.2) is thus:

$$d = (n-2)\,\chi\,.$$

Plugging back to (B.1) yields the unique equilibrium bid of arbitrageur j:

$$z_{Bj}\,(p) = \frac{n-2}{n-1}\chi\,(1-p)\ . \tag{B.3}$$

Aggregating (B.3) then yields the arbitrageurs' market demand curve:

$$\sum_j z_{Bj}\,(p) = \chi\frac{n(n-2)}{n-1}\,(1-p)\ , \tag{B.4}$$

and market clearing finally requires:

$$\sum_j z_{Bj}\,(p) = m\,, \tag{B.5}$$

where m is the amount of stablecoins supplied by investors or noise traders.

If the stablecoin issuer facing redemptions is insolvent at $t = 2$, a similar derivation yields the adjusted market demand curve:

$$\sum_j z_{Bj}\,(p) = \chi\frac{n(n-2)}{n-1}\left(\frac{1-\phi}{m} - p\right)\,.$$

Lemmas 1 and 2 immediately follow from applying the market clearing condition (B.5) at $t = 2$ and $t = 1$.

C Omitted Proofs

Proof of Proposition 1. Denote the run threshold as θ', that is, if investor i observes a private signal $s_i < \theta'$ she sells her stablecoin at $t = 2$; otherwise she waits until $t = 3$. Then the population of investors who runs, λ, can be written as

$$\lambda(\theta, \theta') = \begin{cases} 1 & \text{if } \theta \le \theta' - \varepsilon \\ \frac{\theta' - \theta + \varepsilon}{2\varepsilon} & \text{if } \theta' - \varepsilon < \theta \le \theta' + \varepsilon \\ 0 & \text{if } \theta > \theta' + \varepsilon \end{cases} . \tag{C.1}$$

Let $h(\theta, \lambda)$ be the payoff gain from waiting until $t = 3$ versus selling at $t = 2$. It is straightforward that

$$h(\theta, \lambda) = v_3(\theta, \lambda) - p_2(\theta, \lambda) = \begin{cases} \pi(\theta)\left(\dfrac{1 - \phi - \lambda}{(1-\phi)(1-\lambda)} + \eta\right) - 1 + K\lambda & \lambda \le 1 - \phi\,, \\ -\dfrac{1-\phi}{\lambda} + K\lambda & \lambda > 1 - \phi\,. \end{cases}$$

Notice that $h(\theta, \lambda)$ is concave in λ over $(0, 1 - \phi)$ because

$$\frac{\partial^2 h(\theta, \lambda)}{\partial \lambda^2} = -\frac{2\pi(\theta)\phi}{(1-\lambda)^3(1-\phi)} < 0\,.$$

If investor i observes signal s_i, given that other households use the threshold strategy, she will sell her stablecoin if

$$\int_{s_i - \varepsilon}^{s_i + \varepsilon} h(\theta, \lambda(\theta, \theta'))\, d\theta < 0\,,$$

or stay otherwise. To prove that there exists a unique run threshold θ^*, we need to prove that there is a unique θ^* such that if $\theta' = \theta^*$, the investor who observes signal $s_i = \theta' = \theta^*$ is indifferent between selling and waiting. That is,

$$V(\theta^*) \equiv \int_{\theta^* - \varepsilon}^{\theta^* + \varepsilon} h(\theta, \lambda(\theta, \theta^*))\, d\theta = 0.$$

According to Morris and Shin (2003) and Goldstein and Pauzner (2005), it then suffices to show that $h(\lambda)$ crosses 0 only once, that is, satisfies the single-crossing property when the upper dominance region exists. To show this, first note that $h(1) = -1 + \phi + K < 0$ and that $h(\lambda)$ increases in $(1 - \phi, 1)$. It then must be that $h(1 - \phi) < 0$. On the other hand, note that $h(0) > 0$ when θ, and thus $\pi(\theta)$, are sufficiently large. Because $h(\lambda)$ is continuous and concave in $(0, 1 - \phi)$, it then immediately follows that $h(\lambda)$ must cross 0 once and only once in $(0, 1 - \phi)$. Since $h(\lambda)$ does not cross 0 in $(1 - \phi, 1)$, this implies that $h(\lambda)$ crosses 0 once and only once in $(0, 1)$, concluding the proof. ∎

Proof of Proposition 2. Based on Proposition 1, we first compute the run threshold $\pi(\theta^*)$ directly. By construction, an investor with signal θ^* must be indifferent between selling her stablecoin at $t = 2$ and waiting until $t = 3$. This investor's posterior belief of θ is uniform over the interval $[\theta^* - \varepsilon, \theta^* + \varepsilon]$. On the other hand, she understands that the proportion of investors who sell at $t = 2$, as a function of θ, is $\lambda(\theta, \theta^*)$, where the function $\lambda(\theta, \theta')$ is given by (C.1) in the proof of Proposition 1. Therefore, her posterior belief of λ is also uniform over $(0, 1)$. At the limit, this gives the indifference condition as the Laplace condition:

$$\int_0^{1-\phi} (1 - K\lambda)\, d\lambda + \int_{1-\phi}^{1} \left(\frac{1-\phi}{\lambda} - K\lambda\right) d\lambda = \int_0^{1-\phi} \pi(\theta^*) \left(\frac{1-\phi-\lambda}{(1-\phi)(1-\lambda)} + \eta\right) d\lambda\,, \tag{C.2}$$

which we also give in the main text as (5.6). Solving this Laplace condition (C.2) yields the run threshold (5.7).

We then perform comparative statics about the run threshold $\pi(\theta^*)$. With respect to ϕ, we have

$$\frac{\partial \pi(\theta^*)}{\partial \phi} = \frac{(2 - 2\phi - K)((\phi - 1)(\eta(\phi - 1) + 1) - \ln\phi) - 2(\phi - 1)\ln(1 - \phi)(-2\phi + (\phi + 1)\ln\phi + 2)}{2\left((1 - \phi)(1 + \eta(1 - \phi)) + \phi\ln\phi\right)^2}\,, \tag{C.3}$$

whose denominator is positive. Thus, (C.3) is positive if its numerator is positive. This holds when

$$g(\theta) \equiv \frac{2(\phi - 1)\left(\phi - \ln\phi + \ln(1 - \phi)((1 + \phi)\ln\phi + 2 - 2\phi) - 1\right)}{1 - \phi + \ln\phi} > K\,, \tag{C.4}$$

where $g(\phi)$ is continuous and strictly decreasing in ϕ, and it satisfies $\lim_{\phi\to 0} g(\phi) = 2 > 0$. Thus, conditions (C.3) and (C.4) hold when ϕ is not too large for any given $K \leq 2$, and then the equilibrium run threshold $\pi(\theta^*)$ increases in ϕ.

With respect to K, we have

$$\frac{\partial \pi(\theta^*)}{\partial K} = \frac{\phi - 1}{2\left((1-\phi)(1+\eta(1-\phi)) + \phi \ln \phi\right)} < 0\,. \tag{C.5}$$

To see why (C.5) holds, notice that its numerator is negative. On the other hand, define its denominator as

$$\zeta(\phi) \equiv 2\left((1-\phi)(1+\eta(1-\phi)) + \phi \ln \phi\right)\,.$$

It is straightforward to show that $\zeta(\phi)$ strictly decreases in ϕ while $\lim_{\phi\to 1} \zeta(\phi) = 0$ when $\eta = 0$. Thus, the denominator of (C.5) is positive. This concludes the proof. ∎

Proof of Proposition 3. Suppose condition (C.4) holds, that is, ϕ is not too large. Under this condition, we know from condition (C.3) in the proof of Proposition 2 that the equilibrium run threshold $\pi(\theta^*)$ increases in ϕ. We also consider the limit case of $R'(\phi) = 0$ and the general case of $R'(\phi) > 0$ follows by continuity when ϕ is not too large.

We now consider the first-order condition (FOC) for the issuer's problem (5.10) that determines the optimal K, the slope of arbitrageurs' demand. When $G(\cdot)$ is linear, the FOC is:

$$0 = \frac{\partial E[\Pi]}{\partial K} = \underbrace{\frac{\partial E[W]}{\partial K} \int_{\pi(\theta)\geq\pi(\theta^*)} \pi(\theta)(R-1)dF(\theta)}_{\substack{\text{marginal cost from} \\ \text{reduced investor participation}}} - \underbrace{E[W]\frac{\partial \pi(\theta^*)}{\partial K}\left(f(\theta^*)\pi(\theta^*)(R-1)\right)}_{\substack{\text{marginal benefit from} \\ \text{reduced run risk}}}, \tag{C.6}$$

where according to (5.11),

$$\frac{\partial E[W]}{\partial K} = \underbrace{-2\alpha\delta^2 K}_{\substack{\text{marginal utility cost from} \\ \text{decreasing price stability}}} + \underbrace{\frac{\partial \pi(\theta^*)}{\partial K}\left(f(\theta^*)(1-\phi-K-\pi(\theta^*)(1+\eta))\right)}_{\substack{\text{marginal utility benefit from} \\ \text{increasing financial stability}}} - \int_{\pi(\theta)<\pi(\theta^*)} dF(\theta)\,. \tag{C.7}$$

This first-order condition reveals the various channels through which increasing K affects the stablecoin issuer's expected revenue. The first part of (C.6) captures the marginal effect of changing the population of participating investors, which in turn depends on each investor's expected utility from participating. The second part of (C.6) captures the marginal benefit that directly results from the reduced run risk on issuer revenue (since the issuer captures the revenue only if a run is avoided). Furthermore, (C.7) captures the marginal effects of increasing K on an investor's expected utility: the first term of (C.7) is the marginal cost that results from a lower convenience due to higher price fluctuations, while the second term is the marginal benefit from the reduced run risk on investor utility. Notice that this last marginal benefit then indirectly affects the issuer's expected revenue. In equilibrium, the issuer cares about run risk both directly and indirectly, which are captured by the second term of (C.6) and the second term of (C.7), respectively.

We now compute $dK^*/d\phi$. Using the FOC (C.6) above:

$$\begin{aligned}\frac{\partial FOC_K(K,\phi)}{\partial\phi} &= \underbrace{\frac{\partial^2 E[W]}{\partial K\partial\phi}}_{+}\underbrace{\int_{\pi(\theta)\geq\pi(\theta^*)}\pi(\theta)(R-1)dF(\theta)}_{+} \\ &\quad - \underbrace{\pi(\theta^*)f(\theta^*)(R-1)}_{+}\underbrace{\left(\frac{\partial E[W]}{\partial K}\frac{\partial\pi(\theta^*)}{\partial\phi}+\frac{\partial E[W]}{\partial\phi}\frac{\partial\pi(\theta^*)}{\partial K}\right)}_{-} \\ &\quad - \underbrace{E[W]\pi(\theta^*)f(\theta^*)(R-1)}_{+}\underbrace{\left(\frac{\partial^2\pi(\theta^*)}{\partial K\partial\phi}\pi(\theta^*)+\frac{\partial\pi(\theta^*)}{\partial K}\frac{\partial\pi(\theta^*)}{\partial\phi}\right)}_{-} \\ &> 0\,.\end{aligned}$$

On the other hand, because K^* is an interior solution, we have the second-order condition:

$$\frac{\partial FOC_K(K,\phi)}{\partial K} < 0\,.$$

Applying the implicit function theorem thus yields:

$$\frac{dK^*}{d\phi} = -\frac{\dfrac{\partial FOC_K(K,\phi)}{\partial\phi}}{\dfrac{\partial FOC_K(K,\phi)}{\partial K}} > 0\,,$$

which immediately implies that $dn^*/d\phi < 0$. This concludes the proof. ∎

Proof of Proposition 4. When the stablecoin issuer pays dividend τ, the run threshold changes to

$$\pi(\theta^*;\tau) = \frac{(1-\phi)(2-2\phi-2(1-\phi)\ln(1-\phi)-K)}{2\left((1+\tau+\eta(1-\phi))(1-\phi)+(1+\tau)\phi\ln\phi\right)}\,, \tag{C.8}$$

where $\partial\pi(\theta^*;\tau)/\partial K < 0$ still holds.

The issuer's objective function changes to

$$\max_K E_\tau[\Pi] = \underbrace{G(E_\tau[W])}_{\substack{\text{population of}\\ \text{participating investors}}} \underbrace{\int_{\pi(\theta)\geq\pi(\theta^*;\tau)} \pi(\theta)(R(\phi)-1-\tau)dF(\theta)}_{\substack{\text{expected issuer revenue per}\\ \text{participating investor}}}\,,$$

where each investor's expected utility of participation changes to

$$E_\tau[W] = \underbrace{-\alpha\delta^2K^2}_{\text{short-term convenience}} + \underbrace{(1-\phi-K)\int_{\pi(\theta)<\pi(\theta^*;\tau)} dF(\theta)}_{\text{short-term payoff if runs}} + \underbrace{\int_{\pi(\theta)\geq\pi(\theta^*;\tau)} \pi(\theta)\,(1+\eta+\tau)\,dF(\theta)}_{\text{long-term payoff if no runs}}\,,$$

in which $\pi(\theta^*;\tau)$ is given by (5.7) in Proposition 2.

Similarly, we consider the FOC with respect to K:

$$\begin{aligned} 0 =& \frac{\partial E_\tau[\Pi]}{\partial K} = \underbrace{\frac{\partial E_\tau[W]}{\partial K}\int_{\pi(\theta)\geq\pi(\theta^*;\tau)} \pi(\theta)(R-1-\tau)dF(\theta)}_{\substack{\text{marginal cost from}\\ \text{reduced investor participation}}} \\ & \underbrace{-E_\tau[W]\frac{\partial\pi(\theta^*;\tau)}{\partial K}\left(f(\theta^*)\pi(\theta^*;\tau)(R-1-\tau)\right)}_{\substack{\text{marginal benefit from}\\ \text{reduced run risk}}}\,, \end{aligned} \tag{C.9}$$

where

$$\frac{\partial E_\tau[W]}{\partial K} = \underbrace{-2\alpha\delta^2K}_{\substack{\text{marginal utility cost from}\\ \text{decreasing price stability}}} + \underbrace{\frac{\partial\pi(\theta^*;\tau)}{\partial K}\left(f(\theta^*)(1-\phi-K-\pi(\theta^*;\tau)(1+\eta+\tau))\right)}_{\substack{\text{marginal utility benefit from}\\ \text{increasing financial stability}}} - \int_{\pi(\theta)<\pi(\theta^*;\tau)} dF(\theta)\,.$$

We first use (C.8) to calculate that

$$\frac{\partial^2 \pi(\theta^*;\tau)}{\partial K \partial \tau} = \frac{(1-\phi)(1-\phi+\phi\ln\phi)}{2\left((1-\phi)(1+\tau+\eta(1-\phi))+(1+\tau)\phi\ln\phi\right)^2} > 0\,,$$

and also

$$\frac{\partial\left[(\pi(\theta^*;\tau)(1+\eta+\tau))\right]}{\partial \tau} = \frac{\eta(1-\phi)\phi(1-\phi+\ln\phi)(K+2\phi+2(1-\phi)\ln(1-\phi)-2)}{2\left((1-\phi)(1+\tau+\eta(1-\phi))+(1+\tau)\phi\ln\phi\right)^2}$$
$$> 0\,,$$

when ϕ is sufficiently small. Thus, for $\tau > 0$ we have

$$\left.\frac{\partial \pi(\theta^*;\tau)}{\partial K}\right|_{K=K^*} \left(f(\theta^*)(1-\phi-K^*-\pi(\theta^*;\tau)(1+\eta+\tau))\right)$$
$$< \left.\frac{\partial \pi(\theta^*)}{\partial K}\right|_{K=K^*} \left(f(\theta^*)(1-\phi-K^*-\pi(\theta^*)(1+\eta))\right)\,. \tag{C.10}$$

On the other hand, similar calculation yields:

$$E_\tau[W]|_{K=K^*} \left.\frac{\partial \pi(\theta^*;\tau)}{\partial K}\right|_{K=K^*} \pi(\theta^*;\tau) < E[W]|_{K=K^*} \left.\frac{\partial \pi(\theta^*)}{\partial K}\right|_{K=K^*} \pi(\theta^*)\,. \tag{C.11}$$

Because $R-1-\tau < R-1$, conditions (C.10) and (C.11) thus joinly imply that the new FOC (C.9) also evaluated at K^* is smaller than the old FOC (C.6) evaluated at K^*, which is zero. This immediately implies that $K^*_\tau < K^*$, and hence $n^*_\tau > n^*$. This concludes the proof. ∎

D Additional Empirical Results

Table 7: Primary Market Daily Redemption and Creation Activity (Tron)

Panels (a) to (f) provide statistics about daily primary market redemption and creation activity on the Tron blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across months in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	1	1	1	2
RD Top 1 Share	96	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	450	40	110	460
CR AP Num	3	1	2	3
CR Top 1 Share	81	63	89	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	266	18	66	250

(b) USDC

	mean	p25	p50	p75
RD AP Num	33	7	17	28
RD Top 1 Share	67	45	67	94
RD Top 5 Share	93	91	98	100
RD Vol (mil)	2	0	0	2
CR AP Num	28	5	24	35
CR Top 1 Share	65	35	71	98
CR Top 5 Share	87	78	96	100
CR Vol (mil)	14	0	0	1

(c) TUSD

	mean	p25	p50	p75
RD AP Num	1	1	1	1
RD Top 1 Share	97	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	10	0	0	2
CR AP Num	1	1	1	1
CR Top 1 Share	100	100	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	20	0	0	24

Table 8: Primary Market Monthly Redemption and Creation Activity (Tron)

Panels (a) to (f) provide statistics about monthly primary market redemption and creation activity on the Tron blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across months in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	5	2	4	6
RD Top 1 Share	72	53	68	94
RD Top 5 Share	100	100	100	100
RD Vol (mil)	4625	651	3575	7515
CR AP Num	11	2	12	14
CR Top 1 Share	65	46	54	96
CR Top 5 Share	98	96	99	100
CR Vol (mil)	4991	628	3515	7475

(b) USDC

	mean	p25	p50	p75
RD AP Num	446	11	317	391
RD Top 1 Share	58	33	51	81
RD Top 5 Share	84	78	85	100
RD Vol (mil)	41	3	24	70
CR AP Num	442	8	493	655
CR Top 1 Share	77	56	92	98
CR Top 5 Share	94	97	99	100
CR Vol (mil)	259	11	70	153

(c) TUSD

	mean	p25	p50	p75
RD AP Num	4	2	3	7
RD Top 1 Share	87	69	95	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	61	0	21	32
CR AP Num	3	1	2	3
CR Top 1 Share	95	98	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	85	0	24	80

Table 9: Primary Market Daily Redemption and Creation Activity (Avalanche)

Panels (a) to (f) provide statistics about daily primary market redemption and creation activity on the Avalanche blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across months in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	1	1	1	1
RD Top 1 Share	100	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	31	5	30	60
CR AP Num	1	1	1	1
CR Top 1 Share	100	100	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	26	10	30	40

(b) USDC

	mean	p25	p50	p75
RD AP Num	3	1	2	4
RD Top 1 Share	88	78	99	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	6	0	0	1
CR AP Num	4	2	3	6
CR Top 1 Share	81	70	88	99
CR Top 5 Share	100	100	100	100
CR Vol (mil)	12	0	3	14

(c) BUSD

	mean	p25	p50	p75
RD AP Num	2	1	1	2
RD Top 1 Share	90	86	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	0	0	0	0
CR AP Num	3	1	2	3
CR Top 1 Share	89	86	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	0	0	0	0

(d) TUSD

	mean	p25	p50	p75
RD AP Num	6	3	6	8
RD Top 1 Share	72	54	73	91
RD Top 5 Share	99	99	100	100
RD Vol (mil)	6	1	2	5
CR AP Num	10	3	9	16
CR Top 1 Share	68	49	67	88
CR Top 5 Share	97	96	99	100
CR Vol (mil)	7	1	3	7

Table 10: Primary Market Monthly Redemption and Creation Activity (Avalanche)

Panels (a) to (f) provide statistics about monthly primary market redemption and creation activity on the Avalanche blockchain, including the number of arbitrageurs, the market share of the top 1 and top 5 arbitrageurs, and the transaction volume. For each variable, we show the average, 25^{th} percentile, 50^{th} percentile, and 75^{th} percentile of values across months in our sample.

(a) USDT

	mean	p25	p50	p75
RD AP Num	1	1	1	1
RD Top 1 Share	100	100	100	100
RD Top 5 Share	100	100	100	100
RD Vol (mil)	50	1	10	120
CR AP Num	1	1	1	2
CR Top 1 Share	88	93	100	100
CR Top 5 Share	100	100	100	100
CR Vol (mil)	84	1	45	140

(b) USDC

	mean	p25	p50	p75
RD AP Num	34	18	32	47
RD Top 1 Share	49	31	42	60
RD Top 5 Share	94	87	96	99
RD Vol (mil)	111	3	16	219
CR AP Num	44	34	44	60
CR Top 1 Share	54	43	49	64
CR Top 5 Share	89	83	86	96
CR Vol (mil)	287	20	267	524

(c) BUSD

	mean	p25	p50	p75
RD AP Num	22	10	18	30
RD Top 1 Share	37	30	40	42
RD Top 5 Share	83	73	82	94
RD Vol (mil)	0	0	0	0
CR AP Num	33	11	18	43
CR Top 1 Share	41	34	38	50
CR Top 5 Share	87	82	94	98
CR Vol (mil)	0	0	0	0

(d) TUSD

	mean	p25	p50	p75
RD AP Num	66	49	74	85
RD Top 1 Share	50	36	46	64
RD Top 5 Share	86	79	91	94
RD Vol (mil)	154	31	85	260
CR AP Num	92	53	106	130
CR Top 1 Share	50	33	46	65
CR Top 5 Share	87	83	87	92
CR Vol (mil)	164	30	77	259

E Additional Calibration Details and Results

E.1 Estimating the distribution of $p(\theta)$

The CDS spread s_c on an asset class $c \in \{1 \dots C\}$ can be thought of as the probability of default under a recovery rate of 0. Since we assume 0 recovery rates in our model, for a single asset, s_c maps exactly to p in our model. Now, suppose the issuer holds a fraction q_c of her portfolio in asset class c. If each asset pays off 1 with probability s_c and 0 with probability $(1 - s_c)$, the portfolio as a whole has an expected recovery value:

$$\sum_{c=1}^{C} (1 - s_c)\, q_c$$

We add an adjustment factor to account for the fact that stablecoin issuers tend to be overcollateralized. If the issuer holds $1+\xi$ in assets times the total number of stablecoin issued, then the expected recovery value of assets, for each unit of stablecoin issued, is:

$$p = (1 + \xi) \sum_{c=1}^{C} (1 - s_c)\, q_c \tag{E.1}$$

Since p in the model is equal to the expected recovery value of assets per unit stablecoin issued, we will use (E.1) on each date we observe CDS spreads as one realization of p. We can think of (E.1) as the price of a composite security, which averages across CDS spreads of different components of a stablecoin issuer's portfolio, and accounts for the fact that issuers are slightly overcollateralized. With any set of CDS spreads on a given day, we can calculate a value of p using (E.1). By plugging CDS spreads from different dates into (E.1), we can calculate a distribution of signals p. Note that, when we plug CDS spreads into (E.1), we use spreads from a single day; hence, this method accounts for correlations between CDS prices of different asset classes.

We implement (E.1) we choose the historical CDS series from Markit that is liquid and that best fits each reported asset category. For deposits, we assign the average CDS of unsecured debt at the top 6 US banks to capture the riskiness of the banking sector.[16] We note that despite stablecoin issuers' claim that deposits are riskless in FDIC-insured institutions, they are not riskless or fully insured because

[16] These include Bank of America, Wells Fargo, JP Morgan Chase, Citigroup, Goldman Sachs, and Morgan Stanley.

deposit accounts exceeding 250K are not covered by deposit insurance, as evident from the recent Silicon Valley Bank episode. For Treasuries, we assign the CDS spreads on 3-year US treasuries. For money market instruments, we use CDX spreads on 1-year investment-grade corporate debt. For USDC's corporate bonds, we assign the 10-year investment-grade corporate CDX because they are stated to be of at least a BBB+ rating. For USDT's corporate bonds, we assign the average 10-year corporate CDX. The remaining categories, "foreign" and "other", do not have a clear mapping to the existing CDS series. For USDT, for example, assets in the "other" category include cryptocurrency, which could potentially be very risky. In our baseline results, we use the emerging market CDX spread as a proxy. We use the 10-year high-yield CDX spread as a robustness check. Our sample period is from 2008 to 2022.

Using the daily portfolio-level CDS spreads as observations, we fit a beta distribution for each coin-month by choosing the two beta distribution parameters to match the mean and variance of the empirical distribution of signals p. We then use this beta distribution as the distribution of $p(\theta)$ in the model. Appendix Table 11 shows the parameters of the beta distributions we estimate.

Table 11: Distribution of $p(\theta)$

This table shows the fitted beta distributions for $p(\theta)$, for each stablecoin and month in our data. α and β are respectively the two beta distribution parameters. Mean $p(\theta)$ and SD $p(\theta)$ are the mean and SD of the estimated beta distributions for $p(\theta)$.

Coin	Month	α	β	Mean $p(\theta)$	SD $p(\theta)$
USDT	2021m6	156.24	1.16	0.9926	0.0068
USDT	2021m9	170.15	1.33	0.9922	0.0067
USDT	2021m12	211.54	1.60	0.9925	0.0059
USDT	2022m3	213.25	1.42	0.9934	0.0055
USDC	2021m5	127.59	0.57	0.9955	0.0059
USDC	2021m6	137.00	0.57	0.9959	0.0054
USDC	2021m7	138.22	0.58	0.9958	0.0055
USDC	2021m8	122.20	0.83	0.9933	0.0073
USDC	2021m9	121.81	0.89	0.9928	0.0076
USDC	2021m10	121.81	0.89	0.9928	0.0076

Table 12: Secondary Market Price Deviation versus Redemptions/Creations

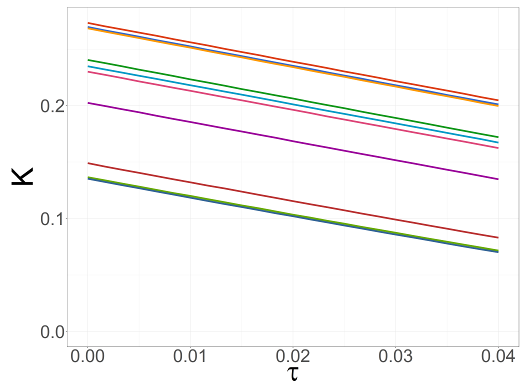
This table shows the results from regressing daily secondary market price deviations against the daily volume of redemptions/creations for USDT and USDC. For redemptions, price deviation is one minus the lowest hourly secondary market price on that day. For creations, price deviation is the highest hourly secondary market price on that day minus one. The daily volumes of redemptions and creations are expressed as a proportion of the total outstanding volume of each stablecoin. We include a year fixed effect to account for structural shifts over time.

	USDT	USDC
	(1)	(2)
Redemption/Creation	0.21***	0.16***
	(0.06)	(0.02)
Observations	1,225	1,792
Adjusted R2	0.01	0.05

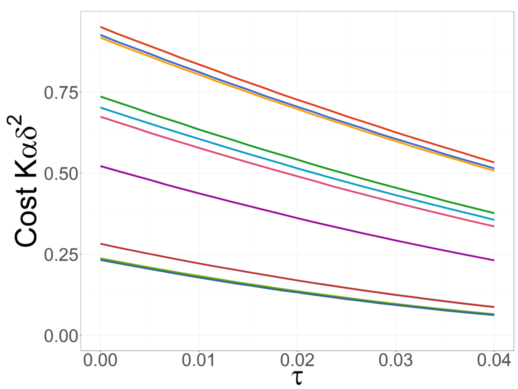
Figure 8: Effect of Dividend Payments (Full Sample Period)

This figure shows the predicted effect of dividend payments to investors on the issuer's choice of K, the cost of price variance $K\alpha\delta^2$, and run probability.

(a) Elasticity K



(b) Price Variance Cost



(c) Run Probability