The Macroeconomics of Central-Bank-Issued Digital Currencies


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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


- 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

Investor \(\rightarrow\) Loan of Goods \(\rightarrow\) Saver

Barter

Collateral

Bank Balance Sheet

Loan of Goods

Deposit of Goods

Loan transaction requires physical saving and intermediation of real resources

Financing Through Money Creation Model

Investor \(\rightarrow\) Loan of Money \(\rightarrow\) Saver

Monetary Exchange

Collateral

Bank Balance Sheet

Loan of Money

Deposit of Money

Loan transaction requires only digital ledger entries and no intermediation
**Key Difference ILF-FMC: Budget Constraints**

- **Budget Constraints in ILF Model: Saver + Borrower Household**
  - Saver Household
    \[ \Delta \text{deposits}_s^t = \text{income}_s^t - \text{spending}_s^t \]
  - Borrower Household
    \[ -\Delta \text{loans}_b^t = \text{income}_b^t - \text{spending}_b^t \]

- **Budget Constraint in FMC+CBDC Model: Representative Household only**
  \[ \Delta \text{deposits}_r^t - \Delta \text{loans}_r^t + \Delta \text{CBDC}_r^t = \text{income}_r^t - \text{spending}_r^t \]
4.3 Banks

- Loans: Bernanke, Gertler and Gilchrist (1999)
  - Costly state verification.
  - Difference: Pre-committed lending rates.

  - 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:
  \[
  f_t^x = \left( (1 - \gamma)^{\frac{1}{\epsilon}} (Deposits_t)^{\frac{e-1}{\epsilon}} + \gamma^\epsilon \left( T_{intec CBDC} \right)^{\frac{e-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}
  \]

- Market clearing: Interest rates on loans, deposits and CBDC adjust.
4.5 Monetary Policy - The Policy Rate

\[ i_t = (i_{t-1})^{i_i} \left( \frac{x \pi^p_{tgt} (1 + \phi_b \left( b_{rat}^t - \bar{b}_{rat} \right))}{\beta_u} \right)^{1-i_i} \left( \frac{\pi^p_{4,t+3}}{\pi^p_{tgt}^4} \right)^{(1-i_i)i_{\pi^p}} \]
4.6 Monetary Policy - CBDC

4.6.1 Quantity Rule for CBDC

\[ m^\text{rat}_t = m^\text{rat}_{tgt}S^\text{ms}_t - 100m_{\pi p}E_t \ln \left( \frac{\pi^p_{4,t+3}}{\left(\pi^p_{tgt}\right)^4} \right) \]

- 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

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

- 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.
Policy Rate = Opportunity Cost of Holding Money

Interest Rate on CBDC

Liquidity Benefit of CBDC

Interest Rate on CBDC

Quantity of CBCD
5 Steady State Effects of the Transition to CBDC

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

• Results:

<table>
<thead>
<tr>
<th>Steady State Output Effect</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Real Policy Rates</td>
<td>+1.8%</td>
</tr>
<tr>
<td>Higher Deposit Rates Relative to Policy Rates</td>
<td>-0.9%</td>
</tr>
<tr>
<td>Reductions in Fiscal Tax Rates</td>
<td>+1.1%</td>
</tr>
<tr>
<td>Reductions in Liquidity Tax Rates</td>
<td>+0.9%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>+2.9%</strong></td>
</tr>
</tbody>
</table>
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
Countercyclical CBDC policy would lower the CBDC rate relative to the policy rate in a boom, and vice versa in a bust.

Bottom Left: Nominal Policy and CBDC Rates
Solid Line = Policy Rate, Dotted Line = Policy Rate minus Fixed Spread, Dashed Line = CBDC Rate
Figure 8. Countercyclical CBDC Price Rules - Credit Cycle Shocks

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

Credit Cycle Shock - CBDC Countercyclical Price Rule

Solid Line = Baseline \( (i^m_{\pi p} = 0) \), Dashed Line = Intermediate \( (i^m_{\pi p} = 0.4) \), Dashed Line = Aggressive \( (i^m_{\pi p} = 0.8) \)
8 Conclusions

- CBDC has significant benefits $\implies$ 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.