Can Stablecoins be Stable?

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BdE-CEMFI Conference on Financial Stability 2023

Stable Coins?

- Stablecoin: crypto pegged to a traditional currency (USD, EUR, ...)

  $\rightarrow$ allegedly combine benefits of blockchains with stability of traditional money

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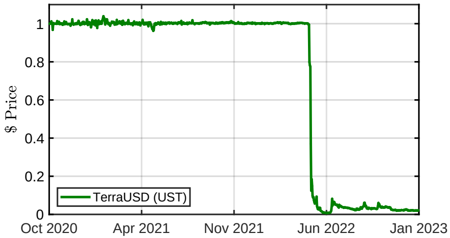
- The Terra crash

other stablecoins



- Regulatory initiatives in the US, EU, UK

Old Problem, New Solutions?

- Stablecoin issuers are “making” money $\sim$ central/commercial banks
  - ▷ stablecoins’ use as crypto money $\rightarrow$ convenience yield
  - ▷ convenience yield $\rightarrow$ seigniorage revenues for issuer

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- Earning seigniorage requires **credibility**: e.g. avoid overprinting.
- **New tools** to reduce monetary policy discretion with stablecoins?
  - blockchain “smart” contracts: programmable decisions
  - delegated issuance with decentralized model (e.g. DAI)
  - equity-financed open market operations

This Paper

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Model:

- Demand: users get time-varying liquidity benefits from stablecoins
- Supply: monopolistic platform maximizes seigniorage revenues

Key Friction: Optimal stablecoin monetary policy is time-inconsistent

$\rightarrow$ platform overissues to dilute past users ($\sim$ Coase) $\rightarrow$ peg is lost

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Results:

- Commitment: demand fluctuations $\rightarrow$ issuance and repurchase
  $\rightarrow$ fragility of algo. stablecoins: peg lost after large demand drop
- No commitment: collateral helps with stability but not commitment
  Decentralized issuance restores commitment

Outline

Stablecoin Demand

- Continuous time $t \in [0, \infty)$ and common discount rate r
- Stablecoin $=$ ∞-maturity asset, pays interest δ_t (in stablecoins), price p_t
- Mass 1 of users value consumption x_t and real stablecoin balances $p_t c_t$

$$(x_t + u_t(p_t c_t))dt \qquad \text{(utility flow)}$$

$\rightarrow$ money in the utility $\approx$ transaction benefits from holding stablecoins

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- Market clearing $c_t = C_t$ (supply) $\rightarrow$ sufficient statistics for demand is

$$\ell_t = u_t'(p_t C_t)$$

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- **Peg assumption**: liquidity benefit enjoyed only under price peg

$$\ell_t = \ell(A_t, C_t)\mathbf{1}_{p_t=1}$$

$\rightarrow$ captures extreme preference for stability (e.g. coins as means of payment)

Stablecoin Supply: Centralized Case

- Stablecoin platform chooses monetary policies to maximize revenues:
  - Stablecoin issuance and buyback policy $\{d\mathcal{G}_t\}_{t\geq 0}$ at market price p_t
  - Interest flow payment to stablecoin owners $\{\delta_t\}_{t\geq 0}$ in stablecoins

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- Collateral: liquid and safe asset, with return $\mu^k \leq r \rightarrow$ holding cost
- Monopolistic platform internalizes effect of policies on equilibrium price

$$p_t = \mathbb{E}_t \left[\int_t^\infty \left(\ell(A_s,\ C_s) \mathbf{1}_{p_s=1} + \delta_s \right) p_s e^{-r(s-t)} ds \right]$$

Outline

Unlimited Commitment Benchmark

- Platform chooses at date 0 policies for all dates $t \geq 0$

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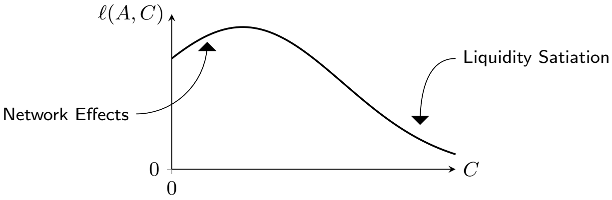
Unlimited Commitment: Stable Equilibrium

Stable Equilibrium with Unlimited Commitment

The optimal policies that support a stable equilibrium ($p_t = 1 \ \forall t$) are:

- $\varphi^\star = 0$ (no collateral)
- stablecoin stock: $C^\star(A_t) = \arg\max_C \ell(A_t, C)C = A_t/a^\star$
- interest-rate on stablecoin: $\delta^\star = r - \ell(A, C^\star(A))$



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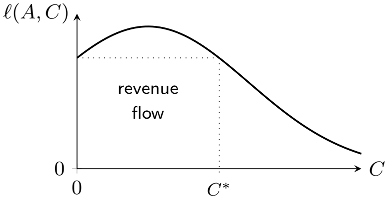

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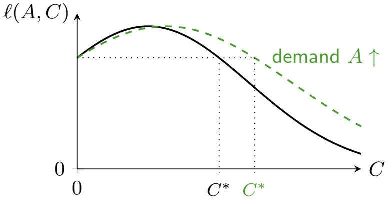

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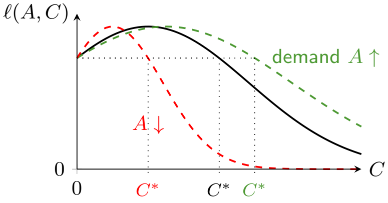

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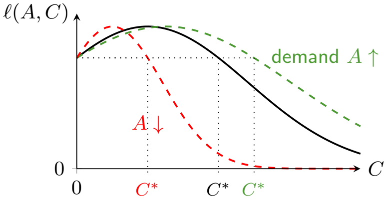

- Implementation with open-market operations
- What if repurchases must be financed with plaftorm's wealth?

Stablecoin Repurchases

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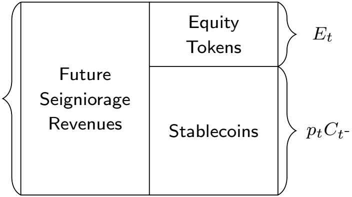

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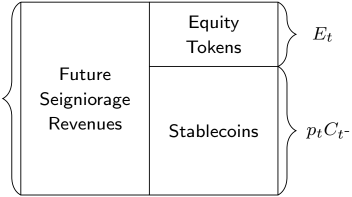

- Algo. implementation of policy in "normal" times (e.g. Terra):
  - ▷ Demand $A \uparrow$ sell stablecoins, pay dividends (buy back equity tokens)
  - ▷ Demand $A \downarrow$ buy back stablecoins by selling equity tokens

- Large $\downarrow\downarrow$ shock to demand $\rightarrow$ devaluation is unavoidable: $p_t < 1$

Algorithmic Stablecoins under Limited Liability

- Optimal issuance-buyback policy is such that:
  - ▷ target demand ratio $a^\star = \frac{A}{C}$ unless demand shock too negative
  - ▷ low demand-ratio region $[0, \overline{a}]$: no issuance nor repurchase

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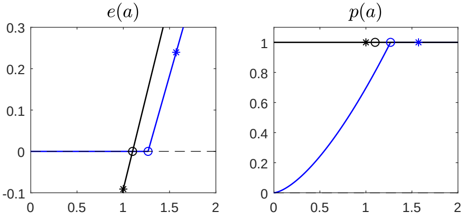

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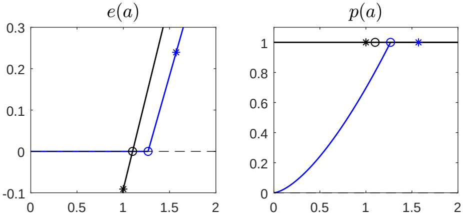
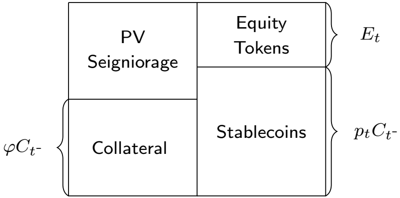


- When peg is lost, $p(a) > 0$ because demand recovers in expectation
- Interest payment in peg region $\approx r - \ell(a^\star) + \mathbb{E}[\text{stablecoin devaluation}]$
- Uncollateralized platform exists only if stablecoin demand grows: $\mu \geq \frac{\lambda}{\xi - 1}$

A Role for Collateral



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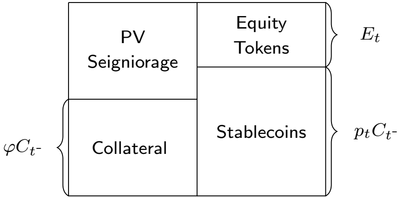

- Collateral relaxes limited liability constraint, $E_t \geq 0$

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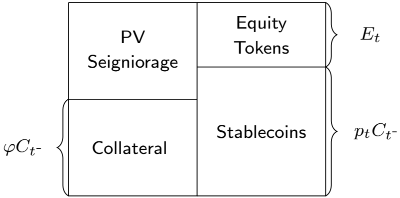

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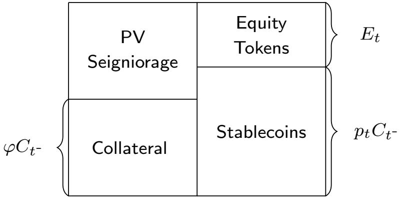

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Narrow Stablecoin ($\varphi^\star = 1$) under Commitment

A fully collateralized stablecoin is stable. It is profitable if $\mu^k \geq r - \ell(a^\star)$.

Outline

Discretionary Issuance

- **Discretionary issuance/repurchase**: $d\mathcal{G}_t$ now decided sequentially
- **Motivation**: difficulty to implement commitment rule with smart contract
  - smart contract = automatic rule executed on blockchain
  - distinction on-chain info vs. off-chain info (harder to embed)
  - commitment rule depends on stablecoin outstanding C_{t^-} and demand A_t
- Commitment to other policies chosen at date 0 is maintained:
  - interest rate δ
  - collateralization ratio φ
- Next: intuition for commitment problem + decentralized issuance model

Time-Consistency Problem: Intuition

- Consider fully collateralized platform ($\varphi = 1$)
- Full commitment: policy maximizes date-0 value of platform

$$C_t = C^\star(A_t) = \arg\max_C \Big[\ell(A_t, C) - (r - \mu^k)\Big] C$$

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- Platform with C_{t-dt} stablecoins outstanding can reoptimize at date t

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Coase

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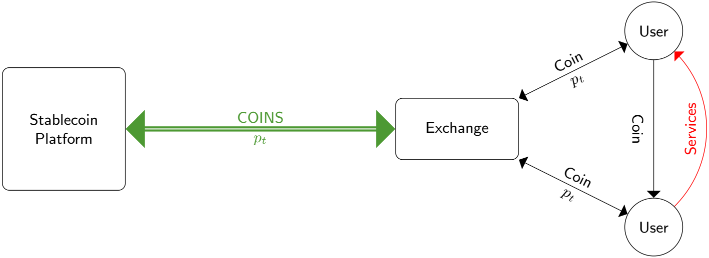
- Choosing $C_t > C^\star(A_t)$ lowers price of new and **past** stablecoins issued

  $\rightarrow$ past stablecoins $=$ platform debt $\Rightarrow$ incentives to dilute with inflation ($\downarrow p_t$)

Outline

Decentralized Issuance



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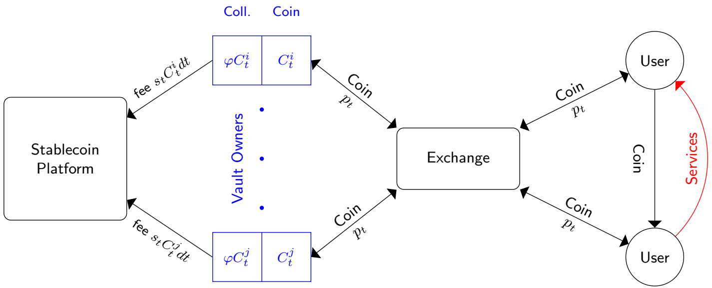

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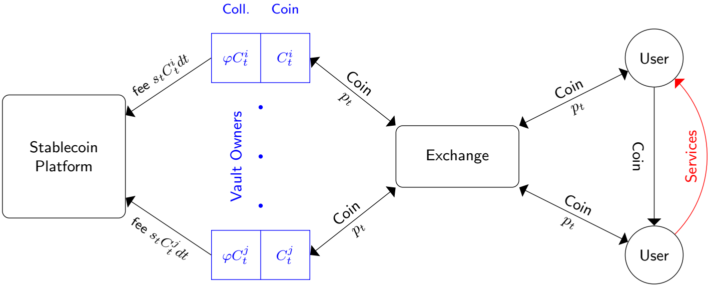
- Decentralized: issuance delegated to small (atomistic) vault owners
  - anyone can open a vault subject to collateral requirement φ/stablecoin
  - platform's income: fee $s_t dt$ per coin outstanding charged to vault owners

Decentralized Issuance



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- Platform uses fee s_t to pay interest rate $\delta_t \rightarrow$ profit flow $(s_t - \delta_t)p_t C_t dt$

Why Decentralization Works?

- Decentralized issuance changes the way platform earns income:
  - Centralized: profit flow $\propto$ new issuance $p_t(C_t - C_{t-dt})$
  - Decentralized: profit flow $\propto$ total stablecoin stock C_t:

$$(s_t - \delta_t)p_t C_t = \ell(A_t, C_t)p_t C_t \mathbf{1}_{p_t=1} - (r - \mu^k)C_t$$

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$\rightarrow$ Rental solution for Coase's monopolist

Coase

- Only commitment to collateralization ratio $\varphi = 1$ is required

  $\rightarrow$ easy to implement with smart contract

Decentralized Issuance

A stablecoin platform with decentralized issuance can implement the full-commitment outcome under full collateralization.

Conclusion

- We provide a general framework to analyze stablecoin stability
- Stablecoin's peg undermined by large negative demand shocks

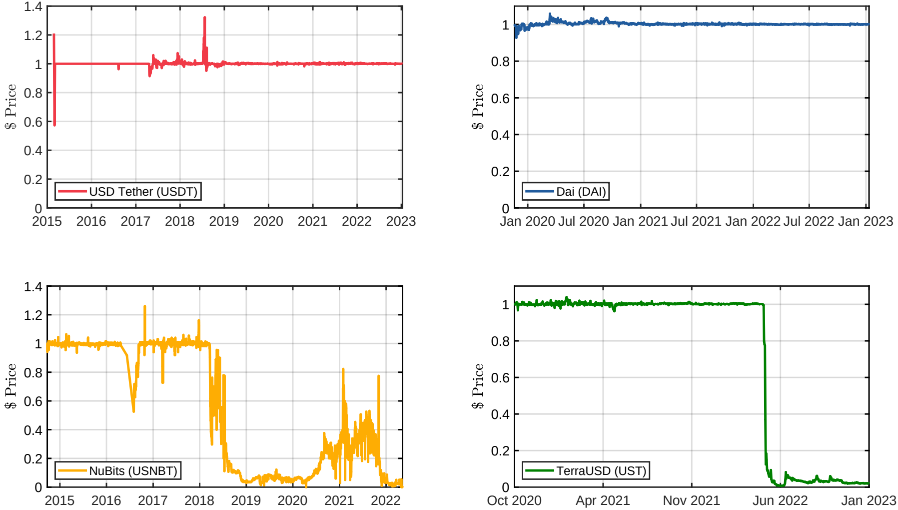
  incentives to overissue
- Collateral improves stability but does not mitigate overissuance incentives
- Decentralized design ties platform's hand via fee-based model

  $\rightarrow$ dominant stablecoins (USDT, USDC, BUSD) have instead centralized design

APPENDIX

Mixed Success

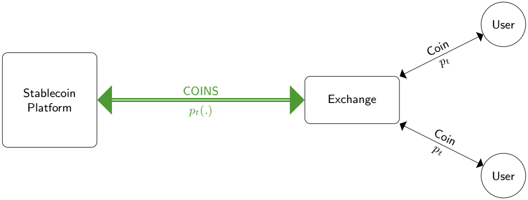
Back



Redemption: Interpretation

Back

- Model: centralized platform issues and repurchases at <u>market price p_t</u>.



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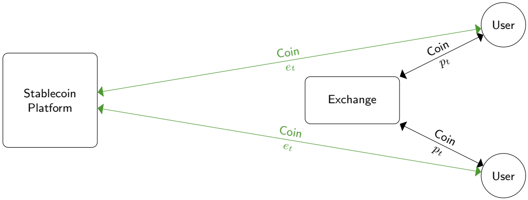
  $\rightarrow$ What if users could redeem stablecoins with the platform at e_t?



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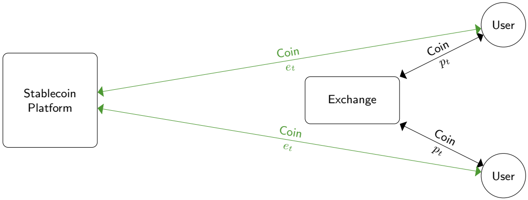

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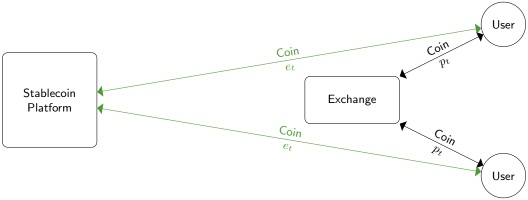

- Platform could set $e_t \Rightarrow$ stock C_t adjusts by user arbitrage $p_t = e_t$

  $\rightarrow$ Monopolistic platform effectively controls market price.

- Difficulty: full redemption rights $\Rightarrow$ self-fulfilling runs are possible

  $\rightarrow$ Only fully collateralized platforms can credibly redeem 1:1 all stablecoins

Limited Liability: Analysis

Back

- We solve for the optimal issuance policy in the following class

$$d\mathcal{G}_t = \begin{cases} G(A_t, C_{t^-})dt & \text{if } \; 0 \le a_t < \overline{a}, \\ \frac{A_t}{a^\star} - C_{t^-} & \text{if } \; a_t \ge \overline{a} \end{cases}$$

- Steps to characterize optimal policy:
  1. Conjecture equilibrium price: $p(a) = 1$ for $a \ge \overline{a}$ and $p(a) < 1$ otherwise
  2. $e(a) = 0$ for $a \le \overline{a} \Rightarrow G = 0$ and $\delta = 0$ for $a \le \overline{a}$
  3. Solve for $p(a)$ in smooth region $[0, \overline{a}]$
  4. Derive optimal values of thresholds $(\overline{a}, a^\star)$ that maximize platform value:

$$\frac{e(a^\star) + p(a^\star)}{a^\star} = \max_{\overline{a}, a^\star} \frac{\overbrace{\ell(a^\star)/a^\star}^{\text{revenue flow}}}{r - \underbrace{\left(\mu - \frac{\lambda}{\xi+1}\right)}_{\mathbb{E}\left[\frac{dA}{A\,dt}\right]} + \underbrace{\left(\frac{\lambda\xi}{\xi+1} - \frac{\lambda\xi}{\xi-\gamma}\right)\left(\frac{a^\star}{\overline{a}}\right)^{-(\xi+1)}}_{\propto \; Pr[\text{lose peg}]}}$$

subject to $\qquad e(\overline{a}) = \left[e(a^\star) + p(a^\star)\right]\frac{\overline{a}}{a^\star} - 1 = 0.$

Decentralized Issuance: Problem

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- Platform chooses δ_t, s_t sequentially given state $(\delta_{t-\Delta t}, s_{t-\Delta t}, A_t)$

$$\Pi(\delta_{t-\Delta t}, s_{t-\Delta t}, A_t) = \max_{(s_t, \delta_t)} (s_{t-\Delta t} - \delta_{t-\Delta t})\Delta_t p_t C_{t-\Delta t} + (1 - r\Delta t)\mathbb{E}\left[\Pi(\delta_t, s_t, A_{t+\Delta t})\right]$$

$$\text{s. to} \quad p_t = l(A_t, C_t) p_t \Delta t \mathbf{1}_{p_t=1} + (1 - r\Delta t)\mathbb{E}\left[p_{t+\Delta t}(1 + \delta_t \Delta t)\right] \qquad \text{(U)}$$

$$1 - p_t = (1 - r\Delta t)\mathbb{E}\left[1 + \mu^k \Delta t - p_{t+\Delta t}(1 + s_t \Delta t)\right] \qquad \text{(V)}$$

- **Guess** Markov equilibrium implements commitment solution:
  - Policies: $(s_t, \delta_t) = (\mu^k, \delta^\star)$
  - ▷ $p^{eq}(\delta_{t-\Delta t}, s_{t-\Delta t}, A_t) = 1$
  - ▷ $C^{eq}(\delta_{t-\Delta t}, s_{t-\Delta t}, A_t) = C^\star(A_t) = \arg\max_C \left[\ell(A, C) - r + \mu^k\right] C$

- **Verify** Given $p_{t+\Delta t} = 1$ and $C_{t+\Delta t} = C^*(A_{t+\Delta t})$, optimize over s_t, δ_t

Decentralized Issuance: Markov Equilibrium

Back

- Platform's profit given $C_{t-\Delta t}, s_{t-\delta_t}, \delta_{t-\Delta t}, A_t$

$$V(\delta, s) = (s_{t-\Delta t} - \delta_{t-\Delta t})\Delta_t p_t C_{t-\Delta t} + (1 - r\Delta t)\mathbb{E}[(s_t - \delta_t)\Delta t] + K_1$$

$$= -(1 - p_t)(s_{t-\Delta t} - \delta_{t-\Delta t})\Delta_t C_{t-\Delta t} + \underbrace{\left[\ell(A_t, C_t)\mathbf{1}_{p_t=1} + \mu^k - r\right] C_t}_{\text{maximized for } p_t=1,\ C_t=C^\star(A_t)} \Delta t + K_2$$

- Given $(s_{t-\Delta t}, \delta_{t-\Delta t}) = (\mu^k, \delta^\star)$ and $p_t \leq 1$, first term is negative
- Hence, $(s, \delta) = (\mu^k, \delta^\star)$ is optimal as it implements $p_t = 1$, $C_t = C^\star(A_t)$
- Platform lost price-setting power and thus ability to deviate

Smart Interest Rule

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Proposition 2: Optimal Policy with Nonprogrammable Issuance

For $\varphi = 1$ (full collateralization), an interest rule can implement the commitment outcome:

$$\delta(A, C) = r - \ell(A, C)$$

- **Intuition**: smart interest rule neutralizes price impact and avoids dilution:

$$p_t = \ell(A_t, C_t)\mathbf{1}_{p_t=1}dt + \delta(A_t, C_t)dt + (1 - rdt)\mathbb{E}_t[\underbrace{p_{t+dt}}_{=1}]$$

- Ex-post, platform affects only the rental rate of stablecoin stock $\ell(A, C)$

  $\rightarrow$ rental solution to Coase's durable good monopolist problem

- Limitation: "smart" contract still require off-chain info. about demand A_t.

Coastian Commitment Problem

Back 1 Back 2

- 2 period model with durable real good. Stock $\{C_t\}_{t=1,2}$
  - decreasing liquidity benefit $\ell(C)$, no demand shock
  - Good price is given by

$$p_1 = \ell(C_1) + \beta p_2$$

$$p_2 = \ell(C_2)$$

  - Issuer profit

$$\Pi_1 = p_1 C_1 + \beta \Pi_2$$

$$\Pi_2 = p_2(C_2 - C_1)$$

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- **Rental**: chooses rental rate $r_t \overset{eq.}{=} \ell(C_t)$ every period.

  $\rightarrow$ issuer internalizes Δ value of total stock (no commitment problem)