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Fundamentals of Stablecoins and the Mechanisms of Arbitrage

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Abstract

Stablecoins are a type of cryptocurrency designed to maintain a stable value by pegging to fiat currencies or other assets through specific mechanisms. Currently, the market features four main types of stablecoins: fiat-collateralized, crypto-collateralized, algorithmic, and newly emerging hybrid models. This paper provides an in-depth examination of the fundamentals, classification and evolution, arbitrage mechanisms, and regulatory risks of stablecoins. The arbitrage mechanisms of stablecoins include simple spot arbitrage, cross-exchange arbitrage, and funding-rate-based arbitrage. These mechanisms play a crucial role in maintaining price stability but are also constrained by market frictions and inherent risks. The rapid development of stablecoins and their potential financial risks have attracted close attention from global regulators, as regulatory frameworks continue to evolve and undergo negotiation. In the future, research on stablecoins should further explore how to strike a new balance between encouraging innovation and preventing systemic risks.

Keywords

stablecoin, arbitrage, cryptocurrency

1. Introduction

Stablecoins are a class of crypto assets that use blockchain technology as their accounting foundation and maintain relative price stability by pegging to fiat currencies, commodities, or other assets through specific mechanisms. At present, various stablecoins exist in the market, including Tether USD (USDT), USD Coin (USDC), Dai (DAI), and Ethena USD (USDe).

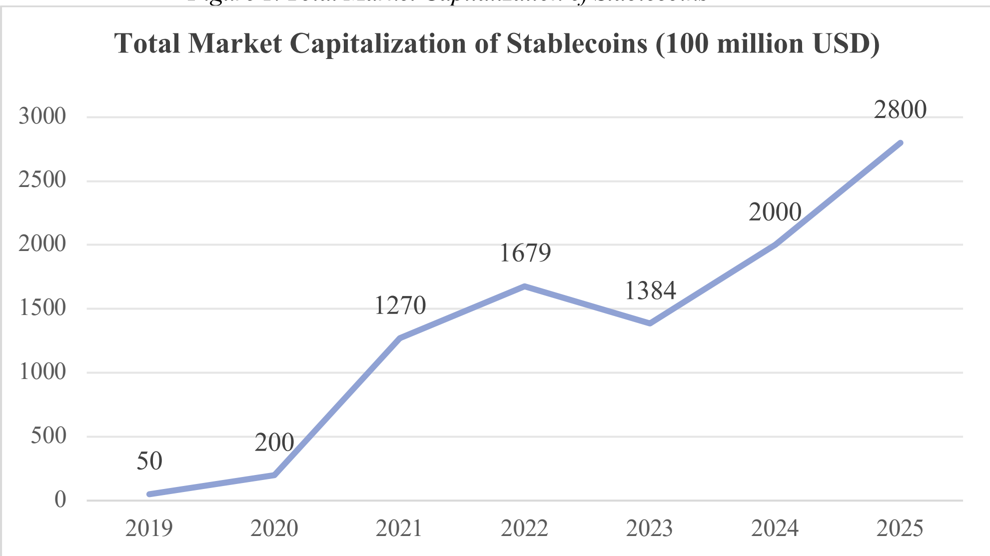
Levy was the first to explicitly summarize, on a mainstream academic platform, the inherent trade-off among the three core objectives of stablecoins-stability, decentralization, and capital efficiency-proposing the concept of the “stablecoin trilemma”, which asserts that the three goals cannot be simultaneously achieved (Levy and Katz, 2021). Lyons examined the dollar-substitution role of USDT in crisis-affected countries and found that the issuance of stablecoins did not drive cryptocurrency prices upward (Lyons and Viswanath-Natraj, 2023). The collapse of UST revealed the fragility of algorithmic models and prompted stricter global regulation. In 2025, a new paradigm began to emerge: Ethena Labs introduced the Delta-neutral architecture of USDe in its white paper, which achieves a 1:1 peg to the U.S. dollar without bank custody by using on-chain assets and derivatives for mirrored hedging (Ethena Labs, 2024).

In summary, while existing research has outlined the classification of pegging mechanisms and the optimization of liquidity pathways, it has yet to adequately address the challenges of insufficient transparency in real-world asset (RWA) backing and the centralization of arbitrage. Therefore, this paper investigates the fundamentals, classification and evolution, arbitrage mechanisms, and regulatory risks of cryptocurrencies, aiming to contribute to resolving these issues.

2. Overview of Cryptocurrencies

Stablecoins are a type of cryptocurrency designed to minimize price volatility by being pegged to stable assets. They serve as a vital bridge between traditional finance and the crypto world, providing both a unit of account and a liquidity foundation for the entire ecosystem. The current market is dominated by three major stablecoins-USDT, USDC, and DAI. As of August 2025, their combined market capitalization exceeds 267 billion USD, indicating significant market size and liquidity, as shown in Figure 1.

Figure 1. Total Market Capitalization of Stablecoins



Stablecoins can be categorized into four main types: fiat-collateralized, crypto-collateralized, algorithmic, and newly emerging hybrid mechanisms. Among them, the first type tends to be more centralized, while the latter three lean toward decentralization (see Table 1).

Table 1. Classification of Stablecoins

		Representative Examples	Core Characteristics
Centralized	Fiat-collateralized	USDT, USDC	Centralized structure, high trust dependence, high capital efficiency, strong stability
Decentralized	Crypto-collateralized	DAI	Over-collateralized, on-chain transparency, low capital efficiency, decentralized
	Algorithmic	Collapsed UST	Algorithm-driven, uncollateralized, extremely high capital efficiency, highly fragile
	Hybrid mechanisms	USDe, Treasury-backed RWA	Derivatives hedging/RWA yield, attempts to overcome the "impossible trinity"

As a key component of the cryptocurrency landscape, stablecoins embody five core functions. They act as the primary medium of exchange and unit of account within the crypto market, providing a stable measure of value. They also serve as a store of value and a digital safe haven, helping residents in regions with unstable fiat currencies preserve purchasing power. Furthermore, they have revolutionized cross-border payments and remittances by enabling peer-to-peer, low-cost, and high-efficiency global transfers. In addition, stablecoins function as the main fiat on- and off-ramp and have evolved into yield-bearing digital assets through real-world asset (RWA) collateralization, continuously expanding the frontiers of financial innovation. Understanding the fundamental "trilemma" of stability, decentralization, and capital efficiency-which cannot be simultaneously achieved-is essential for analyzing the mechanisms and risks of stablecoins (Levy and Katz, 2021).

3. Evolution of Classification and Quantitative Strategies

The mechanisms of stablecoins have evolved through three generations. The first generation, fiat-collateralized stablecoins, relies on centralized institutions holding fiat assets as reserves. Their advantages include strong stability and simple technology, but they are highly centralized and suffer from questionable transparency. The second generation explores decentralization: crypto-collateralized stablecoins achieve on-chain transparency through over-collateralization of crypto assets, but their capital efficiency is low. Algorithmic stablecoins attempt to replace collateral with algorithmic mechanisms, aiming for extremely high capital efficiency. However, their inherent fragility leads to failure. Notably, crypto-collateralized stablecoins, through over-collateralization and on-chain transparency, achieve decentralized operation and censorship resistance (Cong et al., 2022). The third generation, represented by hybrid models, attempts to overcome the stablecoin trilemma. Derivatives-hedging models such as USDe create U.S. dollar exposure through delta-neutral portfolios (Ethena Labs, 2024). RWA-based models allocate large reserves to yield-generating assets, such as U.S. Treasury bonds, transforming stablecoins into interest-bearing assets. Their advantage lies in combining derivatives hedging or real-world assets to enhance both capital efficiency and yield, while simultaneously improving robustness. However, this approach also increases centralization and regulatory dependence (Bank for International Settlements, 2023).

Different mechanisms give rise to specific arbitrage opportunities. Fiat-collateralized stablecoins rely on simple spot-premium arbitrage, exploiting deviations between market prices and the 1:1 USD peg through subscription and redemption (Makarov and Schoar, 2020). Crypto-collateralized stablecoins primarily provide liquidation arbitrage opportunities, in which liquidation bots profit by bidding for collateral at a discount (Qin et al., 2021). Algorithmic designs inherently depend on reflexive arbitrage, but during market downturns, they can accelerate a death spiral (Cong et al., 2022). Arbitrage in new hybrid mechanisms is closely related to derivatives funding rates, requiring arbitrageurs to balance multiple factors, including staking yields and funding costs (Gudgeon et al., 2020).

4. Arbitrage Mechanisms of Stablecoins

4.1 Simple Spot Arbitrage

The logic of simple spot arbitrage lies in the following: when a stablecoin trades at a discount on the secondary market ($P < 1$), arbitrageurs can buy the stablecoin and redeem its underlying assets from the issuer at a value of 1 USD to realize a profit. Conversely, arbitrageurs can mint new stablecoins from the issuer using fiat currency or collateralized assets at a price of 1 USD, and then sell them on the secondary market at a higher price (Lyons and Viswanath-Natraj, 2023).

However, academic research has pointed out that this arbitrage process is subject to significant redemption and minting frictions, including but not limited to fees, time delays, Know Your Customer (KYC) / Anti-Money Laundering (AML) compliance requirements, and high minimum thresholds. These frictions lead to severe liquidity stratification, meaning that arbitrage opportunities are often captured only by a few large professional institutions, while price deviations in the retail market may persist rather than being instantly eliminated as predicted by perfect market theory (Doerr et al., 2021).

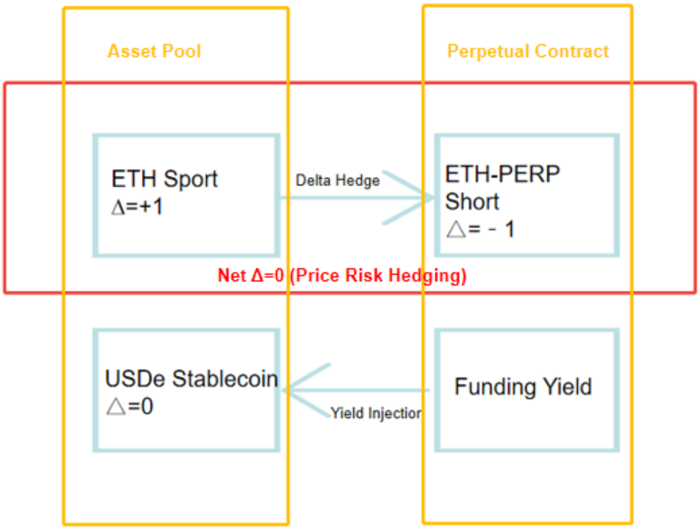
4.2 Cross-Exchange Arbitrage

Cross-exchange arbitrage exploits information asymmetries and market segmentation in microstructure, aiming to capture instantaneous price differences of the same stablecoin across different trading platforms. Arbitrageurs buy on exchanges where prices are lower and simultaneously sell on exchanges where prices are higher to achieve risk-free profits. The effectiveness of this strategy heavily depends on the speed of fund transfers, as delays between exchanges may expose arbitrageurs to price fluctuation risks. Moreover, withdrawal limits, transaction fees, and potential exchange rate risks can erode profits, sometimes making the arbitrage unprofitable under cost constraints. While this strategy has been extensively studied in traditional foreign exchange markets, in the cryptocurrency domain, its effectiveness directly reflects the liquidity depth and market efficiency of individual exchanges.

4.3 Funding-Rate-Based Arbitrage

Funding-rate-based arbitrage is a specialized strategy for algorithmic or synthetic stablecoins. The revenue mechanism of these stablecoins is closely linked to the funding rates in the perpetual futures market. The core strategy is delta-neutral hedging: arbitrageurs or protocols hold stablecoins (or their collateral) while simultaneously establishing an equivalent short position in the perpetual futures market to capture positive funding rate yields, thereby hedging the price risk of the collateral, as illustrated in Figure 2 (Ethena Labs, 2024).

Figure 2. Delta-Neutral Funding Rate Arbitrage Flowchart



However, this strategy is not risk-free. The primary risks include counterparty risk, negative funding rate risk, and basis risk. Counterparty risk refers to potential collateral losses in the event of a centralized exchange default. Negative funding rate risk arises when extreme bearish sentiment turns the funding rate negative, forcing short positions to continuously pay fees, resulting in negative returns and potentially compromising stability. Basis risk occurs when the hedge between spot and futures prices deviates in volatile markets. This strategy highlights the complex financial engineering risks that new algorithmic stablecoins undertake in pursuit of high yields.

5. Risk and Regulation

The rapid development of stablecoins and their latent financial risks have drawn heightened attention from regulators worldwide. Between 2020 and 2024, multiple market crises clearly revealed various dimensions of these risks, and global regulatory frameworks are currently undergoing rapid formation and negotiation.

The risk profile of stablecoins is complex. First, there is credit and reserve risk, which centers on users' trust that issuers hold sufficient, transparent, and high-quality reserve assets. Early controversies over USDT reserves and the USDC de-pegging event triggered by the collapse of Silicon Valley Bank in March 2023 both exposed this risk. Second, there are run and liquidity risks. Whether it is a redemption rush for fiat-backed stablecoins or cascading liquidations triggered by the sharp decline of collateral in crypto-backed stablecoins, such events can trigger self-reinforcing "death spirals". Klages-Mundt's model precisely illustrates how a "deleveraging spiral" can rapidly deplete systemic liquidity (Klages-Mundt and Minca, 2019).

Technological and algorithmic risks are also prominent. Smart contract vulnerabilities, oracle manipulation, and governance attacks are major threats to decentralized stablecoins. The collapse of UST fully exposed the fragility of purely algorithmic models under extreme market conditions. Moreover, systemic risk has become a central regulatory concern. Large stablecoins could serve as channels connecting traditional finance and the crypto market, and their failure could trigger broader financial market instability. Their pseudonymity and cross-border liquidity further introduce significant money laundering and terrorist financing risks.

To address these challenges, global regulatory regimes are evolving rapidly, but significant "regulatory fragmentation" is evident. The U.S. Congress has promoted proposals such as the "Stablecoin Transparency Act", aiming to bring stablecoin issuers under federal banking supervision, imposing strict reserve and capital requirements, and tightly restricting uncollateralized algorithmic stablecoins. The European Union, through the Markets in Crypto-Assets (MiCA) framework, has established a comprehensive regulatory system that sets high standards for issuance, reserve custody, and investor protection. In contrast, Hong Kong has adopted an exploratory "sandbox" approach, testing and evaluating compliant issuers in a controlled environment. These measures have achieved initial success by providing clear compliance pathways and regulatory boundaries, enhancing market trust in compliant stablecoins, and gradually excluding high-risk or non-compliant participants.

6. Conclusion

This paper has reviewed the three major arbitrage mechanisms of stablecoins and draws the following conclusions. First, spot redemption frictions, inter-exchange fund transfer delays, and fluctuations in derivatives funding rates jointly determine the upper bound of arbitrage profits, highlighting an increasing trend toward institutionalization. Second, while Treasury-backed RWAs enhance stability, they bring the trade-offs among decentralization, transparency, and sovereign risk to the forefront, introducing a new dimension to the stablecoin trilemma. Finally, regulatory differences across jurisdictions such as the United States and Hong Kong have created cross-border arbitrage opportunities; however, tightening regulations and high compliance costs are expected to reduce the market share of small- and medium-sized market makers to below 15% within the next two years, making arbitrage opportunities increasingly subject to policy changes.

Looking forward, research on stablecoins needs to address three key issues. First, it is necessary to investigate whether Layer-2 cross-chain MEV can eliminate price discrepancies within minutes, thereby reducing dependence on primary market redemptions. Second, tail risks under extreme negative funding rate scenarios should be quantitatively assessed and incorporated into protocol insurance pools. Third, the effectiveness of real-time on-chain reserve disclosures in statistically reducing the duration of discounts should be evaluated. To adequately address these questions, an integrated approach combining high-frequency on-chain data, regulatory text analysis, and structural modeling is required, so as to find a new balance between fostering innovation and mitigating systemic risk.

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Conflicts of Interest

The authors declare no conflict of interest.

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