CBDC Policy Rules and Welfare

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1 Introduction

- Most central banks are actively studying CBDC.
- Focus has been on microeconomic and technological benefits.
- Somewhat less focus on macroeconomic and financial stability gains.
- This paper studies 3 macro topics that have received less attention:
  1. Steady state efficiency gains due to CBDC: 2% welfare gains.
  2. Optimized countercyclical CBDC policy rules: 1% welfare gains.
  3. Capital flow and exchange rate volatility: 30% to 40% lower.

- The tool: A carefully calibrated and estimated 2-country DSGE model.

- The assumptions about CBDC design:
  1. Retail CBDC (households, firms, banks).
  2. Access to foreign currency CBDC (and bank deposits).
  3. CBDC is interest-bearing and separate from reserves.
  4. CBDC issuance against government bonds, not bank deposits.

2 The Model

2.1 Overview of the Model

- 2 symmetric countries, 2 goods, 2 currencies, 2 banking sectors.
- Real sector as in standard NK models.
- Financial sector as in Jakab and Kumhof (2015, 2019).
- Monetary policy: Taylor rule + CBDC rule.
- Fiscal policy: Deficit rule.

2.2 Banks

- Net worth: Wholesale banks and capital adequacy regulation
  - Choose gross assets & liabilities to maximize net worth.
  - Penalty if net worth below a fraction of risk-weighted assets.
  - **Bank leverage shock:** Time-varying capital adequacy target.
  - Foreign exchange mismatches must be completely eliminated.
- Loans: Retail lending banks and costly state verification
  - Retail lending banks: BGG (1999) but with pre-committed lending rates.
  - Collateral = portion of borrower's capital stock.
  - **Credit supply shock:** Time-varying willingness to lend against collateral.
- Deposits: Retail deposit banks with market power and money-in-advance
  - "Money" = bank deposits + CBDC.

2.3 Households

2.3.1 Preferences

- Standard preferences:

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{hh}^t \left\{ S_t^c \left(1 - \frac{\nu}{x}\right) \log\left(c_t(j) - \nu c_{t-1}\right) - \left(\psi/2\right) h_t\left(j\right)^2 \right\}$$

- Consumption aggregator:

$$c_t = \left[(b^c S_t^m)^{1/\theta_c} \left(c_{H,t}\right)^{\frac{\theta_c - 1}{\theta_c}} + (1 - b^c S_t^m)^{1/\theta_c} \left(c_{F,t}\right)^{\frac{\theta_c - 1}{\theta_c}} \right]^{\frac{\theta_c}{\theta_c - 1}}$$

- Capital accumulation:

$$k_t = \left(1 - \Delta\right) k_{t-1} + I_t S_t^i \left(1 - \phi_i/2 \left(I_t/I_{t-1} - 1\right)^2\right)$$

- Money-in-advance constraints:
  - On consumption & investment:
$$\varkappa^{ci} A_{ci,t} \geq 4 S_t^{mon} \left(P_t c_t \left(1 + \tau_{c,t} \right) + P_{H,t} I_t \right)$$
  - On input purchases:
$$\varkappa^{y} A_{y,t} \geq 4 S_t^{mon} \left(W_t^{pr} H_t + R_{k,t} K_t \right)$$

- **Money demand shock:** Time-varying money-versus-spending preferences.

- Monetary aggregates:
  - Top-level: H and F currency

$$A_{ci,t} = \left[\left(b^o S_t^{ccy} \right)^{1/\theta_o} \left(O_{H,t}^h \right)^{\frac{\theta_o - 1}{\theta_o}} + \left(1 - b^o S_t^{ccy} \right)^{1/\theta_o} \left(O_{F,t}^h \right)^{\frac{\theta_o - 1}{\theta_o}} \right]^{\frac{\theta_o}{\theta_o - 1}}$$

  - Bottom-level: Deposits and CBDC ($O_{F,t}^h$ similar to $O_{H,t}^h$)

$$O_{H,t}^h = \left[\left(b_{ci}^H \right)^{1/\theta_d} \left(D_{H,ci,t}^h \right)^{\frac{\theta_d - 1}{\theta_d}} + \left(1 - b_{ci}^H \right)^{1/\theta_d} \left(\eth M_{H,ci,t}^h \right)^{\frac{\theta_d - 1}{\theta_d}} \right]^{\frac{\theta_d}{\theta_d - 1}}$$

- **Currency demand shock:** Time-varying preferences for currency H.

- Loan adjustment costs:

$$G_{L,t}^h = \check{\ell}_{H,t}^h \frac{\phi_\ell}{2} \left(\check{\ell}_{H,t}^h - \check{\ell}_{H,t-1}^h \right)^2 + e_t \check{\ell}_{F,t}^h \frac{\phi_\ell}{2} \left(e_t \check{\ell}_{F,t}^h - e_{t-1} \check{\ell}_{F,t-1}^h \right)^2$$

2.3.2 Technologies

- Production function in capital and labor:

$$y_t = \left(S_t^a T_t H_t\right)^{1-\alpha} \left(K_t\right)^{\alpha}$$

- Quadratic price adjustment costs.
- Local currency pricing.
- Standard Phillips curves.

2.3.3 Budget Constraint

- Stylized budget constraint:

$$\left(D_{H,t}^h - L_{H,t}^h\right) + E_t\left(D_{F,t}^h - L_{F,t}^h\right) + Q_t k_t + M_{H,t}^h + E_t M_{F,t}^h$$

$=$ Gross Interest Earnings + Net Capital Income + Net Labor Income

$+$ Income from Production of Goods and Capital

- Consumption - Investment

Simultaneous choice of loan and deposit gross positions vis-a-vis banks
This is critical for the modeling of domestic and cross-border gross flows.

2.4 Fiscal Policy

- Budget constraint:

cheaper than before

much cheaper

no deposits

$$\check{b}_t + \check{m}_t = \frac{r_{b,t}}{x}\check{b}_{t-1} + \frac{r_{m,t}}{x}\check{m}_{t-1} + p_{H,t}\check{g}_t - \check{\tau}_t$$

- $\check{b}_t =$ government debt, $\check{m}_t =$ CBDC.

- Fiscal rule:

$$gd_t^{rat} = gd_{ss}^{rat} - 100 d^{gdp} \ln\left(\frac{g\check{d}p_t}{gdp_{ss}}\right)$$

Output Gap: Represents Automatic Stabilizers

2.5 Monetary Policy - The Policy Rate on Reserves

- Forward-looking Taylor rule:

$$i_t = (i_{t-1})^{i_i} (\bar{i})^{1-i_i} \left(\frac{\pi_{t+1}^p}{\bar{\pi}}\right)^{(1-i_i)i_\pi} \left(\frac{gdp_t}{gdp_{t-1}}\right)^{(1-i_i)i_y} S_t^{int}$$

2.6 Monetary Policy - CBDC

2.6.1 CBDC Interest Rate Rule

- Taylor rule remains in effect.
- CBDC interest rate rule:

$$i_{m,t} = \frac{i_t}{\mathfrak{sp}} \left(\frac{\pi^p_{t+1}}{\bar{\pi}} \right)^{-m_\pi} \left(\frac{\check{\ell}^h_{H,t}}{\bar{\ell}^h_H} \right)^{-0.05 * m_{cred}}$$

- Countercyclical policies - $m_{cred} > 0$ or $m_\pi > 0$:
  - Makes CBDC less attractive in a boom.
  - Reduces output and inflation through lower money balances.
- **Key: A lower interest rate on money is contractionary, not expansionary.**
  - Increases the opportunity cost and thus reduces the quantity of money.
  - This increases the cost of doing business.
- Special case: Cash-like CBDC - $i_{m,t} = 1$.

2.6.2 CBDC Quantity Rule

- Taylor rule remains in effect.
- CBDC rule for the CBDC-to-GDP ratio.

3 Calibration/Estimation of Pre-CBDC Model

- US data, 1990Q1 - 2019Q4.
- Calibrate parameters that govern the steady state.
- Estimate the parameters that govern dynamics.
- Imposing symmetry across 2 countries.

3.1 Calibration

- Standard calibration of the real sector.

- Very detailed calibration of the financial sector:
  - Balance sheet ratios to GDP.
  - Interest rate spreads.
  - Failure rates.

3.2 Estimation

- Standard Bayesian techniques.
- 11 quarterly US variables.
- Estimates are well-behaved and have expected magnitudes.

3.3 Variance Decomposition

- Financial shocks account for
  1. Around half the variance of real variables and inflation.
  2. The bulk of the variance of financial variables.
- Important because CBDC responds most effectively to financial shocks.

Share of Variance	**Financial Shocks**	**Demand Shocks**	**Supply Shocks**
Output Growth	44	50	6
Consumption Growth	61	32	7
Investment Growth	54	43	3
Inflation	63	6	31
Policy Rate	94	6	0
Credit Spread	94	5	1
Credit Growth	93	6	1
Exchange Rate	95	5	0

4 Effects of a Transition to CBDC

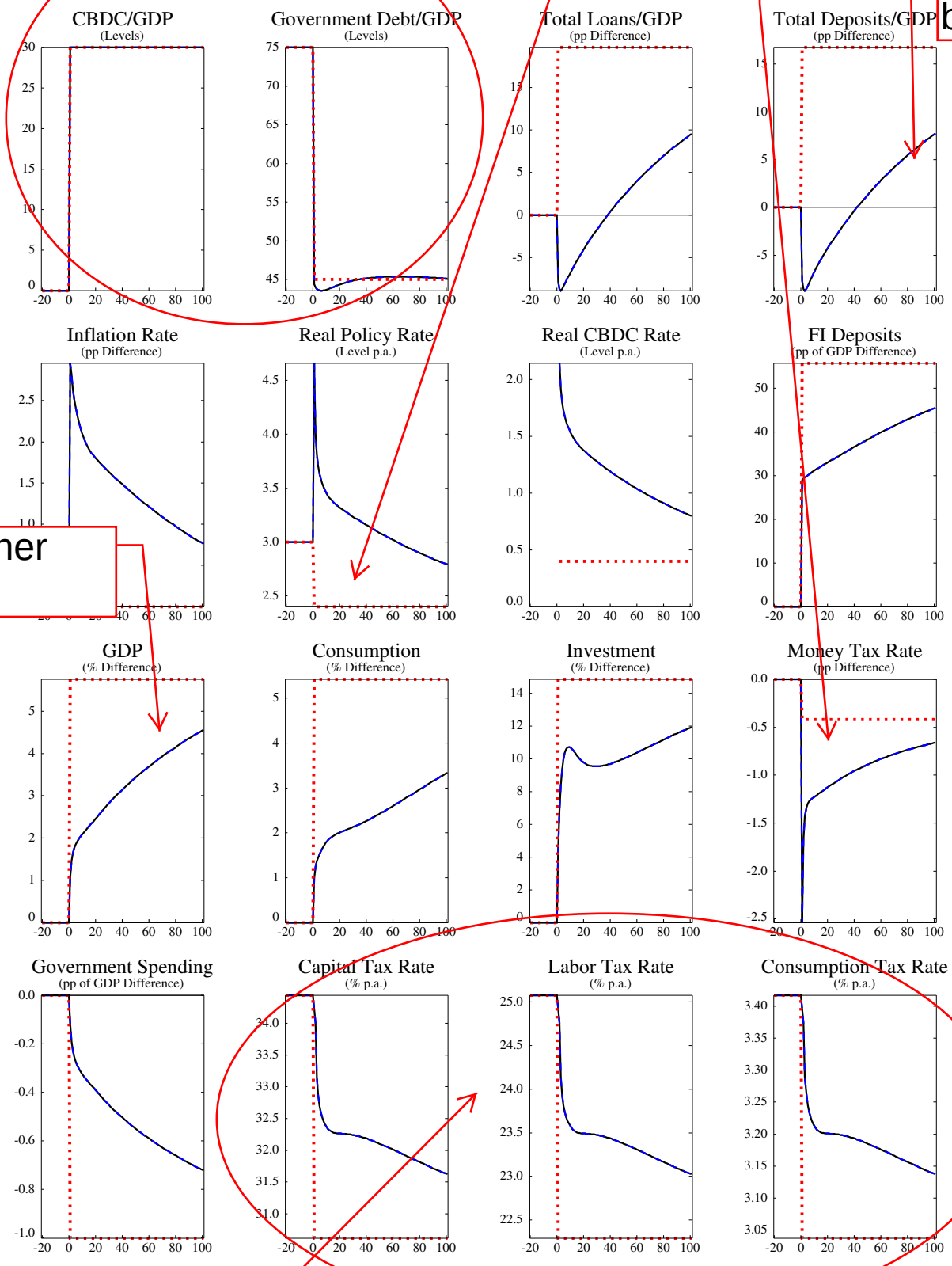
- Issue 30% of GDP of CBDC against government debt by Home only.
- Three reasons for expansionary effects:
  1. **Lower real interest rates.**
  2. **Lower distortionary taxes.**
  3. **More/cheaper liquidity.**
- Effects on GDP:
  - 2% immediate gain.
  - 6% long-run gain.
- Effects on banking:
  - Deposits only drop slightly initially, grow strongly in long run.
  - Deposit composition shifts from retail to wholesale.
  - Average funding cost remains almost unchanged.

1. Swap of govt. debt against CBDC

2. Lower real interest rates

4. Lower monetary frictions

6. Larger banks



5. Higher output

3. Lower tax rates

5 Welfare: Optimized Simple Rules

- The policy problem:
  - Many central banks may issue CBDC, not always for macro reasons.
  - But how should CBDC policy be conducted at the macro level?
  - Specifically, what policy rule would best stabilize the economy?

- Our approach:
  - Specify a number of different possible CBDC policy rules.
  - Evaluate welfare for a grid of Taylor and CBDC rule coefficents.

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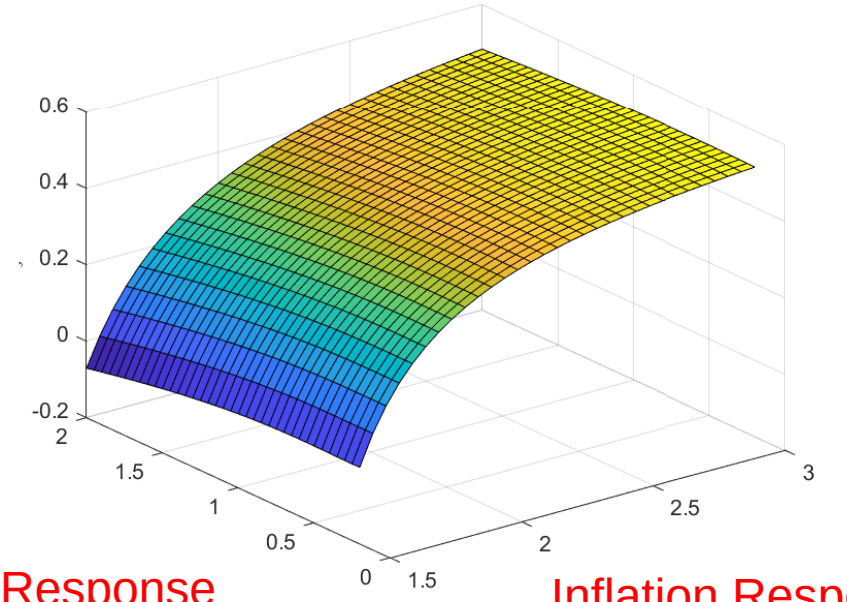
5.1 Pre-CBDC Taylor Rule

- 0.51% CCV gain in Taylor rule inflation gap.
- Very flat in output growth.
- Familiar shape.

Welfare Gain in % of Steady State Consumption (CCV)



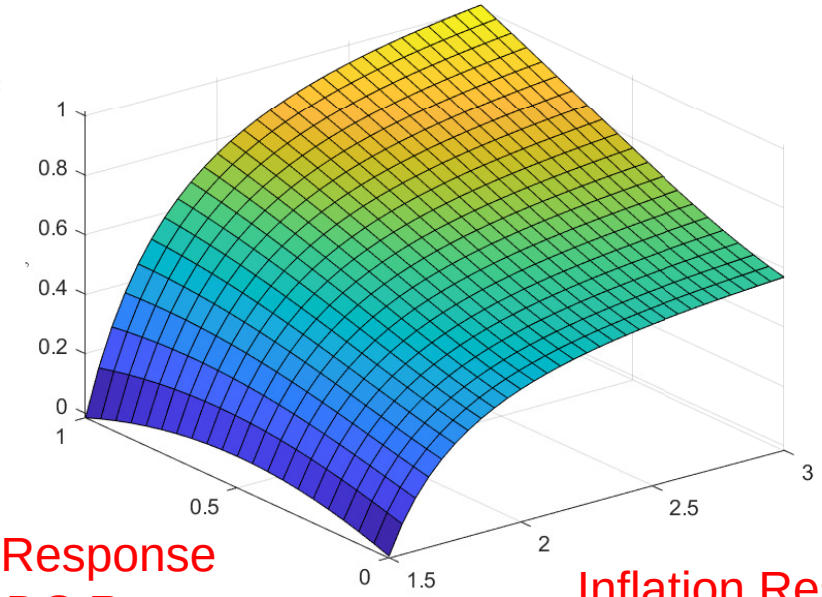
Output Response of Policy Rate

Inflation Response of Policy Rate

5.2 CBDC Interest Rate Rule with Credit Gap

- 0.57% CCV gain in Taylor rule inflation gap.
- 0.44% CCV gain in CBDC rule credit gap.
- 44% of total gain:
  Best CBDC rule.

Welfare Gain in % of Steady State Consumption (CCV)



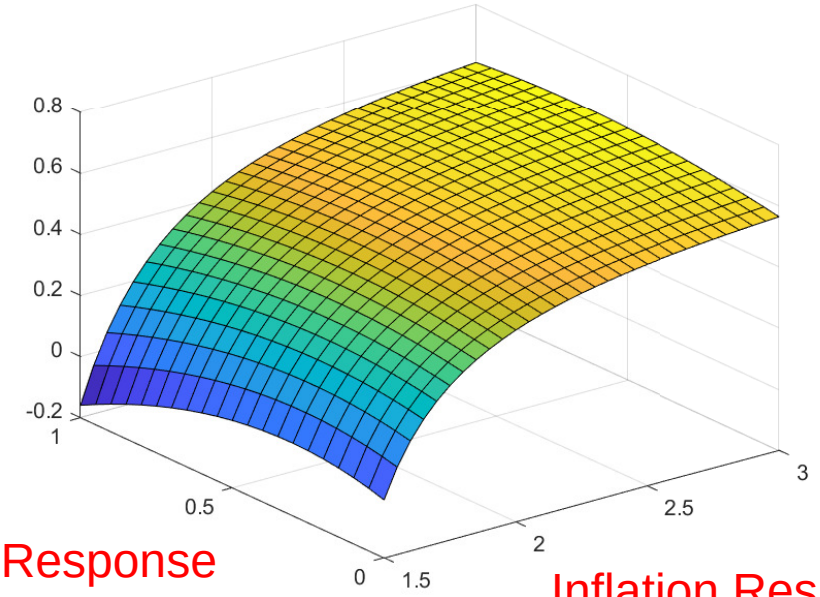
Credit Response of CBDC Rate

Inflation Response of Policy Rate

5.3 CBDC Quantity Rule with Credit Gap

- 0.57% CCV gain in Taylor rule inflation gap.
- 0.06% CCV gain in CBDC rule credit gap.
- 10% of total gain:
  Inferior in welfare terms.

Welfare Gain in % of Steady State Consumption (CCV)



Credit Response of CBDC Quantity

Inflation Response of Policy Rate

- Key shocks responsible for this result:
  - Financial shocks.
  - Especially credit supply shocks.

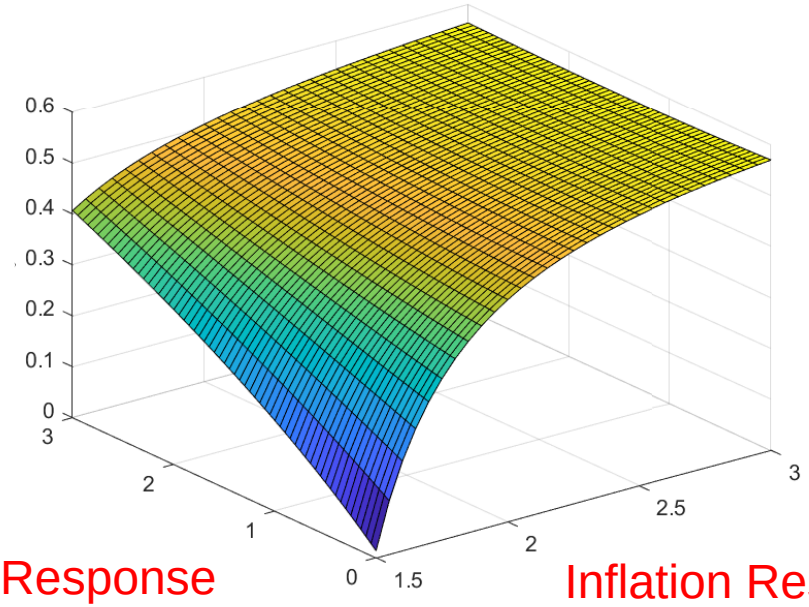
- Economic logic:
  - Poole (1970): Q worse than INT rules under shocks to money demand.
    - Households want more money per unit of output.
    - Q rule does not supply more money.
    - Output needs to contract.
  - Here: Q worse than INT rules under shocks to *excess* money demand.
    - Credit supply.
    - Money demand.
    - Currency demand.

5.4 CBDC Interest Rate Rule with Inflation Gap

- 0.57% CCV gain in Taylor rule inflation gap.
- 0% CCV gain in CBDC rule inflation gap.

  Inferior in welfare terms.

Welfare Gain in % of Steady State Consumption (CCV)



Inflation Response of CBDC Rate

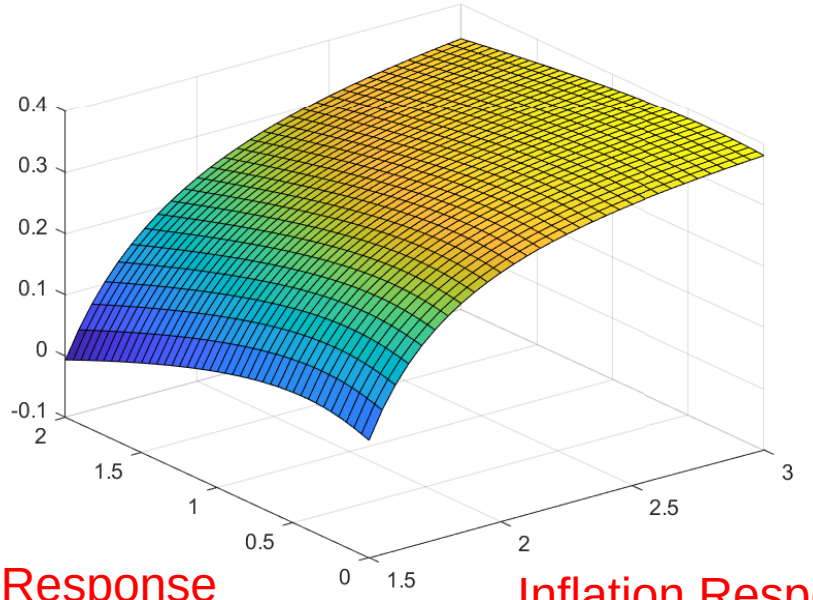
Inflation Response of Policy Rate

Reason: Response of inflation is far more short-lived than response of credit and real variables. Better to target credit.

5.5 Cash-like CBDC

- 0.39% CCV gain in Taylor rule inflation gap.
- Decomposition:
  1. 0.28% due to Taylor rule.
  2. 0.11% due to CBDC spread (+) and low steady state CBDC (-).
- Inferior in welfare terms.

Welfare Gain in % of Steady State Consumption (CCV)



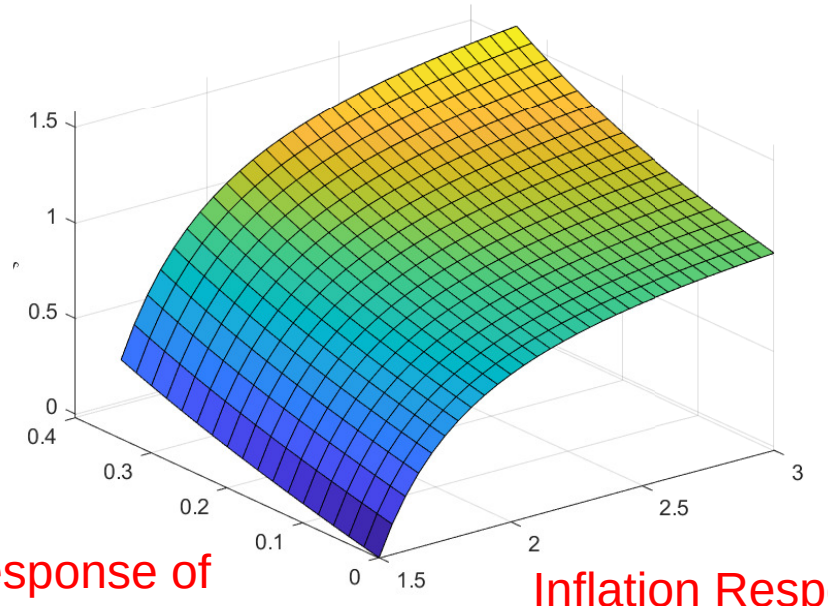
Output Response of Policy Rate

Inflation Response of Policy Rate

5.6 CBDC INT Rule with Credit Gap + Automatic Stabilizers

- 1.58% overall CCV gain.
- Roughly evenly split between:
  1. Taylor rule inflation gap.
  2. CBDC rule credit gap.
  3. Fiscal rule output gap.

Welfare Gain in % of Steady State Consumption (CCV)



Output Response of Fiscal Deficit

Inflation Response of Policy Rate

Reasons:

1. With aggressive CBDC rule 90% of deficits financed by CBDC.
2. This stimulates output.
3. Friedman (1948): Money (CBDC) - financial fiscal deficits.

6 Summary

6.1 Efficiency Gains for 30% CBDC-to-GDP

1. Output gains: Just under 6%.

2. Welfare gains: 2%.

3. Bank balance sheets grow in the long run.

4. Bank average funding costs remain constant.

6.2 Optimized Simple Rules

1. Best CBDC rules: Interest rate rules that respond to credit gaps.
2. Lower-welfare rules:
   (a) Quantity rules.
   (b) Response to inflation gaps.
   (c) Reserves rules.
   (d) Cash-like zero-interest CBDC.
3. Even higher welfare rules: CBDC-financed automatic fiscal stabilizers.

6.3 Open Economy

1. CBDC policies can reduce exchange rate volatility by around one third.
2. CBDC policies can reduce gross capital flow volatility by around one third.
3. Large shocks to CBDC demand have small real effects.

THANK YOU