SoK: Stablecoin Designs, Risks, and the Stablecoin LEGO

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***Abstract*—Stablecoins have become significant assets in modern finance, with a market capitalization exceeding USD 246 billion (May 2025). Yet, despite their systemic importance, a comprehensive and risk-oriented understanding of crucial aspects like their design trade-offs, security dynamics, and interdependent failure pathways often remains underdeveloped. This SoK confronts this gap through a large-scale analysis of 157 research studies, 95 active stablecoins, and 44 major security incidents.**

Our analysis establishes four pivotal insights: 1) stability is best understood not an inherent property but an emergent, fragile state reliant on the interplay between market confidence and continuous liquidity; 2) stablecoin designs demonstrate trade-offs in risk specialization instead of mitigation; 3) the widespread integration of yield mechanisms imposes a "dual mandate" that creates a systemic tension between the core mission of stability and the high-risk financial engineering required for competitive returns; and 4) major security incidents act as acute "evolutionary pressures", forging resilience by stress-testing designs and aggressively redefining the security frontier. We introduce the Stablecoin LEGO framework, a quantitative methodology mapping historical failures to current designs. Its application reveals that a lower assessed risk strongly correlates with integrating lessons from past incidents. We hope this provides a systematic foundation for building, evaluating, and regulating more resilient stablecoins.

I. Introduction

Digital assets, particularly cryptocurrencies, offer a level of transactional convenience that can surpass traditional systems. However, the pronounced volatility of prominent cryptocurrencies like Bitcoin renders them unsuitable as stable mediums of exchange. This limitation underscores the critical need for stablecoins, which aim to facilitate seamless everyday transactions by maintaining a stable value, thereby providing a reliable store of value amidst market fluctuations and economic turbulence.

Blockchain-based stablecoins have rapidly achieved a market capitalization exceeding USD 246 billion, profoundly influencing both the decentralized finance (DeFi) ecosystem and its intersections with traditional financial systems. Yet, despite this systemic importance, the escalating frequency of security incidents (most notably the Terra event, which caused losses near USD 40 billion [1]) underscores an urgent challenge. These developments mandate a rigorous, comprehensive understanding of stablecoin design architectures and inherent risk profiles to inform safer practices and guide future innovation.

While prior research has systematically surveyed the broader DeFi landscape [2], encompassing decentralized exchanges (DEXs) [3], yield aggregators [4], governance [5], and security incidents [6], and while specific studies have addressed stablecoins [7]–[10], these analyses often lack contemporary advancements or are confined by primarily economic viewpoints. Consequently, a significant lacuna persists: the absence of an integrated, interdisciplinary framework for systematically understanding stablecoin design, quantifying associated risks, and evaluating their ecosystem-wide implications.

Our work. This SoK confronts this lacuna directly. Grounded in a large-scale analysis of 157 research studies, 95 operational stablecoins, and 44 major security incidents, we deliver a holistic systematization of the stablecoin ecosystem. Our work is built upon four pivotal insights that challenge prevailing assumptions and provide a new lens for understanding stablecoin security.

Our analysis begins by establishing a foundational premise: **for a stablecoin, stability is an emergent and fragile state, not an inherent property.** Distinct from other DeFi tokens, a stablecoin's sole mission is peg stability. Our analysis reveals this is not a static feature but an adaptive socio-technical process. It relies fundamentally on two market-validated conditions: sustained market confidence, earned through transparent collateral and robust mechanisms, and effective convertibility (liquidity) into its reference value.

This inherent fragility forces designers into a landscape of difficult trade-offs, where we find that **design choices result in risk specialization rather than complete risk elimination.** Stablecoins typically manage certain key risks effectively (e.g., mitigating collateral volatility with fiat reserves) while implicitly concentrating others (e.g., custodial and counterparty risks). This risk specialization, evidenced by the ecosystem's near-even split between fiat- and crypto-backed paradigms, creates critical points of failure that often demand centralized governance, challenging the ethos of decentralization.

This landscape of risk specialization is further complicated by a modern market demand: the integration of yield mechanisms. **This imposes a "dual mandate" that systemically breeds new risk.** The integration of yield mechanisms, now a mainstream feature (56.8% of stablecoins in our study), transforms stablecoins from simple payment tools into complex financial instruments. Fulfilling the mandate for high, competitive returns (with 83.3% of yield-bearers exceeding the US Treasury benchmark) necessitates high-risk financial engineering, including significant reliance on derivatives and external DeFi protocols. This introduces a fundamental tension between the mission for stability and the strategies required for high returns, creating new vectors for contagion and systemic risk.

When these combined tensions culminate in real-world incidents, the ecosystem's evolutionary mechanic is laid bare: **security evolution is forged through trial-by-fire.** Stablecoins undergo a particularly acute evolutionary process driven by security incidents. We find that technical exploits (e.g., code vulnerabilities) and economic attacks that stress-test peg defenses act as stringent "evolutionary pressures." These critical incidents are not merely failures; they are existential tests that necessitate crucial adaptations and redefine the security frontier for subsequent designs.

To translate these analytical insights into a robust evaluative instrument, we introduce the **Stablecoin LEGO framework**. This quantitative methodology, drawing an analogy from the interlocking toy system, systematically deconstructs past stablecoin failures to their root causes and maps these to identifiable preventive and detective measures within extant implementations. The outcome is a structured, weighted risk score for individual stablecoins. The framework also incorporates the analysis of downstream impacts via token distributions, facilitating a holistic comprehension of stablecoins' pivotal role. Initial application to 11 stablecoins using this framework enables the quantification of disparate risk profiles and reveals how factors, such as the comprehensiveness of security auditing, correlate with diminished assessed risk.

A. Contribution

Our contributions are summarized as follows:

1) A comprehensive systematization of knowledge of the stablecoin landscape: We present the security-focused SoK grounded in a large-scale, multi-source analysis of 157 prior studies, 95 active stablecoins[1], and 44 major security incidents.
2) Four pivotal insights into stablecoin definition, design, and security: We challenge prevailing assumptions by establishing that stability is an emergent property, design is a trade-off in risk specialization, yield creates a dual mandate with systemic risk implications, and security evolution is driven by critical failures.
3) The Stablecoin LEGO framework: We propose a novel quantitative methodology for evaluating stablecoin risk by systematically mapping historical failure modes to preventive and detective measures. This enables structured, repeatable risk assessment and supports continuous ecosystem monitoring.

The SoK architecture is organized in Fig. 1. Specifically, we examine previous studies for stablecoin definitions in Section II, designs including collateral assets, stabilization mechanisms, and yield mechanisms in Section III, security risks in Section IV, and the Stablecoin LEGO framework in Section V. All source code and calculation details are published here [2].

[1]Our classification encompasses 95 active stablecoins. Specific sub-analyses may focus on curated subsets for targeted investigation.

[2]https://github.com/stablecoin-sok

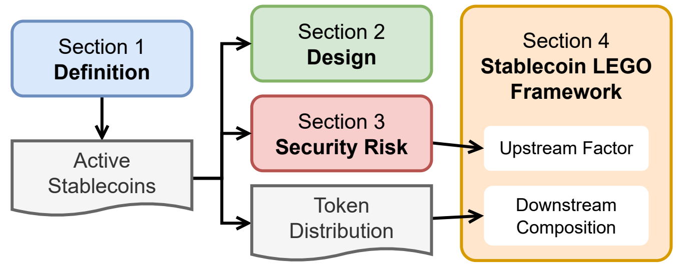

Fig. 1: The SoK architecture.

II. Definition

Establishing a clear definition of "stablecoin" is foundational to systematizing its security landscape. This section delineates the research scope of this paper by dissecting how stablecoins are characterized across academic, governmental, and industry literature. From this comprehensive review, we derive several noteworthy findings regarding the nature and perception of stablecoins.

A. Methodology

Our selection criteria targeted a diverse range of research sources to capture a holistic understanding of stablecoins:

- **Academia (Google Scholar & Top Conferences):** We analyzed the top 100 Google Scholar results for "stablecoin" (with over 20 citations) and relevant papers from the last five years published in 34 leading academic conferences across security, privacy, cryptography, networking, database, software engineering, programming language, and system architecture [11].
- **Governmental & Intergovernmental Bodies:** We reviewed reports from the past five years issued by G20 member states' financial authorities (e.g., central banks) and key international financial organizations (i.e., IMF, WB, BIS, FSB, FATF). Reports expressing non-official views were excluded for rigor[3].
- **Industry (from Web3 Media):** We examined stablecoin-related articles and news from the past five years from the top 5 Web3 media outlets (Cointelegraph, CoinDesk, BeInCrypto, Crypto News, Decrypt), identified via web traffic metrics (details in Appendix A2).

B. Result and Findings

This methodology yielded 157 research studies (56 academic, 81 governmental, 20 industry-focused), the definitions from which are summarized in Appendix A. Our analysis of this corpus reveals several key insights into the evolving understanding of stablecoins.

[3]We exclude the studies that, although published by certain institutions, have specially claimed irrelevance to official views. For instance, some IMF reports claim that "the views expressed in Fintech Notes are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management."

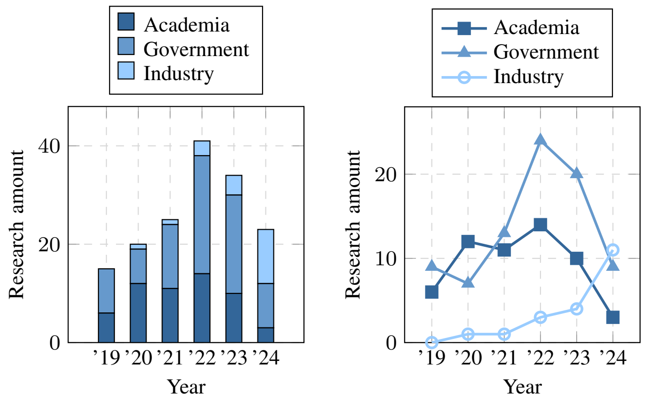

Fig. 2: The year trend of the amount of prior stablecoin research.

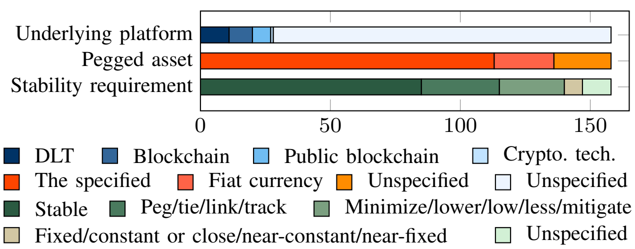

Fig. 3: Stablecoin definitions in terms of underlying platform, pegged asset, and stability requirement.

1) Finding 1: "Stablecoin" is a Contested and Developing Term: A primary finding, consistently highlighted in governmental and regulatory literature, is that "stablecoin" remains an evolving, collective term lacking a universally agreed-upon technical definition [12], [13]. Crucially, the term itself is not an affirmation of achieved stability but is often employed as a marketing label by market participants and authorities [12]–[14]. Consequently, these assets may not always maintain their peg and can exhibit risk profiles comparable to other volatile cryptoassets [15].

2) Finding 2: Stablecoin Research Exhibits a Blooming Trend with Shifting Focus: As illustrated in Fig. 2, the volume of research publications surged from 2019, peaking in 2022. Notably, while academic and governmental research output saw a subsequent decline, industry-focused research and analysis appear to maintain a rising trajectory. This divergence might suggest a recalibration period post-2022 (coinciding with major stablecoin failures), with regulators and academics perhaps adopting a more cautious, observational stance, while the industry continues to innovate and explore new models, potentially driven by persistent market demand or a search for more resilient designs.

3) Finding 3: Definitional Diversity Underscores Stablecoins as Adaptive Systems: Analysis of the collected definitions (Fig. 3) reveals significant heterogeneity across three key descriptive dimensions:

- **Underlying Platform:** A vast majority of definitions (82.28%) do not specify a particular platform type. Those that do describe a spectrum from general Distributed Ledger Technology (DLT) to more specific "blockchain" or "public blockchain" technologies.
- **Pegged Asset:** Most definitions (71.52%) require a specified reference asset (which can include fiat currency, real-world assets (RWAs), or other cryptoassets). A smaller subset (14.56%) restricts this peg exclusively to fiat currencies, while the remainder (13.92%) lack specificity.
- **Stability Requirement:** There is little consensus here. Approximately half (53.80%) merely use the term "stable", implying a desired state rather than a strict technical criterion. Others employ verbs like "peg/tie/link/track" (18.99%) or aim to "minimize/lower/mitigate" volatility (15.82%). Only a small fraction (4.43%) explicitly demand a fixed or near-fixed value, with the rest (6.96%) not detailing the stability criterion.

The inherent vagueness in these common definitional components, particularly regarding the "stability requirement", suggests an implicit acceptance of potential price fluctuations. As noted by the Deutsche Bundesbank [16], the price of a stablecoin is not perfectly correlated with its reference asset due to supply and demand dynamics on trading platforms. This underscores a crucial nature: stablecoins are better understood as adaptive socio-technical systems rather than static monetary instruments. Their stability is consequently a dynamic and often fragile equilibrium, not an inherent, guaranteed property.

C. Research Scope

Given the definitional landscape, we establish our research scope for this SoK as follows:

Broad definition. We acknowledge the widely accepted definition from the Financial Stability Board (FSB) [17], entrusted by the G20: "*A crypto-asset that aims to maintain a stable value relative to a specified asset, or a pool or basket of assets.*"

Strict definition. While the FSB definition is encompassing, significant regulatory and systemic risk concerns prioritize stablecoins pegged to fiat currencies. These are perceived to have a greater potential to become widely accepted means of payment, thereby posing more immediate and substantial monetary and financial stability risks [18], [19]. Therefore, for the purpose of this SoK, we adopt a strict definition: "*A crypto-asset that aims to maintain a stable value relative to a specified fiat currency, or a pool or basket of fiat currencies.*" This focused scope allows for a deeper and more coherent analysis of the security risks pertinent to the most systemically relevant class of stablecoins.

D. Similar Concepts

It is also noteworthy that analogous concepts exist within the aforementioned stablecoin definitions which are prone to confusion. However, in this paper, we intentionally exclude these concepts, as they are either deliberately or incidentally developed for distinct purposes and fall outside the scope of the established community consensus on stablecoins.

Central Bank Digital Currency (CBDC). CBDC is usually the digital form of central bank currency instead of third parties, and may or may not adopt technologies like distributed ledger or blockchain. CBDC would create a modern alternative to stablecoins, as suggested by Deutsche Bundesbank [16].

Tokenized fund. A digital representation of an asset or ownership right as a token on a blockchain [20]–[23], exemplified by Franklin Templeton FOBXX [24] and BlackRock BUIDL [25]. This concept is excluded from this paper as it aligns more closely with financial constructs regulated by securities laws and primarily caters to the asset management and investment sectors, and should be viewed as an alternative to secured stablecoins or a supplement to CBDCs suggested by the Bank of Russia [26].

Wrapped token. A digital asset that reflects the value of another cryptocurrency from a different blockchain, such as Wrapped BTC (WBTC) [27] on Ethereum, aiming at addressing the challenge of interoperability across blockchains [28]–[30]. This concept is excluded from this paper as it primarily functions as an interoperability solution rather than maintaining value stability.

Bridged token. A digital asset that is bridged from one blockchain to the other via a cross-chain bridge. Typical examples include USDC (Ethereum) - USDC.e (Optimism) [31]. It differs from a wrapped token in that it may have already natively existed on the target blockchain before bridging, while still excluded for the same reason.

Liquidity provider (LP) token. A token issued to liquidity providers on AMM protocols, tracking individual shares to the overall liquidity pool [32], [33]. We exclude it because it primarily exists within the AMM system as an ownership certificate, which can take other forms, such as NFTs.

Liquidity staking token (LST). Also known as liquidity staking derivative (LSD), tokenized representations of staked tokens [34], [35]. Typical examples include Lido stETH [36] on Ethereum. We exclude it from this paper because they are considered add-on derivatives of liquidity staking.

> ***Insight 1***: Distinct from multi-utility DeFi tokens, a stablecoin's sole objective is peg stability. As adaptive socio-technical systems, this vital function fundamentally relies on two vital, market-validated conditions: 1) sustained market confidence, paramount due to absent universal backing rules and earned through transparent collateral and robust stabilization, and 2) effective convertibility (liquidity) ensuring consistent exchange for its reference value.

III. Design

Building upon the strict definition of stablecoins (Section II), this section deconstructs their design landscape. While a common initial categorization distinguishes between collateralized stablecoins (backed by assets) and algorithmic stablecoins (relying on dynamic mechanisms), this distinction is not absolute. Many stablecoins employ hybrid approaches,

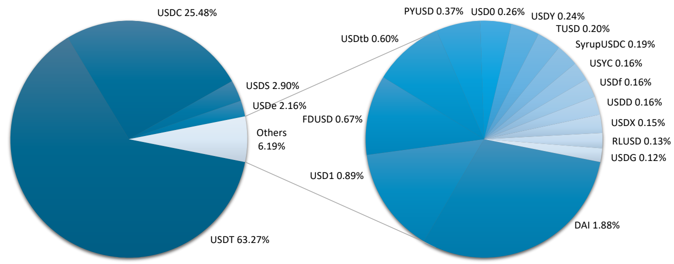

Fig. 4: The distribution of top 20 stablecoins regarding market capitalization (in million USD).

combining collateralization with algorithmic adjustments to pursue stability. We therefore adopt a multi-faceted approach to classify and analyze stablecoin designs.

A. Methodology

To systematically understand stablecoin design, we identify three primary attributes as classification criteria: 1) Collateral Asset types, 2) Stabilization Mechanisms, and 3) native Yield Mechanisms. Our analysis covers 95 existing stablecoins, selected by market capitalization (over $10M from sources of DefiLlama [37], CoinMarketCap [38], and CoinGecko [39]). We verified features via official documentation and excluded failed or inactive projects to focus on currently operational designs (see Appendix B for the list).

Observation 1: Market Concentration. The stablecoin market is highly concentrated: the top 5 (USDT, USDC, USDS, USDe, DAI) constitute over 93% of total market capitalization, and the top 20 represent 98% (Fig. 4). This underscores the dominance of a few major stablecoins, consistent with the Pareto Principle.

Observation 2: Motivations for Stablecoin Emergence. Despite market concentration, new stablecoins continually emerge, driven by diverse motivations beyond simple price stability:

- Regional demand: catering to local economies with fiat-pegged stablecoins (e.g., EURS for Euro).
- Ecosystem demand: providing native stablecoins for burgeoning blockchain ecosystems (e.g., Blast USDB).
- Decentralization focus: offering alternatives (e.g., MakerDAO DAI) to centralized issuers like Tether, aiming to mitigate counterparty risks.
- Stability innovation: introducing novel mechanisms, e.g., hedging strategies, to enhance price stability (e.g., Ethena USDe).
- Financial innovation: incorporating new economic models, governance structures, or yield-bearing features (e.g., Sky USDS).

B. Collateral Asset

Collateral assets are fundamental to many stablecoin designs, underpinning their purported value. Before analysis, we clarify crucial distinctions: the pegged asset is the target value (e.g., USD); the collateral asset backs the stablecoin; and the

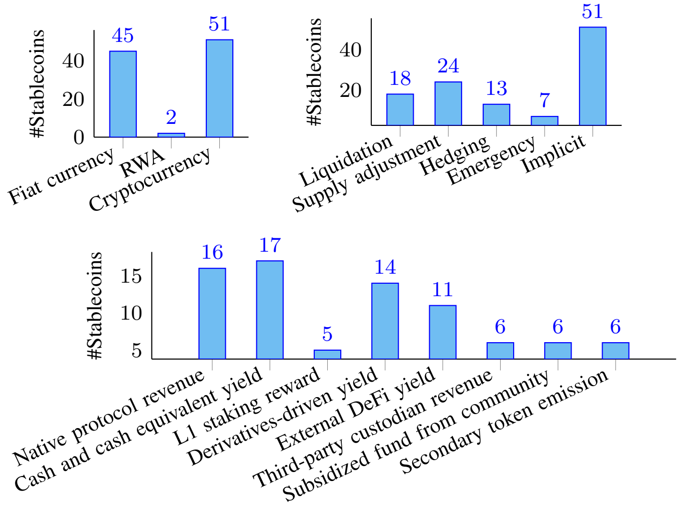

Fig. 5: Stablecoin distributions in terms of collateral asset, stabilization mechanism, and yield sources (across yield-bearing stablecoins).

purchase fund is the medium for acquiring the stablecoin, not necessarily linked to its peg or collateral. We categorize collateral into: 1) *Fiat currency* (or equivalents like government treasuries), 2) *Real-World Assets (RWA)* (e.g., commodities, real estate, stocks), and 3) *Cryptocurrency* (e.g., USDT, BTC, ETH).

Collateralization Landscape. Our analysis of 95 operational stablecoins reveals that all are, at least nominally, fully collateralized (i.e., collateral value larger or equal to 100% of outstanding supply). This suggests a strong market tendency towards, or higher survival rate for, designs with explicit full backing, where complex stabilization algorithms often act as secondary or reinforcing measures. Among these, 45 are primarily fiat-backed, 2 by RWA, and 51 by cryptocurrencies (total exceeds 95 due to multi-collateral designs), indicating a near-even split in preference between fiat and crypto-collateral paradigms (Fig. 5).

Comparative Analysis of Collateral Types. We evaluated USD (fiat), Gold (RWA), and Bitcoin (cryptocurrency) against four key attributes (Table I), including volatility, redemption efficiency, inflation resistance, and compliance. We recognize that liquidity is paramount, with inflation and compliance risks impacting this core tenet. This comparison reveals inherent trade-offs: each asset type excels in some dimensions while underperforming in others, underscoring that collateral choice fundamentally dictates a stablecoin's risk-return profile and operational characteristics.

1) Volatility: Collateral asset volatility directly impacts a stablecoin's ability to maintain its peg. Highly volatile collateral necessitates more aggressive stabilization mechanisms and can undermine user confidence. While fiat currencies, particularly the USD, are generally regarded as the most price-stable collateral options, RWAs like gold exhibit moderate fluctuation based on market dynamics. Cryptocurrencies represent the most volatile class, with potential for drastic price swings. To quantify this, we use the Price Standard Deviation (PSD):

$$PSD = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(P(t)-\mu)^2}, \quad (1)$$

where T is the observation period, $P(t)$ is the asset price at time $t \in T$, and μ is the mean price over T. We calculated PSD using daily closing prices from Yahoo Finance for the five-year period from March 25, 2020, to March 24, 2025. Our analysis confirms that USD exhibits the lowest volatility, whereas Bitcoin demonstrates the highest among the three representative assets.

2) Redemption Efficiency: Redemption efficiency, which is the ease and speed with which collateral can be converted to meet redemption demands without adverse price impact, is crucial for stablecoin trustworthiness. Fiat currencies offer high global liquidity and accessibility. RWAs can face logistical hurdles and slower conversion times. Cryptocurrencies present variable liquidity dependent on the specific asset and prevailing market conditions, potentially stressing stability during demanding redemption periods. We evaluate this using a Redemption Efficiency Index (REI), grounded in market microstructure theory, which amalgamates normalized transaction costs and redemption delays:

$$REI = f' + d', \quad (2)$$

where f', d' are min-max normalized values (scaled to [0,1]) representing typical transaction fees (in USD equivalents) and redemption delays (in days) associated with converting the collateral asset. A lower REI signifies higher efficiency. Our analysis indicates Bitcoin offers the highest redemption efficiency due to its near-instant, on-chain settlement capabilities, while physical gold ranks lowest due to logistical requirements. USD efficiency is high but typically subject to banking system operational hours and settlement lags.

3) Inflation Resistance: Inflation erodes the purchasing power of assets used as collateral. Assets that can hedge against inflation are therefore valuable for preserving a stablecoin's real value. While certain cryptocurrencies, particularly those with capped supplies, are posited as inflation hedges, fiat currencies directly lose purchasing power during inflationary periods. RWAs like gold have a mixed historical record as consistent inflation hedges.

We assess inflation resistance using the real return (r), derived from the Fisher Equation: $(1+i) = (1+r)(1+\pi)$, where i is the nominal return of the collateral asset and π is the relevant annual inflation rate. For low inflation, this approximates to:

$$r \approx i - \pi. \quad (3)$$

We determine i by taking the median yield rate offered by stablecoins in our dataset that are collateralized by the respective asset type (e.g., median yield of USD-backed stablecoins for USD's nominal return). This proxy reflects the returns generated and passed on by stablecoin issuers

	Volatility (PSD)	Redemption efficiency (REI)	Inflation resistance (r)	Compliance (J-Score)
USD (fiat currency)	**5.93**	0.9990	-4.25	**21**
Gold (RWA)	313.77	2.0000	**5.89**	**21**
Bitcoin (cryptocurrency)	23413.08	**0.0000**	**5.78**	13

TABLE I: Comparison of three collateral assets, where bold numbers are better ones.

utilizing that collateral. Our results show that gold and Bitcoin-backed stablecoin models offer superior inflation resistance, while USD-backed models demonstrate negative real returns, reflecting an erosion of purchasing power.

4) Compliance: The regulatory treatment of collateral assets across jurisdictions introduces significant, often unpredictable, risk. While fiat currencies and traditional RWAs like gold are generally accepted within established regulatory frameworks in most G20 nations, cryptocurrencies navigate a more complex and rapidly evolving legal landscape, impacting their suitability and reliability as collateral.

To quantify this, we propose a Legal and Jurisdictional Compliance Score (J-Score), a primarily qualitative aggregation:

$$J = \sum_{k=1}^{N} w_k \cdot C_k, \tag{4}$$

where N is the number of G20 jurisdictions considered (N=21), w_k is the weight for jurisdiction k (here, $w_k = 1$ for all, signifying equal weight), and $C_k \in \{0, 1\}$ indicates whether the collateral asset type is generally considered compliant (1) or faces significant restrictions/lack of clarity (0) for use in financial instruments or as a reserve asset within that jurisdiction. A higher J-Score indicates broader regulatory acceptance of the collateral type. Our analysis suggests that Bitcoin, as a collateral type, faces compliance ambiguities or restrictions in approximately 40% of G20 jurisdictions, a higher percentage than for USD or Gold.

Discussion: Stablecoin Compliance. Beyond collateral, stablecoins also face a rapidly evolving regulatory landscape (e.g., EU's MiCA, frameworks in Singapore, US's STABLE and GENIUS, Hong Kong Stablecoins Ordinance). The security implications of these diverse and emerging regulatory demands warrant continuous investigation.

C. Stabilization Mechanism

Many stablecoins employ explicit mechanisms to actively defend their peg. Our analysis (Fig. 5) shows that while over half (53.68%) rely on an "implicit" mechanism (primarily trust in the issuer and their reserves), others use active strategies. Specifically, liquidation (18.95%) and supply adjustment (25.26%) are prevalent, with hedging (13.68%) and emergency features (7.37%) also utilized (total exceeds 100% as some implement multiple mechanisms).

1) Liquidation: Liquidation mechanisms are foundational to many collateralized stablecoins, enforcing solvency by auctioning off undercollateralized positions. When volatile collateral backing a debt position falls below a predetermined threshold (the liquidation ratio), the system permits liquidators

Algorithm 1: Liquidation

```
Input: current_value, debt, liquidation_threshold,
       discount, liquidation_rate
Output: seized or "Safe"
if current_value/debt < liquidation_threshold then
    seized ← current_value × (1 − discount);
    repay(debt × liquidation_rate);
    return seized
return "Safe"
```

to repay a portion of the debt in exchange for seizing the underlying collateral at a discount [40]–[42]. This process inherently relies on over-collateralization, where the initial collateral value significantly exceeding the minted stablecoin value, to buffer against price declines. MakerDAO DAI is a prominent example.

Considered a relatively robust approach, liquidation is widely adopted. MakerDAO DAI, one of the largest stablecoins employing this, has navigated market volatility without catastrophic failures of its core liquidation engine. A key insight from Klages-Mundt et al. [8] is that such mechanisms shift risk from a systemic "equity risk" (borne by all token holders) to an "agent risk" (borne by individual, over-collateralized vault owners). This design shares structural similarities with borrowing/lending protocols, facilitating their natural integration or evolution into stablecoin issuers (e.g., Aave GHO).

2) Supply Adjustment: This class of mechanisms aims to stabilize price by algorithmically modulating the stablecoin's circulating supply, based on the economic principle that decreasing supply raises prices and vice-versa. While methods vary from direct minting/burning of tokens to adjusting borrowing interest rates to influence demand, they typically rely on arbitrage incentives for market participants. USDD is a notable example.

Theoretically, such mechanisms find grounding in concepts like the Quantity Theory of Money: $M \cdot V = P \cdot Q$, where adjusting money supply M is intended to influence the price level P [7]. By algorithmically contracting supply when the price is below peg (to induce scarcity) or expanding it when above peg (to reduce premium), these systems attempt to dynamically manage inflationary or deflationary pressures on the stablecoin's value.

In practice, however, stablecoins primarily reliant on endogenous supply adjustments have a notable history of failure (e.g., Terra UST, Neutrino USDN, Beanstalk BEAN, Haven xUSD). A critical lesson from these incidents is their acute

Algorithm 2: Supply Adjustment

Input: current_supply, current_price, target_price, adjustment_coefficient

Output: None

$supply\_change \leftarrow current\_supply \times adjustment\_coefficient \times (current\_price - target\_price)$;

if $current\_price > target\_price$ **then**

  mint(supply_change);

else

  burn(abs(supply_change));

susceptibility to reflexive market dynamics and oracle unreliability. The adjustment processes can exhibit significant lags, failing to respond adequately to rapid sentiment shifts or well-capitalized attacks, creating death spirals. The specific security risks inherent in these designs are further explored in Section IV.

3) Hedging: Hedging strategies aim to neutralize the price risk of volatile collateral by establishing offsetting positions in derivative markets [43], [44]. Delta-hedging, for example, seeks a "delta-neutral" position where the stablecoin issuer's net exposure to the collateral's price movement is theoretically zero. If minting a stablecoin against 1 ETH creates a +1 ETH price exposure (positive delta), a corresponding short position in an ETH perpetual contract of equivalent size would be taken to neutralize this. Ethena USDe and Elixir deUSD exemplify this approach.

A critical aspect of these designs is their operational dependency on centralized exchanges (CEXs) for providing the necessary derivative instruments and liquidity for hedging. This introduces significant counterparty risk: the failure or compromise of a CEX partner could jeopardize the hedge and, consequently, the stablecoin's backing. Furthermore, for models like Ethena, where yield is partly generated from derivative positions (e.g., funding rates, basis spreads), the sustainability and security of these yields are also contingent on the continuous, reliable functioning of these CEXs, creating layers of external dependencies.

4) Emergency Mechanism: Acknowledging the limitations of purely algorithmic responses in extreme scenarios, some stablecoins incorporate emergency mechanisms. These can include features to temporarily suspend core functions like transfers or redemptions during severe market dislocations or security incidents (e.g., Curve crvUSD, Paxos USDP). Another approach involves maintaining segregated bailout reserves, deployable via a trusted committee or governance vote to recapitalize the system during a crisis (e.g., Gyroscope GYD, dForce USX).

While intended as safety nets, such mechanisms inherently introduce centralization and governance risks. The power to invoke emergency actions often resides with a core team or a small group of token holders, raising concerns about potential abuse, or failure to act appropriately under pressure. These mechanisms shift trust from fully autonomous code to human judgment and intervention, introducing governance challenges that extend beyond typical smart contract rule-based security considerations.

5) Implicit Stabilization Mechanism: This dominant category (51/95) includes stablecoins lacking explicit, algorithmically-defined stabilization protocols, relying instead on users' trust in the issuer's ability and commitment to maintain the peg, typically through robust reserve management and redemption processes (e.g., USDT, USDC). The "stability" here is an emergent property of this trust and the perceived strength of off-chain backing. However, this category exhibits extremes: from highly resilient, large-cap stablecoins to smaller, more vulnerable ones where "implicit" may equate to an absence of robust defenses, heightening risks like rug pulls if issuer trust is misplaced.

6) Discussion: Towards a Control-Theoretic View of Stabilization: No single stabilization mechanism is flawless, thus effective peg maintenance often requires judicious strategy selection and scaling. Control theory finds extensive applications in financial markets, including monetary policy control, portfolio optimization, trading and market making, and price stabilization for exchange rates and commodities. Therefore, we propose that stablecoin stabilization can be fruitfully modeled as a control system. Price deviations from the peg act as error signals, triggering corrective actions from stabilization mechanisms (control inputs u) to counteract disturbances d (e.g., market volatility) and guide the system state x (stablecoin price $P(t)$) back to its target P_{peg}. A general state-space representation could be:

$$dP(t) = (AP(t) + BU(t))dt + \sigma(P(t))dW(t), \quad (5)$$

where $U(t)$ is a vector of control inputs from mechanisms like supply adjustment (u_s), liquidation (u_l), etc. While a full quantitative development is future work, this control-theoretic perspective offers a powerful abstraction for analyzing the dynamic interactions and potential optimality of combined stabilization strategies.

> ***Insight 2***: The pursuit of stability forces choices that result in *risk specialization rather than comprehensive risk elimination*. This means designs typically manage certain key risks effectively (e.g., reserve volatility in a fiat-backed model) while implicitly accepting or concentrating other risks (like custodial and counter-party risks in the same model), forming a trade-off evidenced by the ecosystem's near-even split between fiat-backed (47.37%) and crypto-backed (53.68%) paradigms. This risk concentration creates critical points of failure that, in turn, demand centralized governance for decisive action and accountability, directly challenging the ethos of decentralization.

D. Yield Mechanism

Native yield offerings are a significant driver for stablecoin adoption and innovation, positioning them as financial

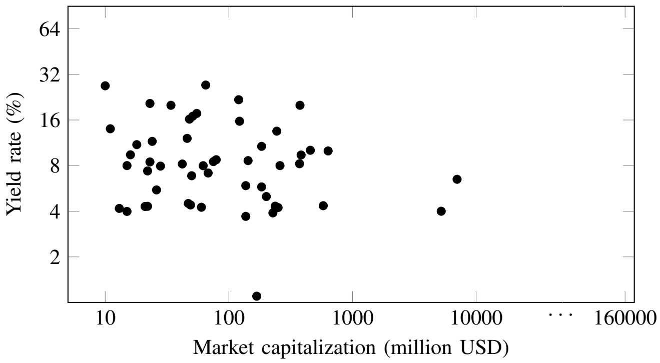

Fig. 6: The yield distribution of stablecoins paired by market capitalization (log form due to imbalanced data).

products beyond simple payment tools. Our analysis considers yields directly provided by issuers, excluding third-party protocol yields, across the 95 selected stablecoins.

1) Yield Rate Landscape: We present the relationship between reported yields and market capitalizations using a log-log distribution (Fig. 6) for effective visualization. This analysis reveals a distinct inverse correlation: stablecoins with smaller market capitalizations tend to offer higher native yield rates. We posit this reflects a common strategy among emerging or smaller protocols to aggressively attract users and compete for market share, often by offering premium returns to incentivize early adoption. Quantitatively, our survey of 95 operational stablecoins indicates that 54 (56.84%) provide native yield-bearing features. Notably, among these yield-bearing stablecoins, 45 (constituting 83.33% of this subset) offer annual percentage yields (APYs) exceeding 4.25%. This threshold renders their offerings competitive with, or superior to, traditional benchmarks of the US 10-year Treasury yield (at the time of writing).

2) Yield Source Taxonomy and Findings: We identified 8 primary yield generation patterns: 1) Native protocol revenue, 2) Cash and cash equivalent yield (e.g., T-bills), 3) L1 staking rewards, 4) Derivatives-driven yield (e.g., basis trading, funding rates), 5) External DeFi protocol yield, 6) Third-party custodian revenue, 7) Community-subsidized funds, and 8) Secondary token emissions. Our analysis (Fig. 5) reveals a complex interplay between traditional financial models and crypto-native risk appetites:

1. Dichotomy in Yield Generation: TradFi Roots with Crypto-Native Risk Layers. The most prevalent yield sources are anchored in traditional finance: “Cash and cash equivalent yield” (utilized by 31.48% of yield-bearing stablecoins in our study) and “Native protocol revenue” from fees (29.63%). This reliance on established models suggests a market inclination towards perceived sustainability. Yet, in striking contrast, the third most common source is “Derivatives-driven yield” (25.93%), signaling a significant embrace of crypto-native financial engineering with distinct risk profiles not found in traditional monetary instruments.

2. Financialization Heightens Complexity and Systemic Interconnectedness. The notable adoption of “Derivatives-driven yield” (25.93%) and “External DeFi yield” (20.37%) transforms stablecoins from mere payment tokens into actively managed financial products. This evolution inherently breeds complexity and new vectors for systemic risk. These strategies create direct counterparty exposures to derivative providers and critical dependencies on the operational security and economic stability of external DeFi applications (e.g., Aave, Curve). Such deep entanglement implies that failures in these third-party services could trigger cascading solvency issues across multiple stablecoins.

3. Unsustainable Yields Signal Structural Fragility in a Market Segment. A significant portion of yield-bearing stablecoins (22.22% combined) rely on inorganic and inherently unsustainable sources: “Subsidized funds from community” and “Secondary token emissions.” These are not revenue from viable economic activity but are functionally marketing expenses or temporary incentives. This indicates that a segment of the market may be structurally fragile, reliant on bootstrapping growth through mechanisms that are finite, potentially masking underlying economic non-viability until subsidies deplete or emission-based tokens devalue under pressure.

> ***Insight 3***: The integration of yield imposes a “*dual mandate*” that reforges stablecoins from passive anchors into complex financial instruments. This transformation is now mainstream: 56.84% stablecoins offer yield, of which 83.33% provide returns exceeding the US 10-year Treasury benchmark. Fulfilling this aggressive yield mandate necessitates high-risk financial engineering, evidenced by the significant reliance on derivatives (25.93%) and external DeFi protocols (20.37%). This tension between the mandate for stability and the strategies required for high returns introduces a web of market, counter-party, and contagion risks that fundamentally redefines the asset’s evolutionary stakes.

IV. Security Risks

The systemic importance of stablecoins means their vulnerabilities can trigger cascading failures. This section analyzes the spectrum of security risks afflicting stablecoins, drawing insights from an empirical study of real-world security incidents detailed in Appendix C. Based on 44 significant incidents, we present a statistical breakdown of their root causes, categorizing them into three primary types: Price Fluctuation, Smart Contract Issues, and Peripheral Factors. Each cause is illustrated with a representative case study. The incidents were selected based on two primary criteria:

- Loss exceeding $100K, collated from reputable sources such as BlockSec Phalcon Explorer [45], REKT Database [46], SlowMist Hacked [47], ChainLight Lumos [48], and Neptune Mutual database [49].
- Direct relevance to stablecoin failures, excluding incidents where non-stablecoin projects failed due to external

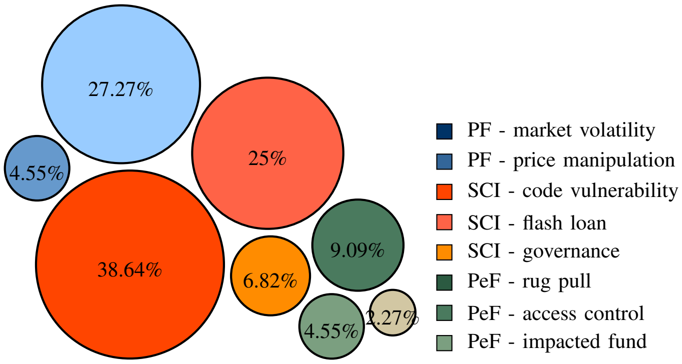

Fig. 7: The cause distribution of historical security incidents (where PF refers to price fluctuation, SCI refers to smart contract issue, and PeF refers to peripheral factor).

stablecoin issues or merely incurred losses denominated in stablecoins.

A. Price Fluctuation

As cryptoassets, stablecoins are inherently exposed to price volatility, a primary concern for both users and attackers. Such fluctuations can be organic, termed market volatility, or maliciously induced, termed price manipulation. These can manifest as gradual drifts, sudden crashes, or even single-transaction shocks, often amplified by tools like flash loans (further discussed in Section IV-B2).

1) Market Volatility: Market volatility tests a stablecoin's resilience across three interconnected stress points:

- Direct volatility of the stablecoin itself, potentially breaching its peg tolerance.
- Devaluation pressure on related protocol tokens (e.g., secondary governance tokens).
- Broad downward trends in the wider cryptocurrency market (e.g., BTC).

Sustained market volatility can critically undermine a protocol's design, implementation, and public confidence.

Case Study: Terra UST/LUNA. The algorithmic stablecoin TerraUSD (UST) aimed for a $1 peg via an arbitrage mechanism with its secondary token, LUNA, where 1 UST was exchangeable for $1 worth of LUNA [1]. This design effectively sacrificed LUNA to stabilize UST during de-peg threats. However, significant sell pressure on LUNA triggered a negative feedback loop, i.e., the "Death Spiral", leading to UST's collapse in May 2022, despite prior academic discussion of this vulnerability.

The sheer scale of the Terra/Luna collapse spurred extensive quantitative modeling. However, a significant body of this research concentrated on the broader financial and economic repercussions, such as contagion effects across crypto markets [1], the market impact of public disclosures [50], [51], flight-to-safety dynamics [52], and overarching devaluation risks [53], [54]. A critical observation is that many of these analyses, while valuable, often did not deeply simulate the stabilization mechanism's specific failure modes under duress, a crucial aspect for understanding its security vulnerabilities against economic attacks or cascading internal breakdowns.

Nevertheless, several studies offered more granular insights into its failings. For instance, Uhlig [55] modeled the crash's progression, highlighting diverse agent behaviors concerning convertibility during the crisis. Kurovskiy et al. [56] explored why the arbitrage mechanism faltered, pinpointing the detrimental effects of floating redemption fees and critical deficiencies in collateral accessibility and liquidity, which are all key parameters for mechanism resilience. From a more technical simulation perspective, Calandra et al. [57] modeled Terra's transaction dynamics and specific de-peg triggers, providing insights into the operational vulnerabilities that precipitated the collapse.

2) Price Manipulation: Price manipulation attacks typically exploit control over a stablecoin's (or its collateral's) reference price sources, which can be:

- Centralized sources: price dashboards (e.g., CoinMarketCap [38]) and CEXs (e.g., Binance [58]). These are generally harder to manipulate but can suffer from reporting lags or inter-exchange price inconsistencies.
- Decentralized sources: oracles (e.g., Chainlink [59]) and DEXs (e.g., Uniswap [60]). Oracles can be vulnerable if their feed sources lack sufficient decentralization or robust validation. DEXs, especially AMM-based ones, can amplify price swings if liquidity pools are shallow, making them targets during periods of high volatility or panic.

Case Study: BonqDAO BEUR. BEUR, an over-collateralized stablecoin pegged to 1 EUR, allowed users to mint BEUR against locked assets. Its vulnerability lay in a permissionless price oracle where the last reported price feed for collateral was considered the spot price. In February 2023, attackers momentarily inflated the price of a collateral asset (WALBT) via this oracle, minted an unearned excess of BEUR, and subsequently halved BEUR's price.

B. Smart Contract Issue

As blockchain-based applications, stablecoins inherit all common smart contract vulnerabilities, while also presenting unique attack surfaces related to their specific economic logic, governance structures, and interactions facilitated by blockchain features like flash loans.

1) Code Vulnerability: Standard software flaws persist in stablecoin contracts, including reentrancy, insufficient input validation (e.g., Beanstalk, Prisma), and logic errors stemming from "copy-paste" practices (e.g., Yearn). The impact of such vulnerabilities is often direct and catastrophic.

Case Study: Cashio CASH. CASH stablecoins could be minted against Saber LP and Arrow Protocol collateral. A critical flaw in the `mint` function involved improper validation of the Arrow account and no token matching. In March 2022, an attacker exploited this by using worthless tokens to mint approximately $53M in CASH, leading to the stablecoin's failure.

2) Flash Loan Attack: Flash loans, which are uncollateralized loans borrowed and repaid within a single atomic transaction [61], [62], provide attackers with immense temporary capital. While a neutral financial tool, they can be weaponized to exploit vulnerabilities in a protocol's economic logic, price oracle dependencies, or governance mechanisms.

Case Study: Beanstalk BEAN. In April 2022, an attacker leveraged a flash loan of over $1 billion (from Aave, Uniswap, SushiSwap) to acquire enough governance tokens to pass malicious Beanstalk Improvement Proposals (BIP18, BIP19). These proposals authorized fund transfers to the attacker. The entire sequence of loan acquisition, voting, proposal execution, and loan repayment occurred within one transaction, resulting in a $182 million loss and the de-facto failure of BEAN as a stablecoin.

3) Governance Attack: Blockchain governance aims to enable decentralized decision-making for protocol evolution and safety [5], [63]. However, poorly designed, implemented, or managed governance systems can introduce critical vulnerabilities, allowing attackers to manipulate outcomes for malicious profit, with effects that are often hard to reverse.

Case Study: Mochi USDM. In November 2021, Mochi exploited Curve's governance by using its USDM stablecoin to acquire a large stake in CVX tokens, thereby gaining disproportionate influence over Curve's reward allocations. This allowed Mochi to boost rewards for its own USDM pool, attract significant liquidity, and subsequently drain $30 million from this pool before abandoning the stablecoin.

C. Peripheral Factor

Beyond the aforementioned, a range of peripheral yet critical factors contribute to stablecoin security risks.

1) Rug Pull: A rug pull is an exit scam where project founders or developers abruptly abandon the project after attracting capital, leaving investors with worthless tokens [64], [65]. This can occur in both centralized and ostensibly decentralized stablecoin projects, often by exploiting pre-set vulnerabilities, centralized control points, or inadequate access controls over protocol funds or liquidity pools.

Case Study: DEFI100. A BSC-based synthetic asset index product, DEFI100 executed an apparent exit scam in May 2021. The project's official website briefly displayed a message "We lied to you, you can't do anything with us" before being taken offline.

2) Access Control: Compromised access control, often involving private keys that represent ultimate authority over contracts or funds, is a fundamental security threat [66]. The security of admin keys, deployer wallets, and multi-signature participants is paramount. Several major stablecoin losses trace back to compromised operational security.

Case Study: Tether. In November 2017, Tether announced that approximately 31 million USDT were illicitly removed from its treasury wallet due to an external attack compromising access. Notably, despite this significant breach, USDT's market dominance was not fatally impacted in the long term, highlighting complex market reactions to such incidents.

3) Impacted Fund: Stablecoins often rely on, or deposit their reserves/collateral into, other DeFi protocols or custodial solutions to generate yield or manage assets. The security of these external dependencies is crucial; a failure in a third-party application can directly impact the stablecoin's backing or solvency.

Case Study: Angle Protocol. The Angle Protocol held $18M USDC in the Euler Protocol. When Euler was hacked for $197M in March 2023, Angle Protocol's funds on Euler were lost, rendering Angle's stablecoin products under-collateralized. Despite this, Angle Protocol has continued to operate, maintaining a notable market share even today.

> ***Insight 4***: While all DeFi systems evolve, stablecoins undergo a particularly acute evolutionary process, focusing on the core mission of improving peg stability. Designs are thus forged through ongoing trial-and-error, where market adoption, liquidity dynamics, and critical incidents, with most notably technical flaws like code vulnerabilities(38.64%) and economic stresses from market volatility(27.27%), act as stringent "*evolutionary pressures*". Market feedbacks and security (near)-incidents challenging peg integrity are pivotal. They necessitate crucial adaptations to a stablecoin's peg mechanism for survival or expose fatal flaws causing failure, which then spurs broader re-evaluation of stability models.

V. The Stablecoin LEGO Framework

This section details the **Stablecoin LEGO** framework, our proposed methodology for evaluating stablecoin resilience. We will 1) present the architecture and scoring methodology of the framework, and 2) demonstrate its practical utility by applying it to real-world stablecoins, an analysis that yields crucial findings regarding their systemic risks and structural integrity.

A. Motivation

A robust evaluation of stablecoins demands a framework that addresses their inherent dual nature: they are simultaneously blockchain-based software and nascent monetary instruments. Unlike traditional decentralized applications (DApps), whose primary role is to provide a service or platform, a stablecoin's core objective is to maintain price stability and function as a reliable digital representation of value. Consequently, any rigorous assessment cannot be confined to technical security audits alone; it must also incorporate analytical models from monetary theory and finance to scrutinize the design, resilience, and economic viability of the stability mechanism itself.

Background. Prior work has initiated the development of stablecoin evaluation frameworks. For instance, Bluechip's SMIDGE framework [67] assesses stablecoins across broad dimensions but primarily offers high-level safety scores without deep, systematic justification for its scoring logic. Similarly, Moody's Digital Asset Monitor [68] provides sophisticated

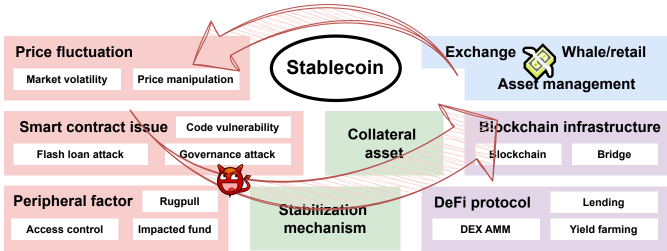

Fig. 8: An overview of the Stablecoin LEGO. The left-hand side represents the upstream while the right-hand side represents the downstream.

tracking of on-chain and off-chain events but concentrates on financial market dynamics, giving less weight to the underlying technical security and specific design choices of the protocols.

While these initial frameworks provide a valuable starting point, they generally do not offer a sufficiently granular or compositional approach to risk. To fill this gap, we introduce the **Stablecoin LEGO** framework, designed for systematic, holistic, and compositional risk evaluation. The name is intentional: complex stablecoins are rarely monolithic. Instead, they are composed of interoperable building blocks (the "LEGOs"), such as collateral management systems, price oracles, governance modules, and redemption mechanisms. Our framework mirrors this reality. It provides a methodology to first deconstruct a stablecoin into its fundamental components (the internal LEGOs), then evaluate each "block" for its specific technical risks and economic assumptions, and finally assess the systemic risks that emerge from their internal composition and external interactions.

B. Methodology

Our Stablecoin LEGO framework models a stablecoin as a dynamic system of three interacting core elements, allowing us to analyze how risks propagate through its ecosystem, as illustrated in Fig. 8. These elements are:

- **Upstream Risk Factors (UP(t)):** External market forces and security threat vectors that impose risks upon a stablecoin (e.g., market volatility, smart contract exploits).
- **Stablecoin Intrinsic State (S(t)):** The internal design choices and active mechanisms that determine a stablecoin's inherent resilience and dynamic response to shocks (e.g., collateralization ratio, governance responsiveness).
- **Downstream Ecosystem Composition (DN(t)):** The network of applications, services, and holder concentrations that build upon or rely on the stablecoin, creating pathways for feedback loops.

These components interact non-linearly, with feedback loops playing a crucial role (e.g., a major downstream event could trigger a crisis of confidence, impacting the stablecoin's intrinsic state and altering upstream market perception). To capture these complex dynamics, we formalize our framework using a System Dynamics Model, an approach widely adopted for modeling complex socio-economic and financial systems [69]–[74].

Formalization. The core of our model is a differential equation that describes the evolution of the stablecoin's state, S(t), over time. For the purpose of this model, S(t) can be represented by a key indicator of its health and scale, such as market capitalization. The state's rate of change is governed by influences from the Upstream (UP(t)), Downstream (DN(t)), and its own internal dynamics:

The core of our model is a differential equation describing the evolution of the stablecoin's intrinsic state, S(t), over time. For the purpose of this model, S(t) can be represented by a key indicator of its health and scale, such as its market capitalization or deviation from peg. The state's rate of change is governed by influences from Upstream risk factors (UP(t)), Downstream ecosystem composition (DN(t)), and its own internal dynamics and resilience mechanisms:

$$\frac{d\mathrm{S}(t)}{dt} = \underbrace{\alpha \cdot \mathrm{UP}(t)}_{\text{External shocks}} + \underbrace{\beta \cdot \mathrm{DN}(t)}_{\text{Ecosystem feedback}} + \underbrace{f(\mathrm{S}(t), \text{params})}_{\text{Internal dynamics}} \quad (6)$$

where α and β are gain coefficients for upstream and downstream inputs, respectively. Our framework then focuses on quantifying the UP(t) and DN(t) components based on empirical data.

1) Upstream Risk Factors: The upstream component, UP(t), quantifies the aggregate external risks facing a stablecoin. We define the sources of these risks, termed Impact Objects, based on common causes of security incidents (detailed in Section IV). To measure the severity of each object, we assign it an Impact Degree, a composite score derived from three facets: exposure index (accessibility of the vulnerable component), impact nature (direct/indirect effect), and loss form (e.g., fund loss vs. control loss), as specified in Table II. These degrees function as risk weights. The total upstream risk is the weighted sum of all impact objects:

$$\mathrm{UP}(t) = \sum_{k=1}^{n} w_k \cdot m_k(t) \quad (7)$$

where for each impact object k, $m_k(t)$ is its quantified metric (e.g., price deviation, audit status) and w_k is the scalar weight derived from its Impact Degree. Specific metrics and their weighting rationale are in Table III.

2) Downstream Ecosystem Composition: The downstream component, DN(t), captures the concentration and composition of a stablecoin's holders and integrated protocols. This determines the potential "blast radius" of a failure and the pathways for contagion: it is critical to understanding how the stablecoin "LEGO brick" interlocks with the broader DeFi structure. A stablecoin's distress can trigger chain reactions, and identifying key dependencies is vital. Our analysis focuses on the top 1000 addresses for each of the 11 stablecoins by market capitalization (see Fig. 9 for the evaluated subset). These typically represent over 75% of the total token supply (while some over 99%). We identify and categorize these holders (e.g., centralized exchanges, DeFi protocols) using services

Impact degree	Explanation	Notation
Exposure index	Exposure concerning basic blockchain, ecosystem, and trading rules.	e_1
	Exposure concerning the protocol designs of specific applications, yet are publicly accessible, e.g., from blockchain data, documentation, audit reports, and open-sourced code.	e_2
	Exposure concerning secret information accessible only within a limited range, e.g., private keys.	e_3
Impact nature	Impact that can indirectly affect the stablecoin.	i_1
	Impact that can directly affect the stablecoin.	i_2
	Impact that can hybrid affect the stablecoin, i.e., directly and indirectly.	i_3
Loss form	The loss is calculated in the form of the number of tokens.	l_1
	The loss is calculated in the form of the price drop.	l_2
	The loss is calculated as a consequence of the loss of control of the stablecoin protocol.	l_3

TABLE II: The definitions of the impact degrees of the upstream risk factors, divided into 3 aspects, each demonstrating 3 levels of impact severity.

Impact object		Quantification metrics	Impact degree
Price fluctuation	Market volatility	Price standard deviation in the past 5 years	(e_1, i_3, l_2)
	Price manipulation	Regular security auditing	(e_2, i_3, l_2)
Smart contract issue	Code vulnerability	Regular security auditing	(e_2, i_1, l_3)
	Flash loan attack	Regular security auditing	(e_2, i_1, l_3)
	Governance attack	Regular security auditing and token decentralization	(e_2, i_1, l_3)
Peripheral factor	Rug pull	Regular security auditing and attestation report	(e_3, i_1, l_3)
	Access control	Regular security auditing	(e_3, i_1, l_3)
	Impacted fund	Regular attestation report	(e_2, i_1, l_1)

TABLE III: The quantification metrics of the upstream for the impacted objects, performing in a weighted manner.

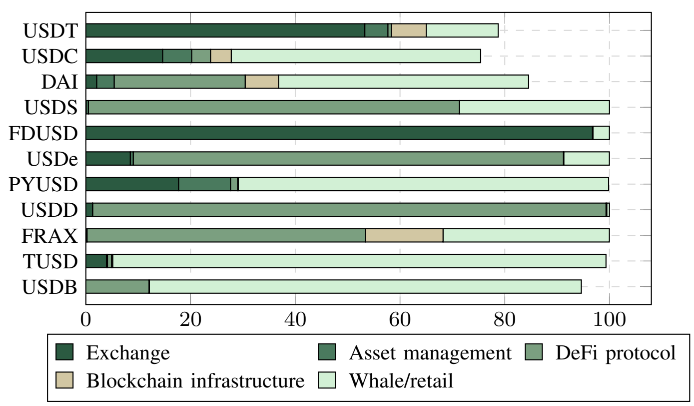

Fig. 9: The token distributions of the 11 stablecoins regarding identity and ownership.

from Etherscan and BlockSec MetaSuite. The downstream impact is thus represented by a vector of token shares held by each category:

$$\text{DN}(t) = \textbf{TokenShare}(t) \tag{8}$$

C. Result

The application of our Stablecoin LEGO framework yields the quantitative risk profiles (initial evaluation on 11 stablecoins, Table IV). The upstream $UP(t)$ score quantifies inherent protocol and market risks (higher is riskier), while the downstream $DN(t)$ distribution reveals concentration, indicating the nature of systemic risk. This section presents our key findings by deconstructing these results through illustrative case studies and pattern analysis, demonstrating how the framework provides a granular, data-driven view of the stablecoin risk landscape.

1) Finding 1: Risk Is Not Monolithic: Our analysis reveals that stablecoins fall into distinct risk archetypes defined by their downstream composition. The LEGO framework's value lies in its ability to differentiate these risk profiles, as illustrated by the following cases.

Case Study 1: The DeFi-centric archetype (USDD). USDD scores a moderately high Upstream risk of 13.25 but, more critically, has a 98.1% downstream concentration in DeFi protocols. This profile is structurally reminiscent of past failures like Terra UST. While its stabilization mechanism differs, its near-total reliance on host DeFi ecosystems creates enormous contagion risk. The framework flags this clearly: a vulnerability in its stabilization logic (reflected in its Upstream score) would hardly be contained. Its impact would be massively amplified, threatening a cascading failure of the liquidity pools and lending platforms that treat it as a foundational "LEGO brick." The framework thus identifies a critical concern: an extreme dependency on the health and security of a few third-party DeFi protocols.

Case Study 2: The exchange-centric archetype (FDUSD). FDUSD presents a different risk profile. Its Upstream score of 12.89 is comparable to USDD's, but its 96.7% concentration on CEXs shifts the primary threat to custodial and counterparty risk. The framework's downstream analysis highlights that for an FDUSD holder, the security of the stablecoin is less about its on-chain mechanism and more about the solvency, security practices, and regulatory standing of a single corporate entity

Stablecoin	UP(t) Price fluctuation	Smart contract issue	Peripheral factor	Total	DN(t) Exchange	Asset management	DeFi protocol	Blockchain infrastructure	Whale/retail
USDT	2.1583	3.7000	5.7101	12.7117	**53.2682**	4.4057	0.6603	6.6690	13.7521
USDC	2.1583	3.7000	5.6553	12.6570	14.6538	5.5597	3.5957	3.9556	47.6325
DAI	1.9833	3.4000	5.4750	11.7492	2.0564	3.3415	25.0256	6.3893	47.7420
USDS	0.0001	0.0000	2.5000	**3.0940**	0.0417	0.4356	**70.8696**	0.0000	28.6523
FDUSD	2.0417	3.5000	5.4803	12.8872	**96.7493**	0.0558	0.0207	0.0169	3.1495
USDe	1.5167	2.6000	4.3366	9.7278	8.4785	0.5660	**82.1671**	0.0634	8.7129
PYUSD	4.1583	3.7000	5.6553	14.8439	17.6987	9.9289	1.3587	0.1112	**70.7349**
USDD	2.1000	3.6000	5.6500	13.2500	1.2696	0.0054	**98.0634**	0.1439	0.5097
FRAX	1.4583	2.5000	4.6875	9.3755	0.0165	0.2029	**53.1922**	14.8037	31.7717
TUSD	2.2167	3.8000	3.3250	11.2278	3.9264	0.1905	0.7820	0.2251	**94.2145**
USDB	2.3347	4.0000	6.0000	14.1825	0.0000	0.0000	12.0578	0.0394	**82.5321**

TABLE IV: The evaluation results of 11 stablecoins under the Stablecoin LEGO framework.

(e.g., Binance). This recalls historical failures like exchange collapses, where users' assets were frozen or lost. Our framework makes this abstract risk concrete and quantifiable.

Case Study 3: The whale-dominated archetype (TUSD). TUSD, with an Upstream risk of 11.23 and a 94.2% concentration in private whale wallets, exemplifies a third archetype. The primary risk here is the centralization of power and market stability. The framework reveals that the asset's fate rests in the hands of a few large, anonymous holders. This composition makes it structurally vulnerable to a "bank run" scenario, where a few entities exiting could collapse market confidence. This insight goes beyond analyzing the protocol's code to assessing the real-world distribution of power over the asset.

2) Finding 2: Common Ecosystem-Wide Weaknesses: Our analysis also reveals that the Peripheral factor (as defined in Table III) is the principal driver of quantifiable risk across almost all stablecoins. Specifically, this category typically accounts for 40-50% of the total UP(t) risk for major stablecoins like USDT (44.9%), USDC (44.7%), and DAI (46.6%), extending to 80.8% for USDS (with TUSD as the main exception where "Smart Contract Issue" leads). This empirical finding signifies a potential systemic misalignment between perceived risk focal points (often core contract logic) and the primary sources of measured upstream vulnerability. The persistently high contribution indicates a critical gap in the efficacy or scope of current industry safeguards for these foundational operational and counterparty threats. This strongly suggests a need for re-prioritizing risk management efforts and audit focuses within the stablecoin ecosystem.

3) Discussion and Implications: The findings from our framework have direct implications for key stakeholders in the ecosystem.

For developers and security auditors: The results advocate for a shift in focus from purely internal code security to a more holistic, compositional risk analysis. For a DeFi-centric coin like USDD, security audits must extend to the host protocols it depends on. For all protocols, the high scores in "Peripheral factors" signal an urgent need to bolster defenses around oracles and governance, which are the very "connective tissue" between LEGO bricks.

For investors and users: The LEGO framework transforms the abstract notion of "risk" into a tangible choice between different risk models. An investor can now consciously select their exposure: the systemic contagion risk of DeFi-centric assets, the corporate counterparty risk of exchange-centric coins, or the market manipulation risk of whale-dominated tokens. Our framework argues there is no safest stablecoin in absolute terms, only one whose risk profile best aligns with an individual's tolerance.

For Regulators: The framework provides a data-driven tool for identifying and monitoring sources of systemic risk. The quantifiable downstream concentration metrics (e.g., FDUSD's 96.7% exchange concentration) can help pinpoint entities that are "too big to fail" within the crypto ecosystem, enabling more targeted oversight.

4) Limitations and Future Work: We acknowledge certain limitations. The risk weights in our model are based on an analysis of historical incidents; a formal sensitivity analysis testing the framework's robustness to different weightings would be a valuable next step to further strengthen our findings. Additionally, our model does not currently incorporate qualitative factors like a protocol's age or reputation (the "Lindy Effect"), which could be an avenue for future research. We advocate for such evaluations to be an enduring commitment for stablecoin integrity. To this end, we will continue to advance the Stablecoin LEGO framework and periodically update its results, contributing to the secure and sustainable growth of the ecosystem.

VI. Conclusion

This SoK facilitates the understanding of stablecoins by analyzing 157 research studies, 95 active stablecoins, and 44 major security incidents. We establish that stability is not an inherent property but a fragile equilibrium governed by risk specialization, i.e., design trade-offs that concentrate unmitigated risks. This tension is now systemically exacerbated by a "dual mandate" for both stability and high-risk yield. To assess these dynamics, we introduce the Stablecoin LEGO framework, a quantitative methodology for risk evaluation. Ultimately, this work provides a rigorous foundation for building, analyzing, and regulating stablecoins.

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Appendix

A. Stablecoin Definition

1) Prior Research Dataset: The stablecoin definitions are from academic papers (Table VII), governmental reports (Table VIII, IX), and industry reports (Table X).

2) Top Web3 Media: The top Web3 media list, shown in Table V, is determined by the total visits in the recent 2 years (December 2022 - November 2024), according to Semrush Traffic Analytics [218].

B. Existing Stablecoins

The list of 95 active stablecoins with a market capitalization exceeding $10M (May 2025) is shown in Table XI, XII.

Media	URL	Visits
CoinTelegraph	https://cointelegraph.com/	235.6M
CoinDesk	https://www.coindesk.com/	232.4M
BeInCrypto	https://beincrypto.com/	124.0M
Cryptonews	https://cryptonews.com/	64.3M
Decrypt	https://decrypt.co/	62.0M
CoinGape	https://coingape.com/	46.1M
Crypto News	https://crypto.news/	42.7M
Bitcoin.com News	https://news.bitcoin.com/	41.2M
The Crypto Basic	https://thecryptobasic.com/	39.0M
U.Today	https://u.today/	35.5M
The Block	https://www.theblock.co/	29.1M
Bitcoinist	https://bitcoinist.com/	23.5M
CryptoSlate	https://cryptoslate.com/	20.4M
CryptoPotato	https://cryptopotato.com/	18.3M
Blockworks	https://blockworks.co/	17.3M
BlockBeats	https://www.theblockbeats.info/	13.8M
Bitcoin Magazine	https://bitcoinmagazine.com/	13.2M
NewsBTC	https://www.newsbtc.com/	12.9M
Foresight News	https://foresightnews.pro/	12.6M
Crypto Daily	https://cryptodaily.co.uk/	11.3M

TABLE V: The visits count of Web3 medias.

No.	Country/ Organization	Department	#
1	Canada	Bank of Canada	3
2	USA	The Federal Reserve	9
3	UK	Bank of England	2
4	France	Banque de France	2
5	Germany	Deutsche Bundesbank	6
6	Italy	Banca d'Italia	0
7	Japan	Bank of Japan	0
8	Brazil	Banco Central do Brasil	2
9	Russia	Bank of Russia	3
10	India	Reserve Bank of India	2
11	China	People's Bank of China, Hong Kong Monetary Authority	4
12	South Africa	South African Reserve Bank	2
13	Mexico	Banco de México	1
14	Argentina	Central Bank of Argentina	*
15	Türkiye	Türkiye Cumhuriyet Merkez Bankası	0
16	South Korea	Bank of Korea	3
17	Indonesia	Bank Indonesia	1
18	Australia	Reserve Bank of Australia	13
19	Saudi Arabia	Saudi Central Bank	0
20	European Union	European Central Bank	5
21	African Union	**	**
22	International Monetary Fund (IMF)		6
23	World Bank (WB)		2
24	Bank for International Settlements (BIS)		8
25	Financial Stability Board (FSB)		10
26	Financial Action Task Force (FATF)		3
27	Group of Seven (G7)		1
		Total	81

TABLE VI: The numbers of the stablecoin-related reports from G20 members and relevant international financial organizations since 2019. * No English version for the websites and publication. ** The central bank related institutions have not yet established. Note that the sum exceeds 81 due to several inter-institution cooperation works.

C. Security Incidents

The dataset of stablecoin security incidents with losses exceeding $100K are detailed in Table XIII.

No.	Research source	Year	Blockchain	Pegged asset	Stability
1	Yujin Potter et al. (ICBC) [10]	2024	Unspecified	Unspecified	Minimize price fluctuations
2	Yizhou Cao et al. (SSRN) [75]	2024	Public blockchain	Stable financial assets	Pegged
3	Cheick Tidiane Ba et al. (arXiv) [76]	2024	Unspecified	Unspecified	Pegging
4	Kun Duan et al. (Finance Res. Lett.) [77]	2023	Unspecified	Fiat currencies or assets that are relatively stable	Maintain a peg
5	Richard K. Lyons et al. (J. Int. Money Finance) [78]	2023	Unspecified	National currency	Lower volatility
6	Ingo Fiedler et al. (Emerald) [79]	2023	Unspecified	Fiat currencies like the dollar or physical assets like gold	Pegged
7	Lennart Ante et al. (FinTech) [80]	2023	Unspecified	Other assets, most often the U.S. dollar but also other fiat currencies or physical assets, such as gold	Peg their value
8	Yiming Ma et al. (SSRN) [81]	2023	Blockchain	$1 (fiat)	Stable
9	Yongqi Guan et al. (SOUPS Poster) [82]	2023	Unspecified	A specific asset	Anchored (fixed value)
10	Bruce Mizrach (arXiv) [83]	2023	Distributed ledger	Fiat assets and other stores of value	Maintain price stability
11	Blanka Łęt et al. (Technol. Forecast. Soc. Change) [84]	2023	Distributed ledger	An underlying asset, e.g., the US dollar, precious metals	Pegged
12	Anneke Kosse et al. (BIS) [85]	2023	Unspecified	A specified peg	Maintain a stable value
13	Christoph Bertsch (Riksbank) [86]	2023	Unspecified	Unspecified	Stable
14	Christian Catalini et al. (Annu. Rev. Financ. Econ.) [87]	2022	Unspecified	A reference asset (typically the US dollar)	Trade at par
15	Ye Li et al. (SSRN) [88]	2022	Unspecified	Fiat currency	Maintain a stable price
16	Binh Nguyen Thanh et al. (J. Ind. Bus. Econ.) [89]	2022	Unspecified	Another asset	Have stable value
17	Ariah Klages-Mundt et al. (Math. Financ.) [90]	2022	Unspecified	Unspecified	Stabilize price/purchasing power
18	Lin William Cong et al. (JFE) [91]	2022	Unspecified	Unspecified	Unspecified
19	Adrien d'Avernas et al. (SSRN) [92]	2022	Unspecified	An official currency	Maintain a peg
20	Martin M. Bojaj et al. (Econ. Model.) [93]	2022	Blockchain	Various currencies and commodities	One-to-one peg
21	Jamie Morgan (RIBAF) [94]	2022	Unspecified	A reference asset (typically a fiat currency such as the US$)	Stabilised
22	Gary B. Gorton et al. (NBER) [95]	2022	Unspecified	Fiat currency	Maintain a constant dollar price
23	Harald Uhlig (NBER) [55]	2022	Unspecified	Unspecified	Unspecified
24	Garth Baughman et al. (Fed) [96]	2022	Unspecified	Real-world asset	Maintain its peg
25	Gordon Y. Liao et al. (Fed) [97]	2022	Distributed ledger	An external reference, typically the U.S. dollar	Peg their value
26	Parma Bains et al. (IMF) [98]	2022	Unspecified	Specified asset(s)	Maintain a stable value
27	Wilko Bolt et al. (DNB) [99]	2022	Unspecified	Fiat currency(ies), commodity(ies), cryptoasset(s), or a combination	Maintain a stable value
28	Lennart Ante et al. (Finance Res. Lett.) [100]	2021	Unspecified	Less volatile assets or currencies	Pegged
29	Dirk G. Baur et al. (Finance Res. Lett.) [101]	2021	Unspecified	Other (relatively) stable assets such as gold or the US dollar	Pegged
30	Lai T. Hoang et al. (Eur. J. Finance) [102]	2021	Unspecified	Currencies or assets that are (relatively) stable such as the US dollar	Pegged
31	Lennart Ante et al. (TFSC) [103]	2021	Public blockchain	Non-volatile values, most commonly a fiat currency	Peg
32	Ariah Klages-Mundt et al. (CES) [9]	2021	Public blockchain	Unspecified	Stabilize the purchasing power
33	Klaudia Jarno et al. (J. Risk Financial Manag.) [104]	2021	Unspecified	Unspecified	Minimize fluctuations
34	Christian Catalini et al. (SSRN) [105]	2021	Unspecified	A reference asset, typically the U.S. Dollar	Maintain stability
35	Cangshu Li et al. (CEJ) [106]	2021	Public blockchain	Legal tender or other assets	Relatively stable price
36	Ingolf G. A. Pernice (FC Workshop) [107]	2021	Unspecified	Unspecified	Close to the price
37	Wenqi Zhao et al. (FC Workshop) [108]	2021	Unspecified	External assets	Minimize the volatility
38	Yujin Kwon et al. (SSRN) [109]	2021	Unspecified	Unspecified	Provide a stable value
39	Amani Moin et al. (FC) [110]	2020	Unspecified	Some reference point, such as USD	Stable
40	Ariah Klages-Mundt et al. (AFT) [8]	2020	Unspecified	Unspecified	Stabilize price&purchasing power
41	Jess Cheng (BBLJ) [111]	2020	Distributed ledger	A reference asset or basket of assets	Stabilize the price
42	Makiko Mita et al. (IJSKM) [7]	2020	Unspecified	Stable assets or major fiat currencies	Peg
43	Clemens Jeger et al. (BCCA) [112]	2020	Unspecified	Fiat currencies, gold or even another cryptocurrency	Maintain a stable value
44	Alexander Lipton et al. (arXiv) [113]	2020	Unspecified	A target quote currency	Low price volatility
45	Alexander Lipton et al. (Building the New Economy) [114]	2020	Unspecified	A target quote currency	Low price volatility
46	Gang-Jin Wang et al. (RIBAF) [115]	2020	Unspecified	A fiat currency (e.g., USD and CNY) or a commodity (e.g., precious metals such as gold and silver)	Low-volatility
47	Mario Bellia et al. (SSRN) [116]	2020	Unspecified	Unspecified	Unspecified
48	Fiona van Echelpoel et al. (ECB) [117]	2020	Unspecified	Currency(ies)	Minimise fluctuations
49	Jon Frost et al. (DNB) [118]	2020	Unspecified	Assets or fiat currencies	Maintain a stable value
50	Douglas W. Arner et al. (BIS) [119]	2020	Unspecified	Fiat currencies or other assets	Tied
51	Makiko Mita et al. (IIAI-AAI) [120]	2019	Blockchain	Another currency	Lower volatility
52	E. L. Sidorenko (ISCDTE) [121]	2019	Unspecified	Underlying asset (national currency, gold, oil, etc.)	Low volatility
53	Aleksander Berentsen et al. (VoxEU.org) [122]	2019	Unspecified	Unspecified	Minimise price volatility
54	Amani Moin et al. (arXiv) [123]	2019	Unspecified	Some reference point	Stable
55	Barry Eichengreen (NBER) [124]	2019	Unspecified	Official numeraire	Maintain a peg
56	Dirk Bullmann et al. (ECB) [125]	2019	Unspecified	Unspecified	Minimise fluctuations

TABLE VII: Stablecoin definitions from academic papers. Note that all descriptions in the last three columns are directly *quoted* from the original text, except for the "Unspecified"s.

No.	Research source	Year	Blockchain	Pegged asset	Stability
1	The Federal Reserve [126]	2024	Unspecified	National currency or another reference asset	Maintain a stable value
2	The Federal Reserve [127]	2024	Unspecified	National currency or another reference asset	Maintain a stable value
3	Banque de France [128]	2024	Cryptographic tech.	A benchmark asset (gold, the euro, the dollar, a group of currencies, etc.)	More stable value
4	Bank of Russia [129]	2024	Unspecified	Fiat currency and other assets (gold, other commodities, cryptocurrencies, etc.) or a basket thereof	Pegged
5	Reserve Bank of India [130]	2024	Unspecified	A numeraire like fiat currency or gold	Maintain a fixed face value
6	Hong Kong Monetary Authority [131]	2024	Blockchain	Certain asset(s), typically fiat currencies	Maintain a stable value
7	Financial Services and the Treasury Bureau, and Hong Kong Monetary Authority [18]	2024	Decentralised distributed ledger or similar tech.	Fiat currencies and other types of assets	Unspecified
8	Bank of Korea [132]	2024	Unspecified	Reserve assets, such as a fiat currency or a commodity	Maintain a stable value
9	International Monetary Fund [133]	2024	Unspecified	Specific currencies, such as the U.S. dollar	Pegged
10	The Federal Reserve [134]	2023	Unspecified	National currency or another reference asset	Maintain a stable value
11	The Federal Reserve [135]	2023	Unspecified	National currency or another reference asset	Maintain a stable value
12	Bank of England [136]	2023	Unspecified	Fiat currency	Maintain a stable value
13	Banque de France [137]	2023	Public blockchain	Fiat currency	Maintain a stable value
14	Deutsche Bundesbank [138]	2023	Unspecified	Government currencies, asset backing, and crypto tokens	Stable
15	Bank of Canada [139]	2023	Unspecified	Fiat currency	Unspecified
16	Bank of Russia [26]	2023	Unspecified	Another asset (fiat currency, precious metals, etc.) or a basket of various assets	Maintain a stable value
17	Banco Central do Brasil [140]	2023	Unspecified	A predefined asset or an asset basket	Peg
18	South African Reserve Bank [141]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
19	Hong Kong Monetary Authority [142]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
20	Bank of Korea [143]	2023	Unspecified	Reserve assets, including currencies and commodities	Achieve price stability
21	Reserve Bank of Australia [144]	2023	Unspecified	A specified unit of account or store of value, such as a national currency or commodity	Maintain a stable value
22	Bank for International Settlements [145]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
23	Bank for International Settlements and Hong Kong Monetary Authority [146]	2023	Unspecified	A specified asset (typically USD), or a pool or basket of assets	Maintain a stable value
24	Bank for International Settlements [147]	2023	Blockchain	A specified asset, or a pool or basket of assets	Maintain a stable value
25	Financial Stability Board [148]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
26	Financial Stability Board and International Monetary Fund [149]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
27	Financial Stability Board [13]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
28	Financial Stability Board [150]	2023	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
29	The Federal Reserve [151]	2022	Unspecified	One or more assets	Peg
30	The Federal Reserve [152]	2022	Unspecified	National currency or another reference asset	Maintain a stable value
31	The Federal Reserve [153]	2022	Unspecified	National currency or another reference asset	Maintain a stable value
32	European Central Bank [154]	2022	Unspecified	Official currency(ies) or other assets	Maintain a stable value
33	Bank of Canada [155]	2022	Unspecified	National currency in most cases	Less volatile than other cryptoassets
34	Banco Central do Brasil [156]	2022	Unspecified	One or more assets (such as sovereign currencies or another asset that is not traded in a cryptocurrency trading environment)	Linked
35	Bank of Russia [157]	2022	Unspecified	Various assets (fiat currency, precious metals and others) or a basket of various assets	Maintain a stable value
36	Reserve Bank of India [158]	2022	Unspecified	A specified asset (typically US dollars), or a pool or basket of assets	Maintain a stable value
37	Bank of Korea [159]	2022	Unspecified	A specific asset (usually a fiat currency)	Stabilize the value
38	Bank Indonesia [160]	2022	Unspecified	A commodity or currency	Relatively stable
39	Reserve Bank of Australia [161]	2022	Unspecified	A specified unit of account or store of value	Maintain a stable value
40	Reserve Bank of Australia [162]	2022	Unspecified	Fiat currencies (particularly the US dollar) or other assets (such as gold)	Maintain a stable value
41	Reserve Bank of Australia [163]	2022	Unspecified	One or more fiat currencies or assets (e.g. the US dollar or gold)	Maintain a stable value
42	Reserve Bank of Australia [164]	2022	Unspecified	Another asset or a basket of assets – commonly a fiat currency (e.g. the US dollar) or a common store of value (e.g. gold)	Minimise price volatility
43	European Central Bank [165]	2022	Unspecified	One or several official currencies or other assets (including crypto-assets)	Maintain a stable value
44	European Central Bank [166]	2022	Unspecified	One or several currencies or other assets (including crypto-assets)	Maintain a stable value
45	European Central Bank [167]	2022	Unspecified	Typically a single fiat currency (or a basket of fiat currencies)	Minimise price volatility
46	International Monetary Fund [168]	2022	Unspecified	Usually a fiat currency	Maintain stable value
47	International Monetary Fund [169]	2022	Unspecified	A stable reference asset	Pegged
48	Bank for International Settlements [170]	2022	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
49	Bank for International Settlements [171]	2022	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
50	Financial Stability Board [172]	2022	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
51	Financial Stability Board [12]	2022	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
52	Financial Stability Board [173]	2022	Unspecified	A specified asset (typically US dollars), or basket of assets	Maintain a stable value
53	The Federal Reserve [174]	2021	Distributed ledger	National currency or other reference asset or assets	Maintain a stable value
54	Bank of England [175]	2021	Unspecified	Government-sponsored or ‘fiat’ currencies	Peg
55	Deutsche Bundesbank [176]	2021	Unspecified	A reference value	Stabilised
56	Deutsche Bundesbank [177]	2021	Distributed ledger	A reference value	Be as stable in value as possible
57	Deutsche Bundesbank [178]	2021	Distributed ledger	Another unit of value	Minimise major fluctuations

TABLE VIII: Stablecoin definitions from governmental institution reports, including government agencies and international organizations. Note that all descriptions in the last three columns are directly *quoted* from the original text, except for the “Unspecified”s.

No.	Research source	Year	Blockchain	Pegged asset	Stability
58	Bank of Canada [179]	2021	Unspecified	A basket of assets	Less volatile
59	South African Reserve Bank [180]	2021	Unspecified	Another asset (typically a unit of currency or commodity) or a basket of assets	Maintain a stable value
60	Banco de México [181]	2021	Distributed registry	Unspecified	Minimize fluctuation
61	Reserve Bank of Australia [182]	2021	Unspecified	A specified asset or pool of assets	Maintain a stable value
62	Reserve Bank of Australia [183]	2021	Unspecified	Unspecified	Maintain a stable value
63	Reserve Bank of Australia [184]	2021	Unspecified	One or more currencies or assets	Maintain a stable value
64	Bank for International Settlements, International Monetary Fund, and World Bank [185]	2021	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
65	Financial Action Task Force [186]	2021	Unspecified	Some reference asset or assets	Maintain a stable value
66	Reserve Bank of Australia [187]	2020	Unspecified	Another asset, typically a unit of currency or a commodity	Maintain a stable value
67	Reserve Bank of Australia [188]	2020	Unspecified	A widely used unit of account (such as the US dollar) or a common store of value (such as gold)	Minimise price volatility
68	Bank for International Settlements and World Bank [189]	2020	Unspecified	Currency/ies	Minimise fluctuations
69	Financial Stability Board [190]	2020	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
70	Financial Stability Board [191]	2020	Unspecified	A specified asset, or a pool or basket of assets	Maintain a stable value
71	Financial Action Task Force [192]	2020	Unspecified	Reference assets	Maintain a stable value
72	Financial Action Task Force [14]	2020	Unspecified	Some reference asset or assets	Maintain a stable value
73	The Federal Reserve [193]	2019	Unspecified	An underlying asset or basket of assets	Tied
74	Deutsche Bundesbank [194]	2019	Unspecified	Unspecified	Maintain a stable value
75	Deutsche Bundesbank [195]	2019	Unspecified	Often an existing currency (or basket of currencies)	Have a stable value
76	Reserve Bank of Australia [196]	2019	Unspecified	Unit of account (often the US dollar) or a common store of value (such as gold)	Minimise price volatility
77	Reserve Bank of Australia [197]	2019	Unspecified	Another asset, typically a unit of currency or a commodity	Maintain a stable value
78	Reserve Bank of Australia [198]	2019	Unspecified	A reference asset (such as a sovereign currency or gold) or a basket of assets	Minimise price volatility
79	European Central Bank [199]	2019	Unspecified	Currency(ies), securities&commodities, crypto-assets, and future expectations	Minimise price fluctuations
80	Financial Stability Board [17]	2019	Unspecified	Another asset (typically a unit of currency or commodity) or a basket of assets	Maintain a stable value
81	Group of Seven, International Monetary Fund, and Bank for International Settlements [15]	2019	Distributed ledger	Fiat currencies	Achieve stable value

TABLE IX: (Cont'd) Stablecoin definitions from governmental institution reports, including government agencies and international organizations. Note that all descriptions in the last three columns are directly *quoted* from the original text, except for the "Unspecified"s.

No.	Research source	Year	Blockchain	Pegged asset	Stability
1	Cointelegraph [200]	2024	Blockchain	Fiat currencies	Offer price stability
2	IDA and Quinlan&Associates [201]	2024	Distributed ledger	Fiat currency values	Ensure close alignment
3	Visa [202]	2024	Blockchain	Unspecified	Maintain a stable value
4	BeInCrypto [203]	2024	Unspecified	Another asset, such as gold, fiat currency, or another cryptocurrency	Maintain a set (near-constant) value
5	Standard Chartered and Zodia Markets [204]	2024	Unspecified	A national currency or other reference rate	Maintain a stable value
6	CoinDesk [205]	2024	Unspecified	Another asset class, such as a fiat currency or gold	Keep a stable, steady value
7	Castle Island Ventures and Brevan Howard Digital [206]	2024	Public blockchain	Fiat currency	Unspecified
8	Chainalysis [207]	2024	Unspecified	Unspecified	Unspecified
9	Chainalysis [208]	2024	Unspecified	Typically U.S. dollar	Pegged
10	CCData [209]	2024	Unspecified	Another currency, commodity, or financial instrument	Pegged
11	Stablecoin Standard [210]	2024	Blockchain	Fiat or e-money	Unspecified
12	PwC and Stellar Development Foundation [211]	2023	Unspecified	Fiat currencies, commodities or other crypto assets	Price stability
13	PwC [212]	2023	Unspecified	Unspecified	Unspecified
14	Moody's [68]	2023	Blockchain	Fiat currencies	Pegged
15	Decrypt [213]	2023	Unspecified	Fiat currency	Pegged
16	PwC [214]	2022	Unspecified	An asset considered to have a stable value (for instance, a fiat currency or precious metals)	Minimise volatility
17	KPMG and Aspen Digital [215]	2022	Unspecified	Unspecified	Unspecified
18	Bluechip [67]	2022	Unspecified	Unspecified	Unspecified
19	Stellar and Wirex [216]	2021	Unspecified	A stable asset	Mitigate the price volatility
20	Castle Island Ventures [217]	2020	Public blockchain	Sovereign currencies	Track the return of sovereign currencies

TABLE X: Stablecoin definitions from industry reports. Note that all descriptions in the last three columns are directly *quoted* from the original text, except for the "Unspecified"s.

No.	Project	Stablecoin	Market cap	Pegged asset	Collateral asset	Stabilization mechanism	Yield rate	Yield source
1	Tether	USDT	$152,797M	USD	Fiat currency	Implicit	N/A	
2	Circle	USDC	$61,523M	USD	Fiat currency	Implicit	N/A	
3	Sky	USDS	$7,007M	USD	Cryptocurrency	Liquidation and Emergency	6.5%	Native protocol revenue, cash and cash equivalents yield, and external DeFi protocol yield
4	Ethena Labs	USDe	$5,216M	USD	Cryptocurrency	Hedging	4%	L1 staking reward, derivatives-driven yield, and third-party custodian revenue
5	MakerDAO	DAI	$4,539M	USD	Cryptocurrency	Liquidation	N/A	
6	World Liberty Financial	USD1	$2,152M	USD	Fiat currency	Implicit	N/A	
7	First Digital Labs	FDUSD	$1,628M	USD	Fiat currency	Implicit	N/A	
8	Ethena Labs	USDtb	$1,443M	USD	Fiat currency	Implicit	N/A	
9	PayPal	PYUSD	$904M	USD	Fiat currency	Implicit	N/A	
10	Usual	USD0	$635M	USD	Fiat currency	Implicit	10%	Cash and cash equivalents yield, and secondary token emission
11	Ondo Finance	USDY	$580M	USD	Fiat currency	Implicit	4.35%	Cash and cash equivalents yield
12	TrueUSD	TUSD	$494M	USD	Fiat currency	Implicit	N/A	
13	Maple Finance	SyrupUSDC	$456M	USD	Cryptocurrency	Liquidation	10.1%	Native protocol revenue
14	Hashnote	USYC	$390M	USD	Fiat currency	Implicit	Not mentioned	Cash and cash equivalents yield
15	Falcon Finance	USDf	$384M	USD	Cryptocurrency	Liquidation, hedging, and supply adjustment	9.4%	Derivatives-driven yield and external DeFi protocol yield
16	USDD	USDD	$376M	USD	Cryptocurrency	Supply adjustment	20%	Community-subsidized fund
17	Stables Labs	USDX	$373M	USD	Cryptocurrency	Hedging	8.23%	Derivatives-driven yield and community-subsidized fund
18	Ripple	RLUSD	$310M	USD	Fiat currency	Implicit	N/A	
19	Global Dollar Network	USDG	$278M	USD	Fiat currency	Implicit	N/A	
20	Resolv Labs	USR	$259M	USD	Cryptocurrency	Hedging	8%	L1 staking reward and derivatives-driven yield
21	Aave	GHO	$250M	USD	Cryptocurrency	Liquidation and supply adjustment	4.23%	Community-subsidized fund
22	Blast	USDB	$244M	USD	Cryptocurrency	Implicit	13.5%	Third-party custodian revenue
23	M0	M	$237M	USD	Fiat currency	Supply adjustment	4.32%	Cash and cash equivalents yield
24	Circle	EURC	$235M	EUR	Fiat currency	Implicit	N/A	
25	OpenEden	USDO	$227M	USD	Fiat currency	Implicit	3.9%	Cash and cash equivalents yield
26	Avalon Labs	USDa	$201M	USD	Cryptocurrency	Liquidation	5%	Native protocol revenue
27	Level	lvlUSD	$184M	USD	Cryptocurrency	Supply adjustment	10.72%	External DeFi protocol yield
28	Elixir	deUSD	$184M	USD	Cryptocurrency	Hedging	5.79%	Derivatives-driven yield and third-party custodian revenue
29	Curve Finance	crvUSD	$168M	USD	Cryptocurrency	Supply adjustment and emergency	1.1%	Native protocol revenue
30	A7A5	A7A5	$143M	RUB	Fiat currency	Implicit	8.63%	Cash and cash equivalents yield
31	Stasis	EURS	$140M	EUR	Fiat currency	Implicit	N/A	
32	Paxos	USDL	$137M	USD	Fiat currency	Implicit	3.7%	Cash and cash equivalents yield
33	Aster	USDF	$137M	USD	Cryptocurrency	Supply adjustment and hedging	5.9%	Derivatives-driven yield and secondary token emission
34	Agora	AUSD	$126M	USD	Fiat currency	Implicit	N/A	
35	Anzen	USDz	$122M	USD	RWA	Supply adjustment	15.7%	Third-party custodian revenue
36	Resupply	reUSD	$120M	USD	Cryptocurrency	Supply adjustment and liquidation	21.77%	Native protocol revenue and secondary token emission
37	Berachain	HONEY	$88M	USD	Cryptocurrency	Implicit	N/A	
38	Inverse Finance	DOLA	$79M	USD	Cryptocurrency	Supply adjustment	8.75%	Native protocol revenue
39	Reservoir	rUSD	$75M	USD	Fiat currency, RWA, and cryptocurrency	Supply adjustment	8.5%	Community-subsidized fund
40	Paxos	USDP	$72M	USD	Fiat currency	Emergency	N/A	
41	Frax Finance	frxUSD	$68M	USD	Fiat currency	Implicit	7.15%	Derivatives-driven yield, external DeFi protocol yield, and cash and cash equivalents yield
42	Bucket Protocol	BUCK	$65M	USD	Cryptocurrency	Liquidation and supply adjustment	27.21%	Not mentioned
43	Avant	avUSD	$62M	USD	Cryptocurrency	Hedging	7.99%	Derivatives-driven yield
44	Cygnus Finance	cgUSD	$60M	USD	Fiat currency	Implicit	4.25%	Cash and cash equivalents yield
45	Anchored Coins	AEUR	$58M	EUR	Fiat currency	Implicit	N/A	
46	Binance	BUSD	$57M	USD	Cryptocurrency	Implicit	N/A	
47	Abracadabra	MIM	$55M	USD	Cryptocurrency	Supply adjustment	17.68%	External DeFi protocol yield
48	Felix	feUSD	$51M	USD	Cryptocurrency	Liquidation and supply adjustment	16.93%	Native protocol revenue
49	Lista	lisUSD	$50M	USD	Cryptocurrency	Liquidation and supply adjustment	6.86%	Not mentioned
50	Web 3 Dollar	USD3	$49M	USD	Cryptocurrency	Implicit	4.4%	Not mentioned
51	Gemini	GUSD	$49M	USD	Fiat currency	Implicit	N/A	
52	Overnight Finance	USD+	$48M	USD	Cryptocurrency	Implicit	16.21%	Native protocol revenue, derivatives-driven yield, and external DeFi protocol yield
53	Transfero	BRZ	$48M	BRL	Fiat currency	Implicit	N/A	
54	Mountain Protocol	USDM	$47M	USD	Fiat currency	Implicit	4.5%	Cash and cash equivalents yield
55	Banking Circle	EURI	$47M	EUR	Fiat currency	Implicit	N/A	
56	Societe Generale	EURCV	$46M	EUR	Fiat currency	Implicit	N/A	

TABLE XI: The list of active stablecoins with a market capitalization exceeding $10M (as of May 2025).

No.	Project	Stablecoin	Market cap	Pegged asset	Collateral asset	Stabilization mechanism	Yield rate	Yield source
57	f(x)	fxUSD	$46M	USD	Cryptocurrency	Emergency	12.1%	L1 staking reward and derivatives-driven yield
58	Rings	scUSD	$42M	USD	Cryptocurrency	Implicit	8.2%	External DeFi protocol yield
59	Liquity	LUSD	$41M	USD	Cryptocurrency	Supply adjustment	N/A	
60	Tether	EURT	$40M	EUR	Fiat currency	Implicit	N/A	
61	Celo	CUSD	$35M	USD	Cryptocurrency	Supply adjustment	N/A	
62	Hive	HBD	$34M	USD	Cryptocurrency	Supply adjustment	20%	Community-subsidized fund
63	StraitsX	XUSD	$34M	USD	Fiat currency	Implicit	N/A	
64	Plume	pUSD	$29M	USD	Cryptocurrency	Implicit	N/A	
65	Liquity	BOLD	$28M	USD	Cryptocurrency	Supply adjustment	7.94%	Native protocol revenue
66	Monerium	EURe	$27M	EUR	Fiat currency	Implicit	N/A	
67	MNEE	MNEE	$26M	USD	Fiat currency	Implicit	N/A	
68	Angle	USDA	$26M	USD	Cryptocurrency	Supply adjustment	5.53%	Third-party custodian revenue, native protocol revenue, and external DeFi protocol yield
69	Hex Trust	USDX	$25M	USD	Fiat currency	Implicit	N/A	
70	Synthetix	sUSD	$24M	USD	Cryptocurrency	Implicit	N/A	
71	Gyroscope	GYD	$24M	USD	Cryptocurrency	Supply adjustment and emergency	11.56%	Not mentioned
72	BiLira	TRYB	$24M	TRY	Fiat currency	Implicit	N/A	
73	StandX	DUSD	$23M	USD	Cryptocurrency	Hedging and emergency	8.46%	L1 staking reward and derivatives-driven yield
74	River	satUSD	$23M	USD	Cryptocurrency	Liquidation	20.57%	protocol fees
75	Noon	USN	$22M	USD	Fiat currency and cryptocurrency	Hedging	7.38%	Derivatives-driven yield, and cash and cash equivalents yield
76	Angle	EURA	$22M	EUR	Cryptocurrency	Supply adjustment	4.31%	Cash and cash equivalents yield, external DeFi protocol yield, and native protocol revenue
77	Electronic Dollar	EUSD	$21M	USD	Cryptocurrency	Implicit	4.3%	Not mentioned
78	GMO Trust	ZUSD	$19M	USD	Fiat currency	Implicit	N/A	
79	Aegis	YUSD	$18M	USD	Cryptocurrency	Hedging and supply adjustment	11%	Derivatives-driven yield
80	Yala	YU	$16M	USD	Cryptocurrency	Liquidation and supply adjustment	9.43%	Native protocol revenue, external DeFi protocol yield, and cash and cash equivalents yield
81	dForce	USX	$15M	USD	Cryptocurrency	Emergency	8%	Community-subsidized fund
82	Solayer	sUSD	$15M	USD	Fiat currency	Implicit	3.99%	Cash and cash equivalents yield
83	PT Rupiah Token	IDRT	$14M	IDR	Fiat currency	Implicit	N/A	
84	Alchemix	alUSD	$14M	USD	Cryptocurrency	Implicit	N/A	
85	Frankencoin	ZCHF	$13M	CHF	Cryptocurrency	Liquidation	4.175%	Community-subsidized fund
86	GMO Trust	GYEN	$13M	JPY	Fiat currency	Implicit	N/A	
87	Orby	USC	$12M	USD	Cryptocurrency	Liquidation	0%	Native protocol revenue and secondary token emission
88	StablR	EURR	$11M	Euro	Fiat currency	Implicit	N/A	
89	Youves	uUSD	$11M	USD	Cryptocurrency	Liquidation	14%	Secondary token emission
90	Moneta	USDM	$11M	USD	Fiat currency	Implicit	N/A	
91	WSPN	WUSD	$11M	USD	Fiat currency	Implicit	N/A	
92	JUST	USDJ	$10M	USD	Cryptocurrency	Liquidation	N/A	
93	StraitsX	XSGD	$10M	SGD	Fiat currency	Implicit	N/A	
94	defi.money	MONEY	$10M	USD	Cryptocurrency	Liquidation	26.90%	Native protocol revenue
95	Anzens	USDA	$10M	USD	Fiat currency	Implicit	N/A	

TABLE XII: (Cont'd) The list of active stablecoins with a market capitalization exceeding $10M (as of May 2025).

No.	Project	Stablecoin	Blockchain	Year	Loss	Root cause
1	Terra	UST	Terra	2022	$40B	Market fluctuation
2	Neutrino	USDN	Waves	2022	$200M	Market fluctuation
3	Beanstalk	Bean	Ethereum	2022	$182M	Flash loan attack and governance attack
4	BonqDAO	BEUR	Polygon	2023	$120M	Price manipulation
5	Cashio	CASH	Solana	2022	$53M	Code vulnerability
6	DEFI100	D100	BSC	2021	$32M	Rug pull
7	Mochi	USDM	Ethereum	2021	$30M	Rug pull and governance attack
8	Tether	USDT	Ethereum	2017	$31M	Access control
9	UwU Lend	sUSDe	Ethereum	2024	$23M	Price manipulation
10	Angle Protocol	EURA&USDA	Ethereum	2023	$18M	Impacted fund
11	Deus Finance	DEI	Fantom	2022	$13M	Flash loan attack and price manipulation
12	Prisma Finance	mkUSD	Ethereum	2024	$12M	Code vulnerability
13	Defrost Finance	H2O	Avalanche	2022	$12M	Flash loan attack, access control, and price manipulation
14	Elephant Money	TRUNK	BSC	2022	$12M	Flash loan attack
15	Yearn Finance	yUSDT	Ethereum	2023	$11M	Code vulnerability
16	Platypus Finance	USP	Avalanche	2023	$8.5M	Price manipulation
17	Haven Protocol	xUSD	Haven	2021	$8.2M	Code vulnerability
18	Origin Protocol	OUSD	Ethereum	2020	$8.0M	Code vulnerability
19	True Seigniorage Dollar	TSD	BSC	2021	$7.1M	Governance attack
20	Abracadabra Money	MIM	Ethereum	2024	$6.5M	Code vulnerability
21	Deus Finance	DEI	BSC, Arbitrum	2023	$6.3M	Code vulnerability
22	Seneca	senUSD	Ethereum, Arbitrum	2024	$6.0M	Code vulnerability
23	XSURGE	xUSD	BSC	2021	$5.6M	Flash loan attack
24	Nirvana	NIRV	Solana	2022	$3.5M	Flash loan attack
25	Raft	R	Ethereum	2023	$3.3M	Flash loan attack
26	Deus Finance	DEI	Fantom	2022	$3.0M	Flash loan attack and price manipulation
27	Zunami Protocol	UZD	Ethereum	2023	$2.2M	Flash loan attack and price manipulation
28	Hope Finance	HOPE	Arbitrum	2023	$1.9M	Rug pull
29	Acala	aUSD	Polkadot	2022	$1.6M	Code vulnerability
30	Minterest	mUSDY	Mantle	2024	$1.5M	Flash loan attack and code vulnerability
31	Hubble Protocol	USDH	Solana	2022	$1.3M	Price manipulation
32	PalmSwap	USDP	BSC	2023	$900K	Code vulnerability
33	bDollar	BDO	BSC	2022	$730K	Price manipulation
34	UPFI Network	UPFI	BSC	2024	$521K	Code vulnerability
35	Anzen Finance	USDz	Base	2024	$500K	Code vulnerability
36	PolBase Cash	PBC	Ethereum	2021	$354K	Rug pull
37	SperaxUSD	USDs	Arbitrum	2023	$300K	Code vulnerability
38	TheStandard.io	PAXG	Arbitrum	2023	$290K	Price manipulation
39	Kujira Network	USK	Kujira	2023	$260K	Code vulnerability
40	Safe Dollar	SDO	Polygon	2021	$248K	Flash loan attack
41	Linear Finance	LUSD	BSC	2023	$212K	Code vulnerability
42	Iron Finance	IRON	BSC	2020	$170K	Code vulnerability
43	Elephant Money	TRUNK	BSC	2023	$165K	Price manipulation
44	Abracadabra Money	MIM	Ethereum	2022	$111K	Price manipulation

TABLE XIII: Existing security incidents of stablecoins with losses exceeding $100K.