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The Four Types of Stablecoins: A Comparative Analysis: Open Review

Matthias Hafner,[*] Marco Henriques Pereira,[†] Helmut Dietl,[‡] Juan Beccuti[§]

Reviewers: Reviewer A, Reviewer B

Abstract. The final version of the paper "The Four Types of Stablecoins: A Comparative analysis" can be found in Ledger Vol. 9 (2024) 108-135, DOI 10.5195/LEDGER.2024.326. There were two reviewers involved in the review process, neither of whom has requested to waive their anonymity at present, and are thus listed as Reviewers A and B. After initial review by Reviewers A and B, the submission was returned to the authors with feedback for revision (1A). The author resubmitted their work and responded to reviewer comments (1B). The paper was returned to the reviewers who recommended the paper be accepted, thus ending the peer review process. Author responses have been bulleted for reader clarity.

1A. Review

Reviewer A

Does this paper represent a novel contribution to cryptocurrency or blockchain scholarship?

Yes, incremental contribution(s)

Please briefly explain why you think the paper makes or does not make a novel contribution.

The typology of stablecoins has been a subject of study for years. However, this paper augments previous methodologies by using an agent-based model to simulate the trajectory of each type of stablecoin. This approach offers incremental contributions to blockchain research, providing a new perspective on the topic.

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Is the research framed within its scholarly context and does the paper cite appropriate prior works?

Yes

Please assess the article's level of academic rigor.

Good (not excellent but a long way from poor)

Please assess the article's quality of presentation.

Excellent (the motivation for the work is clear, the prose is fluid and correct grammar is used, the main ideas are communicated concisely, and highly-technical details are relegated to appendixes).

How does the quality of this paper compare to other papers in this field?

The paper ranks highly but it may not be among the most authoritative references in the field.

Please provide your free-form review for the author in this section.

The agent-based simulation model used in this study provides insightful observations into stablecoin behaviors under diverse market conditions, showcasing the varied responses of four distinct types of stablecoins to demand shocks. This nuanced approach underscores the complexity and dynamic nature of stablecoins.

However, I propose three specific revisions to enhance the study's accuracy and implications:

1. Reclassification of TerraUSD (USTC): The current classification of USTC should be revisited. Given the operational dynamics of USTC via the Terra Protocol, which allows allows anyone to issue the stablecoin without a centralized collateral pool, USTC more accurately fits within the endogenous and decentralized category, similar to sUSD. This is despite the Federal Reserve's characterization of USTC as 'uncollateralized' (https://www.federalreserve.gov/econres/notes/feds-notes/the-stable-in-stablecoins-20221216.html). Its mechanism indicates a decentralized model, necessitating a reevaluation of its categorization.

2. Suggested Example for Endogenous-Central Stablecoins: In light of USTC's reclassification, USDD, issued by Tron Dao Reserve (https://tdr.org/#/), emerges as a more appropriate exemplar of an endogenous-central stablecoin. Despite decentralization claims, USDD's issuance and redemption controls imply central governance. If USDD behaves as predicted in the study, it would greatly enhance the significance and accuracy of the research within the field of blockchain studies.

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3. Refinement of the Endogenous-Decentral Stablecoin Category: This category encompasses a broad spectrum of algorithmic stablecoins, each with unique collateral management and economic frameworks. For instance, Steem Dollar (SBD) operates under a supply constraint tied to the market cap of its base asset (STEEM), illustrating a specific response to supply shocks or relative demand surges. Additionally, the distinction between over-collateralized stablecoins (e.g., sUSD, USDD, USDN) and those with 1:1 collateralization (e.g., USDT) hinges on the critical level of collateralization. This differentiation, based on collateral requirements, is pivotal in understanding the stability mechanisms of these stablecoins.

By incorporating these refinements, we can further enrich our understanding of stablecoin dynamics. I deeply appreciate the comprehensive and insightful work the authors have presented in this study. These suggested adjustments aim to complement the already valuable contributions to blockchain research, potentially broadening the impact and applicability of the findings. Thank you for your pioneering efforts in exploring this complex and evolving field.

Reviewer B:

Does this paper represent a novel contribution to cryptocurrency or blockchain scholarship?

Yes, incremental contribution(s)

Please briefly explain why you think the paper makes or does not make a novel contribution.

The manuscript under review makes an incremental contribution to the literature on stablecoins by providing a specific classification framework based on the source and management of collateral. The use of agent-based simulations to assess the stability of each stablecoin category under different market conditions is commendable and provides insights that could be informative to regulators, policymakers, and investors.

Is the research framed within its scholarly context and does the paper cite appropriate prior works?

Yes

Please assess the article's level of academic rigor.

Good (not excellent but a long way from poor)

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Please assess the article's quality of presentation.

Good (not excellent but a long way from poor)

How does the quality of this paper compare to other papers in this field?

This is a good or average paper.

Please provide your free-form review for the author in this section.

1. The four way classification of the stablecoins seems a bit limited. How do you fit algorithmic stablecoins like Ampleforth and Frax, which take a hybrid approach to adjust their supplies algorithmically in response to demand?
2. The discussion on policy could be enriched by considering various international regulatory perspectives and the potential global impact of stablecoin adoption and regulation.
3. Blurred images used in Figure 3. Please improve the image quality to make the figures consistent across the entire paper.
4. How are the three images Figure-1 (part a, b , and d) representing different types of stablecoins demand changes over time exactly the same? Missing explanation/Incorrect graphs.
5. The paper lacks empirical testing of the model's predictions against real-world data. Including some case studies or historical analysis visually could strengthen the validity of the findings.
6. The conclusion could be strengthened by summarizing key findings more sharply and offering clearer, actionable recommendations for practitioners and policymakers. The points on future research directions are also somewhat vague.

1B. Author Response

Reviewer A

The agent-based simulation model used in this study provides insightful observations into stablecoin behaviors under diverse market conditions, showcasing the varied responses of four distinct types of stablecoins to demand shocks. This nuanced approach underscores the complexity and dynamic nature of stablecoins.

However, I propose three specific revisions to enhance the study's accuracy and implications:

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revisited. Given the operational dynamics of USTC via the Terra Protocol, which allows allows anyone to issue the stablecoin without a centralized collateral pool, USTC more accurately fits within the endogenous and decentralized category, similar to sUSD. This is despite the Federal Reserve's characterization of USTC as 'uncollateralized' (https://www.federalreserve.gov/econres/notes/feds-notes/the-stable-in-stablecoins-20221216.html). Its mechanism indicates a decentralized model, necessitating a reevaluation of its categorization.

- Thank you for your comment! We realize now that we were not as clear as we could and should have been about the stablecoin categorization.
- We classify TerraUSD as centralized because although anyone can get TerraUSD, the Terra Protocol manages the collateral and issues the coins based on predetermined rules. Indeed, individuals trigger issuance as well, but the collateral is still kept in a pooled fashion, as individuals are not themselves responsible to keep the peg. To be classified as decentralized, it would have to be more similar to Dai, where anyone can issue Dai and is also responsible for the collateral, i.e., a user is himself responsible to keep the collateral value above the nominal value of his minted stablecoins. In the case of TerraUSD this is not the case because the "collateral" is the native token Luna which (tries to) ensures stability and has nothing to do with "anyone" who redeemed a token at the central Terra Protocol. We hope this is clearer now, and thank you for pointing out this ambiguity.
- We are now clearer and more explicit about the second dimension (pp. 3-4):
  "The second dimension is collateral management, which can be central entities and mechanisms managing pooled collateral or individuals managing their collateral decentrally.27 The key point here is that to be centralized, an entity (or protocol) issues the stablecoin and also provides collateral (thus the entity ensures stability), whereas to be decentralized, anyone can issue the stablecoin and is also responsible for providing collateral (thus the decentralized nature of the stablecoin design ensures stability). Note the collateral management dimension differs from the custodial/non-custodial dimension as it centers on the issuer of stablecoins, i.e., who owns and manages the collateral, rather than the mode of issuance, whether through a central entity or a smart contract. These two dimensions are complementary and our 2 × 2 matrix could be expanded to a 3 × 3 cube by including the custodial/non-custodial dimension. For the purpose of this paper, however, we will stick with the 2 × 2 matrix."

2. Suggested Example for Endogenous-Central Stablecoins: In light of USTC's reclassification, USDD, issued by Tron Dao Reserve (https://tdr.org/#/), emerges as a more appropriate exemplar of an endogenous-central stablecoin. Despite decentralization claims, USDD's issuance and redemption controls imply central governance. If USDD behaves as predicted in the study, it would greatly enhance the significance and accuracy of the research within the field of blockchain studies.

- Thank you for suggesting this interesting example. In the context of our categorization, USDD is a hybrid stablecoin as it contains "multiple mainstream

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cryptocurrencies" (TDR | TRON DAO Reserve). We have added a sentence in the categorization section explaining that there are also hybrid forms like USDD (p. 4):

- *"However, certain exceptions exist within our stablecoin categorization framework. For example, USDD (link to whitepaper) combines collateral sources that are both exogenous and endogenous, placing it between two categories. Additionally, some assets like AMPL (link to whitepaper) do not fit our definition of a stablecoin, as they fail to maintain a stable wallet value for its users as quantities vary over time due to rebasement. Or in other words, the value of a portfolio AMPL fluctuates over time, where it does not for stablecoins."*

3. Refinement of the Endogenous-Decentral Stablecoin Category: This category encompasses a broad spectrum of algorithmic stablecoins, each with unique collateral management and economic frameworks. For instance, Steem Dollar (SBD) operates under a supply constraint tied to the market cap of its base asset (STEEM), illustrating a specific response to supply shocks or relative demand surges. Additionally, the distinction between over-collateralized stablecoins (e.g., sUSD, USDD, USDN) and those with 1:1 collateralization (e.g., USDT) hinges on the critical level of collateralization. This differentiation, based on collateral requirements, is pivotal in understanding the stability mechanisms of these stablecoins.

- Thank you very much for that thoughtful comment. Again, you are right, and we should have been clearer in describing our categorization. So we have added the following to our categorization section (p. 3).
- *"Our categorization is based on the underlying economic characteristics of stablecoins, rather than on their precise operational mechanisms. Despite the existence of considerable diversity in design, the two economic dimensions identified in our categorization can be applied to all stablecoins."*
- Thank you for mentioning SBD. Although it is theoretically a stablecoin, SBD almost never had a value of (close to) 1 USD. This would again fit our story that this type of stablecoin is in danger of crashing and therefore has the highest volatility.
- You are right, the overcollateralization is critical, which can be shown using our analysis. The endogenous stablecoins have higher collateral ratios because they fluctuate stronger in value and because of the death spiral argument. Decentralized stablecoins also have higher collateral ratios because users or liquidators cannot be expected to be as fast in the supply (or collateral) adjustment as central entities.
- We also highlight the importance of the collateral level in the Trilemma section (p. 10).
- *"[...] However, the trilemma still exists due to the concerns, discussed earlier, about endogenous collateral and the less efficient issuance of sUSD, which requires over-collateralization at a rate of 400%, compared to approximately 150% for Dai and 100% for Tether."*

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Reviewer B:

1. The four way classification of the stablecoins seems a bit limited. How do you fit algorithmic stablecoins like Ampleforth and Frax, which take a hybrid approach to adjust their supplies algorithmically in response to demand?

- Thank you very much for this important observation.
- Frax is similar to Tether. The only difference is that its reserve is managed by a DAO (non-custodial) rather than a single entity (custodial). To make this clearer, we have moved the clarification (that we do not distinguish between custodial and non-custodial stablecoins) from an endnote to the main text (p. 3): *"Note the collateral management dimension differs from the custodial/non-custodial dimension as it centers on the issuer of stablecoins, i.e., who owns and manages the collateral, rather than the mode of issuance, whether through a central entity or a smart contract. These two dimensions are complementary and our 2 × 2 matrix could be expanded to a 3 × 3 cube by including the custodial/non-custodial dimension. For the purpose of this paper, however, we will stick with the 2 × 2 matrix."*
- Moreover, we have added this sentence at the end of our categorization section (p. 4): *"However, certain exceptions exist within our stablecoin categorization framework. For example, USDD (link to whitepaper) combines collateral sources that are both exogenous and endogenous, placing it between two categories. Additionally, some assets like AMPL (link to whitepaper) do not fit our definition of a stablecoin, as they fail to maintain a stable price per coin, despite stabilizing overall wallet value through adjustments in coin quantity."*

2. The discussion on policy could be enriched by considering various international regulatory perspectives and the potential global impact of stablecoin adoption and regulation.

- Thank you for this comment. We have done what you suggested and were able to greatly improve this section (pp. 10-11):
- *"This section discusses policy implications of our findings and includes a brief overview of international perspectives on stablecoin regulation.*
- *The high volatility of the crypto market, the fear of instable stablecoins, such as TerraUSD which had worldwide media attention, and of course the growing adoption of stablecoins in general have raised concerns about potential systemic risks, including bankruns, among financial regulators all over the world. To mitigate these risks, policymakers should implement regulations to ensure that such stablecoins maintain high levels of liquidity and sufficient collateral reserves. For stablecoins that utilize an endogenous source of collateral, more stringent requirements such as over-collateralization are necessary to ensure stability.*
- *In the United States, discussions about stablecoin regulation are particularly active. The U.S. Treasury advocates for regulating stablecoin issuers as banks or similar financial institutions, aiming to maintain stablecoin value during financial stress. Legislative proposals, including the Stablecoin TRUST Act of 2022[41] propose a distinct federal framework for stablecoins, requiring them to be fully backed by highly*

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liquid traditional assets and subject to regular audits. Our analysis shows that decentralized stablecoins that use liquid cryptocurrencies (e.g., DAI) can be less prone to failure than centrally managed stablecoins. We cannot, therefore, follow the recommendation by the TRUST Act, which would disallow DAI from using cryptocurrencies as collateral. Our analysis indicates that the type of collateral alone is not the relevant factor; the mechanism is more important. Regulators should thus focus more on the management of collateral and less on the type. Moreover, a draft for a stablecoin bill[6,42] argues that stablecoins with endogenous collateral sources might not be suitable for use. We suggest regulators should consider not only the collateral source but also collateral management, as stablecoins with endogenous and decentrally managed collateral have demonstrated their functionality thus far (e.g., sUSD).

- *The European Union has proactively addressed stablecoin regulation with its Markets in Crypto- Assets Regulation (MiCA),[43] one of the first comprehensive legal frameworks for crypto- assets, including stablecoins. MiCA emphasizes transparency, requiring issuers to disclose their stabilization mechanisms and reserve management. MiCA also categorizes stablecoins based on their reference values—whether pegged to fiat currencies, commodities, or other assets—imposing specific operational requirements to mitigate risks like reserve runs. We suggest using our stablecoin categorization to better assess the strengths and weaknesses of specific stablecoins according to their type and not just based on their reference values.*
- *In Asia, approaches vary: Japan has revised its Payment Services Act[44] to recognize stablecoins as digital money, linking them to the YEN or another legal tender to ensure consumer protection. In contrast, China has banned all cryptocurrency transactions.*
- *As stablecoin adoption increases worldwide, the response from international regulators has been diverse, reflecting different regional financial systems and risk tolerances. This variation highlights the significant influence of stablecoin regulation on global financial stability and innovation. To ensure the safe operation of stablecoins, policymakers must remain vigilant and proactive. Furthermore, as stablecoins continue to evolve, ongoing international dialogue and cooperation are crucial to align regulatory practices, manage risks, and balance innovations in financial technology with security and systemic stability."*

3. Blurred images used in Figure 3. Please improve the image quality to make the figures consistent across the entire paper.

- Thank you! We have replaced Figure 3 with higher resolution images.

4. How are the three images Figure-1 (part a, b , and d) representing different types of stablecoins demand changes over time exactly the same? Missing explanation/Incorrect graphs.

- Thank you for highlighting this issue! The demand function is given by equation (1) for all four types of stablecoins. The crucial difference is "ot", the collateral level. If the collateral level decreases below 1 but is still higher than the critical level "ocrit",

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demand changes only a little (see the three types that did not crash). Only for the Terra-like type "ocrit" was reached and with it the demand fell to 0.

- In our model, demand is independent of the stablecoin but the price and the staking functions are not independent. So although the demand of the three "surviving" stablecoins evolves in the same way, the price does not.
- We have added endnote 35 explaining this a little more clearly in the paper (p. 6): *"As shown in Eq. 1, each type has the same demand function. The critical values are ot and ocrit, which can be different for each stablecoin and therefore influence demand differently. Only in Figure 1c the critical value is reached and thus the demand behaves differently from the others. So the demand is independent of the stablecoin type, unlike the price and staking functions, which depend on the specific stablecoin type."*

5. The paper lacks empirical testing of the model's predictions against real-world data. Including some case studies or historical analysis visually could strengthen the validity of the findings.

- This is a very good point, thank you. We have added a new subsection in the Results section called "4.2. Case Analyses" (pp. 8-9).
- There we describe in more detail two examples of real-world demand shocks and how the two centrally managed stablecoin types responded.
- In addition, we present empirical evidence that Tether-like stablecoins exhibit less volatility than the decentrally managed stablecoins.
- *"This subsection presents real-world cases of stablecoins that empirically support the findings of our agent-based simulation.*
- *[FIGURE 3]*
- *To begin, an examination of the recent incident involving USDC, a stablecoin with exogenous and centrally-managed collateral, which experienced a demand shock in March 2023, illustrates in Figure 3a that this type of stablecoin demonstrated a behavior consistent with our simulation model (compare Figure 2a): Following the demand shock, the price initially declined but ultimately recovered.*
- *Moreover, the TerraUSD crash in May 2022 provides empirical evidence for a death spiral involving a stablecoin with endogenous and centrally managed collateral.37 Figure 3b illustrates that following the demand shock, the price fell below one USD, briefly remaining below one and above zero before ultimately spiraling to zero as in our simulation (see Figure 2c).*
- *[TABLE 2]*
- *Finally, the behavior predicted by our simulation, as illustrated in Figures 2b and 2d, can be empirically validated by comparing historical price data of these types of stablecoins. A comparison of the price volatility of Dai and sUSD reveals that the price volatility of sUSD has been significantly higher than that of Dai, while the price volatility of Dai has been significantly higher than that of USDT or USDC (compare Table 2). This is again consistent with our simulation results. It is evident that TerraUSD exhibits the highest price volatility."*

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6. The conclusion could be strengthened by summarizing key findings more sharply and offering clearer, actionable recommendations for practitioners and policymakers. The points on future research directions are also somewhat vague.

- Thank you very much for this suggestion, which improves our conclusion a lot.
- In the new conclusion, we first summarize the main findings (here we added a little more than in the previous version), second there is a new and clearer paragraph about possible future research directions, and finally we give some actionable recommendations for practitioners and policy makers (pp. 11-12):
- *"This paper presented a new approach to categorizing stablecoins based on an economic perspective and analyzed their stability under different scenarios using agent-based simulation. We identified a trilemma of stability, independence, and costs. We observed that stablecoins with endogenous collateral are more prone to instability and that centralized collateral management increases the risk of a bank run. Stablecoins with decentralized collateral management can ensure the safety of a crash, but have higher price volatility than centralized stablecoins with an exogenous collateral source.*
- *Given the nascent nature of this field, there are numerous avenues for future research. One fruitful approach would be to employ an empirical analysis of all available data on stablecoins to deepen insights into our four types of stablecoins and stablecoins in general. Comparative studies with other cryptocurrencies and traditional fiat currencies may uncover unique characteristics of stablecoins as a financial asset. Furthermore, an examination of stablecoins through the lens of competition economics could reveal potential winner-takes-all dynamics and interactions with similar financial instruments, such as inflation- responsive "flatcoins." Finally, an assessment of the influence of diverse regulatory environments on stablecoin operations could elucidate how policy shapes market behaviors and stability.*
- *Based on our findings, we offer several actionable recommendations for practitioners and policymakers. Practitioners should gain a deep understanding of the mechanics and incentive schemes of each stablecoin under consideration and use our economic categorization as a preliminary guide to evaluate the strengths and weaknesses of different stablecoins, aiding in investment and transaction decisions. Given the pronounced instability of stablecoins with endogenous collateral, practitioners are advised to approach these currencies with caution. For policymakers, our findings underscore the importance of implementing stricter regulations for the unstable stablecoin type to mitigate systemic risks. At the same time, it may be advisable to adopt lighter regulatory frameworks for the more stable types, with the aim of encouraging innovation without compromising security. Summarizing, the solid foundation established by our findings equips researchers, practitioners, and policymakers with a robust framework to assess and address stablecoin stability in these contexts, facilitating informed decision-making in the ever-evolving landscape of digital currencies."*

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