The Macroeconomics of Central-Bank-Issued Digital Currencies

John Barrdear, Bank of England

Michael Kumhof, Bank of England

Washington, DC, November 30, 2017

Disclaimer

The views expressed herein are those of the authors, and should not be attributed to the Bank of England.

1 Introduction

- The emergence of the distributed ledger technology (DLT) and of Bitcoin was a watershed moment in the history of 'e-monies'.

- It may, for the first time, be **technically feasible** for central banks to offer universal access to their balance sheet.
  - Existing centralized RTGS systems: Not robust for universal access.
  - New decentralized DLT systems: Can potentially solve this problem.

- Question: Is universal access **economically desirable**.

2 What is a Digital Currency?

- Traditional Electronic Payment Systems - **Tiered** Ledgers:
  - Payments are routed through and verified by specific third parties.
  - Third parties arranged in a hierarchical network.
- Digital Currencies - **Distributed** Ledgers:
  - Payments are peer-to-peer and verified by multiple verifiers.
  - Verifiers arranged in a peer-to-peer network.
- Bitcoin - Distributed Ledger + Alternative Monetary System.
  - BoE research rejects the monetary system of Bitcoin.
  - BoE research takes inspiration from its payment system.

Maintaining the Ledger

- Suggested additions to the Bitcoin ledger are **cheap talk**:
  Costless, non-binding and unverifiable.

- Bitcoin (cryptocurrencies) make proposed changes costly:
  - Through a proof-of-work system.
  - Result: Over-investment in computing power.
    * Bitcoin, in 2014, consumed as much electricity as Ireland!
    * And cryptocurrency electricity consumption is growing fast.

- A permissioned system (e.g. CBDC) makes proposed changes binding:
  - Transaction verifiers are regulated to ensure veracity.
  - Trust in central party replaces proof-of-work system.

3 What is a Central-Bank Digital Currency (CBDC)?

- **Access to the central bank's balance sheet.**
- **Availability:** 24/7.
- **Universal:** Banks, firms and households.
- **Electronic:** For resiliency reasons, probably using DLT.
- **National-currency denominated:** 1:1 exchange rate.
- **Issued only through spending or against eligible assets:** Government bonds.
- **Interest-bearing:**
  - To equate demand and supply at 1:1 exchange rate.
  - Second tool of countercyclical monetary policy.
- **Coexisting with the present banking system.**

4 The Model

4.1 Overview

- Based on Benes and Kumhof (2012) and Jakab and Kumhof (2015).
- Households:
  - Deposits: Obtained through bank loans.
  - CBDC: Obtained in exchange for government debt.
  - Deposits and CBDC jointly generate liquidity.
- Banks: Create new deposits by making new loans.
- Government:
  - Fiscal policy.
  - Traditional monetary policy.
  - CBDC monetary policy.

4.2 Endogenous Deposits and Exogenous CBDC

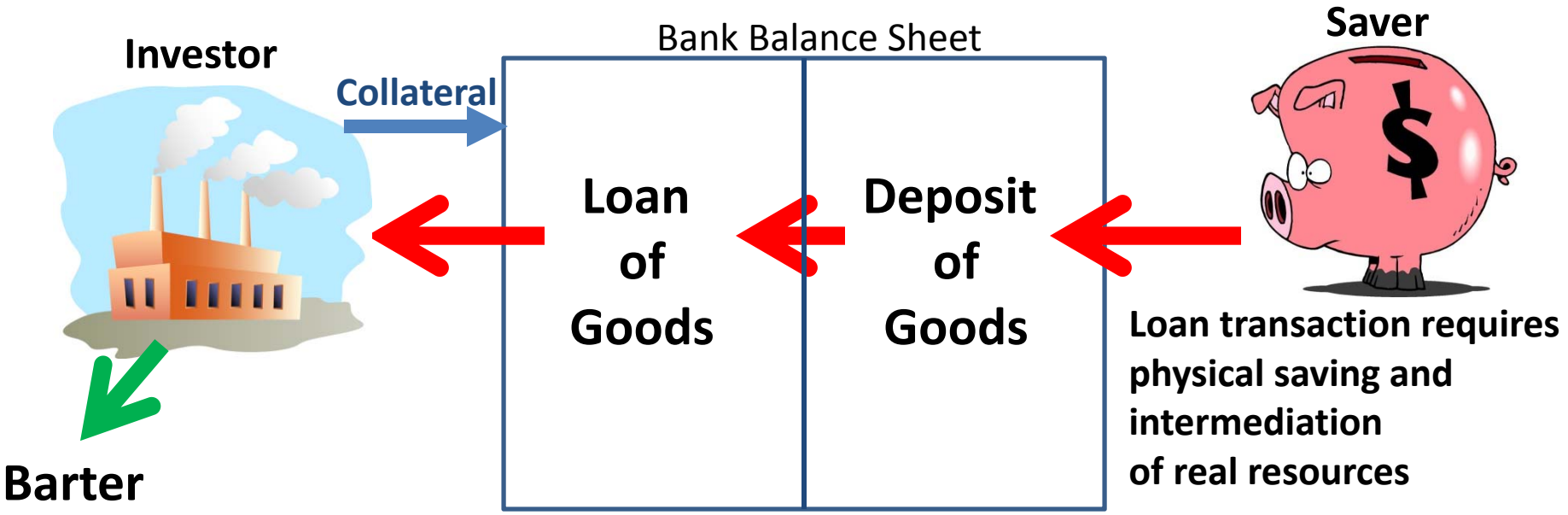
- Sidrauski-Brock monetary models of the 1980s/1990s:
  1. Representative household with a demand for money.
  2. Government exogenously supplies **all** money.

- The main problem is 2, not 1. Therefore, in our model:
  - Bank deposits (97% of all money) enter into TA cost technology.
  - Government money is omitted entirely.

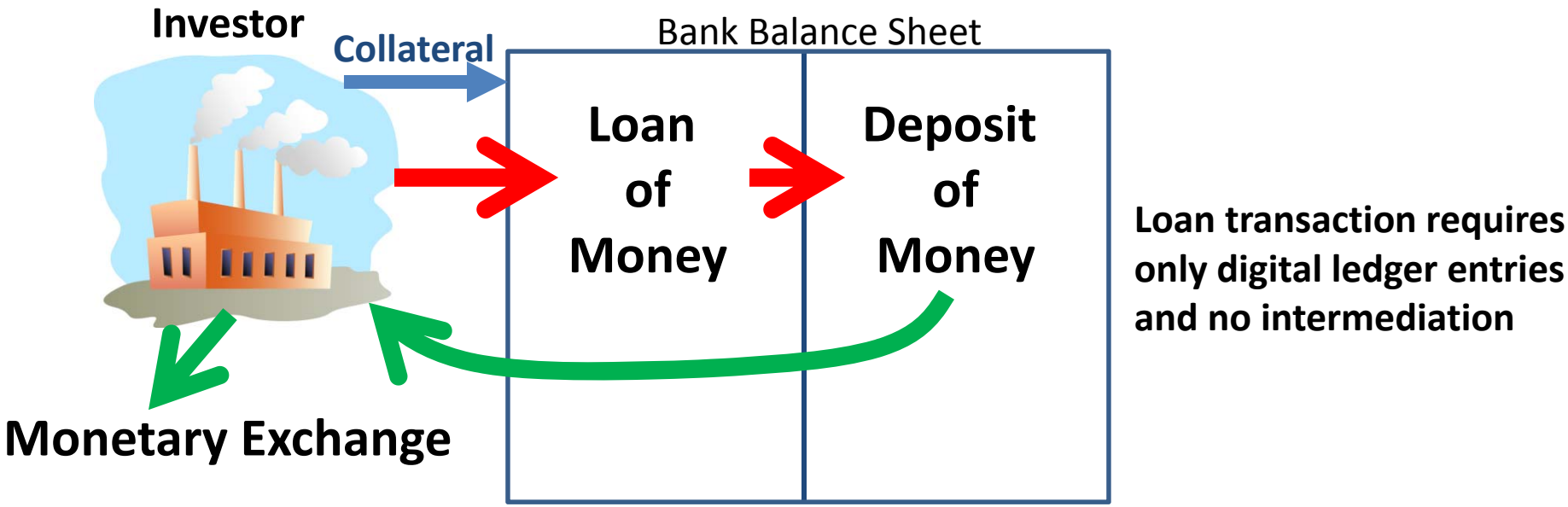
- CBDC puts exogenous government money back into the model. But:
  1. CBDC is universally accessible (unlike reserves).
  2. CBDC is interest-bearing (unlike cash).

Intermediation of Loanable Funds (ILF) versus Financing Through Money Creation (FMC)

Intermediation of Loanable Funds Model



Financing Through Money Creation Model



Deposits and loans are predetermined variables

Key Difference ILF-FMC: Budget Constraints

- Budget Constraints in ILF Model: Saver + Borrower Household
  - Saver Household

$$\Delta deposits_t^s = income_t^s - spending_t^s$$

  - Borrower Household

$$-\Delta loans_t^b = income_t^b - spending_t^b$$

- Budget Constraint in FMC+CBDC Model: Representative Household only

$$\Delta deposits_t^r - \Delta loans_t^r + \Delta CBDC_t^r = income_t^r - spending_t^r$$

Deposits and loans are jump variables

4.3 Banks

- Loans: Bernanke, Gertler and Gilchrist (1999)
  - Costly state verification.
  - Difference: Pre-committed lending rates.
- Deposits: Schmitt-Grohé and Uribe (2004)
  - Transactions cost technology.
  - Difference: "Money" = bank deposits + CBDC.

4.4 The Liquidity-Generating Function (LGF)

- Combines the liquidity generated by bank deposits and CBDC.
- Functional form:

$$f_t^x = \left((1-\gamma)^{\frac{1}{\epsilon}} \left(Deposits_t\right)^{\frac{\epsilon-1}{\epsilon}} + \gamma^{\frac{1}{\epsilon}} \left(T^{fintec} CBDC_t\right)^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}$$

- Market clearing: Interest rates on loans, deposits **and CBDC** adjust.

4.5 Monetary Policy - The Policy Rate

$$i_t = (i_{t-1})^{i_i} \left(\frac{x\pi^p_{tgt} \left(1 + \phi_b \left(b^{rat}_t - \bar{b}^{rat}\right)\right)}{\beta_u} \right)^{(1-i_i)} \left(\frac{\pi^p_{4,t+3}}{\left(\pi^p_{tgt}\right)^4} \right)^{\frac{(1-i_i)i_{\pi^p}}{4}}$$

4.6 Monetary Policy - CBDC

4.6.1 Quantity Rule for CBDC

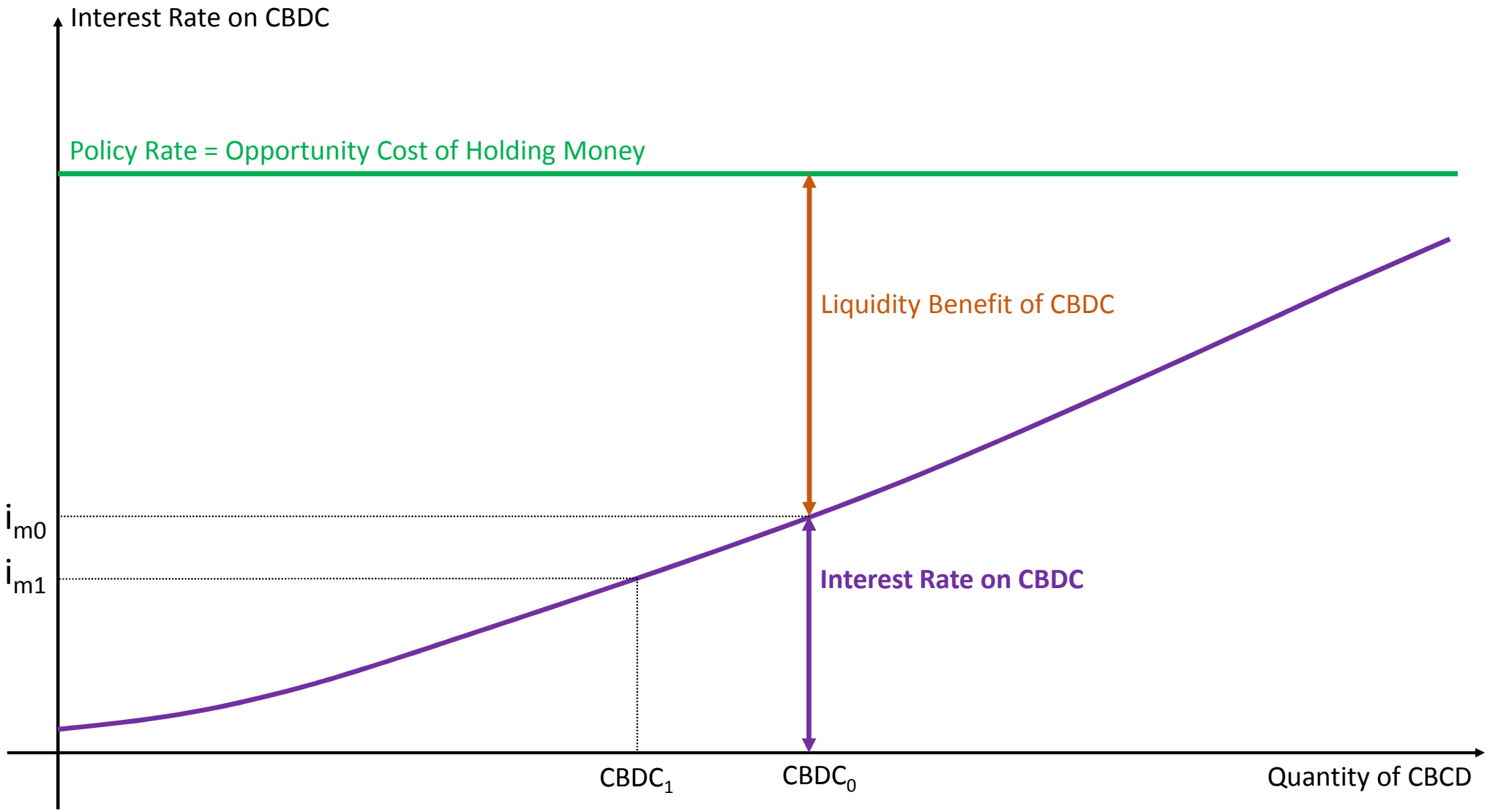
$$m_t^{rat} = m_{tgt}^{rat} S_t^{ms} - 100 m_{\pi^p} E_t \ln \left(\frac{\pi^p_{4,t+3}}{\left(\pi^p_{tgt}\right)^4} \right)$$

- Fix the quantity of CBDC, let CBDC interest rate clear the market.
- $m_{\pi^p} > 0$: Removes CBDC from circulation in a boom.

4.6.2 Price Rule for CBDC

$$i_{m,t} = \frac{i_t}{\mathfrak{sp}} \left(\frac{\pi^p_{4,t+3}}{\left(\pi^p_{tgt}\right)^4} \right)^{-i^m_{\pi^p}}$$

- Fix interest rate on CBDC, let the quantity of CBDC clear the market.
- $i^m_{\pi^p} > 0$: Makes CBDC less attractive in a boom.

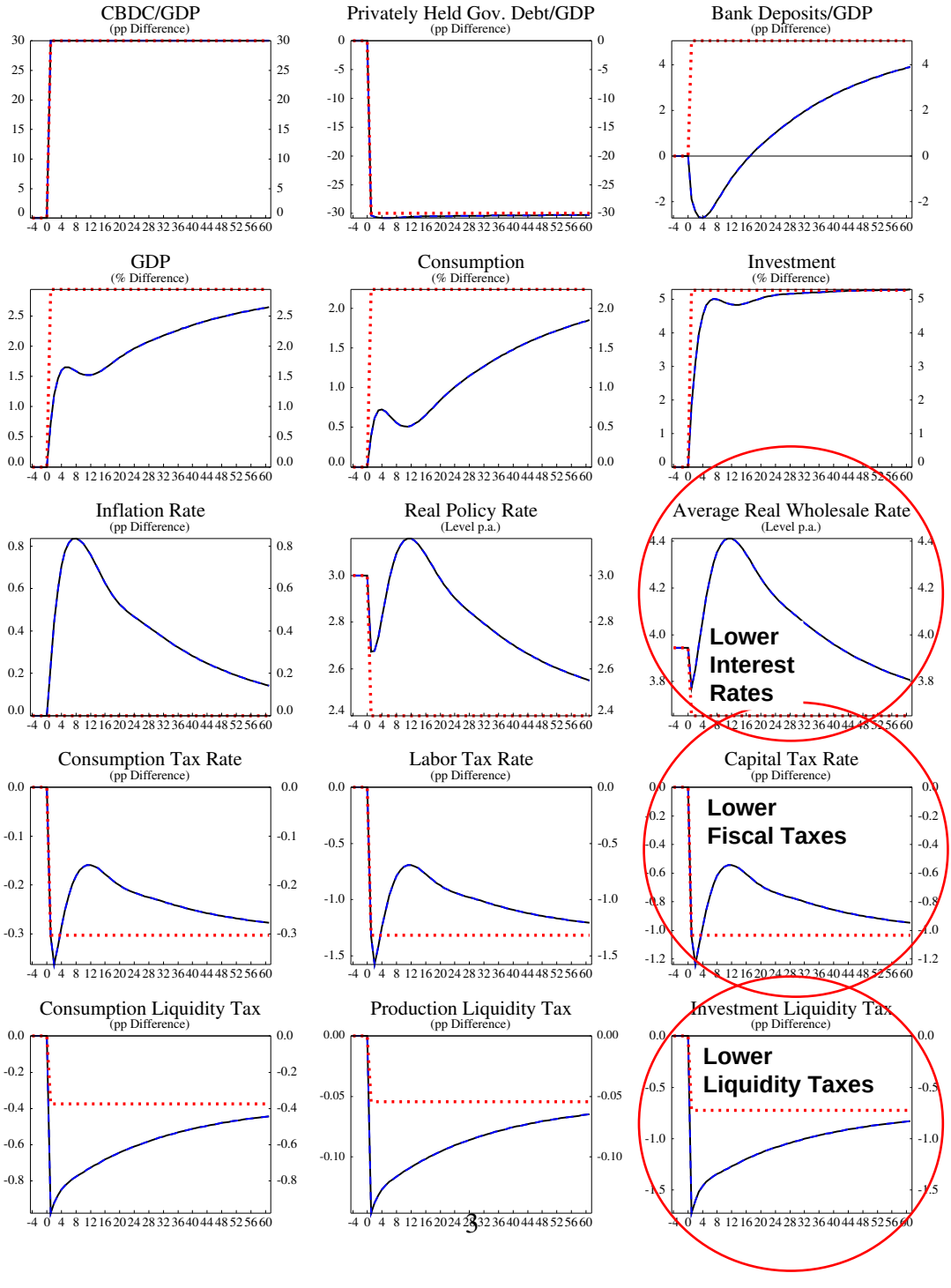

Interest Rate on CBDC
Policy Rate = Opportunity Cost of Holding Money
Liquidity Benefit of CBDC
i_{m0}
i_{m1}
Interest Rate on CBDC
$CBDC_1$
$CBDC_0$
Quantity of CBCD

5 Steady State Effects of the Transition to CBDC

- Assumptions:
  - Issue CBDC against government debt.
  - Magnitude: 30% of GDP.

- Results:

	Steady State Output Effect
1. Lower Real Policy Rates	+1.8%
2. Higher Deposit Rates Relative to Policy Rates	-0.9%
3. Reductions in Fiscal Tax Rates	+1.1%
4. Reductions in Liquidity Tax Rates	+0.9%
Total	+2.9%



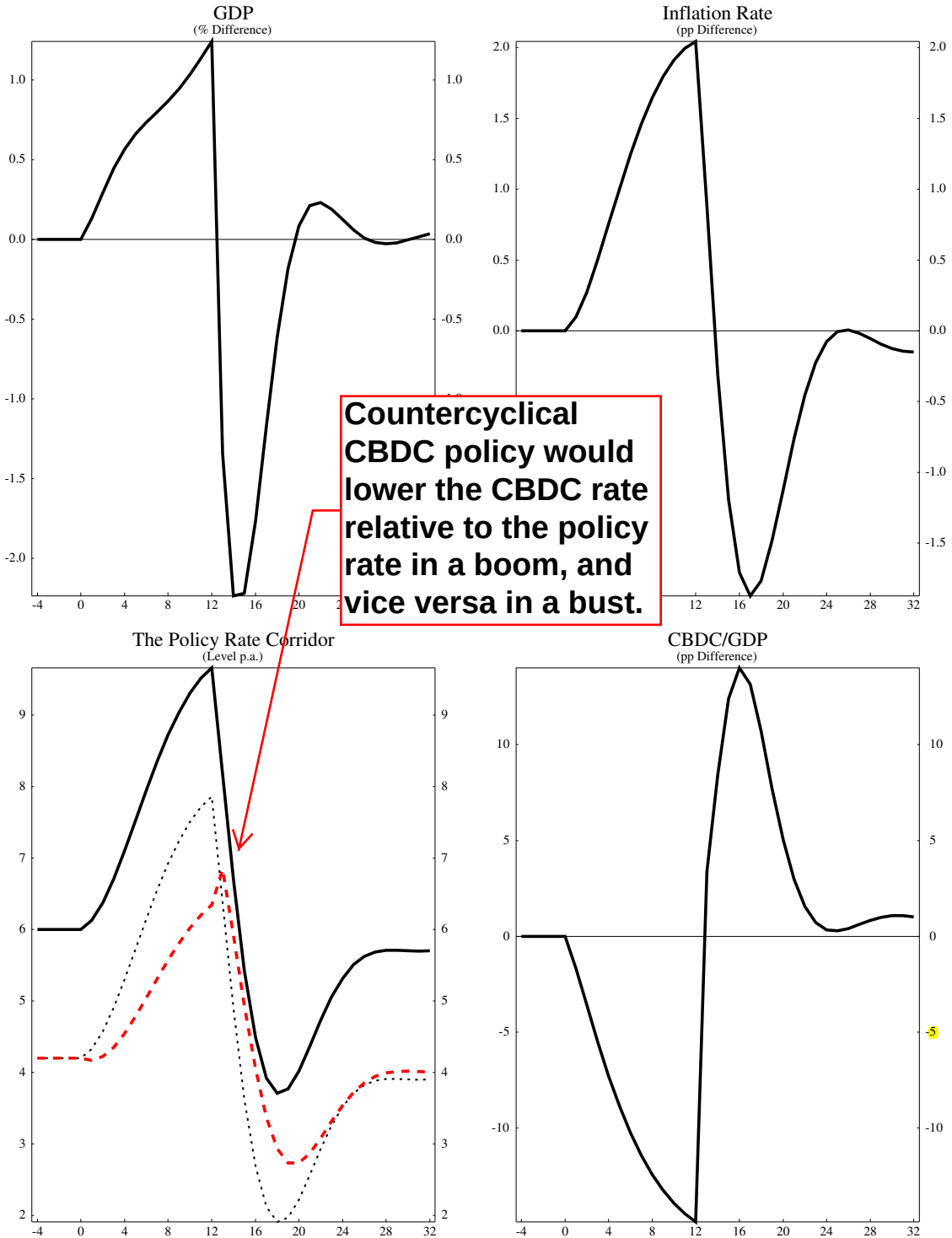
Transition to Steady State with CBDC

solid line = actual transition ; dotted line = change in long-run steady state

6 Financial Stability: CBDC Bank Runs?

- There is no easy way to run from bank deposits to CBDC **in aggregate**.
- Two reasons:
  1. Aggregate increases in CBDC demand do not affect bank deposits:
     - Central bank sells CBDC only against government debt.
     - **Not** against bank deposits.
     - CBDC purchases among non-banks are irrelevant.
  2. CBDC policy rules can further discourage volatile CBDC demand.

7 Countercyclical CBDC Rules

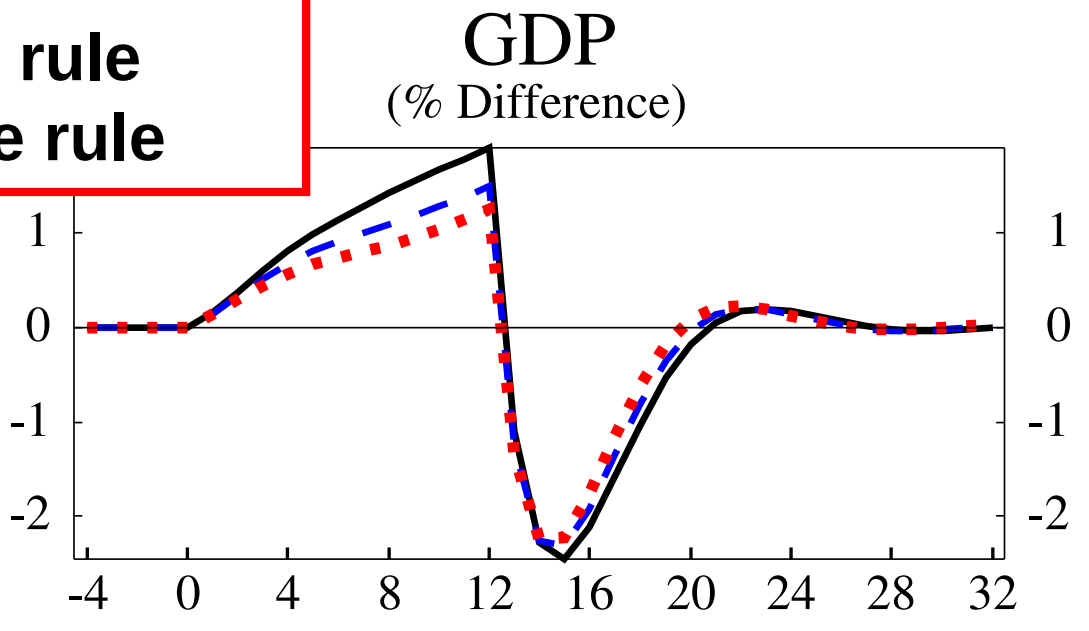


Credit Cycle Shock - Price Rule - Policy Rate Corridor

Bottom Left: Nominal Policy and CBDC Rates

Solid Line = Policy Rate, Dotted Line = Policy Rate minus Fixed Spread, Dashed Line = CBDC Rate

- Solid line = fixed rule
- Dashed line = c'cyclical rule
- Dotted line = aggressive rule



8 Conclusions

- CBDC has significant benefits $\Longrightarrow$ further research is worthwhile.
- Increase in steady-state GDP could be as much as 3%.
- Improved ability to stabilize inflation and the business cycle.
- Should reduce some FS risks, but may introduce others.
- The design of a successful transition is the critical issue.