Money Creation in Decentralized Finance: A Dynamic Model of Stablecoins and Crypto Shadow Banking

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June 17, 2022

Cryptocurrencies and Decentralized Finance (DeFi)

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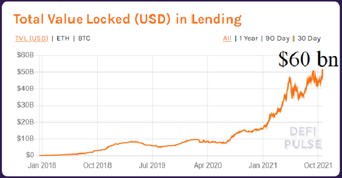
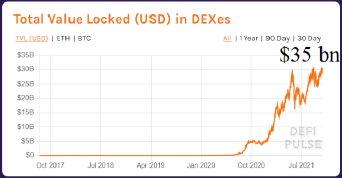
- Most recent phenomenon: Decentralized Finance (DeFi)
  - Blockchain-based alternatives to banking, brokerage, and exchanges

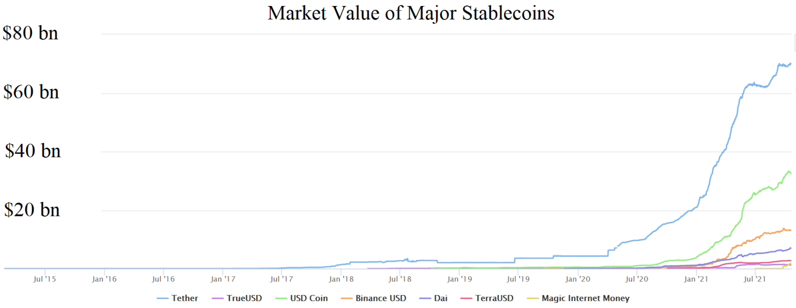
$\Longrightarrow$ Demand for blockchain-based safe assets (= Stablecoins)

  - Many DeFi activities require stable blockchain-based asset
  - Safe asset as a store of value and means of payment

Stablecoins and Decentralized Finance (DeFi)







Stablecoins (Today's Market Cap: $ 150 bn)

- Cryptocurrency pegged to reference unit (e.g., USD)
  - Specialized stablecoin service providers: MakerDAO, Tether, ...
  - Established networks/payment providers: JPM Coin, PayPal

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- Reserve/collateral-based stability mechanisms:
  - Stablecoin backed by risky reserves (e.g., Tether)
  - Open Market Operations (OMO)
- Algorithmic stability mechanisms
  - Typically means less or riskier reserves
  - Example of drastic failure: Iron Finance run or Terra

This Paper — Unifying Model of Stable Asset Creation

Characterize optimal strategies and implementation

- Open market operations, targeted price bands, soft/hard pegs, ...

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- Optimal foreign reserve management and OMOs
- Implementation of price stability and/or peg

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Other applications: Safe asset creation (e.g., by financial intermediaries)

This Paper — Setup

- A dynamic model of stablecoins issued by financially constrained **platform** (i.e., equity issuance is costly)
- Stablecoins offer convenience yield and held by risk-averse users
- To maximize equity value, platform dynamically manages:
  1. Reserve assets
  2. Usage fees
  3. Stablecoin supply (e.g., via issuing/buying stablecoins)

Results — Instability Trap

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  1. No price volatility and stable price
  2. Price is at peg
  3. High stablecoin demand and revenues $\Longrightarrow C \uparrow \Longrightarrow$ Stability $\uparrow$, ...
- When C is low (vicious cycle):
  1. Volatile price & price falls below peg
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$\Longrightarrow$ **Instability Trap**

Results — Stablecoin Regulation

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1. Reserve (capital/collateral) requirements for issuer beneficial
2. To preclude runs: Allow "limited" debasement
3. Volatility Paradox: Restricting riskiness of reserves can reduce stability
4. In general: Stablecoins should not be regulated as banks and there is no "one size fits all" solution

Model — Token Price

- Continuous time and infinite horizon
- Users $i \in [0,1]$) with discount rate (=interest rate) $r > 0$
- Token (= stablecoin) price P_t in dollars:

$$\frac{dP_t}{P_t} = \mu_t^P dt + \sigma_t^P dZ_t \tag{1}$$

- dZ_t: Brownian reserve shock
- Users can trade tokens at price P_t
- Token supply S_t:
  - $dS_t > 0$: Platform issues (mints) tokens
  - $dS_t < 0$: Platform buys back (burns) tokens

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- Stablecoin demand N_t:

$$N_t = \frac{A}{\left(r + f_t - \mu_t^P + \eta|\sigma_t^P|\right)^{\frac{1}{1-\xi}}}$$

- Stablecoin demand N_t decreases with σ_t^P

Model — The Platform's Problem

- Platform reserves evolve according to

$$dM_t = \underbrace{rM_t dt}_{\substack{\text{Interest} \\ \text{earnings}}} + \underbrace{(P_t + dP_t)dS_t}_{\substack{\text{Issuance} \\ \text{proceeds}}} + \underbrace{N_t f_t dt}_{\substack{\text{Fee} \\ \text{revenues}}} + \underbrace{N_t \sigma dZ_t}_{\text{Shock}} - \underbrace{dDiv_t}_{\text{Dividend}} .$$

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- Platform maximizes

$$V_0 \equiv \max_{\{f_t, dS_t, dDiv_t\}} \mathbb{E}\left[\int_0^\infty e^{-\rho t} dDiv_t\right] \quad \text{with} \quad \rho > r$$

Model Solution and Equilibrium

- Market clearing condition:

$$\underbrace{N_t}_{\text{Stablecoin demand in dollars}} = \underbrace{S_t P_t}_{\text{Dollar value of Outstanding stablecoins}} \tag{2}$$

- Platform assets: M_t
- Platform liabilities: $S_t P_t$

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- Platform assets: M_t
- Platform liabilities: $S_t P_t$
- Platform excess reserves only state variable:

$$C_t = \underbrace{M_t}_{\text{Reserve assets}} - \underbrace{S_t P_t}_{\text{Platform liabilities (stablecoins)}}$$

Runs and Liquidation

- Over-collateralization: $C_t > 0$
  - Platform can “defend” exchange rate
- Under-collateralization: $C_t < 0$
  - Platform cannot always “defend” exchange rate
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- Assume: Liquidation (e.g., due to run) at $C = \underline{C} = 0$
  - **Run-proof** stable asset creation
  - Results similar under different (micro-founded) $\underline{C} < 0$

Model Solution — Dynamic Optimization

- Excess reserves evolve according to:

$$dC_t = \Big(\underbrace{rC_t + N_t^{\xi} A^{1-\xi} - N_t \eta |\sigma_t^P|}_{\text{Drift}}\Big) dt + \underbrace{N_t(\sigma - \sigma_t^P)}_{\text{Volatility}} dZ_t - dDiv_t \,.$$

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- Dividends $dDiv > 0$ if and only if $C > \overline{C}$
- $\sigma_t^P > 0$: Risk-sharing via debasement of token price

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1. **Stability Region**: $C \in [\tilde{C}, \overline{C}]$ and

$$N(C) = \min\left\{\left(\frac{\xi A^{1-\xi}}{\gamma(C)\sigma^2}\right)^{\frac{1}{2-\xi}}, \overline{N}\right\} \quad \text{and} \quad \sigma^P(C) = 0.$$

2. **Instability Region**: $C \in (0, \tilde{C})$ and

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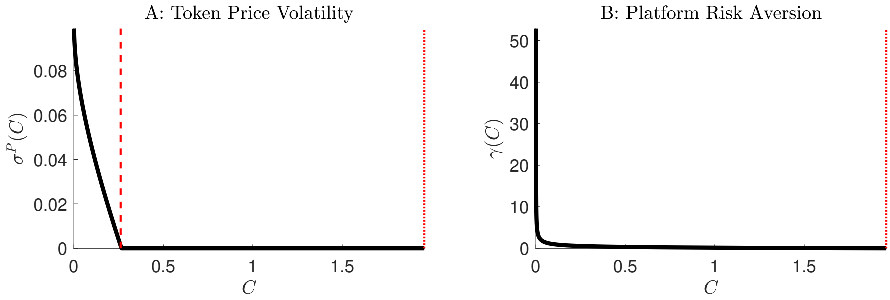
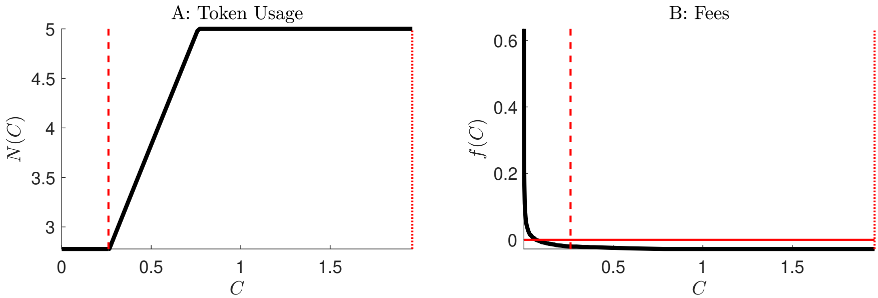
$\Longrightarrow$ As $C \to 0$, $\gamma(C) \to \infty$ and $\sigma^P(C) \to \sigma$

Model Results



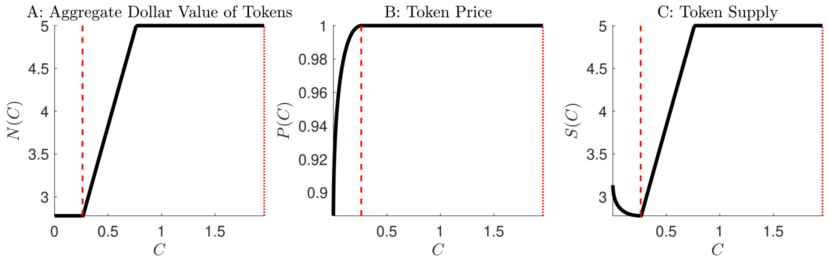
- When C is low: Risk-sharing via debasement ($\sigma^P > 0$)
- When C is high: Stable token price ($\sigma^P = 0$)

Results — Stablecoin Usage



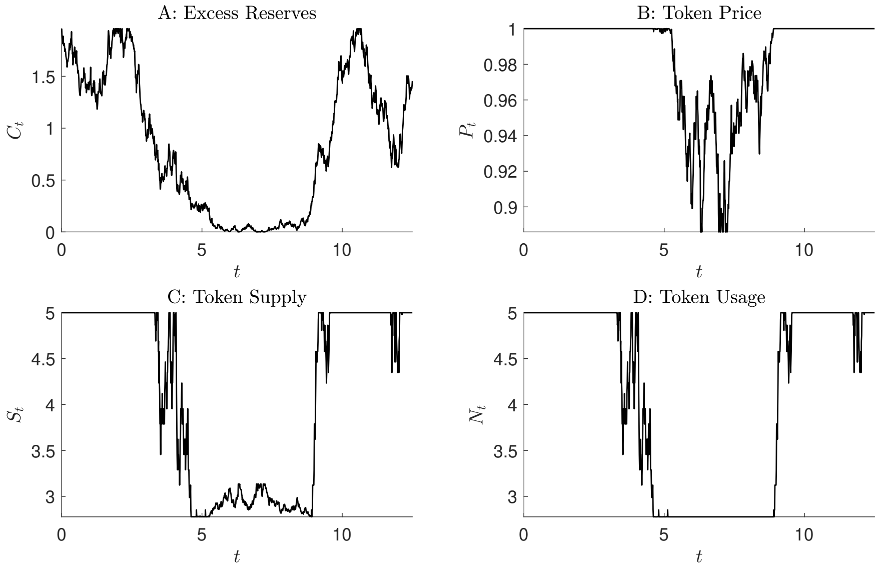
- When C is low: Low stablecoin usage and high transaction fees
- When C is high: High stablecoin usage and **interest** ($f < 0$)

Results — Token Price



- Targeted price band and debasement
- Optimal open market operations:
  1. High C: No open market operations
  2. Intermediate C: Buybacks in response to negative shocks ($dZ < 0$)
  3. Low C: Issuance in response to negative shocks ($dZ < 0$)

Model Results — Instability Trap



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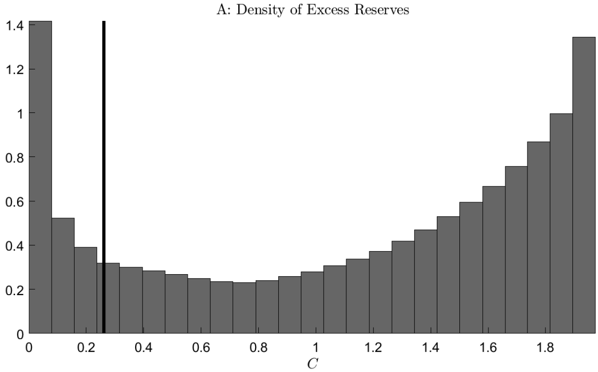
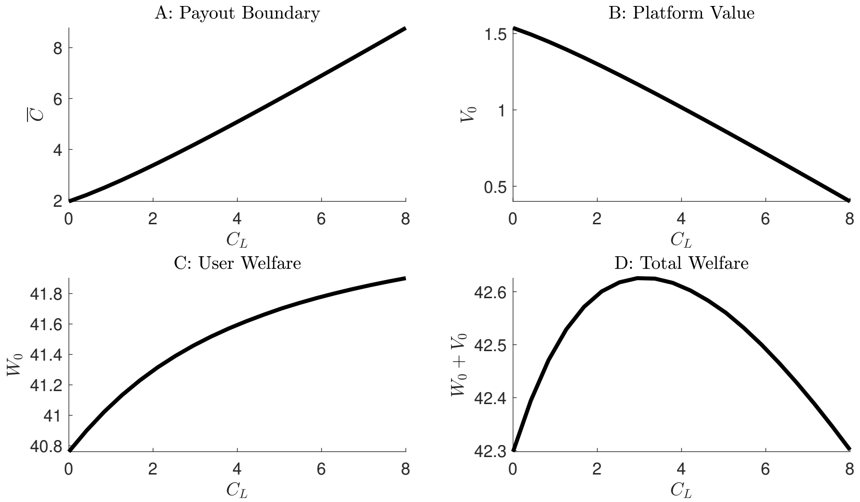


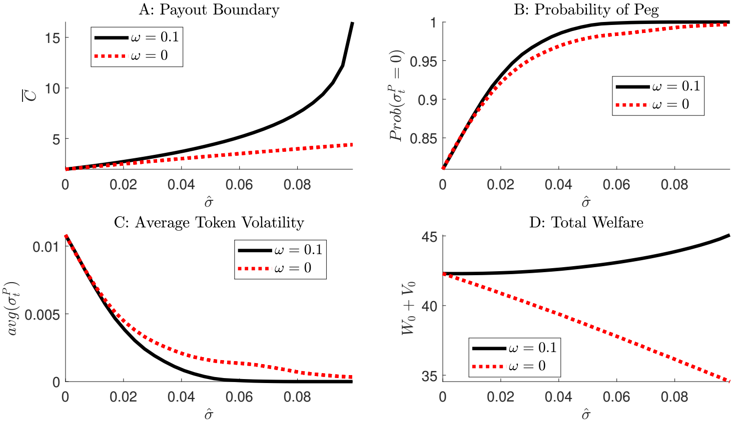
- Distribution of states bi-modal
- Stability persists for most of the time
- **But**: Once volatility rises, recovery back to stability regime is slow

Regulation — Capital Requirements



Capital requirement: C_t must exceed C_L

Regulation — Reserve Risk and Volatility Paradox

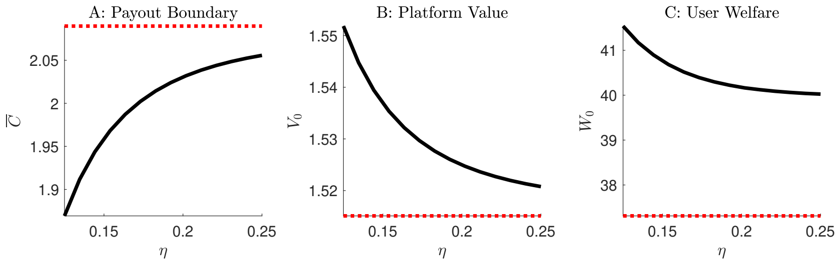


- Reduction in reserve risk, $\hat{\sigma}$, can reduce price stability

$$dM_t = rM_t dt + (P_t + dP_t)dS_t + N_t f_t dt + N_t \sigma dZ_t - dDiv_t + M_t(\hat{\mu} dt + \hat{\sigma} dZ_t)$$

$$\hat{\mu} = \omega\hat{\sigma} \implies \text{constant "Sharpe Ratio"} \quad \omega = \frac{\hat{\mu}}{\hat{\sigma}}$$

Regulation — Requirement to Price Stability



- Dotted red line: Impose locally stable price ($\sigma^P = 0$)
- Commitment to price stability impossible: $\sigma^P = 0$ reduces price volatility in "good times" but raises risk of run

Optimal Issuance of Governance Tokens (Equity)

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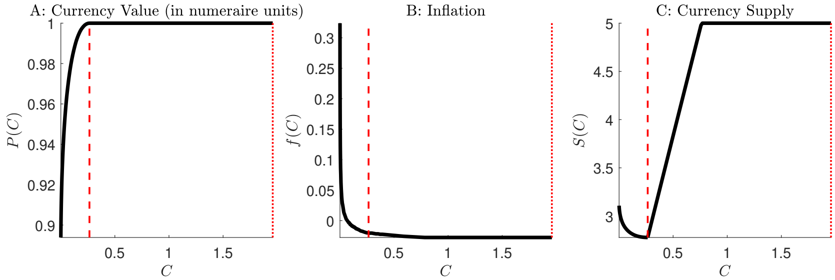
- Three lines of defense:
  1. Reserves
  2. Debasement
  3. Equity issuance at $C = 0$
- Our model: Valuation of governance tokens

Central Banking and Optimal Reserve Management



- Soft peg and hard peg regimes: Targeted price band

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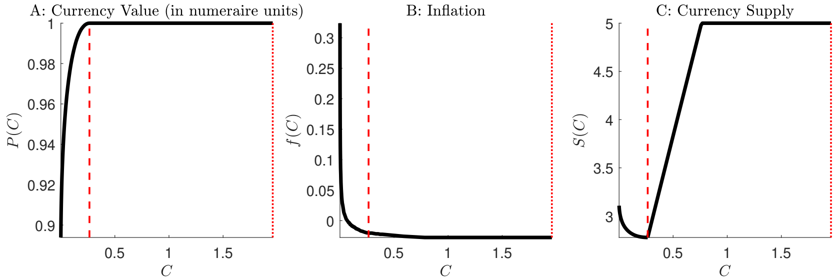
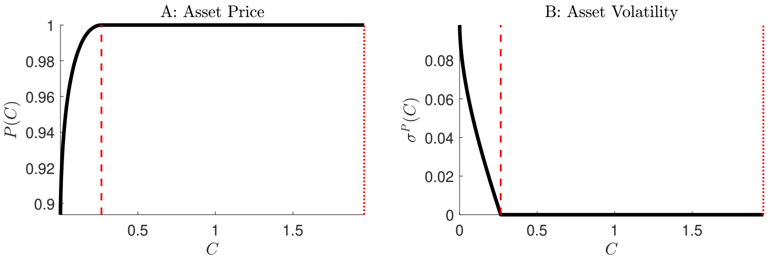


- Soft peg and hard peg regimes: Targeted price band
- Model is very tractable
  - Extensions for more realism feasible
  - Calibration for quantitative analysis

Safe Asset Creation



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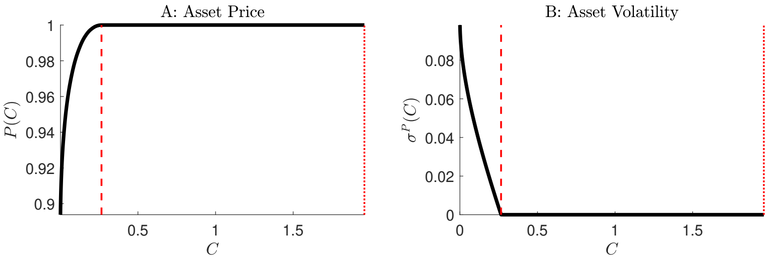

Safe asset creation by financial intermediary (e.g., shadow banking)

Safe asset creation by financially constrained firm

- $P(C)$ resembles risky long-term debt
- Dynamic liquidity management with debt financing

Decentralized Stablecoins and Double Collaterization

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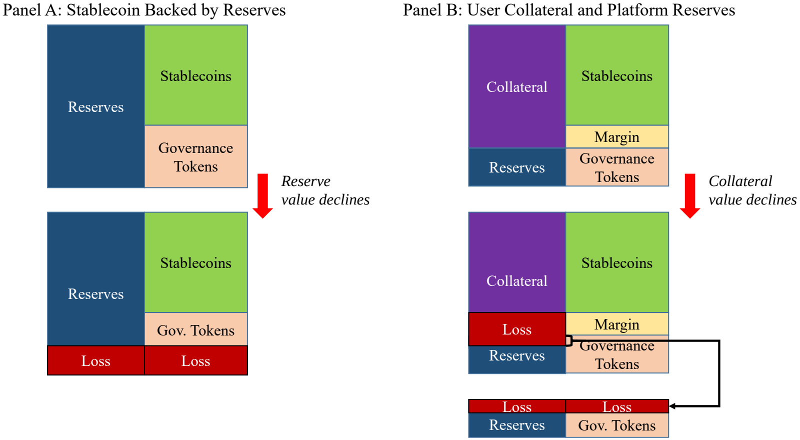
1. Stablecoin backed by reserves: e.g., Tether or USDC
2. Stablecoin backed by reserves and user collateral: e.g., DAI
    - Users deposit risky crypto collateral in vault
    - User borrow stablecoin against collateral subject to margin requirement
    - Platform reserves as second layer of defense
    - Example: DAI

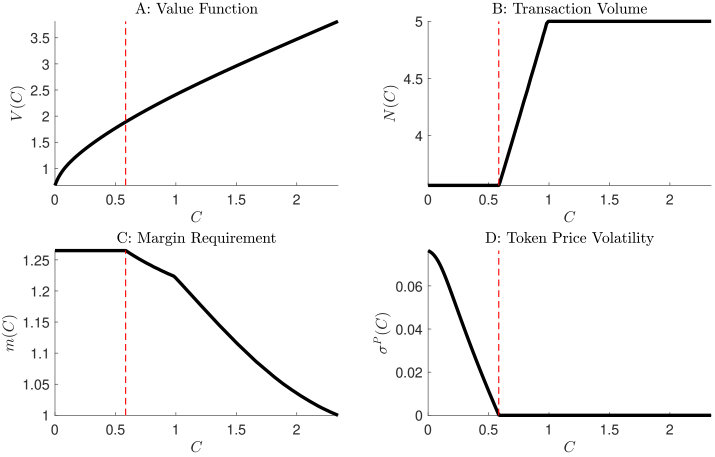
Double Collateralization — Structure



Example: Tether

Example: DAI

Double Collateralization — Results



- For one dollar of stablecoin, $m > 1$ dollars of user collateral required
- **Possibility for Regulation:** Dynamic margin requirements that decrease with platform reserves

Conclusions

Unifying model of stable (safe) asset creation

- Optimal reserve management

Application to stablecoins

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2. Regulation: Capital or collateralization requirements most promising
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