Dynamic Modeling for Optimal Cryptoeconomic Policies

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Research Question

How should we design dynamic staking and burning policies for Proof-of-Stake cryptoeconomies?

- Current protocol-coded policies are static even though crypto-economies face dynamic shocks. “Staking” and “burning” rates are the primary coded policy rules in the underlying blockchain system
  - **Staking (increases “token supply”, decreases “tokens in circulation”)**: mint new tokens and give to those who stake their existing tokens as interest. Similar to interest on reserves.
  - **Burning (decreases “token supply”)**: burn (remove from circulation) a portion of the transaction fee paid by users during blockchain transactions
- Policy goal: maximize welfare for good actors: users (increase in token price) and validators (transaction fees)

Literature Review

- Micro foundations:
  Biais et al. (2019), Budish (2018), Gans and Gandal (2019), Gans and Holden (2022), Huberman et al. (2021), and Nisan et al. (2007), etc.
  → **Block reward and transaction fee as incentive mechanisms**
- Pricing models of cryptocurrencies:
  Bitcoin: *Athey et al. (2016), Biais et al. (2023), Bolt and Van Oordt (2020), Catalini and Gans (2020), Chiu and Koeppl (2017), Garratt and Wallace (2018), Hinzen et al. (2022), and Schilling and Uhlig (2019a, 2019b), etc.*
  Proof-of-stake: *Catalini et al. (2020) and Saleh (2019, 2021)*
  → **Static token supply means all shocks are absorbed by price**
- Monetary policies for stablecoins, platform tokens, and CBDCs:
  Cong, He, and Tang (2022), Cong, Li, and Wang (2022), Cong et al. (2021), d'Avernas et al. (2022), Fernández-Villaverde et al. (2021), Sockin and Xiong (2023a, 2023b), and Zhu and Hendry (2019), etc.
  → **Optimizing policy for defending peg and/or making profit**

Contribution to the Literature

- Practical: Most cryptoeconomic systems feature fixed-schedule token supply
  - deterministic token supply (Bitcoin[1]), fixed burn rate (Ethereum[2]), naive dynamic burning (Binance Coin)
- No published literature has been established on optimal staking and burning policies for proof-of-stake cryptocurrencies.

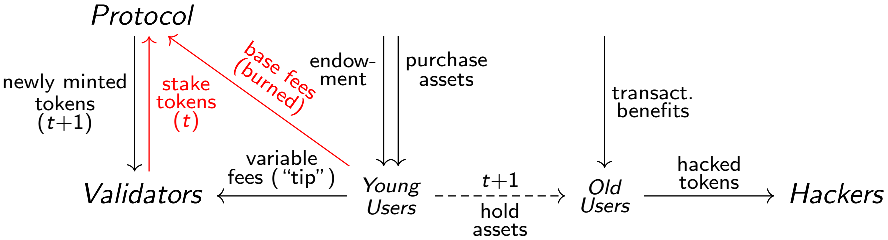
Novelty of this research:

- Applies dynamic general equilibrium methods to model and optimize crypto policies for staking and burning
- Traditional models for optimal fiscal policy (e.g. Ramsey) and monetary policy (e.g. NK) are not directly transferrable to cryptoeconomies due to transaction fee role in the cryptoeconomy

[1]Satoshi Nakamoto (2008). Bitcoin: A peer-to-peer electronic cash system

[2]Ethereum Documentation. "Gas and Fees - Base fees"

A model of proof-of-stake cryptoeconomies



- Inspired by Biais et al. (J Finance 2023) "Equilibrium Bitcoin Pricing"
- Two-period OLG model
- Endogenous token supply (innovation over Biais et al. (2023))
- Assumption: Crypto's fundamental value comes from the stream of future transactional benefits
  - e.g. access to unique goods, not expropriated/taxed/constrained by government, direct internet access

User's problem

- Period t: allocates endowment income e_t^u into three asset classes: risk-free s_t, crypto q_t, and fiat $\hat{q}_t$. To buy crypto they pay a two-part transaction fee φ_t^b (burned) and φ_t^v (goes to validator)
- Period t+1: receive interest r_t, transactional benefits θ_{t+1}, and hacking loss h_{t+1}

$$c_t^u = e_t^u - s_t - (1 + \varphi_t^b + \varphi_t^v) q_t p_t - \hat{q}_t \hat{p}_t \tag{1}$$

$$c_{t+1}^u = s_t(1 + r_t) + (1 - h_{t+1})(1 + \theta_{t+1}) q_t p_{t+1} + \hat{q}_t \hat{p}_{t+1} \tag{2}$$

Validator's problem

- Period t: receive transaction fees φ_t^v, stake L_t
- Period t+1: receive staking yield δ_t

Trade-off:

$$\text{more staking at } t \Rightarrow \begin{cases} \text{more staking yield at } t+1 \\ \text{less circulating supply} \Rightarrow \text{less transact. fees at } t \end{cases}$$

$$c_t^v = e_t^v + \varphi_t^v q_t p_t - L_t p_t \tag{3}$$

$$c_{t+1}^v = (1+\delta_t) L_t p_{t+1} \tag{4}$$

Token supply

$$M_{t+1} = (M_t - L_t) + L_t(1+\delta_t) - \varphi_t^b X_t$$
$$= M_t + \delta_t L_t - \varphi_t^b X_t \tag{5}$$

M_t: total token supply
$X_t \equiv M_t - L_t$: circulating supply
$\Rightarrow$ Token market clearing condition is $X_t = q_t$

* In reality the total reward is $\delta_t L_t^\alpha$, with pre-set $\alpha \in [0,1]$[3]. Here I set $\alpha = 1$ WLOG since δ_t is dynamic.

[3] $\alpha = 0.5$ for Ethereum. See Ethereum Documentation. "Proof-of-Stake Rewards and Penalties"

First order conditions

* for a deterministic version of the model

User's Euler equations:

$$\frac{u'(c_t^u)}{u'(c_{t+1}^u)} = \beta(1+r_t) = \beta\frac{(1+\theta_{t+1})(1-h_{t+1})}{1+\varphi_t^b+\varphi_t^v}\frac{p_{t+1}}{p_t} = \beta\frac{\hat{p}_{t+1}}{\hat{p}_t} \tag{6}$$

Validator's Euler equation:

$$\frac{u'(c_t^v)}{u'(c_{t+1}^v)} = \beta(1+\delta_t)\frac{p_{t+1}}{p_t} \tag{7}$$

WIP: Equilibrium solutions with stochasticity & log/CRRA preferences

Calibration (idea phase)

- **Data sources:** Ethereum prices from Messari API, txn fees from Dune Analytics, staking data from beaconcha.in
- **Period:** Sep 2022 - now, down to block frequency (12s) 24/7
- Proxy for transactional benefits/convenience yields: average onchain txn processing per second a_t(Cong, He, & Tang, 2022)
    - other potential proxies: Metcalfe's measure $\log\left(DailyActiveAddresses^2\right)$; index on US crypto regulation (NCSL.org)
- Proxy for hacking: manually index major hacks and wallet losses

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