Simple Models of Central Bank Digital Currency in Small Open Economies[1]

Carroll Round XX (Georgetown)

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Definitions

- **Open economies**: can trade with other countries, especially with financial products
- **CBDC**: "fiat currency issued by central banks in digital form" (Allen *et al.* 2020)
  - Broadly accessible and have retail use
  - Can be (but not necessarily) interest-bearing, but with different rates from reserves (Kumhof Noone 2018)
  - **"If the Fed issued a digital dollar"**

1. CBDC may be inevitable

- 80% of central banks surveyed were engaging in a CBDC project (Boar Holden Wadsworth 2020)
- Important to investigate the effects of new technologies to know how to set up policy frameworks and rules
- Experiments conducted by central banks such as China, Uruguay, and Ecuador

2. CBDC may be useful for central banks

- Abnormal monetary policy by crossing the ZLB with negative interest rates or lowering quantity of CBDC (Bordo Levin 2017)
- Helicopter drops: disperse CBDC into individual accounts (Bernanke 2002)
- Welfare gains: Injection of CBDC = 30% of GDP resulted in steady state output gains of 3% (Barrdear Kumhoff 2016)

3. Empirical international central banking questions

- Global low interest rate regimes
- Outsize effects of U.S. monetary policy
- Behavior of international monetary policy at the ZLB is not well-characterized theoretically (Amador 2020 ReStud)
- Uncovered interest rate parity puzzles (Valchev 2020 AEJ Macro)

$\Rightarrow$ Does the introduction of CBDC provide any insight to these puzzles?

Literature

- **RBC models of CBDC.** Andolfatto 2020, Oh Zhang 2020, Piazzesi Rogers Schneider 2021, Barrdear Kumhoff 2016, Mishra Prasad 2021
- **International models of CBDC.** George Xie Alba 2020, Ferrari Mehl Stracca 2020
- **Models of money.** Lucas 1987, Kiyotaki Moore 2003
- **Asset pricing for digital/cryptocurrency.** Schilling Uhlig 2019 JME, Niepelt 2020
- **Multiple country models and empirical results.** Galí and Monacelli 2005, Obstfeld Rogoff 1996

This project:

- Compares two-country general equilibrium models with cash-in-advance constraints
- Models:
  1. Cash and Bonds Economy
  2. CBDC and Bonds Economy
- Assets:
  - Always: Interest-bearing bonds
  - Sometimes: Interest-bearing CBDC in home country that replaces cash
  - CBDC interest rate modeled as Taylor rule and spread rule

Key Results:

- Uses a consumption constraint
- Confirms CBDC economies have higher volatility with consumption constraint
- Interest rate design matters

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Model Outline

- Households choose consumption goods c_t and labor n_t to maximize welfare
  - Hold cash h_t and home bonds b_t in cash/bonds economy
  - Hold CBDC d_t and home bonds b_t in CBDC/bonds economy
  - Face CIA constraint
  - Own capital k_t and face capital adjustment costs
- Output from capital and labor
- Government is monetary and fiscal authority and faces a budget constraint (more later)

Governments

- Home government policy tools:
  - i_t^d: interest rate on CBDCs
  - i_t^b: interest rate on bonds
  - μ: rate of money growth of d_t, the household CBDC account

1. Money growth

$$d_{t-1} = \frac{1+\mu}{1+\pi_t} d_t \tag{1}$$

2. Spread rule: θ_2 is spread between bond and CBDC interest rate

$$r_t^d = r_t - \theta_2 \tag{2}$$

3. Taylor-type rule

$$i_t^d = \pi_t + \rho_m(\pi_t - \bar{\pi}) + (1-\rho_m)(y_t - \bar{y}) \tag{3}$$

Transaction Costs

- Following Mishra and Prasad (2021):

$$\psi(c_t, d_{t-1}) = \theta_1 \frac{c_t^{\gamma}}{d_{t-1}^{\zeta}} \tag{4}$$

- CBDCs have higher transaction efficiency than cash (by assumption and calibration)

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Equilibrium

Definition

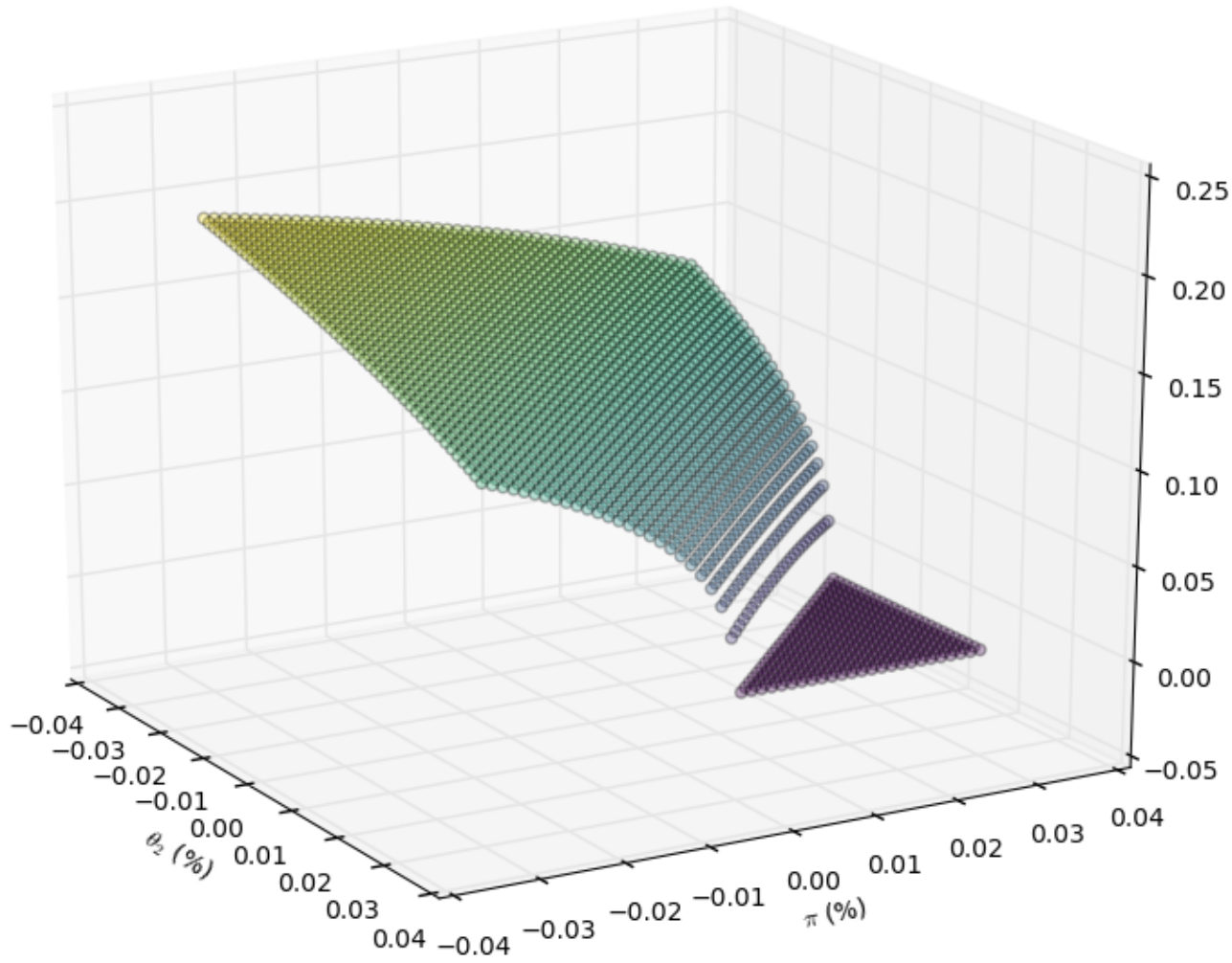
Given a set of realizations $\{A, r^*\}$ at time t, an equilibrium is a state-contingent set of allocations $\{c_t, n_t, b_t, d_t, k_t, I_t\}$ and prices $\{r_t, r_t^d, \pi_t\}$ such that

1. The allocations solve the problems faced by households at these prices.
2. All factor markets clear.
3. The government budget constraint or monetary authority interest rate rules are satisfied.

In the CBDC model, the state variables are $\{b_t, r_t, k_t, A, d_t\}$.

CBDC share is decreasing in π and θ_2

Figure 1: Effects of Varying θ_2 and π on Consumption

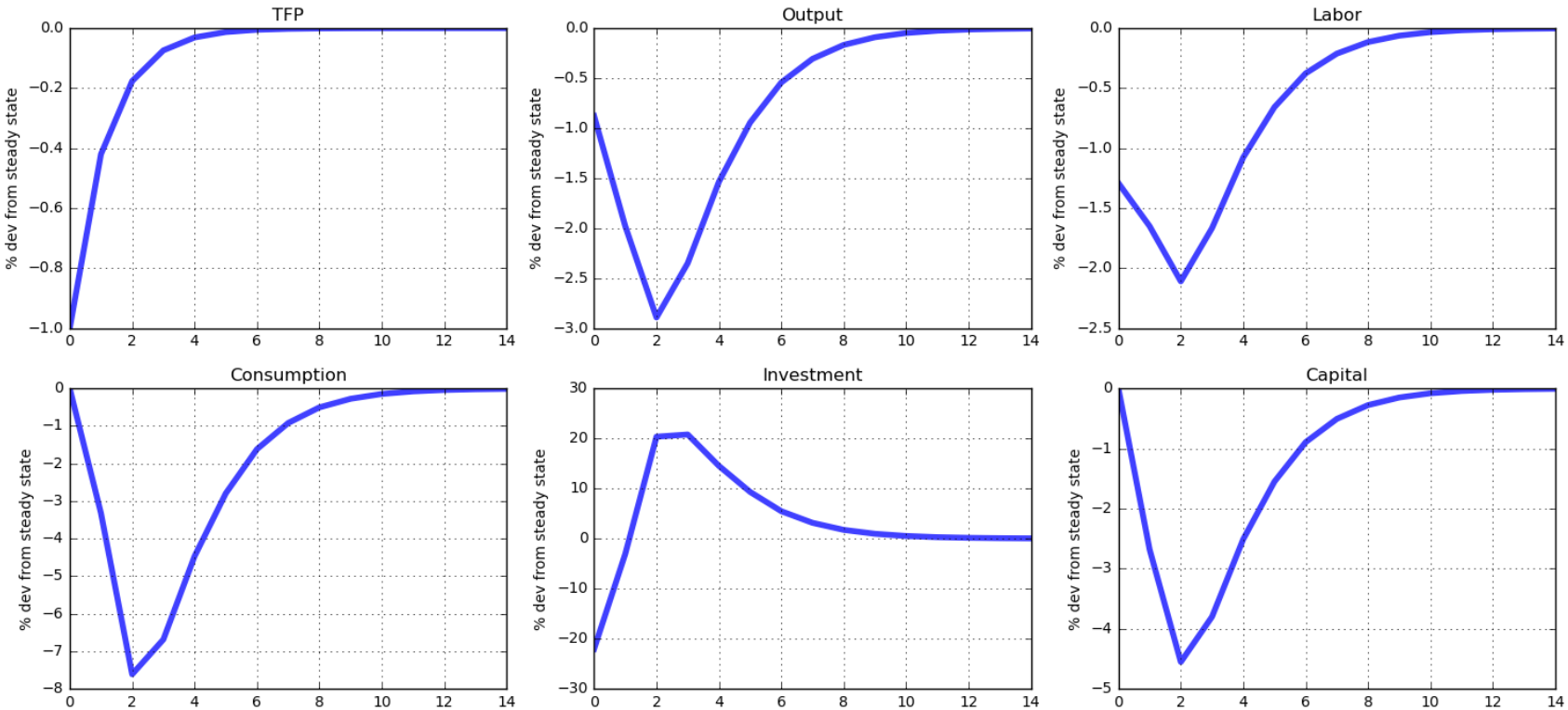


Dynamic Setup

- Household FOCs standard — indifferent across time periods
- Induce stationarity by assuming interest rate is elastic, following Schmitt-Grohé and Uribe (2003)
- Calibrate using parameters in the literature when available and provide intuition otherwise.
- Exogenous productivity shock

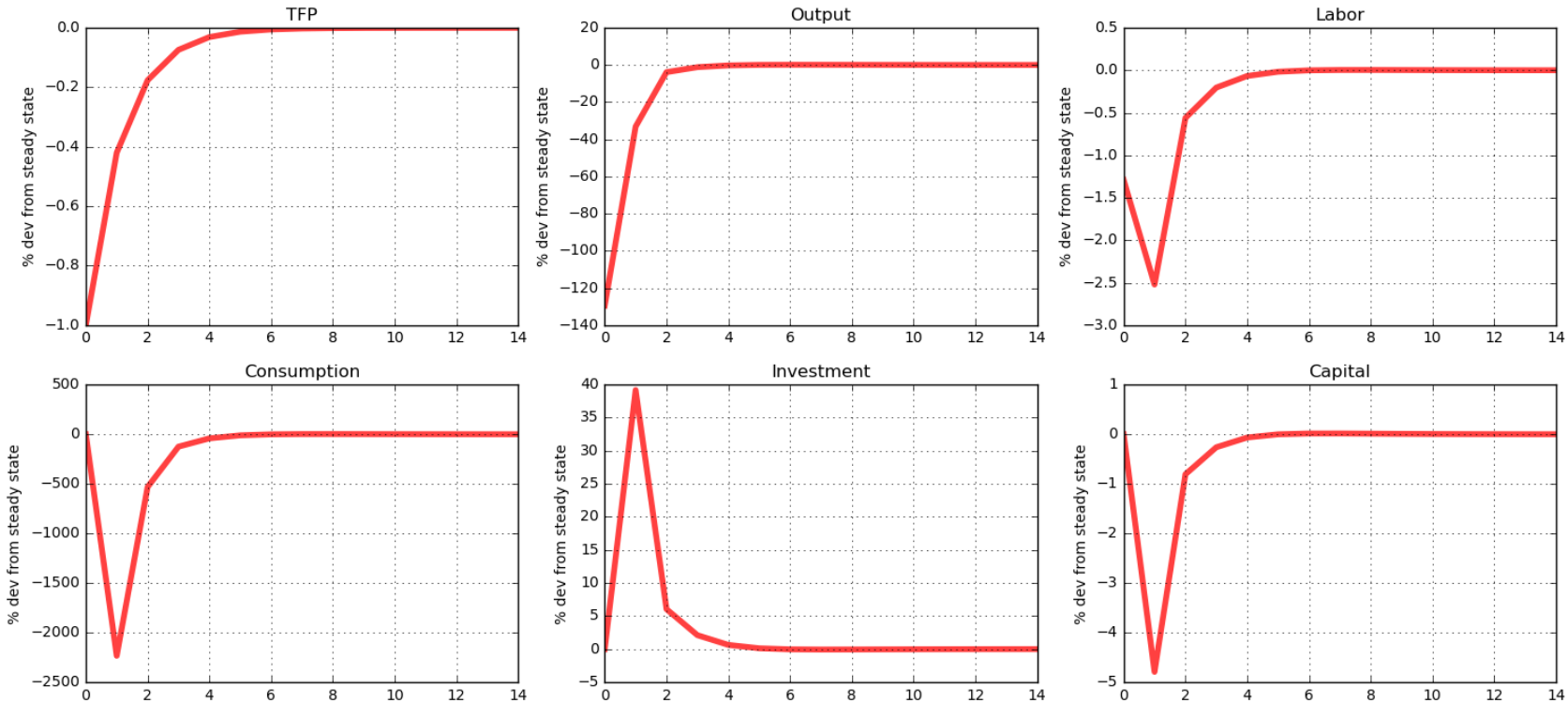
Baseline Model without CBDC

Figure 2: CB Model Impulse Responses



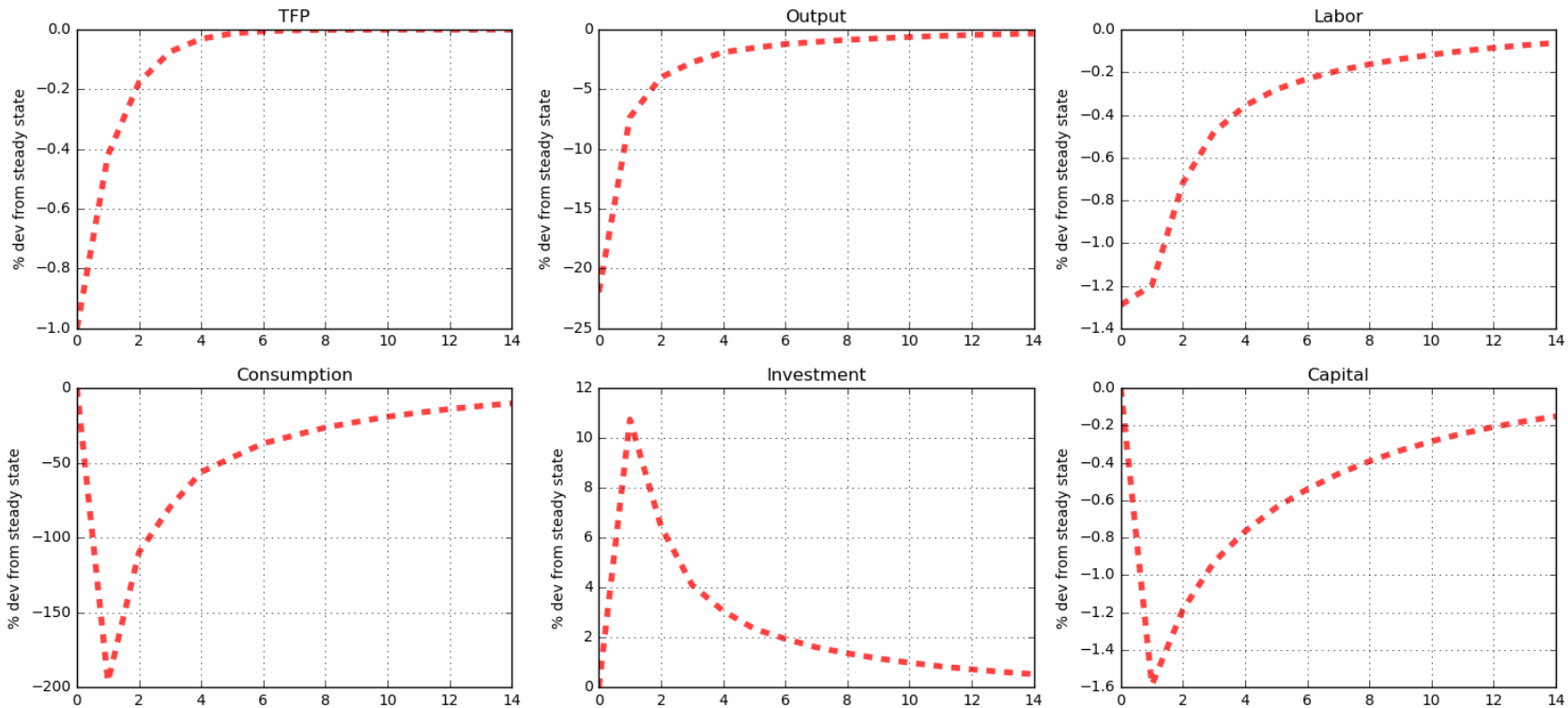
CBDCs have higher volatility

Figure 3: CBDC Model Impulse Responses (Spread Rule)



Taylor rules smooth TFP shocks

Figure 4: CBDC Model Impulse Responses (Taylor Rule)



Contribution

1. Demonstrates use of cash-in-advance constraint
   - Replicates result from MIU models (Ferrari 2020)
2. CBDC economies are more volatile (Fig 2)
   - Adding more financial instruments can induce volatility in real and financial indicators
   - Insight into behavior of monetary policy and financial instrument interlinkages
3. CBDC interest rate choices matter (Fig 3)

Extensions

1. Welfare analysis
2. Explicitly model exchange rates and uncovered interest parity rate assumption
3. Different models of CBDC
   - Quantity rules
   - Cash, bond, and CBDC economies
   - Transaction costs for foreign households buying home CBDC (or for home households converting between CBDC and cash) (Schilling AEA 2019)
   - Large open economies