

Stablecoin Devaluation Risk

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Abstract

Reliance of stablecoin issuers on centralized custodians introduces devaluation risk similar to that observed in traditional currencies under pegged exchange rate regimes. We construct market-based measures of stablecoin devaluation risk using spot and futures prices for Tether. Conditional on full default, our estimates suggest an average devaluation probability of 60 basis points annually, rising to over 200 basis points during the 2022 Terra-Luna crash. In contrast, the probability of a partial default, defined as a 5% devaluation (trading at 95 cents), is approximately 12 percentage points on an annualized basis. Key risk factors include market volatility and transaction velocity. While elevated interest rates suggest heightened devaluation risk, deviations from covered interest parity indicate segmentation between traditional and stablecoin markets, reflecting the effects of leverage trading and arbitrage costs. To mitigate these risks, our findings suggest the importance of greater transparency and regulatory oversight.

Keywords: Cryptocurrency, stablecoins, futures, bank runs, Tether, Bitcoin

JEL Classifications: E5, F3, F4, G15, G18

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1 Introduction and Motivation

Stablecoins are popular onramps and offramps for purchases and sales in the digital sphere. They are widely used as vehicles for transactions in popular cryptocurrencies such as Bitcoin (BTC), and account for over two thirds of recorded cryptocurrency transactions.¹ At their peak in late 2024, US dollar-based stablecoins reached a combined market capitalization of over \$200 billion, demonstrating their importance in facilitating transactions in the cryptocurrency ecosystem.² They find some use for remittances and other cross-border transactions (von Luckner et al., 2023; Adams et al., 2023). Their advocates suggest that they will gain broader acceptance in financial and commercial transactions. An important question in light of their increasing importance is the risks they transmit to users.³ This question motivates the adoption of regulations such as Europe’s Markets in Crypto Assets Regulation (MiCA), designed to prevent stablecoin risks from infecting the broader economy.⁴

The leading stablecoins rely on a centralized custodian of assets held as collateral or reserves. These assets are held off-chain. In some cases, such assets, or a portion thereof, are less liquid than the custodian’s liabilities—that is, than the stablecoin itself. This resembles the liquidity mismatch that characterizes the balance sheet of a bank whose business is maturity transformation. It thus gives rise to a problem of run risk analogous to that to which banks are subject. Relatedly, there is an analogy between a run on the

¹<https://www.chainalysis.com/blog/stablecoins-most-popular-asset/>

²<https://www.theblock.co/post/329947/stablecoin-market-cap-200-billion-usd>

³We discuss these different types of stablecoin risks in Section 2 more thoroughly. These include custodial risk, where centralized issuers may mismanage or abscond with reserve funds; devaluation risk, arising from insufficient or illiquid reserves backing the stablecoin; systemic risk, where stablecoin usage increases risk exposures of financial intermediaries, potentially leading to fire sales of collateral; and payment risk, where entities with stablecoin-denominated receivables are exposed to devaluation in much the same way firms are exposed to exchange rate risk when liabilities are denominated in foreign currencies (Eichengreen et al., 2007).

⁴For the full press release, see <https://www.esma.europa.eu/press-news/esma-news/esma-releases-last-policy-documents-get-ready-mica>. MiCA includes measures to enhance transparency, prevent market abuse, and regulate custodial risks associated with stablecoins, thereby reducing their potential systemic impact.

reserves of a central bank seeking to maintain a set value for a national currency (seeking to defend a currency peg), something that, if sufficiently intense, can result in the currency's devaluation, and a run on a centralized custodian seeking to maintain a set value for a stablecoin against a national currency, something that similarly can force that set value to be abandoned.

It follows that stablecoin devaluation risk can be priced using futures contracts in the same way the risk that a national currency will be devalued can be priced using forward foreign exchange contracts. Our analysis of this relationship focuses on Tether, the most actively traded stablecoin and the only one with traded futures during our period of study.⁵ We use these futures to construct a measure of devaluation risk, which we define as the probability of a speculative attack on the stablecoin peg.

Tether futures regularly trade at a discount to spot prices. We show that, on average, the devaluation risk implicit in this discount is priced at approximately 60 basis points annually. This corresponds to full default, defined as a complete collapse of the peg. This probability exhibits significant time variation, reaching a peak of 200 basis points during periods of market stress through mid-2022. In addition to full default risk, our framework captures partial default scenarios. For example, the annualized probability of a 5% devaluation, defined as Tether trading at or below 95 cents, is estimated at 12.4 percentage points.

This devaluation risk is increasing in Bitcoin volatility. Higher volatility may induce more transactions by investors who have taken leveraged positions in Bitcoin, particularly those using stablecoins as margin collateral. When volatility spikes, margin calls and forced unwinds trigger redemptions of the stablecoin, leading to increased outflows and liquidity stress for the issuer. In turn, this requires the centralized custodian to liquidate reserve assets to meet redemptions. Since liquidating collateral is operationally complex and may involve liquidity mismatches or price impacts, this need—and the uncertainty it

⁵In late 2023, USDC perpetual futures began trading, and we discuss our findings in a robustness test in Appendix F.

creates—shows up as an increase in the perceived probability of devaluation.

Another mechanism linking Bitcoin volatility to stablecoin risk arises from valuation effects on the issuer’s balance sheet. If the stablecoin issuer holds Bitcoin directly as part of its reserves, as in the case of Tether, declines in Bitcoin prices can reduce the mark-to-market value of those assets, weakening reserve coverage. This amplifies concerns about the issuer’s ability to maintain the peg, particularly when other less liquid or opaque assets are also on the balance sheet. Thus, Bitcoin volatility contributes to devaluation risk both through investor behavior and through direct balance sheet exposure.

Network characteristics such as stablecoin velocity (the turnover rate) and redemptions are key predictors of devaluation risk. Higher velocity reflects heightened market activity and investor attention to the custodian’s balance sheet, while increased redemptions amplify the risk of runs.⁶ An Analysis of Variance (ANOVA) shows velocity to be the most significant driver, explaining 14.8% to 16.1% of the variation in devaluation risk, emphasizing the role of trading intensity in signaling run risk.

Two case studies illustrate these connections. One is the TerraUSD crash of May 9th, 2022, when Tether’s price fell to 95 cents in intra-day trading. We document a 200 basis point probability of Tether devaluation. We observe an increase in velocity and redemption behavior as investors exited the cryptocurrency market and re-balanced their portfolios toward other cryptocurrencies.

The second case is USDC stablecoin de-pegging when Silicon Valley Bank (SVB) went bust in March 2023. This event raised concerns about whether USDC was fully backed, given that it held reserves at SVB. At one point, USDC fell to 87 cents. This rise in perceived devaluation risk was accompanied by a rise in monetary velocity, as in the TerraUSD crash. USDC stabilized when it transferred cash reserves at SVB to other banking partners. Redemptions following the event then helped stabilize the coin’s secondary market value.

Investors can be compensated for devaluation risk through stablecoin lending, where

⁶Large deposit outflows have similarly been implicated in the run on Silicon Valley Bank ([Van Vo and Le, 2023](#)).

interest rates reflect this risk (Gorton et al., 2022b). We analyze the behavior of Tether’s borrowing and lending rates, showing how they respond to devaluation risk while controlling for factors like the Crypto Fear and Greed Index and USD money market rates. Our findings reveal that a one percentage point increase in devaluation risk corresponds to a similar rise in Tether interest rates on platforms like Compound and Aave, indicating that these rates serve as compensation for risk.

Along with devaluation risk, market sentiment is a key driver of stablecoin interest rates. A strong positive correlation between the Crypto Fear and Greed Index and stablecoin rates suggests that market optimism increases borrowing demand as traders take leveraged positions. Conversely, we observe a negative relationship between stablecoin rates and USD money market rates, in contrast to the expected positive pass-through from monetary policy to traditional money markets. An ANOVA confirms that market sentiment is the dominant factor, explaining 22% of rate variation, while devaluation risk and money market rates account for just 3.5% and 1%, respectively. These results highlight a disconnect between traditional financial markets and the dynamics of stablecoin lending.

Finally, we conduct a formal test of market integration by constructing a measure of covered interest parity (CIP). This condition uses futures contracts to compare rates after hedging exchange rate risk. We find that stablecoin interest rates are systematically higher than money market rates after hedging exchange rate risk. There are systematic deviations from CIP, in other words. As explanations, we point to market segmentation due to the presence of leveraged trading and limits to arbitrage between the two markets. Such limits include lack of term structure in decentralized finance (DeFi) interest rates, lack of arbitrage capital in cryptocurrency markets, and gas fees charged to validate transactions on the blockchain.

We conduct a series of robustness tests to validate our baseline estimates. First, we compare our model-implied partial default probabilities to market-implied probabilities from Polymarket, a decentralized prediction market platform. Polymarket’s contract on

a potential USDT de-pegging in 2025 assigns a probability of 14–18% to a devaluation event defined as Tether trading below 98 cents for a full 24-hour period. By comparison, our estimates imply a 31.1% annualized probability for a comparable 2% devaluation threshold, suggesting that Polymarket may understate the risk of partial default. This difference partially reflects Polymarket’s stricter resolution criteria, which require the de-pegging to persist over a full 24-hour period.

We also test the robustness of our results using funding rates from USDT and USDC perpetual futures contracts. Perpetual futures provide an alternative to fixed-maturity contracts by using funding rates—recurring payments between long and short positions—to keep futures prices anchored to spot prices. For USDT, negative funding rates during stress periods—such as the Terra-Luna collapse—correspond to elevated devaluation risk, and funding rate dynamics align with the same drivers identified in our baseline regressions. For USDC, by contrast, weaker results are observed due to lower market liquidity, a more conservative reserve composition, and an absence of stress episodes during the sample period.

Over time, stablecoins could potentially come to be used more widely for remittances and other payments, leading to closer connections between stablecoin markets and traditional financial markets. If these connections strengthen, concerns may arise about volatility in stablecoin markets spilling over into conventional financial systems. The question is what to do about this. One response might be to limit stablecoin volatility through real-time audits using proof-of-reserve systems. These systems, powered by smart contracts, allow new tokens to be minted only when verified reserve balances increase, providing real-time detection of custodial issues.⁷

Another approach would be for regulatory authorities to license stablecoin platforms, impose capital and liquidity requirements, and conduct regular audits of their balance

⁷A smart contract is a self-executing set of instructions, written in computer code, that defines contractual conditions for each counterparty under different scenarios. As it is managed by code and recorded on the blockchain, it can be publicly verified by all network participants.

sheets, similar to how banks are regulated. Alternative private money arrangements, such as tokenized deposits and reserve-backed tokens, could preserve monetary stability by ensuring that issuers operate as narrow banks with fully backed assets ([Garratt and Shin, 2023](#); [Goel, 2024](#)). We analyze these options further in Appendix [A](#).

Related Literature. Our work contributes to a growing literature on stablecoin and cryptocurrency markets. Empirical studies have examined stablecoin properties and compared them with traditional financial assets ([Eichengreen, 2019](#); [Berentsen and Schär, 2019](#); [Bullmann et al., 2019](#); [?](#); [Arner et al., 2020](#); [Frost et al., 2020](#); [ECB, 2020](#); [Barthelemy et al., 2021](#); [Oefele et al., 2024b,a](#)), explored arbitrage opportunities in cryptocurrency markets ([Lyons and Viswanath-Natraj, 2023](#); [Makarov and Schoar, 2019, 2020](#); [Borri and Shakhnov, 2023](#); [Pernice, 2021](#); [Kozhan and Viswanath-Natraj, 2021](#); [Ma et al., 2023](#); [Hautsch et al., 2024](#)), stablecoin price dynamics ([Baur and Hoang, 2021](#); [Hoang and Baur, 2024](#); [Baumohl and Vÿrost, 2020](#); [Wang et al., 2020](#); [Bianchi et al., 2020](#); [Gloede and Moser, 2021](#); [Nguyen et al., 2022](#); [Duan and Urquhart, 2023](#)), the macroeconomic and financial stability implications of stablecoins ([Cong and Mayer, 2022](#); [Catalini and de Gortari, 2021](#); [Catalini and Shah, 2021](#); [Allen et al., 2022](#); [Gorton and Zhang, 2023](#); [Gorton et al., 2022a](#); [Murakami and Viswanath-Natraj, 2021](#); [Barthelemy et al., 2021](#); [Kim, 2022](#); [Liu et al., 2023b](#); [Martin, 2022](#); [Charoenwong et al., 2023](#); [Dionysopoulos et al., 2024](#); [Maex and Slavov, 2024](#)), and understanding cryptocurrency market risks, including trading patterns, discontinuous price movements, and spillover effects from monetary policy ([Liu et al., 2023a](#); [Gkillas et al., 2024](#); [Elsayed and Sousa, 2024](#); [Urquhart and Yarovaya, 2024](#)).

Our work is most closely related to [Gorton et al. \(2022a,b\)](#), who discuss the concept of stablecoin inconvenience yields, suggesting that stablecoins require higher interest rates due to their imperfect substitutability with conventional money. Complementary to this, [Gorton et al. \(2022b\)](#) provide a global games framework for understanding stablecoin runs. Their paper establishes that a decrease in demand for the cryptocurrency or an increase in the issuer’s riskiness pushes the stablecoin price below its peg. While these authors use

perpetual funding rates to proxy for risk premia, we utilize a more direct measure of peg risk derived from futures prices. Our approach has the advantage of capturing risk related to the issuer and beliefs about peg fundamentals rather than broader cryptocurrency market sentiment. Perpetual funding rates, as in [Gorton et al. \(2022b\)](#), may reflect a combination of speculative demand and market sentiment, which can make it challenging to isolate run risk. For instance, high stablecoin interest rates could result from optimism-driven borrowing activity rather than concerns about devaluation or capital flight. In contrast, futures prices explicitly reflect expectations of peg deviations under current market conditions, enabling us to tie devaluation risk more directly to observable drivers such as market volatility, redemption activity, and speculative demand.

Theoretically, our study complements research on stablecoin price dynamics, reserve buffers, and over-collateralization aimed at preventing speculative attacks and peg discounts ([Routledge and Zetlin-Jones, 2022](#); [Li and Mayer, 2022](#); [Cong et al., 2021](#); [Kwon et al., 2021](#); [d’Avernas et al., 2022](#); [Bertsch, 2022](#); [Uhlig, 2022](#); [Aldasoro et al., 2023](#)). Our findings support the framework of stablecoin runs proposed by [Bertsch \(2022\)](#), while extending it with empirical evidence on the interaction between market fundamentals and investor beliefs.

Finally, our paper relates to the broader literature on speculative attacks on pegged exchange rates and models of devaluation risk in currency boards ([Obstfeld, 1996](#); [Asici and Wyplosz, 2003](#); [Eichengreen et al., 1995](#); [Chamley, 2003](#); [Drapeau et al., 2021](#)). Theoretical models of speculative attacks and fixed exchange rate regimes emphasize the role of beliefs and fundamentals in driving devaluation risk (e.g., [Obstfeld, 1996](#); [Krugman, 1979](#); [MORRIS and SHN, 1998](#)). Complementary to these studies, we use futures prices to estimate devaluation risk, applying this approach to stablecoins while highlighting the importance of belief-driven channels in shaping peg price dynamics.

In [Section 2](#), we introduce a taxonomy of stablecoin risks, outline our data sources, and construct a market-based measure of run-risk using spot and futures data. [Section](#)

3 analyzes the determinants of run-risk, incorporating both econometric and case-study evidence, and examines the behavior of stablecoin interest rates on DeFi lending protocols. Finally, Section 4 concludes and discusses the implications of our findings for policymakers.

2 Definitions and Data

2.1 Stablecoin Taxonomy

Stablecoins operate on the blockchain and are typically pegged at parity to the U.S. dollar. U.S. dollar-denominated stablecoins reached a peak market capitalization of over \$150 billion in late 2021, and are dominated by Tether, USDC, Binance USD, and DAI, as shown in Panel A of Figure 1. They serve as vehicles for trading crypto assets generally, owing to the fact that they, like other crypto assets, operate on the blockchain, thereby reducing intermediation and transactions costs.⁸ Specific use cases include serving as a vehicle currency on centralized exchanges like Binance, decentralized exchanges like Uniswap (an open-source protocol for trading tokens without intermediaries), and DeFi lending protocols for leveraged trading. Stablecoins are also used, though to a lesser extent, for remittances and cross-border payments. Additionally, residents of developing countries may use stablecoins to evade capital controls and hedge against high domestic inflation (Adams et al., 2023).

Stablecoins typically follow three designs, as outlined in Panel B of Figure 1. A first type, as in the case of Tether, is backed by collateral held off chain by a custodian. In Tether’s case, the custodian is centralized. It is responsible for managing Tether’s fixed peg to the dollar, and can be thought of analogously to a currency board that manages a fixed currency peg to the dollar. The second-largest stablecoin, USDC, has decentralized

⁸Stablecoins are widely used in the cryptocurrency market due to the added intermediation costs when trading cryptocurrencies against dollars and their usability across a greater cross-section of crypto exchanges. For example, total trading volume between Bitcoin and Tether surpassed the trading volume of BTC/USD in 2019.

governance, with multiple custodians providing and redeeming tokens.

Not all dollar reserves are held in the form of cash or cash-equivalents. Historically, Tether and USDC's balance sheets have included commercial paper and other assets that may become illiquid during risk-off events.

A second design is decentralized, cryptocurrency (over) collateralized, and custodian free, as in the case of MakerDAO's DAI. DAI tokens are generated when an investor deposits collateral, typically Ether (ETH), into a collateralized debt position (CDP). Based on the value of collateral, an investor can issue (borrow) a certain amount of DAI tokens. The number of DAI they can borrow is limited by a smart (auto-executing) contract.⁹ This approach is capital inefficient since positions are over-collateralized.

A third design is algorithmic. In this case there may be zero collateral. The algorithm managing the system is programmed to increase and reduce the supply of the stablecoin as its value rises and falls relative to parity. A leading algorithmic stablecoin is TerraUSD, which reached a peak market capitalization of 40 USD billion in April 2022. TerraUSD is entirely backed by Luna, the native token of the Terra blockchain. Users can create 1 USD worth of TerraUSD by burning 1 USD of Luna. The Luna token is used to pay fees for validating transactions on the blockchain, staking tokens in governance votes, and earning yields on DeFi lending protocols.

This third approach economizes on capital costs (since there is no capital) but is prone to instability, as evident in the substantial discounts at which algorithmically collateralized stablecoins sometimes trade. An example is when the TerraUSD peg was broken on May 12th, 2022, triggering loss of confidence in the Terra blockchain and governance token. This triggered a spiral of falling Luna and TerraUSD prices; on May 12th, 2022 the ratio of the value of Luna to the circulating supply of TerraUSD declined to approximately 0.1.

Compared to dollar-backed stablecoins like Tether and over-collateralized crypto-

⁹The contract liquidates underlying Ethereum collateral if the value of that collateral is less than 150% of the corresponding DAI-borrowing value. Agents therefore have an incentive to scale back borrowing by redeeming DAI when Ethereum prices fall in order to prevent their collateral from breaching the 150% level.

backed coins like as DAI, algorithmically-backed stablecoins such as TerraUSD suffer from absence of an effective arbitrage mechanism between primary and secondary markets. The governance token Luna is unsuitable as collateral backing since it is systemically dependent on the value of the TerraUSD token and hence on the growth of the Terra blockchain.

In practice, the distinctions between these designs are not always clear-cut. Many stablecoins now adopt hybrid approaches, combining features from multiple categories. For example, Frax is a partially collateralized stablecoin that uses a mix of on-chain crypto assets and algorithmic mechanisms to maintain its peg. Frax's system includes a collateral ratio that adjusts dynamically based on market conditions: it increases collateralization during periods of instability while relying more on algorithmic stabilization during normal conditions. Additionally, Frax employs Algorithmic Market Operations (AMOs), which allow for minting and redeeming FRAX tokens on decentralized exchanges and other protocols to maintain the peg through predefined algorithms.¹⁰ This hybrid design balances the capital efficiency of algorithmic stablecoins with the relative stability of collateralized systems.

A similar evolution can be observed with the DAI stablecoin. While DAI was initially designed to accept only on-chain collateral, its collateral structure has diversified significantly since 2022 to include real-world assets (RWAs). The largest RWA vaults backing DAI include U.S. Treasury securities, credit assets such as consumer receivables and real estate finance, and USDC-backed assets. These RWAs are managed through special purpose vehicles (SPVs) and overseen by trustees, enabling MakerDAO to interface with traditional financial markets without formal legal standing. Although this approach allows DAI to diversify its collateral base, it also brings the system closer to a hybrid stablecoin design.

¹⁰For more information on AMOs, see <https://docs.frax.finance/amo/overview>.

2.2 Stablecoin Risks

It is useful to distinguish four risks associated with stablecoins: custodial risk, devaluation risk, systemic risk, and payments risk.

- **Custodial risk:** This can arise when a centralized issuer responsible for reserve management absconds with funds.
- **Devaluation risk:** This can arise when reserves or backing are less than 100 percent of the value of issuance or less than perfectly liquid.
- **Systemic risk:** Stablecoins used in cryptocurrency markets can increase risk exposures of financial intermediaries. Because stablecoin issuers hold traditional assets, a run on stablecoins can lead to systemic risks to the financial sector and financial intermediation, for example when they are forced to engage in fire sales of commercial paper and other assets held by stablecoin issuers as collateral.
- **Payment risk:** If a firm or other entity has receivables denominated in stablecoins, its flows are subject to devaluation risk.¹¹ This is similar to the exchange rate risk that occurs when firms denominate liabilities in foreign currency and are subject to a revaluation of foreign debt when the local currency depreciates (Eichengreen et al., 2007).

We illustrate these risks in the context of Tether, the stablecoin that is the focus of our empirical analysis. Since March 2021, Tether has provided a breakdown of its reserves, which are subject to quarterly attestation reports, initially by the accounting firm Moore Cayman, and subsequently by BDO since June 2022. Tether's first statement of March 2021 revealed that it was only 75.6 % backed by cash or cash equivalents (less liquid asset

¹¹Other use cases for stablecoin payments are in cross-border flows or as a hedge against macroeconomic risk (Adams et al., 2023).

categories such as commercial paper, fiduciary deposits and treasury bills).¹² In its 2023 Q1 quarterly attestation, Tether had fully liquidated its commercial paper holdings. However, only 84.65% of its assets were held in cash or cash equivalents, while the remaining 15.35% were allocated to less liquid assets such as corporate bonds, precious metals, and cryptocurrencies, including Bitcoin (Table 1).

In the absence of 100 percent liquid reserves, Tether can be susceptible to bank-run-like problems. If demands to redeem Tether exceed liquid reserves, Tether must suspend redemptions or sell less liquid assets at a loss. This is analogous to how, at the height of the Global Financial Crisis in 2008, money market funds were forced to "break the buck" due to a fall in the value and liquidity of their commercial paper holdings.

An issue here is Tether's holdings of Bitcoin, whose price is volatile. While these holdings constituted just a small fraction (1.8 %) of Tether's balance sheet on March 31st, 2023, they made the value of Tether's backing subject to fluctuations. A crash in the value of cryptocurrencies, such as Bitcoin, can reduce the value of Tether's assets. This decline in asset value can trigger redemptions, as demonstrated by the link between the profitability of Tether's balance sheet and stablecoin growth in [Dionysopoulos et al. \(2024\)](#). We study this market risk in Section 3.2.

While our study focuses on Tether, concerns about the valuation of assets and the extent of collateralization are relevant to other stablecoins as well. For example, [Liao \(2022\)](#) highlights significant differences in asset composition across stablecoins. Tether diversifies its balance sheet by holding a fraction of its reserves in less liquid assets, including cryptocurrencies, corporate bonds, and precious metals. In contrast, USDC, managed by Circle, adopts a model closer to "tokenized cash," where reserves are fully backed by highly liquid and secure assets. These include U.S. Treasury securities, repurchase agreements, and cash held in segregated accounts at regulated financial institutions.

¹²Quarterly statement released by Tether Ltd on breakdown of reserves. Statement issued on May 13th, 2021 on Tether's twitter account. Available at https://twitter.com/Tether_to/status/1392811872810934276

To illustrate, as of November 2024, Circle reported reserves exceeding \$39 billion, ensuring 1:1 backing for USDC tokens.¹³ This robust reserve composition has contributed to the relative stability of USDC, even during periods of market stress. However, USDC is not entirely immune to external shocks, as demonstrated by the March 2023 de-pegging event triggered by the collapse of Silicon Valley Bank. The bank, which held a portion of USDC's cash reserves, went bankrupt, leading to temporary disruptions in USDC's peg. The market response was similar to that observed for Tether during other stress events, with liquidity constraints and redemption pressures driving price volatility.

Thus, in Section 3.2.2, we highlight the role of Silicon Valley Bank's collapse in triggering a USDC de-pegging event that occurred in March 2023, when the bank, which held cash reserves for USDC, went bankrupt. The reaction of USDC in this episode was much like the reaction of Tether in other instances.

2.3 Stablecoin Risk Management

Opacity and lack of auditing requirements can heighten the risks enumerated above. For example, because Tether's assets are kept off-chain, investors are unable to confirm that its balance sheet is fully collateralized in real time. Attestations are done only once a quarter. Doubts about the value of collateral can then give rise to mass redemptions as holders seek to avoid being last in the queue, a la [Diamond and Dybvig \(1983\)](#).

Real-time audits using third-party proof-of-reserve systems such as Chainlink are one possible solution to this problem. These audits provide transparency with regard to collateral values and alert stakeholders to anomalies. Auditing is conducted at a high frequency, in contrast to Tether and USDC, which provide audit reports on a monthly or quarterly basis. By more tightly connecting the minting of new tokens to reserves, such systems enforce full collateralization, thereby reducing the risk of a stablecoin run. However, concerns about oracle risk remain; who audits the auditor, in other words? A

¹³USDC reserve details are available at <https://www.circle.com/transparency>.

possible solution here is to require decentralized consensus among oracles.¹⁴

Regulatory frameworks have also been proposed to address stablecoin devaluation risk. These frameworks potentially entail capital requirements, access to central bank liquidity facilities, and potential insurance for stablecoin users. Stablecoin issuers might be required to align with Basel regulations on capital requirements for banks.

Finally, alternative stablecoin designs are proposed to mitigate devaluation risks. These include tokenized deposits and reserve-backed tokens (RBTs). Tokenized deposits, as outlined by [Garratt and Shin \(2023\)](#), operate on a non-bearer instrument model, ensuring singleness of value within a platform by settling transactions on a central bank's balance sheet, eliminating credit exposures across institutions. Reserve-backed tokens, discussed by [Goel \(2024\)](#), involve issuers holding asset reserves with a central bank. RBTs promise financial stability, independence from custodians, and reduced risk through full backing by safe assets.

We provide additional detail on these risk management solutions in [Appendix A](#).

2.4 Data

2.4.1 Network Measures

Tables [2](#) and [3](#) present definitions and summary statistics for the variables used in our analysis. Network measures are from Coin Metrics, a blockchain data company providing transfer value and related variables for major cryptocurrencies. We classify transactions that are "sent" as deposits, and transactions when the Treasury receives Tether as redemptions. We only consider Tether circulation net of supply held by the Treasury; this is labeled free float supply in the Coin Metrics database. We construct the measure

¹⁴The oracle problem refers to the challenge of integrating reliable and secure real-world data into blockchain applications, as blockchains themselves cannot access external data directly. This limitation creates a reliance on oracles-entities or systems that act as intermediaries to fetch and deliver this data. Oracle risk arises when these intermediaries are compromised, leading to potential manipulation, inaccurate data, or a single point of failure. Decentralized Oracle Networks, such as Chainlink, mitigate these risks by employing independent and incentivized node operators to provide data in a secure, reliable, and decentralized manner. We provide supplementary detail on Chainlink in [Appendix A](#).

of Tether in circulation for three blockchains that account for over 95% of Tether creation: Omni, Ethereum and Tron. For each platform, we utilize data on transactions of the Tether Treasury with secondary market wallets. Panel A of Figure 2 plots Tether supplied on each blockchain. While Tether was initially issued on the Omni blockchain, the two primary blockchains since 2019 have been Ethereum and Tron. Tether’s move to the Ethereum and Tron blockchain is driven by several factors, including ability to serve a larger number of cryptocurrency investors, facilitate exchange with Ethereum (ERC20) and Tron (TRX) tokens, enable faster arbitrage opportunities, and reduce transaction costs.¹⁵ Cryptocurrency exchanges like Bittrex and Huobi recognize the benefits of the Ethereum blockchain for Tether.¹⁶

In addition to the quantity of Tether in circulation, we employ a measure of velocity: the ratio of value transferred in the trailing year divided by the current supply at the end of the period. This can be thought of as turnover – as the number of times that an average native unit has been transferred in the past year. Panel B of Figure 2 plots velocity across all 3 blockchains, together with a value-weighted measure. As value on the Omni network declined, so did the velocity of transactions. In contrast, we see an increasing trend in velocity on the Tron blockchain, followed by an increase in the value-weighted measure.

2.4.2 Spot and Futures Prices

For USDT spot and futures prices, we draw data from Coinapi, which gives historical cryptocurrency OHLCV (Open, High, Low, Close and Volume) data through an API.¹⁷ Prices for Tether futures are available from the FTX exchange from February 28th 2020 until June 18th, 2022.¹⁸

¹⁵ERC20 and TRX are standards which provide features including the transfer of tokens from one account to another, measuring the current token balance of an account, and measuring the total supply of the token available on the network. It deploys smart contracts, auto-executing code on the blockchain, to perform these various functions.

¹⁶Huobi exchange statement on the migration to the Tether blockchain, <https://prn.to/2ZkPzw0>

¹⁷Data available at <https://www.coinapi.io/>.

¹⁸Our sample closes with the June 2022 futures contract and does not include the collapse of FTX in November 2022, which introduced counterparty and settlement risks. As of June 2022, FTX appeared financially

Closing futures prices are at a daily frequency. To control for futures prices approaching spot at the expiry of the contract, we create a constant maturity series by linearly interpolating between successive futures contracts. For spot prices the earliest historical series for Tether is obtained from the Kraken exchange, the most liquid exchange for spot USDT/USD trading, which is available from April 2017.

Figure 3 plots spot and futures prices, along with the basis, defined as the difference between futures and spot rates. The basis is typically negative, consistent with investors pricing devaluation risk. For market volatility risk, we use a measure of intra-day volatility for Bitcoin, calculated as the square root of the sum of squared hourly returns for each day, consistent with standard realized volatility measures.

2.4.3 Interest Rates

For interest rates on Tether we use borrowing and lending rates from Compound and Aavev2, available from the Kaiko API, which provides data from August 5 2021.¹⁹ These are the two major lending protocols during our sample period, and we use them to construct a value-weighted borrowing and lending interest rate for our analysis in Section 3. These rates are compounded every block (approximately every 15 seconds on the Ethereum blockchain) and are determined by the utilization percentage in the market, which is the percentage of the asset supplied to the protocol that is borrowed.²⁰

stable, with plans to acquire BlockFi and Voyager (Sigalos, 2022). However, we recognize the systemic role of Alameda Research, a firm closely tied to FTX, in Tether markets. Between 2014 and 2021, Alameda accounted for 37% of all USDT distribution, highlighting the interdependence of major market participants (Protos Staff, 2023). The interconnected risks between FTX, Alameda Research, and Tether only surfaced after our sample period, as highlighted by media reports on Alameda’s reliance on FTX’s proprietary token for its balance sheet (Allison, 2022) in November 2022.

¹⁹API available at <https://docs.kaiko.com/v/kaiko-rest-api/defi-and-blockchain/lending-and-borrowing-data/lending-rates>.

²⁰For example, the interest rate model for borrowing rates on the Compound protocol is given by the piecewise equation (1). a_0 is the base rate, and is the rate corresponding to zero utilization. The slope parameter b_0 measures the sensitivity of interest rates to utilization. Typically the threshold \bar{u} is set at 0.8.

$$i_{USDT}^{borrow} = \begin{cases} a_0 + b_0 u, & u \leq \bar{u} \\ a_0 + b_0 \bar{u} + b_1(u - \bar{u}), & u > \bar{u} \end{cases} \quad (1)$$

For money market rates, we use the 3 month USD OIS rate from Bloomberg. The 3 month maturity matches the term structure of 3 month futures USDT/USD contracts.

2.4.4 Market Sentiment

To measure market sentiment, we use the Crypto Fear and Greed Index.²¹ This is designed to quantify the emotional sentiment in the cryptocurrency market, specifically focusing on Bitcoin. The index is calculated on a scale from 0 to 100, where 0 indicates "Extreme Fear" and 100 indicates "Extreme Greed."

The index combines data from five sources. Volatility, accounting for 25% of the index, compares Bitcoin's current volatility and maximum drawdowns against its 30- and 90-day historical averages to assess market fear. Market Momentum and Volume, also contributing 25%, evaluate daily trading activity relative to historical trends to identify market greed. Social Media, weighted at 15%, analyzes Twitter activity and engagement rates to measure public interest and sentiment. Dominance, comprising 10%, reflects Bitcoin's market cap dominance as an indicator of market fear or greed, particularly in relation to altcoins. Finally, Trends, making up the remaining 10%, leverages Google Trends data to track changes in search volumes for Bitcoin-related queries, signaling shifts in market sentiment.

3 Model and Evidence

3.1 Model of Devaluation Risk

Our model of devaluation risk follows the literature that estimates the currency risk of the Hong Kong Currency Board (Blagov and Funke, 2016; Zhang and Drapeau, 2022; Drapeau et al., 2021; Schmukler and Servén, 2002). Define s_t, f_t as the spot and futures rates, expressed as the dollar price of a unit of Tether. Assume that the spot price follows

²¹Available through an API at <https://alternative.me/crypto/fear-and-greed-index/>.

an AR(1) process with mean-reversion coefficient ρ in equation (2).²²

$$s_{t+1} = 1 + \rho(s_t - 1) + \epsilon_{t+1}, 0 < \rho < 1 \quad (2)$$

Stability requires $\rho < 1$. The coefficient ρ provides an estimate of the half-life of the system.²³ The reduced form dynamics of the peg capture an arbitrage mechanism through which peg-price deviations are reduced and eliminated. Intuitively, a positive peg premium increases stablecoin supply through arbitrage flows, having a stabilizing effect on the price. Practically, half-life typically is short, 1 to 5 days for major stablecoins (Lyons and Viswanath-Natraj, 2023).

The AR(1) process provides a tractable mapping between the spot price today and its value at expiry.²⁴

At expiry $t + h$, the spot rate follows equation (3). With probability \mathcal{P} , the stablecoin regime collapses, and the spot rate falls to $\underline{s} < 1$, with full default corresponding to $\underline{s} = 0$. With probability $1 - \mathcal{P}$, the spot rate is determined by iterating equation (2) forward. In this case, the future spot price follows an exponential decay of peg-price deviations, incorporating a series of shocks discounted by the mean reversion coefficient ρ and a discounted sum of Tether-specific shocks ϵ_{t+s} .

²²Alternatives such as a VAR model augmented with a Markov regime switching method have been used in (Blagov and Funke, 2016; Zhang and Drapeau, 2022).

²³To measure the half-life, we run an auto-regressive process of order 1 on the deviations, $\Delta = \rho\Delta_{t-1} + u_t$. The half-life, or the time it takes for a shock to dissipate by 50%, is $T = \frac{\log(0.5)}{\log(\rho)}$.

²⁴In unreported results, we find three pieces of evidence supporting the sufficiency of an AR(1) model for evaluating the expected future spot price. First, the ACF and PACF plots show significant partial autocorrelations up to lag 5, suggesting that higher-order AR models (e.g., AR(5)) may fit better. Second, AIC and BIC results indicate that the optimal lag length is 9 for AIC and 5 for BIC, consistent with the PACF findings. Third, regression results show that the partial R-squared increases from 0.447 in AR(1) to 0.514 in AR(5), highlighting diminishing returns from including additional lags. Together, these findings suggest that while AR(5) may marginally improve fit, AR(1) remains a tractable and sufficiently accurate representation of spot price dynamics.

$$s_{t+h} = \begin{cases} 1 + \rho^h(s_t - 1) + \sum_{s=1}^h \rho^{h-s} \epsilon_{t+s}, & \text{with probability } 1 - \mathcal{P} \\ \underline{s}, & \text{with probability } \mathcal{P} \end{cases} \quad (3)$$

Under the expectations hypothesis, the futures price for a contract expiring h periods from now is equal to the expectation of the spot rate h periods from now. The futures contract at expiry is given by equation (4).

$$f_t = \mathbb{E}_t[s_{t+h}] \quad (4)$$

$$= (1 - \mathcal{P}) \times (\mathbb{E}_t[s_{t+h}]|\text{No Default}) + \mathcal{P} \times (\mathbb{E}_t[s_{t+h}]|\text{Default}) \quad (5)$$

$$= (1 - \mathcal{P}) \times \left(1 + \rho^h(s_t - 1)\right) + \mathcal{P} \times \underline{s} \quad (6)$$

Utilizing the probabilities of the 'default' and 'no-default' states, we can show that stablecoin futures equal the expected price.

The probability of a run is captured by equation (7).

$$\mathcal{P}_t = \frac{1 + \rho^h(s_t - 1) - f_t}{1 + \rho^h(s_t - 1) - \underline{s}} \quad (7)$$

This probability can be estimated using observable spot and futures rates. It is decreasing in the futures rate and increasing in the spot rate. It is inversely related to the futures-spot basis $f_t - s_t$. As the horizon of the futures contract $h \rightarrow \infty$, when the exchange rate in the devaluation state is $\underline{s} = 0$ the equation simplifies to $\mathcal{P} = 1 - f_t$.

We show our measure of devaluation risk in Panel C of Figure 3.²⁵ There is significant time variation in the implied probability, with a peak of 2 % (annualized). The two local peaks are the 'Black Thursday' March 12th, 2020 Crypto crash, when the prices of major currencies such as Bitcoin fell by 50 %; and the TerraUSD crash on May 9th, 2022, when

²⁵To compute the default probability, we first estimate the auto regressive parameter ρ in equation (2). and use an average estimate of $\rho = 0.67$ over the full sample. In calculating the annualized probability, we use the estimate of ρ and assume a horizon $h = 90$ of the futures contract. We assume $\underline{s} = 0$ for the baseline specification.

investors priced an increase in the probability of a Tether-de-pegging event. We discuss the TerraUSD crash further in section 3.2.

In Panel D of Figure 3, we measure the average default probability conditional on different degrees of devaluation \underline{s} . The default probability has an average of 62 basis points for the baseline specification of $\underline{s} = 0$, suggesting there is an approximate 0.6 % probability (annualized) of complete default. In contrast, the probability of partial default of 5% devaluation ($\underline{s} = 0.95$) is 12.4 percentage points annualized.²⁶

3.2 Correlates of Run Risk

We test for the determinants of the probability of a stablecoin devaluation using equation (8). Explanatory variables include network measures such as the rate of turnover (also referred to as monetary velocity). For this analysis, velocity is de-meanned, meaning the average velocity over the sample period is subtracted from daily observations. Proxies for market volatility includes a measure of intra-day volatility of Bitcoin. Finally, we consider a variable capturing periods of net redemptions of Tether, that is, periods when the supply of Tether (net of Treasury) falls.

$$\mathcal{P}_t = \beta_0 + \beta_1 Velocity_t + \beta_2 \sigma_{BTC}_t + \beta_3 D_{redemption}_t + \epsilon_t \quad (8)$$

Table 4 presents the results. Columns (1) to (4) use the baseline measure of devaluation risk based on equation (8). Columns (5) to (8) use the devaluation risk measure based on linear interpolation of futures contracts. Our findings are robust to using both devaluation risk measures. Velocity is positively associated with devaluation risk. In our full specifications in columns (4) and (8), a unit increase in velocity increases the devaluation risk measures by 2.4 and 2.8 basis points respectively. This result is suggestive of the central

²⁶In addition to the sensitivity analysis to \underline{s} , we conducted sensitivity analyses to evaluate the impact of varying h (horizon) and ρ (persistence) on devaluation risk. For h , the default probability (annualized) ranges from 8.11% at $h = 7$ to approximately 0.16% at $h = 360$, confirming that shorter horizons amplify perceived devaluation risk. For ρ , devaluation risk increases moderately, rising from 0.62% at $\rho = 0.01$ to 0.69% at $\rho = 0.99$. These results indicate that lower persistence and shorter horizons elevate the likelihood of perceived devaluation, while longer horizons and higher persistence mitigate this risk.

role of trading intensity in signaling run risk, as heightened velocity reflects periods of increased market activity, potentially associated with investor concerns about the coin's stability or panic-driven attempts to redeem at par.

In addition, devaluation risk is associated with high Bitcoin volatility. Periods of high Bitcoin volatility can increase devaluation risk due to investor concerns about the role of Tether as a vehicle for transactions in Bitcoin and related cryptocurrencies. In columns (4) and (8), a 1 percentage point increase in Bitcoin volatility increases the devaluation risk measures by 3.4 and 6.0 basis points respectively. Finally, we control for the redemption behavior of investors. We find that periods of redemptions are associated with an increase in devaluation risk. Based on our full specifications in columns (4) and (8), such periods are associated with an 7.8 and 16.9 basis point increase in our measures of devaluation risk.

To further explore the relative importance of these predictors, we conducted an ANOVA for both our baseline and linear interpolation measures of devaluation risk in Appendix C. The results show that velocity is the most important driver, explaining 14.8% and 16.1% of the variation, respectively. This highlights the critical role of trading intensity in signaling run risk. Elevated velocity likely reflects heightened market uncertainty, as investors rebalance portfolios or rush to redeem stablecoins amid concerns of overvaluation or peg instability.

By comparison, market volatility explains 1.8% and 5.0%, while redemption activity contributes 3.2% and 6.2% of the explained variation. The relatively lower contribution of market volatility aligns with Tether's limited exposure to Bitcoin price fluctuations, which, based on public attestations, accounts for approximately 2% of its total assets. Furthermore, Bitcoin volatility can also coincide with favorable market conditions, driving up Tether usage as a vehicle currency, thereby mitigating negative pressure on the peg.

Redemption activity, while a direct signal of liquidity stress, explains a modest share of variability, partly due to its infrequent occurrence. The mean value of the redemption

indicator in our sample is 0.19, indicating that only 19% of days feature net redemptions. Moreover, not all redemption episodes reflect concerns about peg sustainability; some may simply indicate reduced transactional demand for Tether as a vehicle currency in periods of subdued trading activity.

Overall, these findings align with theoretical models of stablecoin devaluation risk (Bertsch, 2022; Routledge and Zetlin-Jones, 2022; Li and Mayer, 2022; d’Avernas et al., 2022; Gorton et al., 2022b), which emphasize the importance of cryptocurrency-related fundamentals. Trading intensity emerges as the dominant predictor, suggesting that heightened activity serves as an early warning signal of run risk.

3.2.1 Case Study: the May 9th, 2022, TerraUSD Crash

TerraUSD is an algorithmic stablecoin backed by Luna, the native token of the Terra blockchain. (In other words, TerraUSD is not collateralized by dollar reserves. The TerraUSD treasury also holds reserves of Bitcoin for use in extremis, but only limited amounts.) TerraUSD is pegged to 1 USD by arbitrage. When the price of TerraUSD is above par, an investor can sell 1 USD worth of Luna and buy TerraUSD for 1 USD, and then sell TerraUSD in the secondary market for an arbitrage profit. Conversely, when the dollar price of TerraUSD is below one, an investor can buy TerraUSD on the exchange and sell TerraUSD for 1 USD worth of Luna tokens.

This arbitrage is not risk-free: investor profits are driven by expectations of the valuation of the governance token. It follows that algorithmic stablecoins such as TerraUSD are subject to instability (Briola et al., 2023; Liu et al., 2023b; Ma et al., 2023; Uhlig, 2022). An instance of this problem was in May 2022, when TerraUSD traded at a large discount from the peg. This in turn triggered a loss of confidence in the blockchain and the governance token, resulting in a spiral of falling Luna and TerraUSD prices. The TerraUSD treasury’s Bitcoin reserve was fully depleted.

Although design features affecting the TerraUSD peg were not shared by other sta-

blecoins such as Tether, Tether fell to 95 cents USD intra-day on May 12th, 2022, three days after the initial TerraUSD collapse. This may have indicated investor expectations of reduced utility of stablecoins for cryptocurrency transactions. In addition, Liao (2022) documents a shift from Tether toward USDC, an alternative stablecoin with more transparent and extensive backing, suggestive of investor search for greater transparency and security.

Figure 4 shows the dynamics of Tether spot and futures prices, the implied probability of default, and various network characteristics around the event. While there was a decline in spot prices, futures prices fell by more and did not rebound as quickly. The implied probability of Tether default rose to 200 basis points annualized. The basis (futures less spot) took weeks to recover to levels prevailing prior to the TerraUSD collapse.

In addition there was an increase in Tether velocity and a consequent decline in the measure of free float supply of Tether in circulation. As investors exited, redemptions were required to stabilize the peg. The increase in velocity presumably reflected a tendency for investors to rebalance their portfolios toward other stablecoins such as USDC, consistent with the narrative in Liao (2022).

In the face of this negative shock, supply should be reduced commensurate with demand, and redemption mechanisms should operate so as to return the price to par. Following the de-pegging event, we in fact observe a -10 USD Billion change in the supply of Tether in circulation. This redemption mechanism is analogous to how a central bank defends an exchange rate peg. When the peg trades at a discount to par, arbitrageurs have an incentive to buy Tether in the secondary market and redeem at the Treasury at par. The consequent reduction in stablecoin supply stabilizes the price in the secondary market. However, limits to redemptions, such as fees and minimum withdrawals, can lead to inefficiency of this process.²⁷

²⁷The minimum fees for withdrawals on Tether are \$1,000 for fiat withdrawals or up to 10 basis points of the transaction, whichever is greater, and vary for blockchain transfers depending on the network used. For more details, we refer readers to <https://tether.to/en/fees/>.

3.2.2 Case Study: March 11th, 2023, the USDC De-Pegging Event

A second case is the USDC de-pegging event in March 2023, when Silicon Valley Bank, which held reserves for USDC, went bankrupt. USDC reportedly held some 3.3 USD billion of cash reserves at SVB. The run on SVB caused investor concern about whether these reserves would be lost, since they far exceeded the cap on federal deposit insurance. In turn this spawned questions about whether or not the coin was still fully backed. USDC fell to 87 cents on March 11th. Prices then stabilized on March 13th, when the Federal Deposit Insurance Corporation (FDIC) had announced that all deposits at SVB would be fully guaranteed and available, and USDC transferred its reserves to other banking partners.²⁸

Although we lack futures data for the USDC stablecoin during this period, we can still assess the external validity of our interpretation by examining the behavior of related variables depicted in Figure 5. Using the estimated specification in equation (7), we construct a counterfactual measure of USDC devaluation risk based on observables such as velocity, market volatility, and redemption behavior. We assume that these variables relate to USDC devaluation risk in a manner similar to Tether.

Our devaluation risk measure, in Panel A, shows an increase of up to 50 basis points following the USDC de-pegging event on March 11th, 2023. This rise in imputed devaluation risk coincides with a significant increase in velocity, indicating intensified secondary market trading as investors sought to exchange USDC for USD reserves. In the subsequent weeks, redemptions reduced the free float supply of USDC from 40 billion USD to 32 billion USD, akin to the redemptions during Tether's de-pegging in May 2022. These actions helped to stabilize USDC's secondary market value at par by exerting upward pressure on prices.

The impact of market volatility was temporary and limited to the USDC peg without

²⁸For a full account of USDC's reserve composition and the de-pegging event, we refer readers to <https://www.circle.com/blog/an-update-on-usdc-and-silicon-valley-bank>

affecting the broader cryptocurrency market. During the de-pegging event, the substitutability between stablecoins played a crucial role, as noted by [Oefele et al. \(2024b\)](#). Investors transitioned to Tether, which has less exposure to U.S. banks, thereby limiting contagion from USDC's de-pegging to the broader market.

In sum, these patterns suggest a narrative consistent with the Tether de-pegging event discussed earlier.

3.2.3 USDT Quarterly Attestation Reports

Understanding the impact of Tether's quarterly attestations is crucial for assessing the transparency and solvency of stablecoins. These attestations serve as key market signals, indicating whether Tether's reserves adequately back its token liabilities. Related literature on transparency measures and regulatory reporting suggests that such disclosures improve peg stability and increase issuance, as observed in data for five major stablecoins ([Maex and Slavov, 2024](#)). Therefore, we hypothesize that the release of attestation reports reduces perceived devaluation risk by providing information on the stablecoin issuer's solvency.

Appendix [E](#) summarizes Tether's attestation history from Q1 2021 onward. Initially conducted by Moore Cayman and later by BDO, these attestations reflect increasing transparency, including significant reductions in commercial paper holdings and greater allocations to U.S. Treasuries. Recent reports also disclose alternative asset holdings, such as cryptocurrencies and gold, and highlight growing excess reserves and profitability.

An event study in Appendix [E](#) examines how devaluation risk responds to attestation releases. While immediate effects are negligible, we observe a gradual decline in devaluation risk in the weeks following each release, particularly during periods of balance sheet improvements (e.g., the reallocation to U.S. Treasuries from Q2 2021 to Q1 2022). However, the results suggest a delayed market reaction, potentially due to staggered news dissemination.

Despite these findings, concerns remain regarding the reliability of attestation reports.

As point-in-time assessments, attestations confirm reserve sufficiency only at a specific date, leaving questions about the issuer’s ongoing solvency. The absence of a standardized performance framework makes it difficult to assess the level of assurance and extent of work performed. As a result, regulators have cautioned investors against relying on attestation reports (Maex and Slavov, 2024). Alternative transparency measures, such as Chainlink’s proof of reserve, are discussed further in Appendix A.

3.3 Interest Rates and Devaluation Risk

We now examine the determinants of interest rates and whether devaluation risk is priced. If stablecoins are subject to devaluation risk, it should be reflected in higher stablecoin interest rates. To test this, we analyze the determinants of Tether borrowing and lending rates using equation (9). This specification regresses stablecoin interest rates on two measures of devaluation risk: the baseline measure and the linear interpolation measure. In controlled specifications, we also include the Crypto Fear and Greed Index (capturing market sentiment toward risky cryptocurrencies) and the USD 3-month OIS rate as a proxy for money market conditions.

$$i_{USDT,t} = \beta_0 + \beta_1 \mathcal{P}_t + \beta_2 FG_{index,t} + \beta_3 i_{USD,t} + \epsilon_t \quad (9)$$

Table 5 presents the results. Columns (1)-(4) use the USDT supply rate as the dependent variable, while columns (5)-(8) analyze the USDT borrow rate. Devaluation risk, measured using both the baseline and linear interpolation methods, is consistently priced into both supply and borrow rates. In the baseline specifications without controls (columns 1 and 5), a 1 percentage point increase in the baseline devaluation risk measure is associated with a 1.11 and 1.25 percentage point increase in the USDT supply and borrow rates, respectively. Adding controls (columns 2 and 6) reduces these estimates to 0.51 for supply rates and 0.58 for borrow rates, though they remain statistically significant. The linear interpolation

measure yields similar results (columns 3, 4, 7, and 8), with coefficients ranging from 0.64 to 0.84. These findings indicate that stablecoin interest rates reflect compensation for devaluation risk, aligning with [Gorton et al. \(2022b\)](#), who argue that stablecoin rates compensate for leveraged positions.

The inclusion of controls provides further insight into the role of broader market conditions. While devaluation risk is priced in interest rates, an ANOVA estimation (Appendix C) shows that market sentiment explains 21-23% of the variation in value-weighted borrowing and supply rates. In contrast, devaluation risk accounts for only 3.5%, and money market rates explain no more than 1%, with the remaining variation unexplained. Some of this unexplained variation may stem from liquidity mining programs, which incentivize investors to supply and borrow stablecoins through governance token rewards ([Park and Stinner, 2023](#)). These incentives can distort stablecoin rates, causing deviations from traditional money market dynamics.

Market sentiment, as proxied by the Crypto Fear and Greed Index, is positively associated with interest rates, consistent with traders borrowing stablecoins to finance speculative positions during periods of optimism ([Gorton et al., 2022b](#); [Chaudhary et al., 2023](#); [Barbon et al., 2023](#); [Cornelli et al., 2024](#)). This behavior aligns with studies showing how lending protocols are used to borrow stablecoins for leveraged trading in financial markets. As traders increase borrowing to finance such positions during periods of optimism, borrowing demand rises, driving up stablecoin interest rates.²⁹

Money market rates, however, exhibit a negative relationship with stablecoin interest rates in our sample, suggesting frictions in the integration between traditional money markets and DeFi platforms. While perfect integration would imply a one-for-one pass-through between USD risk-free rates and stablecoin interest rates, our results suggest otherwise. Stablecoin rates appear to operate in a segmented market, disconnected from

²⁹Stablecoin borrowing rates are algorithmically determined on lending protocols as a positive function of utilization. Increased borrowing raises utilization, which subsequently increases both borrowing and supply rates.

conventional financial markets.³⁰

Appendix D provides protocol-specific results for Compound and Aave v2, which confirm that devaluation risk is a key driver of stablecoin interest rates on both platforms. The effects are generally stronger for Compound, reflecting differences in liquidity conditions and investor behavior across the two protocols.

3.4 Deviations from CIP

Our analysis so far documents the disconnect between interest rates and futures prices in the stablecoin market on the one hand, and conditions in conventional financial markets on the other. To test integration between markets more concretely, we can measure deviations from CIP.

We use borrowing and lending rates for Tether, on DeFi lending protocols such as Compound and Aave, together with futures contracts to investigate the existence of such deviations. Equivalently, we can use them to construct the risk premium of holding Tether instead of the USD after hedging the exchange rate risk. The deviation from CIP is computed as in equation (10). It is the difference between a synthetic dollar rate $i_{\$,t}^{synthetic}$ and a direct dollar rate $i_{\$,t}$. The synthetic dollar rate can be constructed by converting dollars to Tether at spot rate s_t , lending Tether at $i_{usdt,t}$, and then re-converting Tether to dollars at maturity at the forward rate f_t . The horizon h is set at 90 days (3 months) for our analysis.

In a frictionless setting, we would expect interest rates to be equalized after hedging exchange risk using a futures contract. Therefore, the benchmark for efficient interest rate markets suggests that CIP deviations should be zero or within bounds governed by transaction costs such as gas fees (fees users pay to process transactions or use smart

³⁰Appendix D explores this further by examining the impact of Federal Reserve policy rate announcements on stablecoin interest rates, prices, and issuance. We find no significant response of borrowing or supply rates to Federal Open Market Committee (FOMC) announcements, consistent with segmented markets. However, higher interest rates are associated with declines in stablecoin prices and issuance, reflecting reduced demand for stablecoins as investors rebalance toward higher-yielding assets.

contracts) on the Ethereum blockchain.

$$CIP_t = i_{\$,t}^{synthetic} - i_{\$,t} \quad (10)$$

$$= \left(\left(\frac{f_t}{S_t} \left(1 + i_{usdt,t} \frac{h}{360} \right) - 1 \right) \times \frac{360}{h} - i_{\$,t} \right) \times 100 \quad (11)$$

Figure 6 plots the CIP deviation (along with the synthetic dollar interest rate and direct dollar rates). Deviations are persistently positive. The average CIP deviations based on borrowing and supply rates are 4.43 and 3.14 percentage points respectively. These indicate the existence of a risk premium embedded in stablecoin rates even after controlling for exchange risk using a futures contract. Note that the deviation narrows somewhat in the second half of the sample period, and is negative for CIP deviations based on supply rates towards the end of our sample.

3.4.1 Limits to Arbitrage in CIP Trade

Our explanation for the weak integration between stablecoin and traditional interest rates has primarily focused on market segmentation and the influence of leveraged trading on lending protocols. We now consider a second source of friction: limits to arbitrage in these markets. In a classic CIP arbitrage trade, money market rates in two currencies must share the same maturity. However, while money market rates are fixed for specific maturities, interest rates on lending protocols lack a term structure; interest accrues approximately every 15 seconds in block time on the Ethereum blockchain.

Because Tether interest rates are not fixed at a 3-month term like USD money market rates, there is no risk-free arbitrage profit in a standard CIP trade. To construct a synthetic dollar interest rate, an investor would need to lock funds in Tether for 3 months before reconverting to dollars at a forward rate, relying on the expected interest rate over that period. The positive premium on stablecoin rates over money market rates may partly reflect this interest rate risk.

Arbitrage between stablecoin interest rates and money market rates entails transaction

costs, given the need to move capital from financial intermediaries to DeFi platforms. These costs include gas fees, as noted above, analogous to commissions paid on exchanges. In this case these costs are paid to validators authenticating transactions on the Ethereum blockchain. Other costs of providing liquidity to stablecoin markets can include costs of liquidating debt. In addition there is the cost of supporting an off-ramp from Tether to USD in order to conduct a round-trip arbitrage trade. Retail investors need to access spot markets in USDT/USD on centralized cryptocurrency exchanges like Bitfinex. Processing lags for withdrawals of dollars on these exchanges are substantial, and fees are imposed when dollar withdrawals are frequent or large.³¹ Finally, counterparty risk on a futures exchange, including the risk of liquidations due to not posting sufficient margin, can also be a limit to arbitrage. This has been documented specifically for the BTC/USD pair (Schmeling et al., 2023).

3.5 Robustness Tests

3.5.1 Market-Based Measure of Partial Default: Comparison with Polymarket

While our baseline estimates focus on the probability of full default ($\underline{s} = 0$), our framework also yields materially higher probabilities of partial default. As shown in Panel D of Figure 3, the estimated probability of a 5% devaluation—that is, Tether trading at or below 95 cents—is 12.4 percentage points on an annualized basis.

These estimates are broadly comparable to other market-based indicators of partial default risk. For example, Polymarket has recently launched a prediction market on the likelihood of Tether de-pegging in 2025.³² The contract pays out if USDT trades below 98 cents for an entire 24-hour period on Coinbase at any point during 2025.³³

³¹For more information, refer to the following announcements by Bitfinex: <https://bit.ly/2NEzITW> and <https://www.bitfinex.com/posts/311>. Bitfinex states that it takes investors 7 to 15 days to make dollar withdrawals from their platform in order to comply with intermediation procedures. Bitfinex has also introduced a transaction cost of 3% for investors who make more than two dollar withdrawals a month, or for withdrawals of more than \$1 million in a given month.

³²<https://polymarket.com/event/usdt-depeg-in-2025>

³³Specifically, the market resolves to "Yes" if *all* one-minute candles for USDT-USD on Coinbase are below

When the market opened on January 1, 2025, the implied probability of de-pegging was 16% (Figure 7). By the end of March 2025, the price of a 'YES' token had declined to 14 cents, implying an annualized probability of approximately 18%. By comparison, our model yields an estimated devaluation probability of 31.1% annually when the threshold is set to $\underline{s} = 0.98$. While this suggests that Polymarket may be underpricing the risk of partial default, we caution that the resolution criteria used by Polymarket are relatively strict: the payout condition requires all trading intervals within a 24-hour period to remain below the 98 cent threshold. This restriction implies that transient deviations below parity—followed by quick reversion—would not trigger a payout. Our estimate, by contrast, captures the average pricing of devaluation risk over time and is sensitive to any observed discount, regardless of its persistence. This helps explain the differences between our estimates and those implied by the Polymarket trading platform.

3.5.2 USDT Perpetual Futures and Devaluation Risk

While the analysis so far has focused on the USDT/USD three-month futures contract to measure devaluation risk, another contract traded on the FTX exchange during this period is the USDT/USD perpetual futures contract. Perpetual futures provide a novel framework for evaluating devaluation risk, leveraging their absence of expiry dates and the use of funding rates to align futures prices with spot prices. These unique features make perpetual futures a valuable tool for gauging market sentiment in cryptocurrency markets (Chaudhary et al., 2023; Gorton et al., 2022b).

Appendix F utilizes the funding rate as an alternative proxy for measuring devaluation risk. Compared to three-month futures contracts, perpetual futures exhibit closer alignment with spot prices and significantly higher average daily trading volumes of 11.24 million USD. During periods of market stress, such as the Terra-Luna crash in May 2022, perpetual futures markets displayed heightened trading activity, more pronounced neg-

0.98000 (i.e., a high of 0.97999 or lower) for any 24-hour window between 01 Jan 2025 and 31 Dec 2025 (Eastern Time). A 24-hour period that begins on 31 December 2025 is also eligible.

ative funding rates, and a decline in the futures-spot basis. These negative funding rates reflect increased market pessimism about the stability of the USDT peg, contributing to heightened devaluation risk.

A robust negative correlation is identified between funding rates and devaluation risk derived from three-month futures contracts. Higher funding rates, indicative of greater confidence in the USDT/USD peg, correspond to lower devaluation risk. Additionally, we find the correlates of the funding rate include USDT velocity, Bitcoin volatility, and redemption activity, which are identified as determinants driving devaluation risk observed in the analysis of three-month futures contracts in Section 3.2.

3.5.3 USDC Perpetual Futures and Devaluation Risk

A similar robustness test is performed using USDC/USD perpetual futures, introduced on the Kraken exchange in late 2023. Perpetual futures for USDC share the same structural features as USDT perpetual futures, with funding rates serving as a mechanism to align futures prices with spot prices and as an indicator of market sentiment.

Appendix G provides a detailed analysis of USDC perpetual futures. These markets exhibit significantly lower liquidity, with average daily trading volumes of just 3,920 USD compared to USDT's 11.24 million USD. Additionally, USDC funding rates are more volatile, averaging -0.15%.

The determinants of USDC funding rates are less robust. Velocity remains a significant factor, but Bitcoin volatility shows weak significance, and redemption activity does not meaningfully affect funding rates. These differences arise due to several factors. First, USDC markets are far less liquid, limiting price discovery and market efficiency. Second, USDC maintained a stable peg throughout the sample period (December 2023 to December 2024), with minimal redemption activity or market stress. Third, the asset composition of USDC reserves is substantially different. USDC reserves are fully backed by highly liquid assets such as U.S. Treasury securities, repurchase agreements, and segregated

cash, ensuring stronger market confidence.³⁴

In contrast to USDT, the absence of significant market stress events for USDC reduces the explanatory power of funding rate determinants. This suggests that, for USDC, our measure of devaluation risk is less informative under the relatively stable market conditions observed during the sample period.

4 Conclusion

4.1 Summary

Stablecoins are integral to the cryptocurrency ecosystem, facilitating the purchase and sale of cryptoassets at lower cost than national currencies and serving as vehicles for remittances and cross-border transactions. Popular stablecoins depend on centralized custodians holding assets off-chain. When collateralization is partial and less liquid, this can prompt mass withdrawals, risking suspension of convertibility and collapse of the peg.

This paper presents a market-based measure of devaluation probabilities using futures for Tether, the dominant stablecoin. On average, the probability of full default, defined as a complete collapse of the peg, is priced at 60 basis points annually, with significant time variation that can spike during periods of stress. We also quantify partial default risk, estimating an annualized probability of 12.4 percentage points for a 5% devaluation (i.e., trading at or below 95 cents).

Several factors contribute to devaluation risk, including market risks like BTC volatility and network characteristics such as transaction velocity and investor redemptions, which can lead to run-like behavior on stablecoins.

³⁴USDC reserves are composed of highly liquid assets, including U.S. Treasury securities, repurchase agreements, and cash held in Circle Reserve Funds and segregated accounts at regulated financial institutions. As of November 2024, total reserves were \$39.48 billion (November 27) and \$39.80 billion (November 29), exceeding USDC in circulation and ensuring 1:1 backing. See <https://www.circle.com/transparency> for more details.

Stablecoin interest rates price devaluation risk. However, we identify a disconnect between stablecoin markets and traditional financial markets. Stablecoin rates are more influenced by market sentiment and devaluation risk than by conventional money market rates. Even after hedging exchange rate risk using futures contracts, stablecoin rates remain systematically higher, violating CIP. Factors contributing to the weak integration of stablecoin and traditional markets include market segmentation, lack of term structure in DeFi interest rates, and transaction costs of arbitrage.

Our findings are robust to alternative specifications, including the use of perpetual futures and comparison with market-based probabilities from Polymarket.

4.2 Policy Implications

While stablecoins primarily facilitate leveraged trading within cryptocurrency markets, their broader adoption for cross-border and financial transactions could significantly impact traditional financial markets, raising concerns for investors, regulators, and policymakers.

For investors, our work highlights the importance of understanding run-risk determinants and addressing frictions in segmented money markets that contribute to stablecoin vulnerabilities. Enhancing redemption processes and integrating stablecoin interest rate markets more effectively would attract arbitrage capital, helping to maintain the peg. Tracking devaluation risk offers a practical way to assess stablecoin stability and guide investment decisions.

For regulators, our findings emphasize the need for a robust framework to address systemic risks.³⁵ Europe's MiCA, introduced in December 2024, takes steps toward this goal by imposing strict reserve management requirements, enhancing transparency, and mandating operational and prudential standards for issuers. By clarifying the treatment of crypto-assets and custodial risk, it aims to reduce vulnerabilities in the stablecoin

³⁵For more details, see Appendix A.

ecosystem.

While MiCA provides a strong regulatory foundation, private-sector innovations can enhance stability and trust. For example, TrueUSD's real-time reserve audits via Chainlink, implemented in February 2023, ensure that new tokens are issued only when reserves are verified. Such initiatives provide practical models for improving governance in the stablecoin ecosystem.

Further measures could include capital requirements, central bank support, or insurance mechanisms to protect users. Policymakers might also encourage alternative stablecoin designs, such as tokenized deposits or reserve-backed tokens, which combine central bank-backed stability with private digital currency features, addressing liquidity and redemption risks ([Garratt and Shin, 2023](#); [Goel, 2024](#)).

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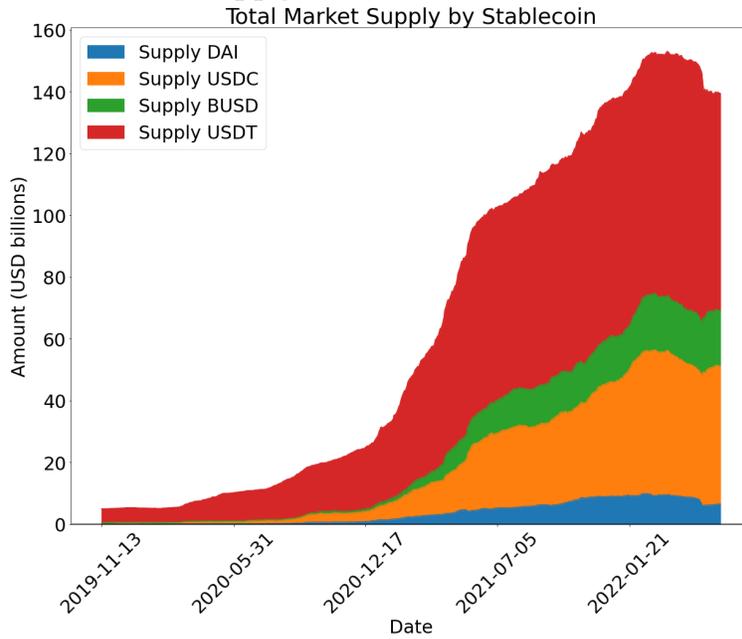
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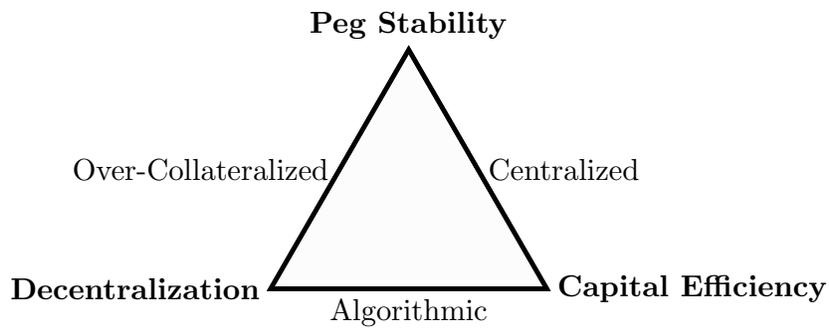
Figures

Figure 1: Stablecoin Ecosystem

Panel A: Total supply of DAI, USDC, BUSD, and USDT

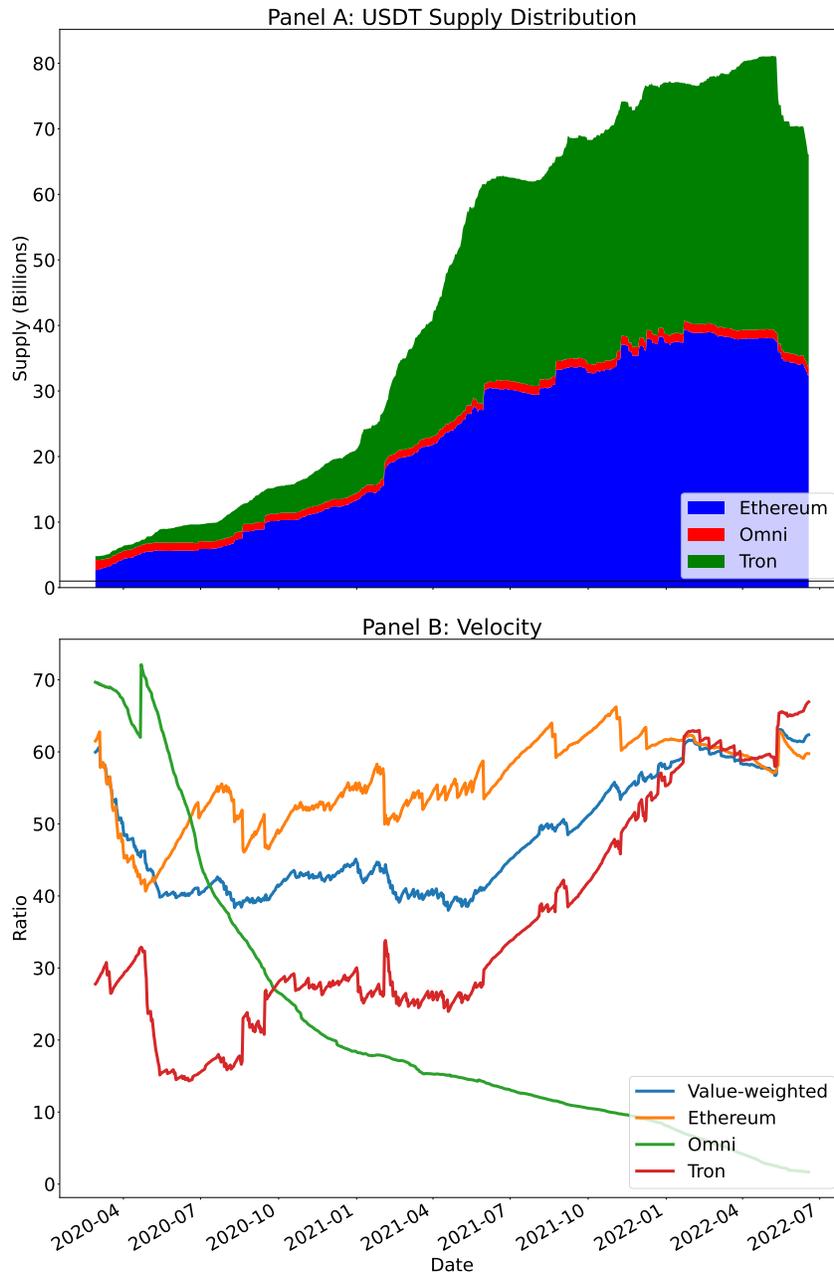


Panel B: Stablecoin Trilemma



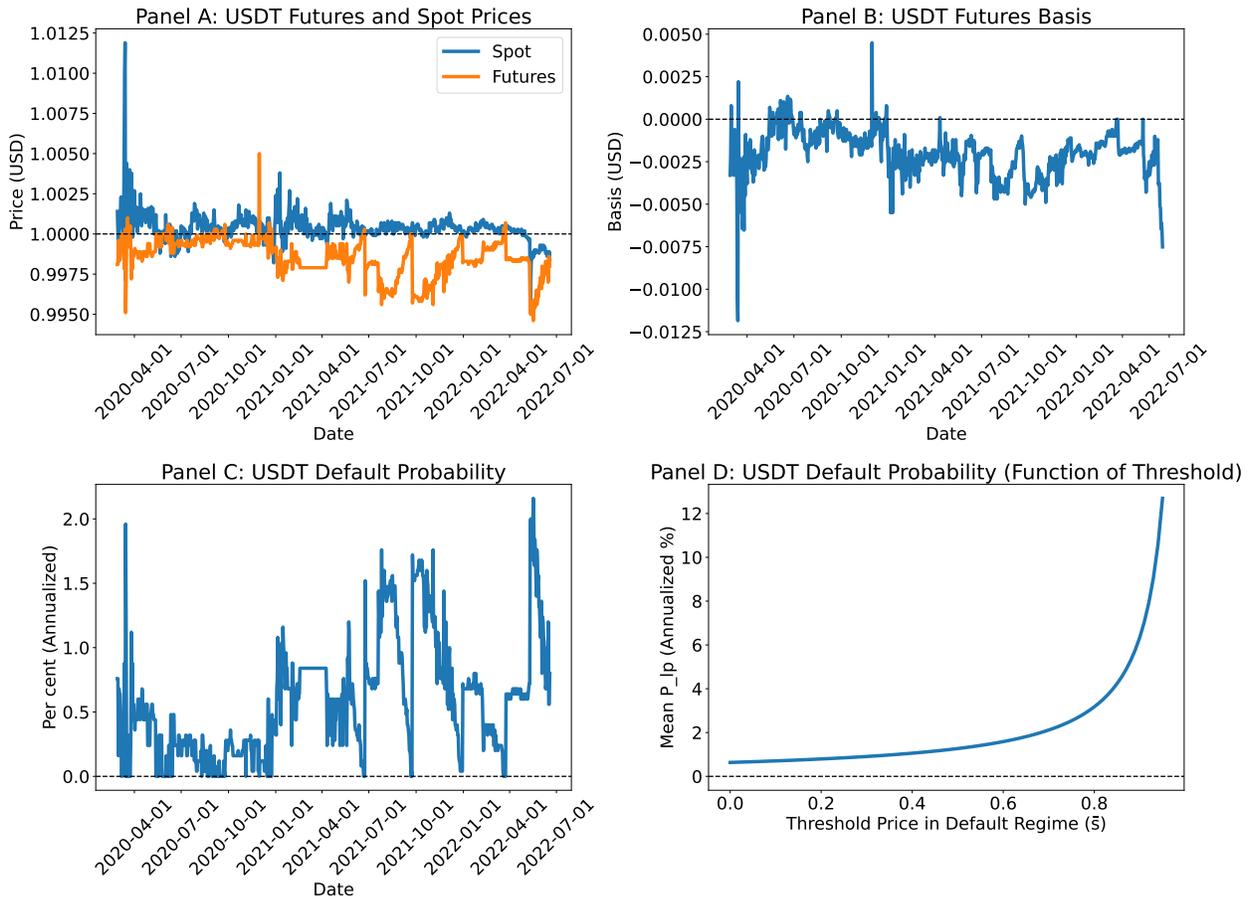
Note: Panel A reports the aggregate free float supply of stablecoins Tether (USDT), USDC, BUSD and DAI, in Billions USD. Panel B reports the trilemma, which states that stablecoins face a trade-off between three objectives: peg stability, decentralization, and capital efficiency. Stablecoin designs can be categorized into centralized, over-collateralized (decentralized), and algorithmic stablecoins based on which objectives they achieve.

Figure 2: Stablecoin Network Characteristics



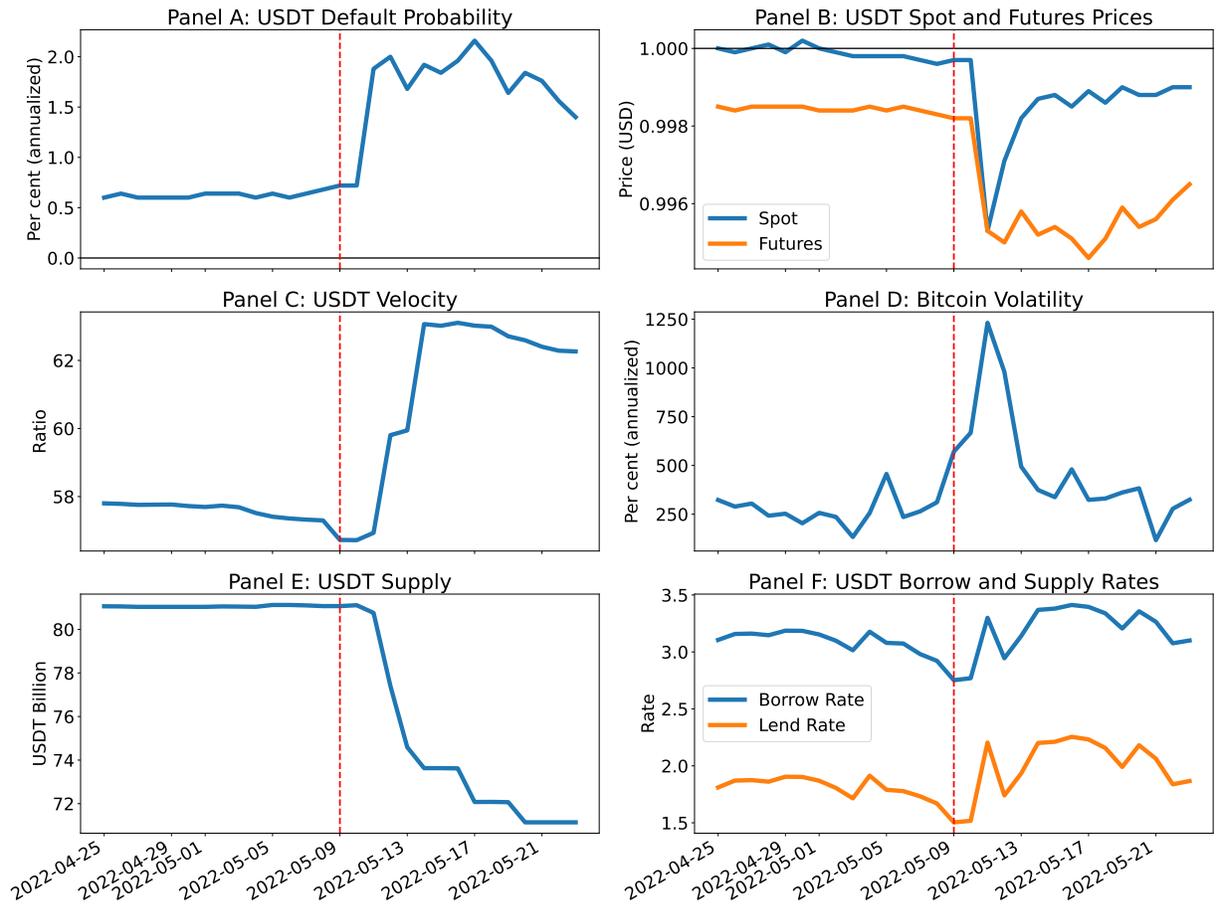
Note: Panel A reports the total free float supply of Tether across blockchains Omni, Tron and Ethereum, in Billions USD. Panel B reports the velocity of Tether transactions on Omni, Tron and Ethereum blockchains. Free float supply is measured as Tether in circulation held by wallets net of Treasury balances. Velocity is defined as the ratio of the value transferred (i.e., the aggregate size of all transfers) divided in the last year to date. It can be interpreted as the number of times that an average native unit has been transferred in the past 1 year.

Figure 3: USDT Futures and Spot Prices on FTX Exchange



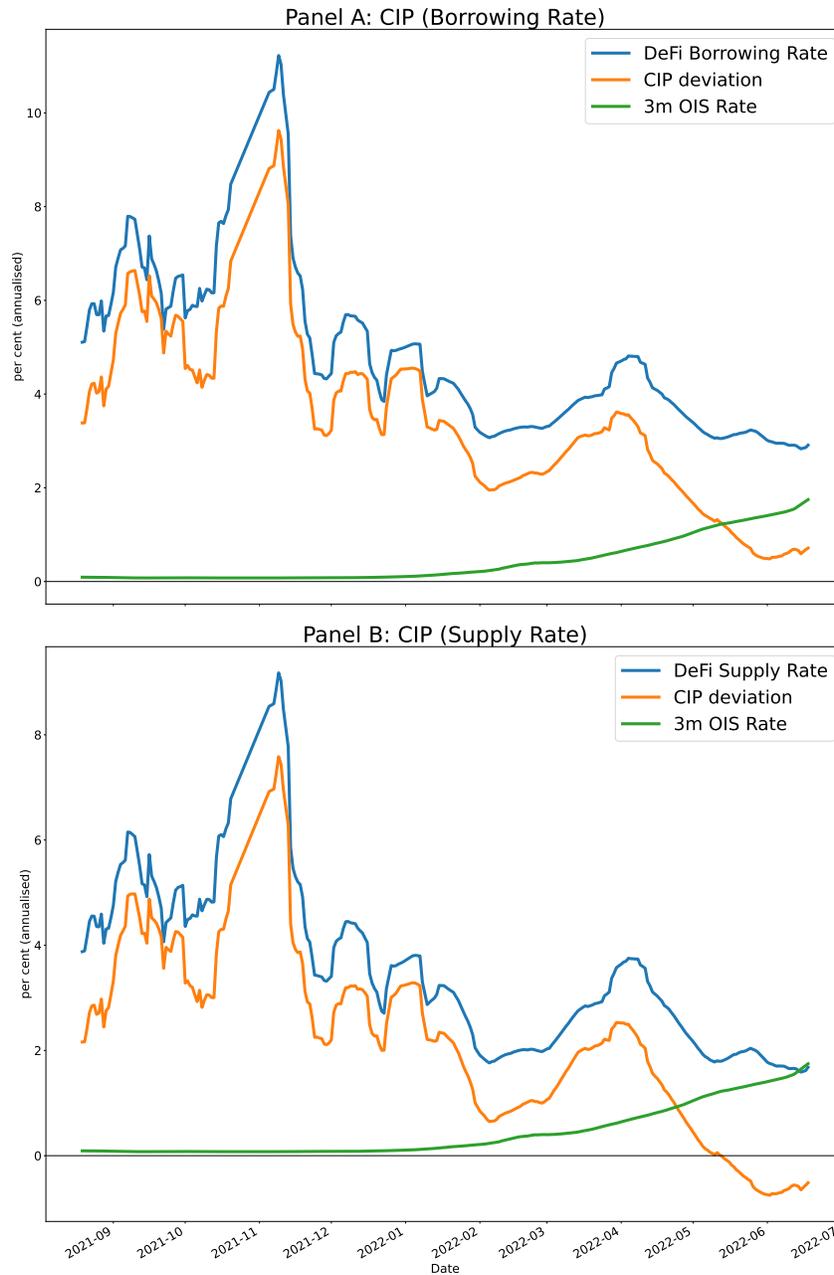
Note: This figure presents time series of futures, spot and devaluation risk probabilities for the USDT/USD pair. Panel A reports USDT futures and spot prices on the FTX exchange. Panel B reports the difference between futures and spot prices, which is referred to as the basis. Panel C plots implied default probabilities based on spot, futures prices and the average mean reversion coefficient, for threshold value $\bar{s} = 0$ in default state. Panel D plots average default probability over the sample period conditional on different values of \bar{s} in the default state. For panels A to C, the sample runs from February 28th, 2020, to June 18th, 2022.

Figure 4: Event Study: USDT Peg Collapse May 2022



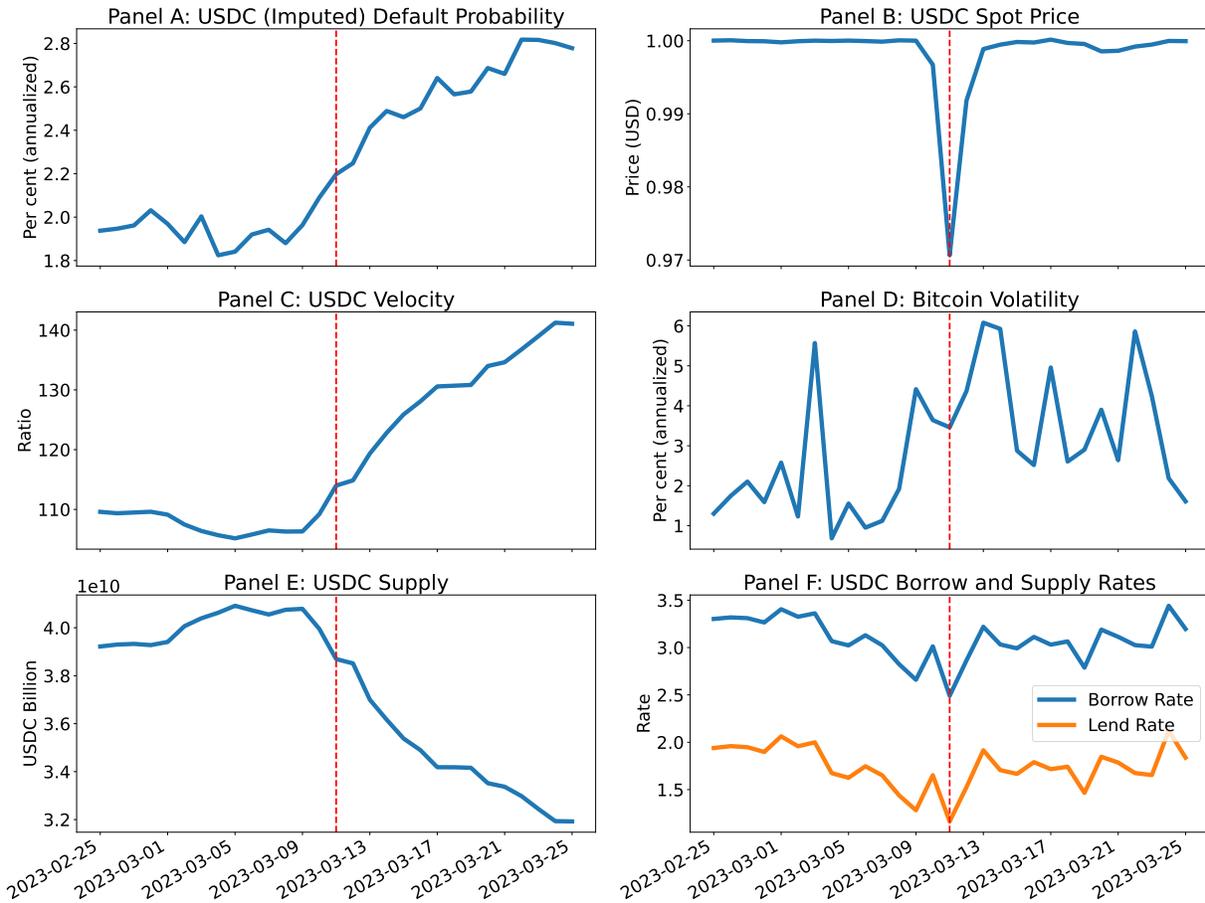
Note: This figure presents event study results for various variables during a window of one week before and after the USDT peg collapse in May 2022. The vertical dotted line marks the beginning of the Terra Luna crash on May 9th, 2022, with the USDT peg collapse occurring on May 12th, 2022. Panel A shows the USDT default probability, while Panels B, C, and E display USDT spot prices, velocity, and supply, respectively. Panel D reports Bitcoin volatility. Panel F presents USDT borrow and supply rates, calculated as value-weighted averages from Compound and Aave2, based on the aggregate liquidity supplied in each protocol.

Figure 6: Money Market, Stablecoin Rates and Deviations of CIP



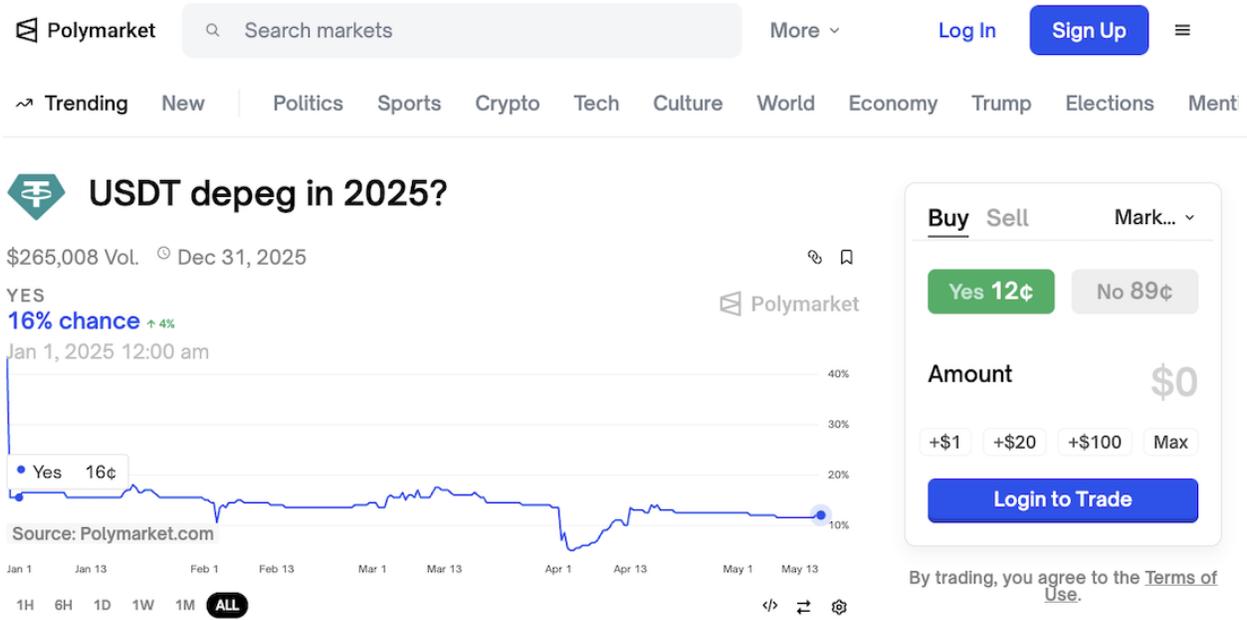
Note: Figure plots USDT supply and borrow rates, USD money market (3m OIS) and CIP deviations. Panel A measures CIP deviations based on borrow rates, and Panel B measures CIP deviations based on supply rates. CIP deviations are equal to the difference between stablecoin and USD rates after hedging exchange rate risk with a futures contract. All rates are a 14 day rolling average, and annualized. The sample runs from August 5th 2021 to June 18th, 2022.

Figure 5: Event Study: USDC Crash March 2023



Note: Figure reports event study for various variables during a window of 1 week before and after the USDC peg collapse in March 2023. The vertical line is the day of USDC peg collapse, which is 11th March 2023. Panel A plots the USDC imputed default probability, based on observables of USDC velocity, redemptions and Bitcoin volatility. USDC spot prices, velocity and supply are reported in Panels B, C and E. Bitcoin volatility is reported in Panel D. USDC borrow and supply rates are reported in Panel F, which are value-weighted average of rates in Compound and Aavev2 based on the aggregate liquidity supplied in each protocol.

Figure 7: Polymarket-Implied Probabilities of USDT De-pegging in 2025



Note: Figure plots the daily price of the Polymarket prediction contract on whether Tether (USDT) will de-peg from the U.S. dollar in 2025. The contract resolves to "Yes" if, at any time in 2025, all 1-minute Coinbase USDT-USD candles within a 24-hour period close below 98 cents. Prices are interpreted as market-implied probabilities. Data accessed from Polymarket: <https://polymarket.com/event/usdt-depeg-in-2025>.

Tables

Table 1: Q1 2023 Tether Attestation: Consolidated Reserves Report

Assets	Amount (USD Billion)	% Balance Sheet
US T-Bills	53.04	64.78%
Overnight Reverse Repo Agreements	7.50	9.17%
Term Reverse Repo Agreements	0.79	0.97%
Money Market Funds	7.45	9.08%
Cash and Bank Deposits	0.48	0.59%
Non-U.S. T-Bills	0.05	0.06%
Cash or Cash Equivalents Sub-Total (1)	69.31	84.65%
Corporate Bonds	0.14	0.17%
Precious Metals	3.39	4.14%
Bitcoin	1.50	1.83%
Other investments	2.14	2.62%
Secured loans	5.35	6.54%
Non-Cash or Cash Equivalents Sub-Total (2)	12.52	15.35%
Total (1)+(2)	81.83	100.00%

Note: This table presents Tether attestation by accounting firm BDO for Quarter 1 2023. Balance sheet breaks down all assets held by Tether into categories. For more details and the full attestation, see Tether's press release ([link](#)).

Table 2: Variables used in Regression Analysis

Variable	Description
s	Closing spot price of USDT in units of USD.
f	Closing future price of USDT in units of USD.
$f_t - s_t$	The difference between spot and future price of USDT, referred to as the futures-spot basis.
$BidAsk_{px}$	The difference between bid and ask future price of USDT, referred to as the bid-ask spread, measured in basis points.
$\mathcal{P}_{baseline}$	The probability of default of USDT based on the baseline specification in equation (7), measured in percentage points.
\mathcal{P}_{lin}	The probability of default of USDT based on linear interpolation, measured in percentage points.
Velocity	The ratio of the value transferred (i.e., the aggregate size of all transfers) divided in the last year to date. It can be interpreted as the number of times that an average native unit has been transferred in the past 1 year.
σ_{BTC}	BTC volatility, calculated as the square root of the sum of square hourly returns over a daily interval, measured in percentage points.
$D_{Redemption}$	Takes value of 1 if there is a decline in the free float supply of USDT compared to the previous day, and 0 otherwise.
i_{USDT}^{borrow}	USDT borrow rate (annualized). Value-weighted average of USDT rates on Compound and Aavev2, measured in percentage points.
i_{USDT}^{supply}	USDT supply rate (annualized). Value-weighted average of USDT rates on Compound and Aavev2, measured in percentage points.
FG_{index}	Crypto fear and greed index measures market sentiment by analyzing factors such as volatility, market volume, and social media.
i_{USD}	USD 3 month OIS interest rate, measured in percentage points.

Table 3: Summary Statistics

	Mean	Std	25%	50%	75%	Min	Max	Count
s (USD)	1.000	0.001	1.000	1.000	1.001	0.995	1.012	842
f (USD)	0.999	0.001	0.998	0.999	0.999	0.995	1.005	791
Basis (USD)	-0.002	0.001	-0.003	-0.002	-0.001	-0.012	0.004	791
f_{bid} (USD)	0.998	0.001	0.998	0.999	0.999	0.991	1.003	794
f_{ask} (USD)	0.999	0.001	0.998	0.999	1.000	0.995	1.007	794
$BidAsk_{px}$ (bps)	3.770	5.002	1.000	2.000	5.000	1.000	81.000	794
Volume (USDT Million)	0.345	1.420	0.000	0.031	0.197	0.000	26.861	792
$\mathcal{P}_{baseline}$ (%)	0.573	0.459	0.240	0.520	0.720	-0.000	2.160	791
\mathcal{P}_{lin} (%)	0.621	0.506	0.240	0.600	0.771	-0.000	3.646	791
Velocity	48.072	7.834	40.917	44.580	56.405	38.000	63.105	842
$D_{Redemption}$	0.189	0.392	0.000	0.000	0.000	0.000	1.000	842
σ_{BTC} (%)	3.284	1.922	2.128	3.041	3.892	0.000	16.599	842
i_{borrow}^{USDT} (%)	4.911	3.221	3.321	3.979	4.891	2.244	36.808	318
i_{supply}^{USDT} (%)	3.620	2.839	2.051	2.917	3.830	1.024	32.093	318
FG_{index}	48.385	26.032	24.000	44.000	73.000	6.000	95.000	842
i_{USD}^{OIS} (%)	0.229	0.371	0.075	0.080	0.095	0.044	2.022	842
cip_{borrow}^{USDT} (%)	4.426	3.423	2.858	3.632	4.589	0.269	36.571	317
cip_{supply}^{USDT} (%)	3.139	3.057	1.582	2.575	3.540	-0.950	31.876	317

Table 4: Determinants of Probability of Default

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	\mathcal{P} (baseline)				\mathcal{P} (linear interpolation)			
Velocity	0.024*** (0.003)			0.024*** (0.002)	0.030*** (0.003)			0.028*** (0.003)
σ_{BTC}		0.032*** (0.010)		0.034*** (0.009)		0.060*** (0.015)		0.060*** (0.012)
$D_{redemption}$			0.227*** (0.052)	0.078* (0.047)			0.357*** (0.069)	0.169*** (0.053)
$BidAsk_{px}$	-0.004 (0.004)	-0.005 (0.005)	-0.003 (0.004)	-0.005 (0.004)	-0.007* (0.004)	-0.008 (0.005)	-0.005 (0.004)	-0.007* (0.004)
Intercept	0.577*** (0.025)	0.486*** (0.042)	0.540*** (0.030)	0.451*** (0.036)	0.633*** (0.027)	0.455*** (0.051)	0.569*** (0.029)	0.404*** (0.045)
R-squared	0.176	0.022	0.040	0.205	0.212	0.059	0.082	0.292
Nr. obs.	791	791	791	791	791	791	791	791

Note: This table uses a regression analysis to identify determinants of USDT default probability. Columns (1) to (4) use the baseline value of devaluation risk estimated in equation (7). Columns (5) to (8) use a measure of devaluation risk based on linear interpolation of futures contracts. Both measures are measured in percentage points. $Velocity$ is the ratio of the value transferred (i.e., the aggregate size of all transfers) divided in the last year to date, with the mean subtracted to account for average activity. It can be interpreted as the number of times that an average native unit has been transferred in the past year, relative to the mean. σ_{BTC} is the intra-day volatility of BTC, measured in percentage points. $D_{redemption}$ is equal to 1 if there is a decline in the free float supply of USDT compared to the previous day, and 0 otherwise. $BidAsk_{px}$ measures the bid-ask spread of the USDT-USD 3 month futures contract, reflecting its market liquidity, in basis points. The sample specification is from February 28th, 2020, to June 18th, 2022. Newey-West standard errors, which adjust for heteroscedasticity and autocorrelation, are reported in parentheses. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table 5: USDT Interest Rates and Devaluation Risk

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	i_{supply}^{USDT}				i_{borrow}^{USDT}			
\mathcal{P} (baseline)	1.109*** (0.427)	0.511* (0.301)			1.254*** (0.482)	0.576* (0.347)		
\mathcal{P} (linear interpolation)			0.643* (0.370)	0.745*** (0.237)			0.752* (0.412)	0.836*** (0.270)
FG_{Index}		0.051*** (0.009)		0.049*** (0.009)		0.057*** (0.011)		0.055*** (0.011)
i_{USD}		-0.817*** (0.198)		-1.079*** (0.214)		-0.802*** (0.222)		-1.094*** (0.243)
Intercept	2.681*** (0.305)	1.566*** (0.411)	3.016*** (0.295)	1.508*** (0.384)	3.849*** (0.342)	2.558*** (0.465)	4.204*** (0.326)	2.494*** (0.435)
R-squared	0.036	0.279	0.015	0.289	0.035	0.259	0.016	0.269
Nr. obs.	317	317	317	317	317	317	317	317
Controls	X	✓	X	✓	X	✓	X	✓

Note: This table presents a regression analysis of the determinants of USDT interest rates. Columns (1)-(4) report results for supply rates, and (5)-(8) for borrow rates. Rates are value-weighted averages from Aavev2 and Compound. \mathcal{P} measures devaluation risk. Standard errors are Newey-West robust. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Internet Appendix to

"Stablecoin Devaluation Risk"

(Not for publication)

We provide a roadmap of each section of our Appendix.

1. Appendix **A** explores stablecoin risk management solutions, including private sector approaches such as proof-of-reserve systems and potential government regulations.
2. Appendix **B** documents liquidity statistics for USDT/USD 3-month futures, focusing on bid-ask spreads and trading volumes.
3. Appendix **C** highlight the contribution of determinants of devaluation risk and interest rates using an ANOVA analysis.
4. Appendix **D** present additional results on Compound and Aave2 interest rates, and decomposes interest rates using ANOVA to highlight the contribution of devaluation risk and other factors to borrow and supply rates on Compound and Aavev2.
5. Appendix **E** provides a summary of Tether's quarterly attestation reports, including an event study of market reactions to these reports.
6. Appendix **F** investigates the use of USDT perpetual futures as an alternative measure of devaluation risk. It includes a summary of perpetual futures market dynamics, scatter plots of funding rates, and determinants of the funding rate.
7. Appendix **G** shifts the focus to USDC/USD perpetual futures, examining their market characteristics and applicability as a devaluation risk measure.

Appendix A: Stablecoin Risk Management Solutions

A.1 Private Sector Solutions

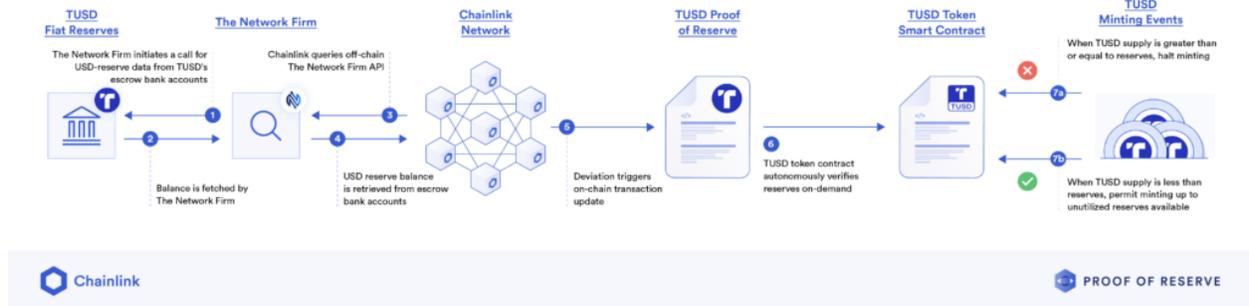
One possibility for minimizing devaluation risk is real-time audits by a third party proof-of-reserve system. Third party verification of stablecoin collateral at a block-time frequency would provide more transparency on the value of collateral. Real-time auditing can also mitigate the risk of an issuer absconding with funds held off-chain by providing an early alert.

An example is the proof of reserve system provided by the blockchain firm Chainlink.³⁶ Chainlink conducts automated audits designed to help prevent systemic failures in DeFi applications. A stablecoin that uses Chainlink's proof of reserve is TrueUSD. On February 23rd, 2023, TrueUSD (TUSD) partnered with Chainlink to verify its minting of new stablecoin tokens in real time.

Figure A1 is a schematic. First, Network Firm (an accounting firm) initiates a call for USD-reserve data from TUSD's escrow bank accounts. Network Firm is an oracle, an entity that brings data from off the blockchain (off-chain) data sources, such as the reserves held by TrueUSD in bank accounts. It then transfers this onto the blockchain for use by smart contracts, which are auto-executing code. The use of oracles is necessary because smart contracts running on the Ethereum blockchain cannot access information stored outside the blockchain network.

³⁶([link](#))

Figure A1: Chainlink Proof of Reserve



Note: Schematic documents the proof of reserve for TUSD minting events. In the first step, the Network Firm (An accounting firm) initiates a call for USD-reserve data from TUSD's escrow bank accounts. Chainlink queries the Network Firm API to determine the balance from escrow bank accounts. This triggers an update on the blockchain. The TrueUSD smart contract is hard wired to only mint TUSD tokens when the supply is less than reserves held off-chain.

Once the new balance of reserves held in escrow accounts is verified, Chainlink triggers an update on the blockchain. The TrueUSD smart contract, which is auto-executing, mints or burns tokens based on the change in the value of reserves it receives from Chainlink's proof of reserve. In particular, minting of new tokens can only occur once Chainlink verifies that the reserve balances held at the escrow accounts have increased.

This proof of reserve system addresses some of the factors creating stablecoin devaluation risk. First, it ensures that the minting of new tokens is tied to reserves and enforces full collateralization at all times. There can still be a run on the stablecoin if investors want out, but there will now be sufficient reserves to meet all redemption requests at par in all states of the world. And since reserves are sufficient to meet redemption requests, the risks of a run are likely to be less.

Second, this is a significant improvement over the existing transparency measures of the largest stablecoins Tether and USDC, which provide attestation reports at monthly or quarterly frequencies. Auditing of assets in block-time by a proof-of-reserve system is at a much higher frequency.

Third, investors can more readily verify the liquidity and riskiness of the assets held by the issuer. If the issuer holds U.S. Treasury securities, the CUSIPs of those individual

Treasuries can be verified by the oracle.

A concern is oracle risk, in other words, insufficient quality or misreporting of data received by the oracle on reserves held in escrow accounts. Chainlink requires multiple oracles to achieve consensus on the value of reserves held by the issuer.³⁷ At the time of writing in May 2023, 16 different companies (and oracles) validate the reserves held by TrueUSD. Chainlink only updates the level of reserves held by TrueUSD when there is consensus among the oracles on the network.

Third-party auditing is only as reliable as the third-party auditor, in this case Chainlink. Questions about the reliability of such auditors have given rise to calls for government regulation, to which we now turn.

A.2 Government Regulations

Recent analysis by the Bank of England suggests a regulatory framework for mitigating stablecoin devaluation risk (BOE, 2021).³⁸ It points to the need for capital requirements, for the issuer to maintain a sufficiently high fraction of high-quality liquid assets (HQLA) in its reserve portfolio. Second, it suggests that the central bank can provide liquidity support to meet redemptions. This can be provided through access to the central bank discount window facilities used by banks. Third, central banks can provide arrangements for stablecoin users to access their funds in the event that a stablecoin fails. This can be through providing full or partial insurance of customer holdings.

One suggestion is for issuers to be required to meet the capital requirements imposed by Basel regulations on internationally active banks (Catalini and Shah, 2021; Liao, 2022). Some will argue that stablecoin issuers, or at least some of them, have already moved in this direction. For example, Caramichael and Liao (2022) show that USDC has a historically

³⁷In technical parlance, Chainlink introduces the concept of decentralized oracle networks. This avoids the risk of a centralized entity controlling an oracle or potentially manipulating the smart contract. For more details we refer readers to <https://blog.chain.link/what-is-the-blockchain-oracle-problem/>

³⁸For more information, refer to the BOE report on stablecoins <https://www.bankofengland.co.uk/paper/2021/new-forms-of-digital-money>

high level of HQLA based on liquidity coverage ratio calculations. The authors find that USDC has at least two times the amount of HQLA as traditional banks, when benchmarked against historical gross outflows over a 30-day ahead period.

The European Union's Markets MiCA, set to come into force in December 2024, complements these approaches by introducing a comprehensive regulatory framework for stablecoins and other crypto-assets. MiCA emphasizes requirements for reserve composition, operational resilience, and transparency, aiming to reduce custodial and systemic risks.

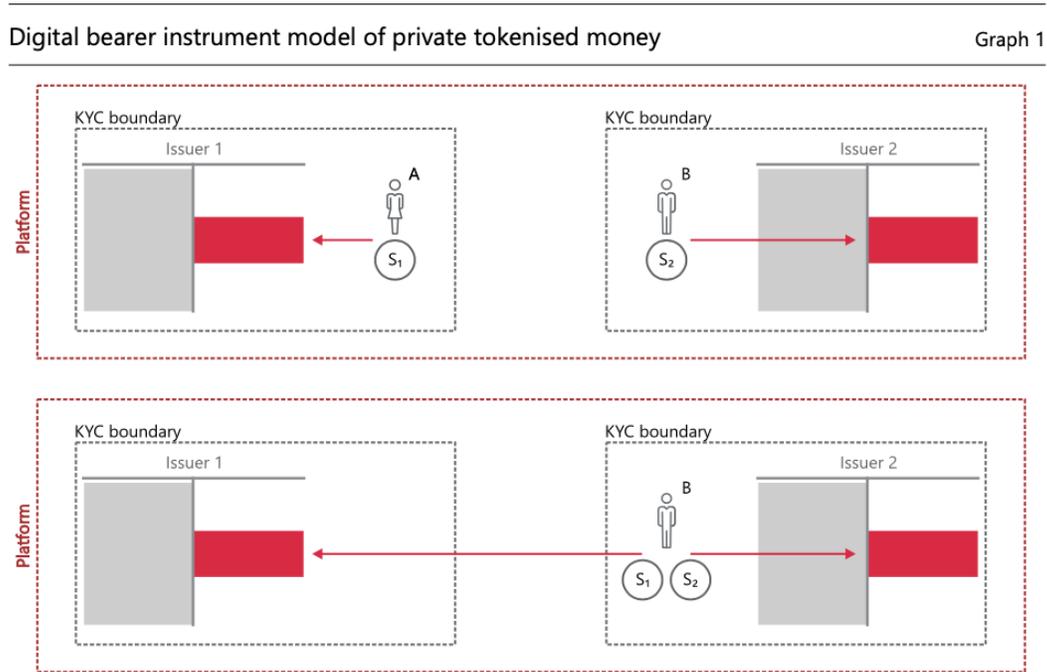
A.3 Alternative Stablecoin Designs

Policy-makers have suggested alternative arrangements to address stablecoin devaluation risk. These alternatives, namely tokenized deposits and reserve-backed tokens, aim to enhance the stability and reliability of existing stablecoin designs.

A.3.1 Tokenized Deposits

Stablecoins as currently designed follow the bearer instrument model (Figure A2). In this case, transfers between users (individuals A and B in the Figure) can occur without the issuer's consent, allowing the new holder to become the owner of the issuer's liability. Tokens circulate as transferable financial assets with market prices that may fluctuate. Exchange rates can deviate from par due to settlement frictions, and their stability largely depends on the credibility of the issuer's promise. The maintenance of singleness in value is contingent not only on the creditworthiness of the issuer but also on shared confidence in the value of the money.

Figure A2: Bearer Instrument Model

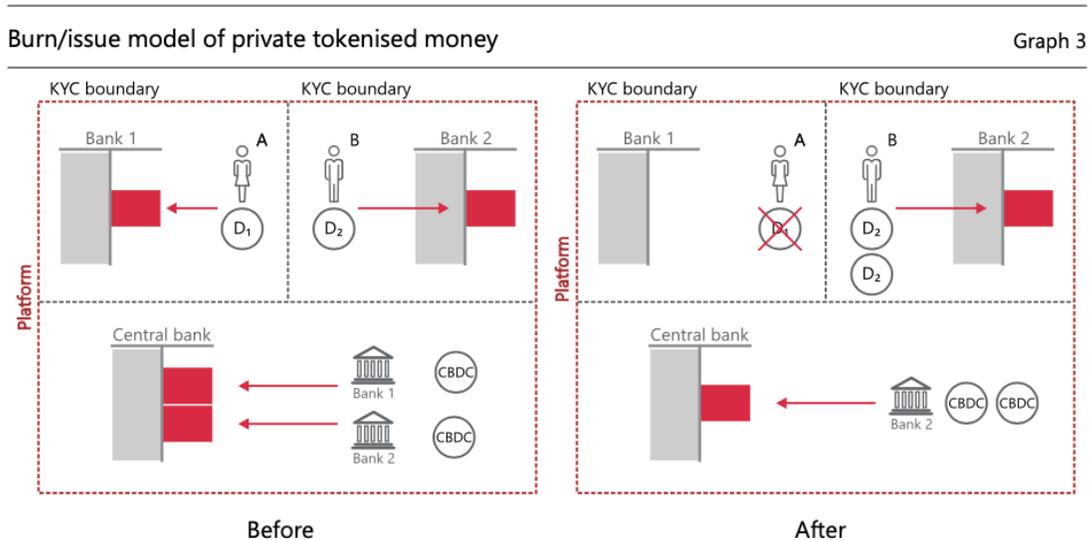


Source: [Garratt and Shin \(2023\)](#)

In contrast, Tokenized deposits, as proposed by [Garratt and Shin \(2023\)](#), present a model where private money tokens act as a transferable claim on the issuer, functioning without updating the issuer's balance sheet during regular transfers. This model stipulates that tokens representing an issuer's liability are not directly transferable outside the Know Your Customer (KYC) boundary, and follows a non-bearer instrument model, as shown in Figure A3. Payments involve debiting the sender's account, crediting the receiver's account, and settling on the central bank's balance sheet. Within the same issuer's platform, customers can transfer tokens amongst themselves, addressing singleness concerns. This payment method modifies liabilities between banks and customers without introducing credit exposures across institutions. Central bank digital currency (CBDC) ensures settlement in central bank money, eliminating doubts about exchange value and maintaining singleness. In summary, Tokenized deposits are proposed as a solution to achieve singleness, offering an alternative to the bearer instrument model currently used

by stablecoins.

Figure A3: Tokenized Deposit Model



Source: Garratt and Shin (2023)

A.3.2 Reserve-Backed Tokens

Reserve-backed tokens (RBT), as discussed by Goel (2024), allow issuers to hold asset reserves with a central bank, enhancing peg stability and obligating the issuer to function as a narrow bank. This structure also facilitates easier redemption processes. The overall risk associated with RBTs depends on the transfer model, particularly if tokens are traded in secondary markets where they can deviate from par.

Figure A4 illustrates the creation of RBT using the balance sheets of the issuer and central bank before and after the transaction. When an issuer creates new tokens, they are supplemented by traditional reserves held with the central bank. As users switch from holding deposits with a private bank to holding them with an RBT issuer, there is a corresponding contraction in the bank's balance sheet.

RBTs offer several advantages, including reducing the impact on balance sheets during redemptions, ensuring issuer independence from custodians, and mitigating risk through full backing by safe assets. Additionally, the simplified structure of RBTs facilitates more

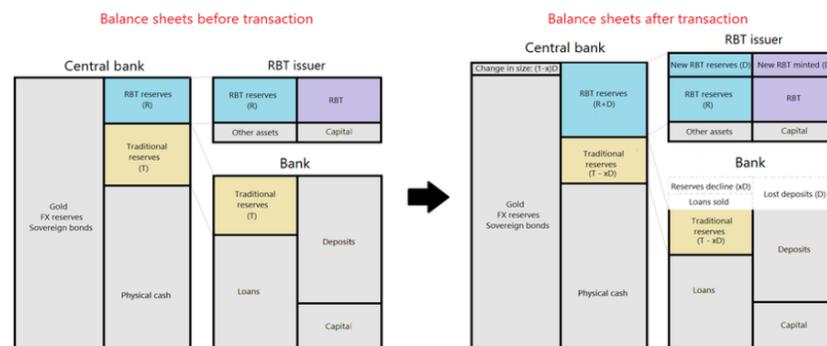
effective regulation, ensuring compliance with financial standards and improving overall market integrity.

The Bank of England also discusses a related scenario where stablecoin issuers hold central bank digital currency (CBDC), the ultimate HQLA, as reserves. In exchange for granting access to these reserves, the central bank could audit the stablecoin issuer's balance sheet and impose capital and liquidity requirements. Holding CBDC reserves increases the likelihood that stablecoin providers can maintain the value of their tokens at par, as they would have sufficient funds to process redemptions (Martin, 2022). If reserves are inadequate, the issuer could borrow from the central bank against high-quality but illiquid collateral, with customer holdings potentially guaranteed up to a specified limit.

In this scenario, the central bank effectively regulates the stablecoin issuer similarly to banks, as recommended by Gorton and Zhang (2024). However, if a stablecoin issuer is regulated as a narrow bank, it is unclear how it could compete with existing fractional reserve banks. If regulated like existing banks, the primary difference might be its deposit base and transactions technology.

In conclusion, both tokenized deposits and reserve-backed tokens address devaluation risks associated with current stablecoin designs. Tokenized deposits ensure the singleness of value within a platform, while RBTs provide enhanced stability through central bank-backed reserves.

Figure A4: RBTs Balance Sheet

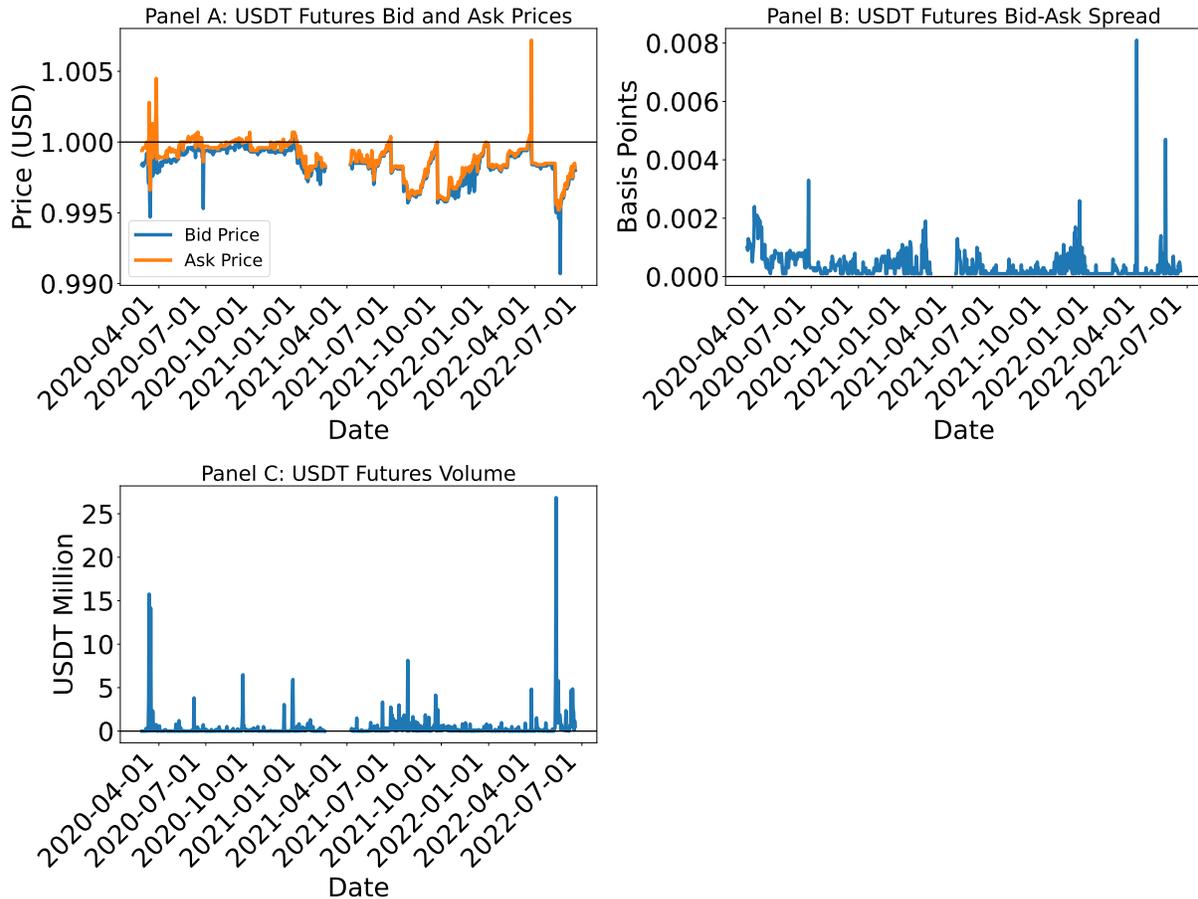


Note: An illustration of how the various balance sheets could adjust when bank deposits are converted to RBTs.

Source: Goel (2024)

Appendix B: Market Liquidity USDT/USD 3 Month Futures

Figure A5: USDT Bid-Ask Prices and Volume on FTX Exchange



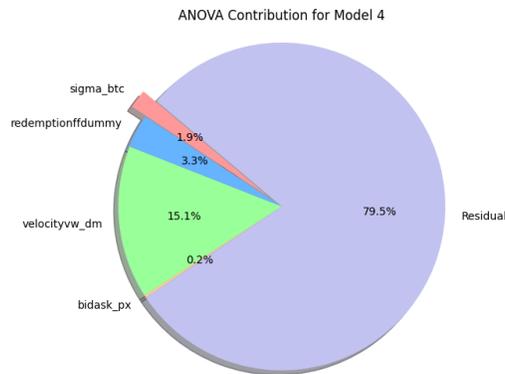
Note: Panel A reports USDT bid and ask prices for the USDT/USD 3 month futures contract on the FTX exchange. Panel B reports the bid ask spread, which is defined as the difference between ask and bid prices, in basis points. Panel C reports the trading volume in USDT Million. The sample runs from February 28th, 2020, to June 18th, 2022

Appendix C: ANOVA Analysis

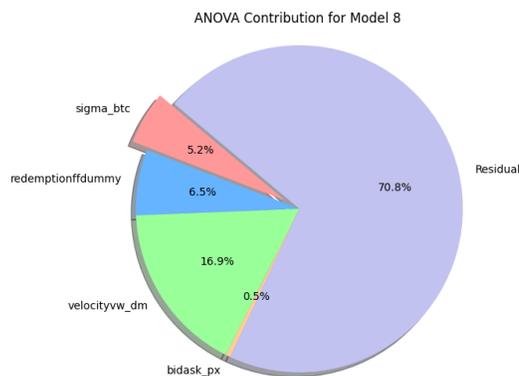
C.1 Devaluation Risk

Figure A6: Devaluation Risk Determinants-ANOVA

Panel A: Baseline measure



Panel B: Linear interpolation measure

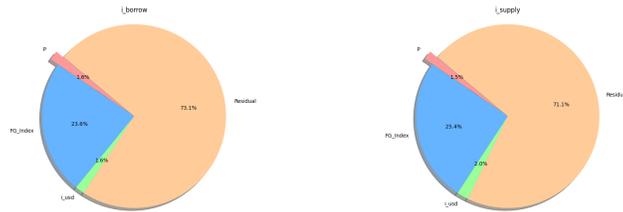


Note: The figure displays ANOVA results for determinants of devaluation risk, with baseline and linear interpolation measures shown in Panels A and B, respectively. Independent variables include *Velocity*, defined as the ratio of the total value transferred (i.e., the aggregate size of all transfers) over the past year to the current supply. It can be interpreted as the number of times an average native unit has been transferred in the past year. σ_{BTC} represents the intra-day volatility of BTC, measured in percentage points. $D_{redemption}$ is a binary variable equal to 1 if there is a decline in the free float supply of USDT compared to the previous day, and 0 otherwise. The sample period spans from August 5, 2021, to June 18th, 2022.

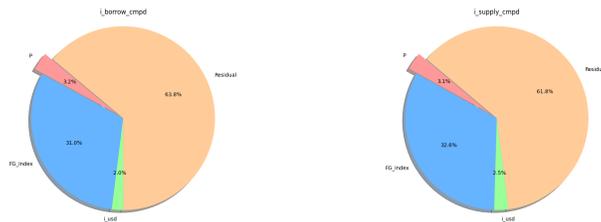
C.2 Interest Rates

Figure A7: Interest Rate Determinants-ANOVA

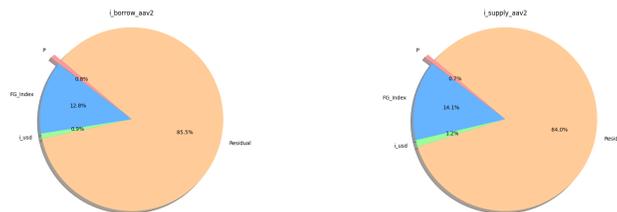
Panel A: Value-weighted interest rates



Panel B: Interest rates - Compound



Panel C: Interest rates - Aavev2



Note: Figure shows ANOVA for determinants of devaluation risk. Panel A uses the baseline measure, while Panel B uses the linear interpolation measure. Independent variables include *Velocity*, defined as the ratio of the total value transferred (i.e., the aggregate size of all transfers) over the past year to the current supply. It can be interpreted as the number of times an average native unit has been transferred in the past year. σ_{BTC} represents the intra-day volatility of BTC, measured in percentage points. $D_{redemption}$ is a binary variable equal to 1 if there is a decline in the free float supply of USDT compared to the previous day, and 0 otherwise. The sample runs from August 5th 2021 to June 18th 2022.

Appendix D: Interest Rate Analysis: Additional Tables

D.1 Interest Rate Determinants-Compound and Aavev2

Table A1: USDT Interest Rates and Devaluation Risk - Compound Protocol

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	i_{supply}^{USDT}				i_{borrow}^{USDT}			
\mathcal{P} (baseline)	1.218*** (0.351)	0.741*** (0.254)			1.413*** (0.401)	0.868*** (0.294)		
\mathcal{P} (linear interpolation)			0.666** (0.312)	0.744*** (0.210)			0.772** (0.354)	0.835*** (0.243)
FG_{Index}		0.041*** (0.007)		0.041*** (0.007)		0.047*** (0.009)		0.047*** (0.009)
PX_{LAST}		-0.693*** (0.197)		-0.880*** (0.211)		-0.710*** (0.219)		-0.908*** (0.239)
Intercept	2.321*** (0.215)	1.441*** (0.297)	2.725*** (0.229)	1.452*** (0.293)	3.693*** (0.238)	2.669*** (0.333)	4.163*** (0.254)	2.692*** (0.330)
R-squared	0.079	0.376	0.031	0.382	0.081	0.358	0.032	0.362
Nr. obs.	317	317	317	317	317	317	317	317
Controls	X	✓	X	✓	X	✓	X	✓

Note: This table presents a regression analysis of the determinants of USDT interest rates on the Compound protocol. Columns (1) to (4) analyze supply rates, (5) to (8) analyze borrow rates. Independent variables include devaluation risk \mathcal{P} (baseline and interpolated), the Crypto Fear and Greed Index, and 3-month USD OIS rates. All variables are expressed in percentage points. Sample spans Aug 5, 2021 to Jun 18, 2022. Standard errors are Newey-West robust. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A2: USDT Interest Rates and Devaluation Risk - Aavev2 Protocol

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	i_{supply}^{USDT}				i_{borrow}^{USDT}			
\mathcal{P} (baseline)	1.075*	0.376			1.212*	0.415		
	(0.625)	(0.487)			(0.712)	(0.566)		
\mathcal{P} (linear interpolation)			0.670	0.797**			0.801	0.896**
			(0.487)	(0.375)			(0.546)	(0.432)
FG_{Index}		0.060***		0.056***		0.067***		0.062***
		(0.014)		(0.015)		(0.017)		(0.017)
PX_{LAST}		-0.928***		-1.263***		-0.867***		-1.246***
		(0.281)		(0.327)		(0.323)		(0.381)
Intercept	2.947***	1.639**	3.229***	1.527**	3.957***	2.420***	4.232***	2.292***
	(0.450)	(0.657)	(0.385)	(0.612)	(0.515)	(0.753)	(0.433)	(0.701)
R-squared	0.014	0.153	0.007	0.160	0.014	0.138	0.008	0.145
Nr. obs.	317	317	317	317	317	317	317	317
Controls	X	✓	X	✓	X	✓	X	✓

Note: This table presents a regression analysis of the determinants of USDT interest rates on the Aavev2 protocol. Columns (1) to (4) analyze supply rates, (5) to (8) analyze borrow rates. Independent variables include devaluation risk \mathcal{P} (baseline and interpolated), the Crypto Fear and Greed Index, and 3-month USD OIS rates. All variables are expressed in percentage points. Sample spans Aug 5, 2021 to Jun 18, 2022. Standard errors are Newey-West robust. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

D.2 Interest Rates and FOMC Announcements

Table A3: USDT Spot, Borrowing, Lending Rates and Issuance Changes around FOMC Announcements

	(1)	(2)	(3)	(4)
	$\Delta i_{\text{supply,agg}}^{USDT}$	$\Delta i_{\text{borrow,agg}}^{USDT}$	$\Delta \log(\text{USDT Spot})$	$\Delta \log(\text{USDT Net supply})$
Δi_{USD}	-0.272 (2.119)	-0.289 (1.826)	-0.269** (0.133)	-3.491** (1.372)
$FOMC_{dummy}$	-0.398 (0.331)	-0.303 (0.278)	-0.002 (0.010)	0.028 (0.135)
$FOMC_{dummy} \times \Delta$	-11.587 (13.409)	-9.695 (10.882)	1.021 (0.816)	-30.571 (26.140)
Intercept	0.010 (0.138)	0.008 (0.119)	-0.000 (0.002)	0.313*** (0.029)
R-squared	0.000	0.000	0.005	0.024
Nr. obs.	317	317	841	841

Note: This table regresses USDT spot price changes on a set of independent variables. $FOMC_{dummy}$ is the dummy variable, which takes a value equal to 1 if it is a day with FOMC announcement, and 0 otherwise. Δi_{USD} is the change in USD interest rate. $FOMC_{dummy} * \Delta i_{USD}$ is the interaction variable between $FOMC_{dummy}$ and Δi_{USD} . Changes in USDT supply are measured in Billions USD. All interest rates are measured in percentage points. The USDT spot price change is measured in USD. Newey-West standard errors, which adjust for heteroscedasticity and autocorrelation, are reported in parentheses. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Appendix E: Quarterly Attestation Reports

E.1 Summary of Attestations

Table A4: Summary of Tether Attestations

Date of Attestation	News Release	Accounting Firm	Summary of Main Changes
03/31/21	04/29/21	Moore Cayman	The assurance opinion confirmed that all Tether tokens were fully backed by reserves as of March 31, 2021. This report marked the beginning of Tether's commitment to quarterly reporting to enhance transparency and accountability. The document emphasized full reserve backing without specific asset breakdown percentages.
06/30/21	08/09/21	Moore Cayman	Reiterated full reserve backing and liquidity focus. No specific changes in asset percentages provided.
09/30/21	12/03/21	Moore Cayman	Reported reduced commercial paper investments and an increase in Treasury allocations. Cash and cash equivalents percentage not disclosed.
12/31/21	02/21/22	MHA Cayman	Highlighted a 21% decrease in commercial paper and increased money market and Treasury investments. Cash and cash equivalents percentage not disclosed.

Table A4: Summary of Tether Attestations (continued)

Date of Attestation	News Release	Accounting Firm	Summary of Main Changes
03/31/22	05/13/22	MHA Cayman	Reported 13% increase in U.S. Treasury bills, reducing reliance on commercial paper to \$20.1 billion.
06/30/22	08/19/22	BDO	Reduced commercial paper holdings by 58% to \$8.5 billion. Increased cash and bank deposits by 32%. Liquid assets accounted for 82% of total assets.
09/30/22	11/10/22	BDO	Commercial paper reduced to near zero, with U.S. Treasury bills exceeding 58% of total assets. Liquid assets accounted for 82% of total reserves.
12/31/22	02/08/23	BDO	Reported net profit of \$700 million, reducing secured loans, and highest percentage of U.S. Treasury bills in reserves to date. Liquid assets accounted for 85%.
03/31/23	05/10/23	BDO	Introduced new transparency categories, including Bitcoin and gold. Net profit of \$1.48 billion increased reserves surplus to \$2.44 billion. Liquid assets accounted for 85%.
06/30/23	07/30/23	BDO	Excess reserves increased to \$3.3 billion, with 85% held in cash and cash equivalents. Treasury exposure reached \$72.5 billion.

Table A4: Summary of Tether Attestations (continued)

Date of Attestation	News Release	Accounting Firm	Summary of Main Changes
09/30/23	10/31/23	BDO	Secured loans reduced by \$330 million. Cash and cash equivalents reached 85.7%, with Treasury exposure of \$72.6 billion.
12/31/23	01/31/24	BDO	Achieved \$2.85 billion profit in Q4, with 90% of total assets held in cash and cash equivalents. Treasury exposure reached \$80.3 billion.
03/31/24	05/01/24	BDO	Profits of \$4.52 billion and net equity of \$11.37 billion. Treasury exposure exceeded \$90 billion.
06/30/24	07/31/24	BDO	H1 2024 profits reached \$5.2 billion. Treasury exposure surpassed \$97.6 billion, the highest recorded.
09/30/24	10/31/24	BDO	U.S. Treasury exposure increased to \$102.5 billion. Liquid assets accounted for over 83%. Profits for 2024 reached \$7.7 billion with an excess reserve buffer of over \$6 billion.

E.2 Event Study Analysis

A detailed record of all quarterly attestations is presented in Table A4, sourced from <https://tether.io/news/>. These attestations began in Q1 2021 and were initially conducted by Moore Cayman, covering the period from Q1 2021 to Q1 2022. From Q2 2022 onward, attestations have been performed by BDO. Reports typically provide aggregate data on Tether’s assets, liabilities, excess reserves, and profits. Over time, the scope of these reports has expanded to include details on the composition of total assets, such as the percentage allocated to cash or cash equivalents (including commercial paper and U.S. Treasuries) and alternative asset classes like cryptocurrency investments and precious metals.

In principle, increased transparency through these attestations and consistent reporting of positive excess reserves (aggregate assets exceeding aggregate liabilities) should signal solvency to the market. Consequently, we hypothesize that the release of quarterly attestations reduces perceived devaluation risk.

To test this hypothesis, we conduct an event study analyzing the response of devaluation risk, as shown in Figure A8. This analysis focuses on a subset of five quarterly attestation events between February 28th 2020, and June 18th, 2022. The event date for each attestation is defined as the news release date, as this is when financial markets first receive relevant information. While we observe negligible changes in devaluation risk within the immediate event window, there is a trend decline in the weeks following the news release, with the exception of the Q1 2021 attestation.

To formally aggregate these findings, we conduct an event study, presented in Figure A9. Panels A and B show the results for the baseline and linear interpolation measures of devaluation risk, respectively. Both measures indicate a statistically significant decline of approximately 20 basis points two weeks after the news release. However, this effect becomes statistically insignificant at a 30-day horizon. This delayed reaction may arise

from staggered dissemination of news. Financial news outlets, such as Coindesk, often report on attestations days after their release. For example, Coindesk’s coverage of the Q2 2023 attestation occurred a day after Tether’s announcement.³⁹

In addition, observed directional changes may depend on compositional shifts in Tether’s balance sheet. For instance, pronounced declines in devaluation risk were observed from Q2 2021 to Q1 2022, coinciding with a significant reallocation from commercial paper to U.S. Treasuries. This shift enhanced the liquidity of Tether’s balance sheet, signaling greater financial stability. Furthermore, the Q1 2022 attestation followed the Terra-Luna crash, during which Tether emphasized the resilience of its balance sheet and its ability to process redemptions, a critical factor for maintaining solvency and market confidence.

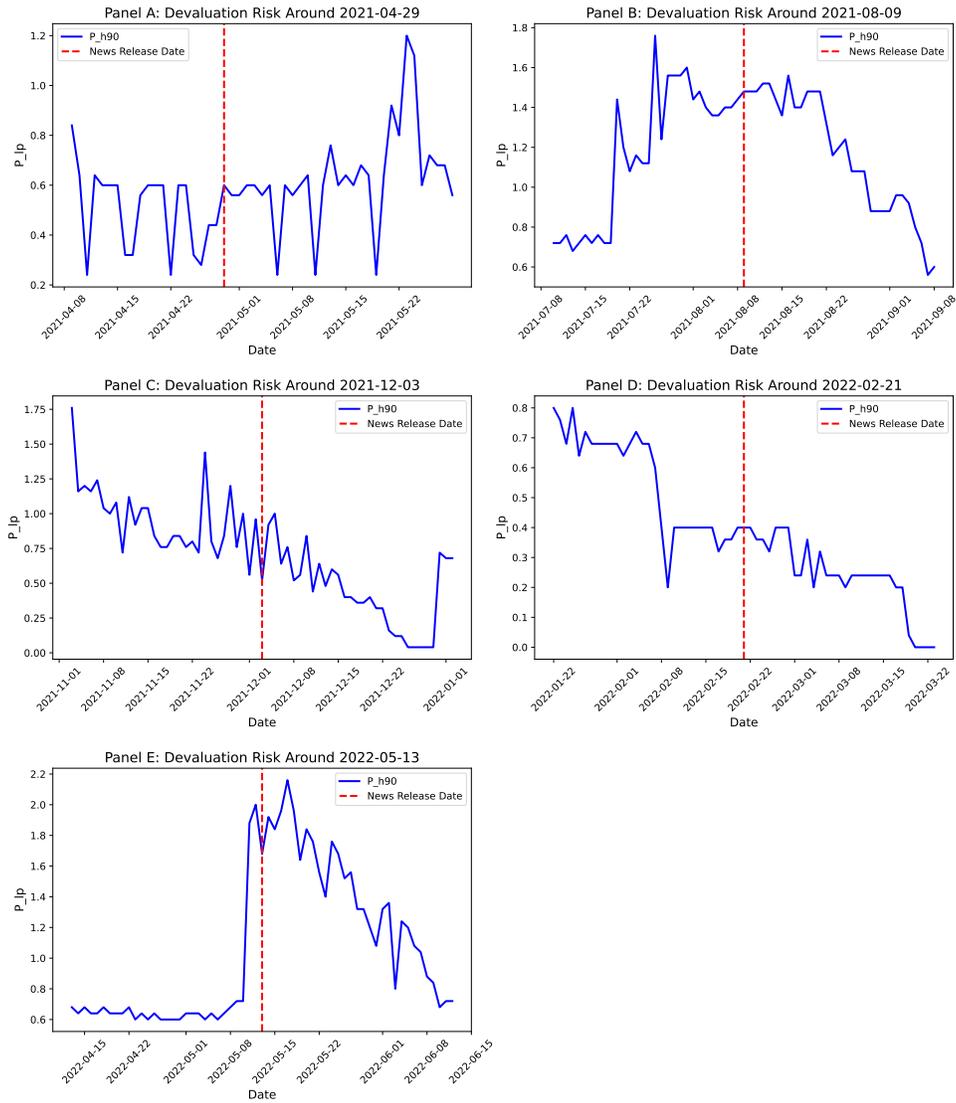
Most importantly, there may be concerns regarding the quality of attestations. For example, in response to an initial Tether attestation in Q1 2021, there were concerns that the attestation only accounted for funds on February 28th 2021; it was not clear whether Tether was fully backed prior to or following the attestation. In other words, the attestation can only account for the balance sheet at a specific point in time, whereas a full audit would provide a more comprehensive assurance that a stablecoin is fully collateralized at all times.⁴⁰

Therefore, while attestations are a step in the right direction, more comprehensive measures, such as Chainlink’s proof of reserve, which we discuss further in Appendix A, are necessary to enhance market confidence.

³⁹See <https://www.coindesk.com/business/2023/07/31/tether-reports-33b-in-excess-reserves-in-q2-up-850m-f>

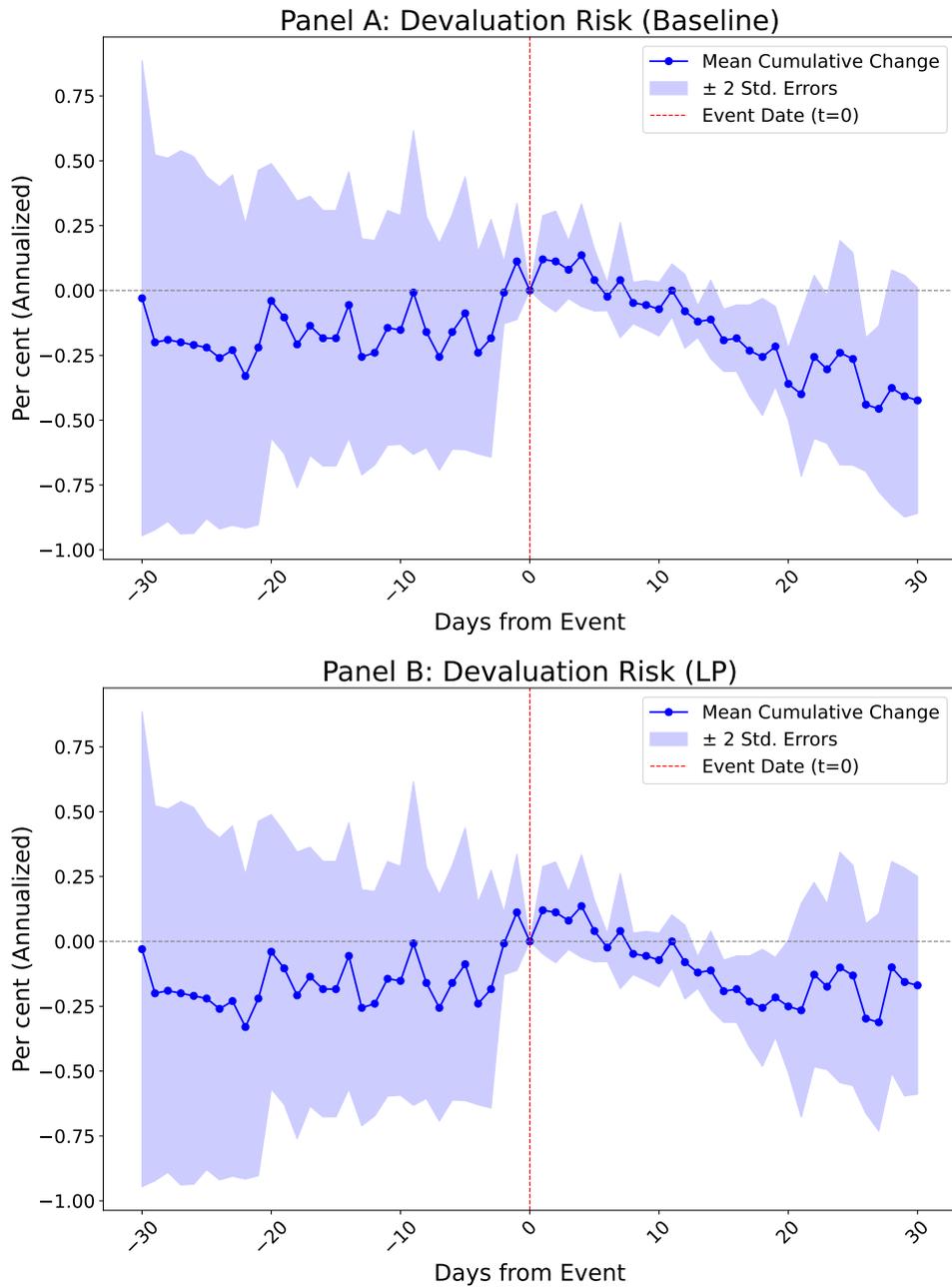
⁴⁰For more details on the questions raised about the February 28 attestation, see <https://decrypt.co/63577/tether-attestation-takeaways>.

Figure A8: Event Study News Release Dates



Note: This figure presents devaluation risk measures around five news release dates for Tether's quarterly attestations, spanning from Q1 2021 to Q1 2022. Each panel illustrates changes in devaluation risk within the event window.

Figure A9: Event Study Devaluation Risk



Note: This figure reports event study coefficients of the effect of news releases on devaluation risk. Panel A reports estimates using the baseline measure of devaluation risk, while Panel B reports estimates based on linear interpolation measure. The event study analyzes the average response in devaluation risk across the five attestation events from Q1 2021 to Q1 2022.

Appendix F: USDT Perpetual Futures and Devaluation Risk

This section explores the use of perpetual futures as an alternative measure of devaluation risk. Perpetual futures provide an innovative tool for price discovery in cryptocurrency markets, distinguished by their lack of expiry dates. Unlike traditional futures, these contracts rely on a funding rate mechanism to align futures prices with spot prices. The funding rate is a periodic payment, exchanged between long and short position holders (e.g., every eight hours on Binance), that reflects prevailing market conditions. It serves as a key indicator of market sentiment and offers an alternative to fixed-maturity futures premiums for measuring devaluation risk. Perpetual futures have been widely utilized in the literature. For example, [Chaudhary et al. \(2023\)](#) employs perpetual futures to examine the integration between DeFi lending protocols and interest rate markets. Similarly, [Gorton et al. \(2022b\)](#) uses funding rates on cryptocurrencies such as ETH/USDT and BTC/USDT perpetual futures to capture market sentiment.

However, in the context of our devaluation risk framework, perpetual futures prices pose challenges. These prices are typically indexed to the spot price over the trading day, with the funding rate ensuring alignment. Consequently, perpetual futures prices often trade at either a premium or a discount, complicating their direct use in devaluation risk measures. For instance, as illustrated in Equation (7), a futures price exceeding parity ($f_t > 1$) would imply a negative devaluation probability, which is not theoretically consistent. Despite these limitations, the funding rate itself provides a valuable proxy for devaluation risk. A negative funding rate, for example, implies that short position holders must compensate long position holders, indicating pessimism about the stability of the USDT peg. Thus, we hypothesize that declines in funding rates are associated with heightened devaluation risk.

F.0.1 Summary Statistics

We begin our analysis by presenting summary statistics for Tether perpetual futures prices, the basis, and trading volume in Table A5 and visualizing these metrics in Figure A10. Compared to three-month futures contracts, perpetual futures prices exhibit closer alignment with spot prices. Panel C of Figure A10 illustrates the funding rate, which is generally negative, averaging -0.38% annually over the sample period. Daily trading volumes are substantially higher in the perpetual futures market, with an average of 11.24 million USD, compared to 0.35 million USD for the three-month contract.

During de-pegging events, such as the Terra-Luna crash in May 2022, similar market dynamics emerge. Following this event, we observe more negative funding rates, heightened trading volumes, and a decline in the basis (the difference between futures and spot prices). These patterns align with the event study findings in Section 3.2.1, further highlighting the relevance of perpetual futures in assessing market stress.

F.0.2 Funding Rate and Devaluation Risk Correlations

Next, we investigate the relationship between funding rates and our primary measure of devaluation risk. Figure A11 presents scatterplots of funding rates against devaluation risk derived from three-month USDT/USD futures contracts. Panel A uses the baseline measure of devaluation risk, while Panel B applies a linear interpolation method. Both panels reveal a negative correlation: higher funding rates, indicative of positive sentiment towards the USDT/USD peg, correspond to lower devaluation risk. The daily correlations between funding rates and devaluation risk measures are -0.34 for the baseline approach and -0.57 for the linear interpolation method, suggesting that funding rates serve as a complementary indicator of devaluation risk.

F.0.3 Determinants of the Funding Rate

Finally, we examine whether the determinants of devaluation risk identified in Table 4 extend to funding rates. Table A6 reports regression results on the drivers of funding rates. Key findings indicate that velocity, a proxy for USDT market activity, and Bitcoin intraday volatility significantly correlate with funding rates. Additionally, reductions in the free float supply of USDT, as captured by an indicator for redemptions, are associated with more negative funding rates. These results mirror the determinants of devaluation risk based on three-month futures contracts. Specifically, periods of higher velocity, market volatility, and redemption activity correspond to more negative funding rates, consistent with increased pessimism towards USDT/USD prices in the perpetual futures market.

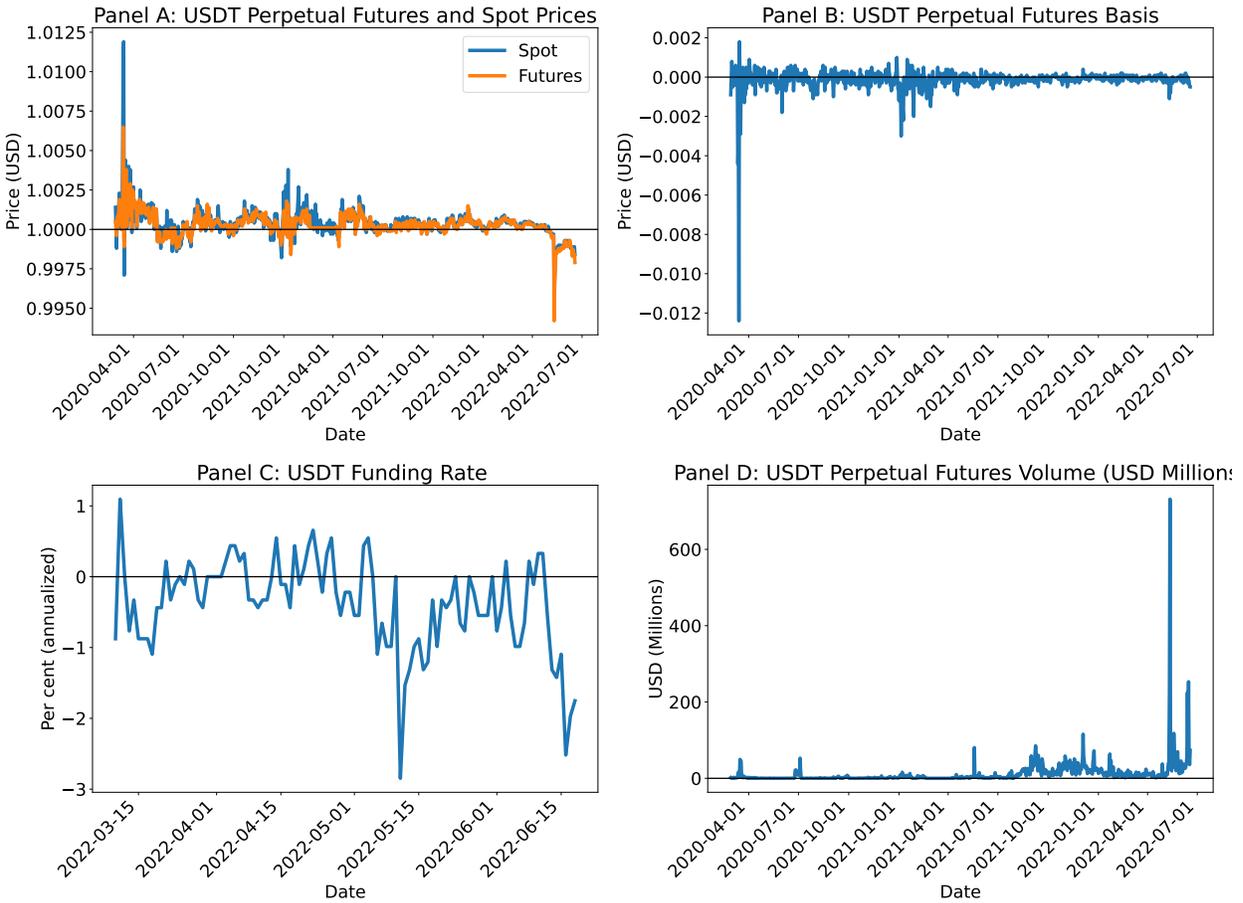
In summary, while limited funding rate data constrains our analysis, the evidence indicates that funding rates serve as an alternative measure of devaluation risk, particularly during market stress events like the Terra-Luna crash.⁴¹

Table A5: Summary Statistics

	Mean	Std	25%	50%	75%	Min	Max	Count
s (USD)	1.0004	0.0009	1.0001	1.0004	1.0007	0.9953	1.0119	842
f (USD)	1.0003	0.0007	1.0000	1.0003	1.0006	0.9942	1.0065	842
basis (USD)	-0.0001	0.0006	-0.0002	-0.0001	0.0001	-0.0124	0.0018	842
funding rate (% annualized)	-0.3849	0.6571	-0.7665	-0.3285	0.0000	-2.8470	1.0950	101
Volume (USD Million)	11.2411	32.1711	0.2963	2.8928	12.7269	0.0000	731.5717	842

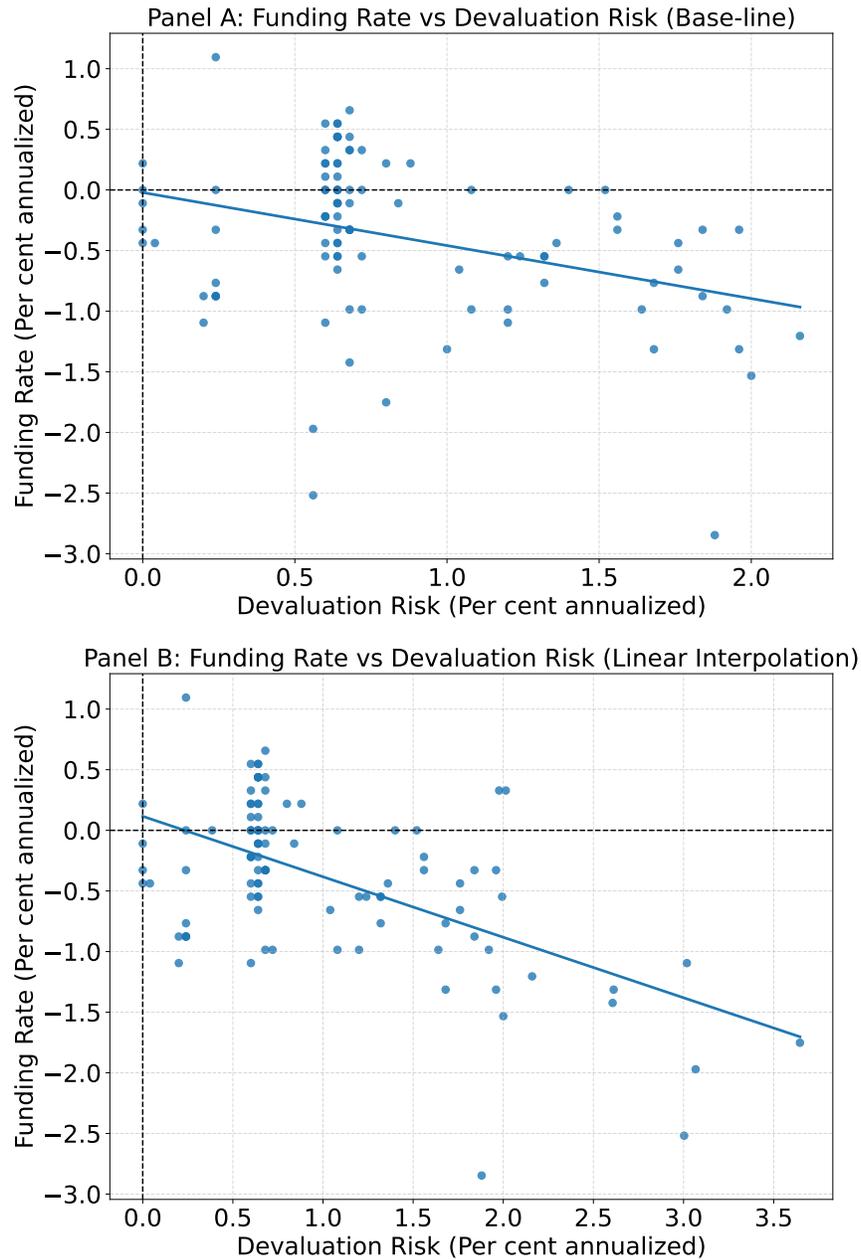
⁴¹We have informed Coinapi about the limited availability of funding rate data in their API. While perpetual futures price data are available from February 2020, funding rate data collection only begins in March 2022.

Figure A10: USDT Perpetual Futures



Note: Panel A reports spot and futures prices for the USDT/USD perpetual futures contract. Panel B reports the basis, defined as the difference between futures and spot prices. Panel C reports the funding rate on the perpetual futures contract. Panel D reports the trading volume in USD Million. For panels A, B and D, the sample runs from February 28th, 2020, to June 18th, 2022. For panel C, due to data limitations, the sample runs from March 10, 2022 to June 18th, 2022.

Figure A11: Scatter Plots of Funding Rate and Devaluation Risk



Note: This figure presents scatter plots of the funding rate and devaluation risk. The funding rate is measured in percentage points (annualized) for the USDT/USD perpetual futures contract. Devaluation risk is measured in percentage points (annualized) and is inferred from 3 month USDT/USD futures contracts. Panel A reports a scatter plot estimates using the baseline measure of devaluation risk, while Panel B reports estimates based on linear interpolation measure.

Table A6: Determinants of USDT/USD Funding Rate

	(1)	(2)	(3)	(4)
Velocity	-0.124*** (0.043)			-0.074** (0.033)
σ_{BTC}		-0.188*** (0.023)		-0.150*** (0.032)
$D_{redemption}$			-0.581*** (0.147)	-0.271** (0.129)
$BidAsk_{px}$	-0.003 (0.006)	-0.001 (0.002)	-0.004 (0.005)	-0.000 (0.003)
Intercept	7.022*** (2.577)	0.214** (0.095)	-0.119** (0.059)	4.603** (1.934)
R-squared	0.132	0.309	0.199	0.415
Nr. obs.	101	101	101	101

Note: This table uses a regression analysis to identify determinants of the funding rate on the USDT/USD perpetual futures contract. The funding rate is measured in percentage points (annualized). *Velocity* is the ratio of the value transferred (i.e., the aggregate size of all transfers) divided in the last year to date. It can be interpreted as the number of times that an average native unit has been transferred in the past 1 year. σ_{BTC} is the intra-day volatility of BTC, measured in percentage points. $D_{redemption}$ is equal to 1 if there is a decline in the free float supply of USDT compared to the previous day, and 0 otherwise. $BidAsk_{px}$ measures the bid-ask spread of the USDT-USD perpetual futures contract, reflecting its market liquidity, in basis points. The sample specification is from March 10th, 2022, to June 18th, 2022. Newey-West standard errors, which adjust for heteroscedasticity and autocorrelation, are reported in parentheses. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Appendix G: USDC/USD Perpetual Futures

This section introduces USDC/USD perpetual futures, launched on the Kraken exchange in late 2023. We compare these futures with their USDT counterparts to evaluate whether the determinants of USDT devaluation risk also apply to the USDC peg.

G.0.1 Summary Statistics

Table A7 provides summary statistics for USDC/USD perpetual futures prices, basis, funding rates, and trading volumes. The sample begins on December 11, 2023, the first date of continuous trading on Kraken. USDC perpetual futures markets exhibit significantly lower liquidity, with average daily trading volumes of only 3,920 USD compared to USDT's 11.24 million USD. Funding rates are more volatile, averaging -0.15% annually, with fluctuations reaching as high as $\pm 6.89\%$. These patterns reflect USDC's smaller market size and reduced trading activity.

Figure A12 visualizes spot and perpetual futures prices, basis, funding rates, and trading volumes. Funding rates show less consistent alignment with spot prices, emphasizing liquidity constraints and the absence of significant de-pegging events in USDC's history.

G.0.2 Determinants of USDC Funding Rates

The analysis of funding rate determinants in Table A8 reveals weaker relationships for USDC compared to USDT. Velocity, a proxy for USDC market activity, remains significant, while Bitcoin intraday volatility (σ_{BTC}) shows weak significance in the full specification. Redemption behavior does not exhibit any meaningful relationship with funding rates.

Several factors explain the differences between USDC and USDT funding rate determinants. First, USDC markets are far less liquid, with trading volumes significantly lower than those of USDT, limiting price discovery and market efficiency. Second, the sample period (December 2023 to December 2024) lacks significant de-pegging events, with USDC maintaining a stable peg and experiencing minimal redemption activity. Third, the

asset composition of USDC reserves differs substantially. While USDT reserves during its analysis period in 2022 included a mix of cash, precious metals, cryptocurrencies, and corporate bonds, USDC reserves are fully backed by highly liquid and secure assets. These include U.S. Treasury securities, repurchase agreements, cash held in Circle Reserve Fund accounts, and segregated cash at regulated financial institutions.⁴²

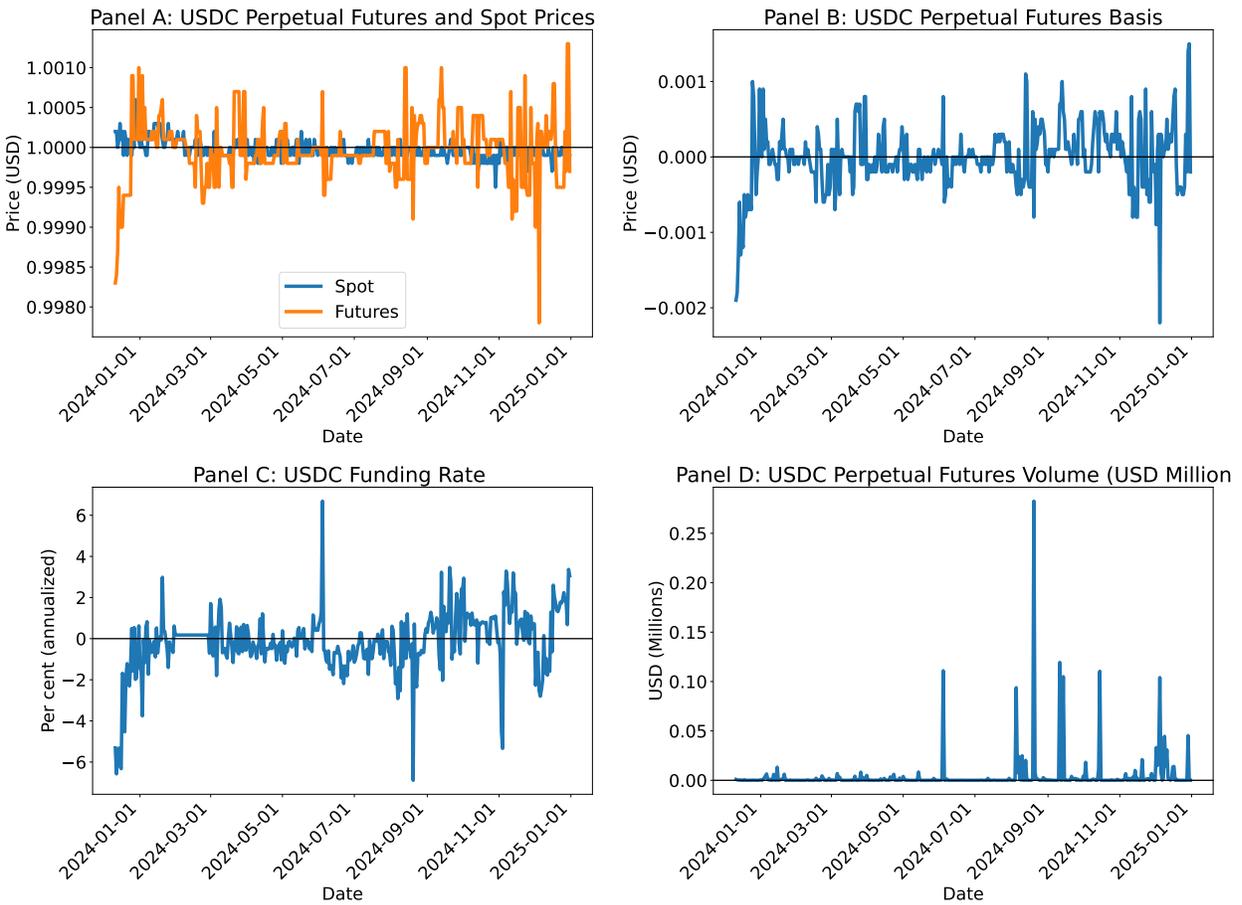
In summary, USDC funding rates are less responsive to changes in market volatility compared to USDT. This stability is largely attributed to its robust reserve composition and the absence of significant market stress events during the sample period. Future research could explore how USDC funding rate determinants evolve under different market conditions or during potential stress events.

Table A7: Summary Statistics

	Mean	Std	25%	50%	75%	Min	Max	Count
s (USD)	0.99997	0.00011	0.99990	1.00000	1.00000	0.99950	1.00060	387
f (USD)	0.99996	0.00040	0.99980	0.99990	1.00010	0.99780	1.00130	387
basis (USD)	-0.00001	0.00042	-0.00020	0.00000	0.00020	-0.00220	0.00150	387
funding rate (% annualized)	-0.15503	1.48243	-0.72903	-0.12836	0.60871	-6.88937	6.68548	387
Volume (USD Million)	0.00392	0.02000	0.00000	0.00000	0.00051	0.00000	0.28260	387

⁴²USDC reserves are composed of highly liquid and secure assets, including U.S. Treasury securities, repurchase agreements, and cash held in Circle Reserve Funds and segregated accounts at regulated financial institutions. As of November 2024, total reserves were \$39.48 billion (November 27) and \$39.80 billion (November 29), exceeding USDC in circulation and ensuring 1:1 backing. See <https://www.circle.com/transparency> for more details.

Figure A12: USDC Perpetual Futures



Note: Panel A reports spot and futures prices for the USDC/USD perpetual futures contract. Panel B reports the basis, defined as the difference between futures and spot prices. Panel C reports the funding rate on the perpetual futures contract. Panel D reports the trading volume in USD Million. The sample runs from December 11, 2023 to December 31, 2024.

Table A8: Determinants of USDC/USD Funding Rate

	(1)	(2)	(3)	(4)
Velocity	-0.030** (0.014)			-0.032** (0.014)
σ_{BTC}		-8.564 (6.524)		-12.129* (6.699)
$D_{redemption}$			-0.056 (0.148)	-0.090 (0.145)
Intercept	2.533** (1.192)	0.046 (0.178)	-0.130 (0.130)	3.037** (1.240)
R-squared	0.041	0.005	0.000	0.051
Nr. obs.	387	387	387	387

Note: This table uses a regression analysis to identify determinants of the funding rate on the USDC/USD perpetual futures contract. The funding rate is measured in percentage points (annualized). *Velocity* is the ratio of the value transferred (i.e., the aggregate size of all transfers) divided in the last year to date. It can be interpreted as the number of times that an average native unit has been transferred in the past 1 year. σ_{BTC} is the intra-day volatility of BTC, measured in percentage points. $D_{redemption}$ is equal to 1 if there is a decline in the free float supply of USDC compared to the previous day, and 0 otherwise. The sample specification is from December 11, 2023, to December 31st, 2024. Newey-West standard errors, which adjust for heteroscedasticity and autocorrelation, are reported in parentheses. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.