Dynamic Modeling for Optimal Cryptoeconomic Policies

Pitch Proposal

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Motivation

- Cryptoeconomies are highly dynamic
  - the nature of blockchain is decentralized
  - many sources of exogenous shocks
- But most crypto monetary policies today are static:
  - deterministic token supply e.g. Bitcoin
  - fixed burn rate e.g. Ethereum
  - naive dynamic burning e.g. Binance Coin
- Problems occur in the long term
  - larger shocks from RBCs
  - when issuance schedule ends

Motivation

- Cryptoeconomies are highly dynamic
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shocks from the real economy: Banks failing, stock market, interest rates
shocks from other cryptoeconomies: Luna-Terra, FTX/Alameda

The crypto monetary system

Core Mechanisms:

1. Minting (increases token supply)
   - initial coin offering (ICO)
   - block rewards via staking or mining (happens constantly)

   $\Rightarrow$ Most cryptoeconomies are inflationary by default
2. Burning (decreases token supply)
   - buy back and burn (BBB)
   - partial burning of transaction fees

Research Question

How should we design cryptoeconomic policies (staking and burning) that respond dynamically to endogenous and exogenous shocks?

- Cryptoeconomy: blockchain/cryptocurrency-based economy e.g. the Ethereum blockchain
- Similar to how central banks implement fiscal and monetary policies e.g. interest rate, taxation, money supply
- Policy goal: maximize welfare for good actors, disincentivize malicious actors

Literature Review

- Micro foundations
  - [Nisan et al., 2007], etc. Algorithmic game theory
  - [Gans and Holden, 2022], etc. Mechanism design
  - [Budish, 2018, Gans and Gandal, 2019] Costs of securing blockchain
- Models of the Cryptoeconomy
  - [Yermack, 2015] Bitcoin is not a currency
  - [Cong et al., 2021, Cong et al., 2022] Asset pricing model featuring token issuance as means of platform financing and user growth
  - [Athey et al., 2016, Catalini and Gans, 2020] Partial equilibrium
  - [Schilling and Uhlig, 2019a, Schilling and Uhlig, 2019b] Crypto vs. Fiat as mediums of exchange with transaction fees
  - [Catalini et al., 2020] Demand and supply of PoS tokens under attack
  - [Biais et al., 2020] An OLG model of prices and transactional benefits
  - [Bolt and Van Oordt, 2020] Modeled crypto exchange rates with quantity theory of money

Contributions to the Literature

Gaps in the literature:

- Most cryptoeconomic models feature a fixed token supply schedule
- Traditional models for optimal fiscal policy (e.g. Ramsey) and monetary policy (e.g. NK) are not directly transferrable to cryptoeconomies
- No literature has been established on optimal economic policies for cryptocurrencies in general (some on CBDC and stablecoins)

Novelty of this research:

- Applies dynamic general equilibrium methods to model and optimize crypto policies for staking and burning

The baseline model (Biais et al. 2020, Journal of Finance)

Idea: The fundamental value of crypto comes from the stream of future transactional benefits [Tirole, 1985]
e.g. access to unique goods, not expropriated/taxed/constrained by government, direct internet access

- Setup: Overlapping generations; discrete time; exogenous endowment
- Three actors: users, validators (miners), hackers
- Three financial assets: a risk-free asset, a standard currency (dollar), a cryptocurrency (Bitcoin)
- Sources of shocks: endowment, transactional benefit, fees

The baseline model: Users

$$\text{Young users: } c_t^y = e_t - s_t - (1+\varphi_t)q_t p_t - \hat{q}_t \hat{p}_t$$
$$\text{Old users: } c_{t+1}^o = s_t(1+r_t) + (1-h_{t+1})q_t p_{t+1} + \hat{q}_t \hat{p}_{t+1} + \theta_{t+1} q_t p_{t+1}$$

e_t: endowment
s_t: quantity of risk-free assets held
$q_t, \hat{q}_t$: quantities of crypto and dollars held
$p_t, \hat{p}_t$: prices (in units of consumption goods) of crypto and dollars
h_{t+1}: portion of crypto hacked by hackers
φ_t: transaction fees involved in using crypto (exog.)
θ_{t+1}: transactional benefits from using crypto (exog.) (assume $\theta_{t+1} \geq 1$)

The baseline model: Validators and hackers

$$\text{Validators: } c^v_{t+1} = (X_{t+1} - X_t)p_{t+1} + \varphi_{t+1}q_{t+1}p_{t+1}$$
$$\text{Hackers: } c^h_{t+1} = h_{t+1}q_t p_{t+1}$$

X_t: stock token supply
$X_{t+1} - X_t$: increase in token supply (newly minted tokens)

The baseline model: Market clearing

Markets for financial assets:

$$\text{crypto: } q_t = X_t$$
$$\text{dollars: } \hat{q}_t = m$$
$$\text{risk-free assets: } s_t = 0$$

Market for consumption goods (by Walras's Law):

$$c_t^y + c_t^o + c_t^v + c_t^h = e_t$$

The baseline model: Solution

A young user in period t solves:

$$\max_{s_t, q_t, \hat{q}_t} u(c_t^y) + \beta \mathbb{E}_t u(c_{t+1}^o)$$
$$\text{s.t. } c_t^y \geq 0$$

* Information set at period t includes $\{\theta_t, \varphi_t, \pi_t\}$

From FOCs obtain the equilibrium pricing equation:

$$p_t = \underbrace{\frac{1}{1+r_t}}_{\text{discount}} \mathbb{E}_t \left[\underbrace{\frac{u'(c_{t+1}^o)}{\mathbb{E}_t[u'(c_{t+1}^o)]}}_{\text{risk-neutral prob}} \underbrace{(1 - h_{t+1})}_{\text{hack risk}} \underbrace{\frac{1+\theta_{t+1}}{1+\varphi_t}}_{\substack{\text{net transact.} \\ \text{benefits}}} p_{t+1} \right] \tag{1}$$

Modifications to the baseline model

1. Introduce two-part transaction fee with burning
2. Introduce an interest-bearing staking mechanism
3. Modify validators' budget constraint: incorporates costs of validation under PoS and PoW [Biais et al., 2019, Saleh, 2019, Saleh, 2021]
4. Use vector autoregression models for exogenous process in variable transaction fees and transaction benefit (e.g. sign restrictions)
5. Improvement in model calibration (estimation of transactional benefits and fees)

Proposed Project Timeline

- Spring '23: As final project for ECMA33603 (Macro & Financial Frictions), replicate the baseline model and implement modification 1 and 2 (endogenous money supply)
- Summer '23: More model modifications and seek analytical solutions; gather ideas from industry internship in Ethereum research & dev
- Fall '23 - Winter '24: Data collection, model estimation
- Spring '24: Finish paper

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