The Macroeconomics of Central-Bank-Issued Digital Currencies

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Fintech and Digital Currencies Conference
BIS, Basel, September 27, 2019
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 routed through and must be verified by **specific** third parties.
  - Third parties arranged in a hierarchical network.

- Digital Currencies - **Distributed** Ledgers:
  - Payments are peer-to-peer and can be 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.
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

- The non-monetary model elements are standard New Keynesian fare.
- Households:
  - Deposits: Created by banks through loans.
  - CBDC: Created by central bank, issued via OMO or spending/lending.
  - Deposits and CBDC jointly serve as medium of exchange.
- Banks: Create new deposits by making new loans.
  - Loans are risky → banks can make losses.
  - Deposits reduce costs of transactions → can pay a lower interest rate.
- Government:
  - Fiscal policy.
  - Traditional monetary policy.
  - CBDC monetary policy.
4.2 Endogenous Deposits and Exogenous CBDC

- Monetary models of the 1980s/1990s:
  1. Representative household with a demand for money.
  2. Government money (3% of all money) is the **only** money.

- The main problem is 2, not 1. Therefore, in our model:
  - We keep the representative household assumption.
  - Bank deposits (97% of all money) enter into TA cost technology.
  - Government money (3% of all 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

Loan transaction requires physical saving and intermediation of real resources.

1. Barter
2. Monetary Exchange

Financing Through Money Creation Model

Loan transaction requires only digital ledger entries and no intermediation.

1. Collateral
2. Loan of Money
3. Deposit of Money
Key Difference ILF-FMC: Budget Constraints

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

- Budget Constraint in **FMC Model**: Representative Household only
  \[ \Delta \text{deposits}_t^r - \Delta \text{loans}_t^r = \text{income}_t^r - \text{spending}_t^r \]

- Budget Constraint in **FMC+CBDC Model**: Representative Household only
  \[ \Delta \text{deposits}_t^r - \Delta \text{loans}_t^r + \Delta CBDC_t^r = \text{income}_t^r - \text{spending}_t^r \]
4.3 Loan Issuance: Costly State Verification


- Important modifications:
  1. Precommitted lending rates: Banks can make loan losses.
  2. Stochastic willingness to lend against collateral: New source of shocks.
4.4 Deposit Issuance: TA Cost Technologies

- Schmitt-Grohé and Uribe (2004) technology:
  \[ s_t^x(i) = s_t^x(v_t^x(i)) = S_t^{md} A_x v_t^x(i) + \frac{B_x}{v_t^x(i)} - 2 (A_x B_x)^{\frac{1}{2}} \]

- \( S_t^{md} \) = shock to demand for total liquidity = “flight to safety”.

- Velocity:
  \[ v_t^x(i) = e_t^x(i) \]
  \[ f_t^x(i) \]
  - \( e_t^x(i) \) = sector-specific expenditure.
  - \( f_t^x(i) \) = sector-specific monetary transaction balances = composite:
    1. Bank deposits.
    2. CBDC.
• Monetary Distortion Markups = Liquidity Taxes:

\[ \tau_{x,t}^{l,iq} = 1 + s_t^x + s_t^{x'} v_t^x \]

- Their effects are equivalent to consumption and capital income taxes!
- It is through these quasi-tax-rates that banks affect the real economy, not through intermediation of “loanable funds”!
- With sufficiently low interest semi-elasticities of money demand (such as cash-in-advance), liquidity shortages can nevertheless be a very tight constraint.

• What is the Distortion?
  - Shortage, relative to the Friedman rule, of liquidity.
  - This can never be completely eliminated because the cost of creating bank deposits can never go to zero.
4.5 The Liquidity-Generating Function (LGF)

  - Transactions cost technology: Money reduces transactions costs.
  - Difference: “Money” = bank deposits + CBDC, not cash + reserves.

- Functional form:

\[
 f_t = \left( (1 - \gamma) \frac{1}{\epsilon} (Deposits_t)^{\frac{\epsilon-1}{\epsilon}} + \gamma \frac{1}{\epsilon} (CBDC_t)^{\frac{\epsilon-1}{\epsilon}} \right)^{\frac{\epsilon}{\epsilon-1}}
\]
4.6 Fiscal Policy

4.6.1 Government Budget Constraint

\[ b_t^g + m_t^g = r_t b_{t-1}^g + r_{m,t} m_{t-1}^g + g_t + tf_t - \tau_t \]

- CBDC enters like government debt.
- But it is much cheaper.
4.6.2 Fiscal Policy Rule

- Overall Deficit Ratio:
  \[ gdx_{t}^{rat} = 100 \frac{gdx_t}{gdpt} = 100 \frac{B_t^g + M_t^g - B_{t-1}^g - M_{t-1}^g}{GDP_t} \]
  
  - Relevant stock change: Government Debt + CBDC.
  - Insulates budget from potentially highly volatile CBDC seigniorage flows.

- Rule for Deficit Ratio:
  \[ gdx_{t}^{rat} = gdx_{ss}^{rat} - 100d^{gd} \ln \left( \frac{gdpt}{gdps_{ss}} \right) \]
4.7 Monetary Policy

4.7.1 Monetary Policy - The Policy Rate

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

Steady state nominal interest rate (model-specific expression)
4.7.2 Monetary Policy - CBDC

- Why not target monetary aggregates? The 1980s debate versus CBDC.

- Three arguments against targeting monetary aggregates:
  1. Problems in defining the relevant aggregate: Does not apply to CBDC.
  2. Problems in controlling the aggregate: Does not apply to CBDC.
     - Volatility increases if money demand shocks are important.
     - This argument does apply in our model, but much more weakly than in Poole (1970).
     - Reason: Banks remain the creators of the marginal unit of money.

- To study the third argument, we need to define CBDC policy rules.
Quantity Rule for CBDC

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

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

Price Rule for CBDC

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

- Fix interest rate on CBDC, let the quantity of CBDC clear the market.
- \( i_{\pi^p}^m > 0 \): Makes CBDC less attractive in a boom.
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>1. Lower Real Policy Rates</td>
<td>+1.8%</td>
</tr>
<tr>
<td>2. Higher Deposit Rates Relative to Policy Rates</td>
<td>-0.9%</td>
</tr>
<tr>
<td>3. Reductions in Fiscal Tax Rates</td>
<td>+1.1%</td>
</tr>
<tr>
<td>4. Reductions in Liquidity Tax Rates</td>
<td>+0.9%</td>
</tr>
<tr>
<td>Total</td>
<td>+2.9%</td>
</tr>
</tbody>
</table>
The Main Factors Explained

1. **Lower real interest rates:**
   - Assumption: CBDC issued against government debt.
   - CBDC is not defaultable, government debt is.
   - CBDC carries a lower interest rate than government debt.

2. **Lower distortionary taxes:**
   - Much larger central bank balance sheet.
   - Therefore much larger seigniorage flows.
   - Also: Lower interest costs (see above).
   - Assumption: Seigniorage is used to reduce distortionary taxes.

3. **Lower transactions costs:**
   - Modern money is 95%+ created by private banks.
   - This is costly: Spreads, regulation, bank market power, collateral.
   - You can therefore never reach the Friedman rule.
   - But with CBDC you can get much closer.
Transition to Steady State with CBDC
solid line = actual transition ; dotted line = change in long-run steady state
6 Quantity Rules or Price Rules for CBDC?

A Poole (1970) contractionary money demand shock.
The Poole (1970) effect whereby Q rules are worse than P rules is weak.

Liquidity demand is mostly satisfied by instantaneous creation of bank deposits through loans. But CBDC can help.
7 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: No unconditional LoLR guarantee.
     - CBDC purchases among non-banks are irrelevant.
  2. CBDC policy rules can further discourage volatile CBDC demand.
     - Quantity rule:
       * CBDC supply fixed, CBDC interest rate clears the market.
       * **Lower political bound on CBDC rate?** Switch to price rule.
     - Price rule:
       * CBDC supply endogenous, CBDC quantity clears the market.
       * **Running out of government bonds?** Switch to other securities.
8 Countercyclical CBDC Rules

A boom-bust credit cycle.
Figure 9. Countercyclical CBDC Price Rules - Credit Cycle Shocks - Policy Rate Corridor

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

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Figure 8. Countercyclical CBDC Price Rules - Credit Cycle Shocks

- Solid line = fixed rule
- Dashed line = c’yclical rule
- Dotted line = aggressive rule

Credit Cycle Shock - CBDC Countercyclical Price Rule

Solid Line = Baseline ($i_{mp}^m = 0$),  Dashed Line = Intermediate ($i_{mp}^m = 0.4$),  Dashed Line = Aggressive ($i_{mp}^m = 0.8$)
9 Conclusions

• CBDC has significant benefits $\implies$ further research is worthwhile.

1. Steady state efficiency:
   • Lower interest rates, higher seigniorage, more and cheaper liquidity.
   • Increase in steady-state GDP could be as much as 3%.

2. Business cycle stability:
   • Second policy instrument.
   • Improved ability to stabilize inflation and the business cycle.

3. Financial stability:
   • CBDC should reduce many financial stability risks.
   • But if it is not designed well it may introduce others.
   • The “run risk” can be mostly eliminated by sound system design.

• Critical issue: Design of a smooth transition.
Thank you!