MONETARY POLICY TRANSMISSION, CENTRAL BANK DIGITAL CURRENCY, AND BANK MARKET POWER

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Norges Bank – October 2023

MOTIVATION: SOME DEVELOPMENTS

- Central bank digital currency (CBDC)
  - Interest rate on CBDC as monetary policy tool
  - Competition with bank deposits
- Bank market power
  - Increasing deposit market concentration
  - Banks' pricing power

QUESTIONS

- Does bank market power influence the transmission of CBDC rate?
- Does bank market power influence the optimal policy?

OUR CONTRIBUTION

- Macroeconomic impact of CBDC
  - Barrdear and Kumhof (2021); Niepelt (2021); Burlon et al. (2022)
- Bank market power and policy transmission
  - Drechsler et al. (2017); Wang et al. (2022)
- What we do
  - Deposit channel in a macroeconomic (RBC) model
  - Impact of market concentration on fluctuations

PREVIEW OF RESULTS

- Banking concentration amplifies impact of CBDC
  - Increases banks' responsiveness
- Optimal interest policy follows Friedman-rule type logic
  - Optimal CBDC rate not affected by concentration
  - Optimal reserve rate decreases with concentration
- Optimal bank subsidy increases with market concentration

MODEL IN A NUTSHELL

- Households
  - Preference for liquidity through CBDC and deposits (MIU)
  - CBDC and deposits are imperfect substitutes
  - Deposits at different banks are imperfect substitutes
- Banks
  - Issue debt to invest in capital and reserves
  - Deposit issuance is costly
  - Market power due to concentration and imperfect substitutability

MODEL IN A NUTSHELL

- Competitive firms
  - Cobb-Douglas production function
  - Capital and labor as inputs
- Consolidated government
  - Collects taxes and issues CBDC and reserves
  - CBDC and reserves involve resource costs

PARALLELS TO BASELINE RBC MODEL

- Three core equilibrium conditions

$$\text{Euler equation}: \quad c_t^{-\sigma} x_t^{\upsilon} \Omega_t^{c} = \beta \mathbb{E}_t \left[R_{t+1}^{k} c_{t+1}^{-\sigma} x_{t+1}^{\upsilon} \Omega_{t+1}^{c} \right] \tag{1}$$

$$\text{Labor supply}: \quad \frac{c_t^{1-\sigma}}{1-\sigma} \upsilon x_t^{\upsilon-1} \Omega_t^{x} = w_t c_t^{-\sigma} x_t^{\upsilon} \Omega_t^{c} \tag{2}$$

$$\text{Resource constraint}: \quad k_{t+1} = a_t k_t^{\alpha} (1 - x_t)^{1-\alpha} + k_t (1 - \delta) - c_t \Omega_t^{rc} \tag{3}$$

IMPACT OF LIQUIDITY

- Impact of liquidity summarized by

$$\begin{aligned} \Omega_t^c &\rightarrow \text{marginal utility of consumption} \\ \Omega_t^x &\rightarrow \text{marginal utility of leisure} \\ \Omega_t^{rc} &\rightarrow \text{capital accumulation} \end{aligned}$$

- Ω_t^c, Ω_t^x, and Ω_t^{rc} are functions of the *average cost of liquidity* χ_{t+1}^z

COSTS OF LIQUIDITY

- CBDC and reserve spreads are determined by the government

$$\chi^m_{t+1} \equiv 1 - \frac{R^m_{t+1}}{R^f_{t+1}}, \quad \chi^r_{t+1} \equiv 1 - \frac{R^r_{t+1}}{R^f_{t+1}} \tag{4}$$

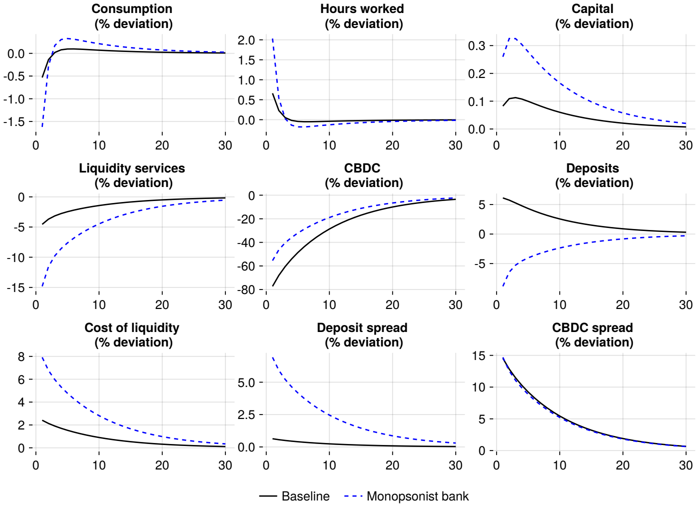
- Household's average cost of liquidity χ^z_{t+1}

$$\chi^z_{t+1} = f(\chi^m_{t+1}, \chi^n_{t+1}) \tag{5}$$

- Deposit spread is determined by the banking sector

$$\chi^n_{t+1} = \underbrace{MU(\chi^m_{t+1}; N)}_{\text{mark-up}} + \underbrace{MC(\chi^r_{t+1})}_{\text{marginal cost}} \tag{6}$$

RESPONSES TO 25 BP DECREASE IN CBDC RATE

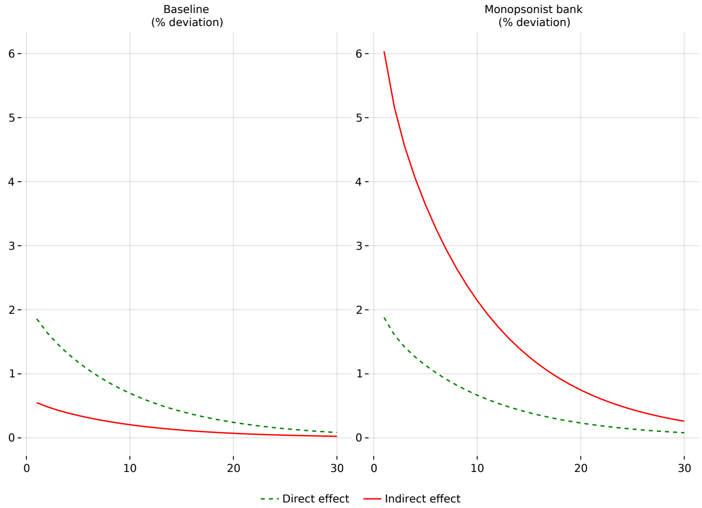


DECOMPOSITION

$$
\begin{tikzcd}
\text{Shock to CBDC rate} \arrow[d] & \\
\text{Cost of CBDC} \arrow[r] \arrow[d, "direct"] & \text{Cost of deposits} \arrow[dl, "indirect"] \\
\text{Average cost of liquidity} &
\end{tikzcd}
$$

$$\frac{\partial \chi^{z}_{t+1}}{\partial \chi^{m}_{t+1}} = \underbrace{\left((1-\gamma)\frac{\chi^{z}_{t+1}}{\chi^{m}_{t+1}}\right)^{\frac{1}{\epsilon}}}_{\text{direct effect}} + \underbrace{\left(\gamma\frac{\chi^{z}_{t+1}}{\chi^{n}_{t+1}}\right)^{\frac{1}{\epsilon}} \overbrace{\frac{\partial \chi^{n}_{t+1}}{\partial \chi^{m}_{t+1}}}^{\text{deposit channel}}}_{\text{indirect effect}} \tag{7}$$

DECOMPOSITION



IMPACT OF CBDC ON BANKS: BANK MARKET POWER MATTERS

- Competitve banking sector implies $\frac{\partial \chi^n_{t+1}}{\partial \chi^m_{t+1}} = 0$

$$\underbrace{\chi^n_{t+1} = MC}_{\text{competitve}} \quad \text{or} \quad \underbrace{\chi^n_{t+1} = \frac{MC}{1-\eta}}_{\text{monopolistically competitve}} \tag{8}$$

- In general, χ^n_{t+1} depends on a weighted average of $1/\psi$ and $1/\epsilon$

$$\frac{1 - s(\chi^m_{t+1})}{\psi} + \frac{s(\chi^m_{t+1})}{\epsilon}, \quad s(\chi^m_{t+1}) \in [0, 1] \tag{9}$$

IMPACT OF CBDC ON BANKS: BANK MARKET POWER MATTERS

- Increase in CBDC spread implies

$$\frac{\partial s(\chi^m_{t+1})}{\partial \chi^m_{t+1}} < 0 \tag{10}$$

- Market concentration, $1/N$, amplifies effect through elasticity of demand for deposits

$$-\frac{1}{N}\left(\frac{1 - s(\chi^m_{t+1})}{\psi} + \frac{s(\chi^m_{t+1})}{\epsilon}\right) - \left(1 - \frac{1}{N}\right)\frac{1}{\eta} < 0 \tag{11}$$

OPTIMAL POLICY RULES

- Government can implement first-best allocation
- First-best allocation = social planner solution
- First-order approach to find $\{R^m_{t+1}, R^r_{t+1}, \theta_t\}_{t\geq 0}$

OPTIMAL INTEREST RATE RULES

- Private opportunity cost = societal cost

$$\text{CBDC:} \quad \chi^{m*}_{t+1} = \mu, \quad R^{m*}_{t+1} = R^{f}_{t+1}(1-\mu) \tag{12}$$

$$\text{Reserves:} \quad \chi^{r*}_{t+1} = \frac{1}{N}\rho, \quad R^{r*}_{t+1} = R^{f}_{t+1}\left(1-\frac{1}{N}\rho\right) \tag{13}$$

- To correct for bank market power

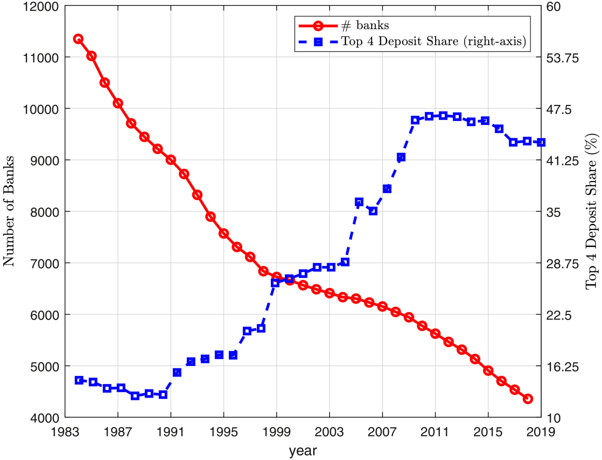
$$\theta_t^* = \chi_{t+1}^{n*} \left(\frac{1}{N} \left(\frac{1 - s(\chi_{t+1}^{m*})}{\psi} + \frac{s(\chi_{t+1}^{m*})}{\epsilon} \right) + \left(1 - \frac{1}{N}\right) \frac{1}{\eta} \right)^{-1} \tag{14}$$

CONCLUSION

- Banking concentration amplifies impact of CBDC
  - Increases banks' responsiveness
- Optimal interest policy follows Friedman-rule type logic
  - Optimal CBDC rate not affected by concentration
  - Optimal reserve rate decreases with concentration
- Optimal bank subsidy increases with market concentration

APPENDIX: FIGURES

U.S. bank concentration (Corbae and D'Erasmo 2020)



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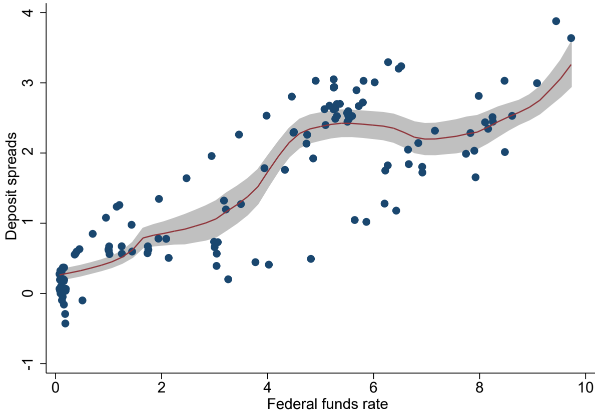
APPENDIX: FIGURES

U.S. deposit spread (Wang et al. 2022)



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APPENDIX: HOUSEHOLD PREFERENCES

- Household values consumption c, leisure x and liquidity services z

$$u(c_t, z_{t+1}, x_t) = \frac{\left((1-v)c_t^{1-\psi} + v z_{t+1}^{1-\psi}\right)^{\frac{1-\sigma}{1-\psi}}}{1-\sigma} x_t^{\upsilon} \tag{15}$$

- Liquidity composes of CBDC m and bank deposits n

$$z_{t+1} = \left((1-\gamma)m_{t+1}^{1-\epsilon} + \gamma n_{t+1}^{1-\epsilon}\right)^{\frac{1}{1-\epsilon}} \tag{16}$$

- Bank deposits are a composite good issued by a set of N banks

$$n_{t+1} = \left(\frac{1}{N}\sum_{i=1}^{N}\left(n_{t+1}^{i}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}} \tag{17}$$

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APPENDIX: HOUSEHOLD PROBLEM

- Household chooses $\{c_t, x_t, k^h_{t+1}, m_{t+1}, n^i_{t+1}\}_{t=0}^{\infty}$ to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, z_{t+1}, x_t), \tag{18}$$

subject to budget constraint

$$\begin{aligned} c_t + k^h_{t+1} + m_{t+1} + \sum_{i=1}^{N} \frac{n^i_{t+1}}{N} + \tau_t = w_t(1 - x_t) + \pi_t \\ + k^h_t R^k_t + m_t R^m_t + \sum_{i=1}^{N} \frac{n^i_t R^{n,i}_t}{N} \end{aligned} \tag{19}$$

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APPENDIX: BANK SETUP

- Bank i has balance sheet

$$r^i_{t+1} + k^i_{t+1} = n^i_{t+1} \tag{20}$$

- Bank's unit cost of issuing deposits

$$\nu^i_t = \phi \left(\frac{r^i_{t+1}}{n^i_{t+1}} \right)^{1-\varphi} \tag{21}$$

back

APPENDIX: BANK SETUP

- Bank i faces a demand schedule for its deposits

$$n^i_{t+1} = n_{t+1} \left(\frac{\chi^{n,i}_{t+1}}{\chi^n_{t+1}} \right)^{-\frac{1}{\eta}} \tag{22}$$

where

$$\chi^{n,i}_{t+1} \equiv 1 - \frac{R^{n,i}_{t+1}}{R^f_{t+1}}, \quad \chi^n_{t+1} \equiv \left(\frac{1}{N} \sum_{i=1}^{N} \left(\chi^{n,i}_{t+1} \right)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}} \tag{23}$$

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APPENDIX: BANK PROBLEM

- Bank i chooses r^i_{t+1} and $R^{n,i}_{t+1}$ to maximize

$$-n^i_{t+1}\nu^i_t + \mathbb{E}_t\left[\Lambda_{t+1}\left(k^i_{t+1}R^k_{t+1} + r^i_{t+1}R^r_{t+1} - n^i_{t+1}R^{n,i}_{t+1}\right)\right], \tag{24}$$

where Λ_{t+1} is the household's stochastic discount factor

$$\Lambda_{t+1} = \beta\frac{u_{c,t+1}}{u_{c,t}} \tag{25}$$

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APPENDIX: FIRM PROBLEM

- Representative firm solves a profit maximization problem

$$\max_{k_t, l_t} \quad a_t k_t^{\alpha} l_t^{1-\alpha} - k_t \left(R_t^k - 1 + \delta \right) - w_t l_t \tag{26}$$

back

- Government collects taxes, invests in capital k^g, and issues CBDC and reserves

$$k^g_{t+1} - m_{t+1}(1-\mu) - \sum_{i=1}^{N} \frac{r^i_{t+1}(1-\rho)}{N} = k^g_t R^k_t + \tau_t - m_t R^m_t - \sum_{i=1}^{N} \frac{r^i_t R^r_t}{N} \tag{27}$$

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APPENDIX: SELECTED EQUILIBRIUM CONDITIONS

- Impact of liquidity

$$\Omega_t^c = (1-v)^{\frac{1-\sigma}{1-\psi}} \left(1 + \left(\frac{v}{1-v}\right)^{\frac{1}{\psi}} \left(\chi_{t+1}^z\right)^{1-\frac{1}{\psi}}\right)^{\frac{\psi-\sigma}{1-\psi}} \tag{28}$$

$$\Omega_t^x = (1-v)^{\frac{1-\sigma}{1-\psi}} \left(1 + \left(\frac{v}{1-v}\right)^{\frac{1}{\psi}} \left(\chi_{t+1}^z\right)^{1-\frac{1}{\psi}}\right)^{\frac{1-\sigma}{1-\psi}} \tag{29}$$

$$\Omega_t^{rc} = 1 + \left(\frac{v}{1-v}\frac{1}{\chi_{t+1}^z}\right)^{\frac{1}{\psi}} \left(\left((1-\gamma)\frac{\chi_{t+1}^z}{\chi_{t+1}^m}\right)^{\frac{1}{\epsilon}} \mu + \left(\gamma\frac{\chi_{t+1}^z}{\chi_{t+1}^n}\right)^{\frac{1}{\epsilon}} \left(\phi\zeta_{t+1}^{1-\varphi} + \zeta_{t+1}\rho\right)\right) \tag{30}$$

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APPENDIX: SELECTED EQUILIBRIUM CONDITIONS

- Household's average cost of liquidity

$$\chi_{t+1}^{z} = \frac{\chi_{t+1}^{m}\chi_{t+1}^{n}}{\left((1-\gamma)^{\frac{1}{\epsilon}}\left(\chi_{t+1}^{n}\right)^{\frac{1-\epsilon}{\epsilon}} + \gamma^{\frac{1}{\epsilon}}\left(\chi_{t+1}^{m}\right)^{\frac{1-\epsilon}{\epsilon}}\right)^{\frac{\epsilon}{1-\epsilon}}} \tag{31}$$

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APPENDIX: SELECTED EQUILIBRIUM CONDITIONS

- Bank pricing equation

$$\chi_{t+1}^{n} + \chi_{t+1}^{n} \left(\frac{1}{N} \left(-\frac{1 - s_t}{\psi} - \frac{s_t}{\epsilon} \right) - \left(1 - \frac{1}{N} \right) \frac{1}{\eta} \right)^{-1} = \varphi \phi \zeta_{t+1}^{1-\varphi}, \tag{32}$$

where

$$s_t = (1 - \gamma)^{\frac{1}{\epsilon}} \left(\frac{\chi_{t+1}^{z}}{\chi_{t+1}^{m}} \right)^{\frac{1-\epsilon}{\epsilon}}, \quad \zeta_{t+1} = \left(\frac{\chi_{t+1}^{r}}{\phi(\varphi - 1)} \right)^{-\frac{1}{\varphi}} \tag{33}$$

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APPENDIX: PREDEFINED PARAMETERS

Predefined parameters

	Value	Source/motivation
β	$(1.03)^{-1/4}$	Steady state annual risk-free rate 3%
γ	0.5	Assumption
ϵ	1/6	Bacchetta and Perazzi (2021)
η	1/6	Assumption
σ	0.5	Niepelt (2021)
υ	0.85	Steady state labor supply $\approx 1/3$
ψ	0.6	$\psi > \sigma$
α	1/3	Standard value
δ	0.025	Standard value
ρ	0.01	Niepelt (2021)

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Calibrated parameters

	Baseline $\frac{1}{N} = 1/3$	Alternative $\frac{1}{N} = 1.0$
v	0.02368	0.02368
ϕ	0.00526	0.00267
φ	1.24806	1.39707
μ	0.00992	0.00714

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APPENDIX: SOCIAL PLANNER PROBLEM

- Social planner maximizes

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t, z_{t+1}, x_t) \tag{34}$$

$$\text{s.t.} \quad k_{t+1} = a_t k_t^{\alpha}(1 - x_t)^{1-\alpha} + k_t(1 - \delta) - \ldots \tag{35}$$

$$\ldots c_t - m_{t+1}\mu - \sum_{i=1}^{N} \frac{n_{t+1}^i \nu_t^i}{N} - \sum_{i=1}^{N} \frac{r_{t+1}^i \rho}{N}$$

by choosing $\{c_t, x_t, k_{t+1}, m_{t+1}, n_{t+1}^i, r_{t+1}^i\}_{t=0}^{\infty}$

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