Making Money: Commercial Banks, Liquidity Transformation and the Payments System

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Motivation

- In the normal course of business, banks
  1. Accept Deposits from Households/Allow agents to withdraw cash
  2. Make loans (typically in the form of demand deposits)
  3. Borrow and lend in the interbank market (trade reserves)
  4. Transfer funds to other banks to settle consumer payments.
     - CHIPS (one of the US systems) settles on average USD 1.5 trillion a day. (US GDP $\approx$ 17 trillion)

- These activities drive the economy.
  1. How are these different forms of bank liquidity related?
  2. How does a banks' place in the payments system affect their lending function?
  3. How will changes in payments systems "FinTech" affect these different forms of bank liquidity?

What we do

- Construct a model of a banking economy with strategic banks who
  1. Accept deposits (in the form of cash)
  2. Make Loans (in the form of digital claims)
  3. Participate in the interbank market (trade reserves)
  4. Participate in the payments system
- Simple comparative statics on the effects of
  1. Changes in demand for cash,
  2. Greater economic integration,
  3. Cost changes in the payments system

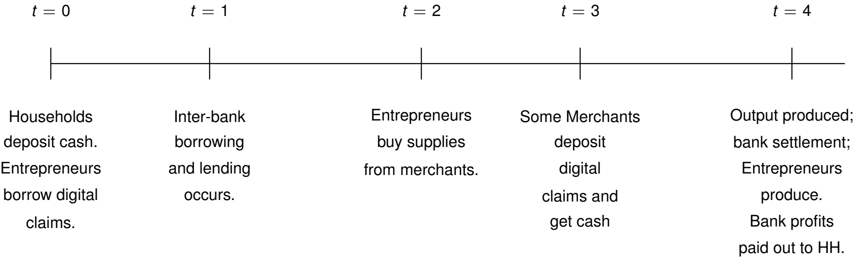
Overview of Results

- Liquidity does not flow smoothly through these markets. We find:
  1. A decrease in the consumer demand for money, increases productive efficiency, and can increase or decrease the interbank rate.
  2. An increase in economic integration, weakly increases the interbank rate but decreases productive efficiency.
  3. A decrease in the cost of settling payments, increases the interbank rate and increases productive efficiency.

Brief Overview of the Model

- $N + 1$ banking "zones" or systems.
- Each zone features a continuum of entrepreneurs and merchants
- Banks participate in an interbank market in which reserves are traded
- Banks facilitate payment.

Sequence of Events within each of the $N + 1$ banking zones



Entrepreneurs

- Each zone i has a continuum of entrepreneurs.
- Each entrepreneur has a production technology that uses real inputs k and produces:
  $\mu_i f(k)$
- μ_i defines "productivity" of the zone.
  - Assume productivities ordered and $\mu_{i+1} = \mu_i + \delta$,
  - Size of δ determines if zones are similar or not.

Buying and Spending

- Entrepreneurs go to the local bank and get a loan (digital claim).
- Entrepreneurs use this to buy inputs from merchants.
- Each entrepreneur is randomly assigned a location to buy inputs.
  - With probability $(1 - \alpha)$ they buy inputs at home,
  - With probability α they buy inputs in another zone.
  - Spend $\frac{\alpha}{N}$ in each of the other N zones.
  - So $\alpha = 0 \implies$ autarky.
- Assume a flat supply curve for inputs in each zone.
  - 1 unit of digital claims buys 1 unit of real inputs.

Merchants

- The entrepreneurs give their digital claims to the relevant merchant.
- He deposits these into his local bank. (This may or may not be the entrepreneur's bank.)
- With probability λ, he wants to cash in these claims immediately for cash,
- Else he waits until the end of the game.

- Entrepreneur's need to shop for inputs $+$ merchants' need for cash creates the need for a payments system.

Central Bank Reserves and Bank Transfers

- There are two types of interbank transfers:
  1. Interim: Banks can trade reserves in the interbank market at r_b
     - They will lend if they have more deposits than investment opportunities.
     - They will borrow if they need extra cash to cover liquidity demand.
     - Price set by market clearing.
     - This is the opportunity cost of real lending.
  2. At the end of the game: Banks transfer reserves to settle net digital claims.
     - If banks have issued more claims than other banks, they will be net payers.
     - If banks have issued fewer claims than other banks, they will be reimbursed.
     - The cost of being a net payer is τ per unit (collateral cost).

Equilibrium

Definition

An equilibrium in the model consists of a vector of digital claims $(d_1^*, \cdots, d_{N+1}^*)$ and an interest rate in the inter-bank market, r_b^*, such that:

(i) For each bank i, d_i^* maximizes its payoff π_i, given r_b^* and the digital claims issued by all other banks, $(d_1^*, \cdots, d_{i-1}^*, d_{i+1}^*, \cdots, d_{N+1}^*)$.

(ii) The inter-bank loan market clears; that is, $\sum_{i=1}^{N+1} d_i^* = \frac{(N+1)D}{\lambda}$.

- Nash equilibrium in lending $+$ inter-bank market clears.
  - Note: Bank acts as price-taker in inter-bank market.

Frictions in Investment

1. Banks face a deadweight cost to transfer funds through the payments system
   - A strictly positive cost acts like a tax on the most productive banks, and reduces their investment.
2. Coordination Friction: banks mimic other banks to avoid the cost of transferring payments.
   - McAndrews and Potter (2002), found evidence of gaming in payments after the 2001 bombing.
3. Merchant's intermediate liquidity generates a demand for cash.
   - The interbank rate is a friction because the most productive banks have to share some of the surplus from investment.

Banks Objective Function

Bank's best Response

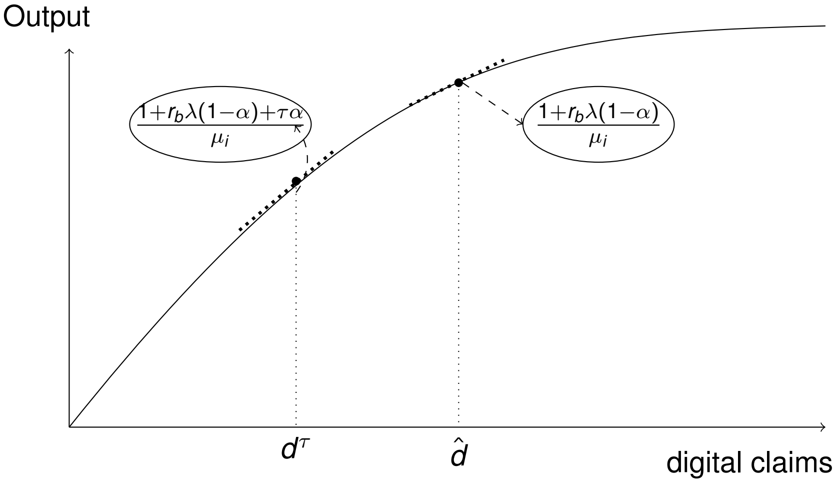


Figure: **At d^τ, the MPK includes the transfer cost, τ. This corresponds to a lower level of claims and inputs.**

Bank's best reponse

Lemma

Suppose all other banks issue aggregate digital claims $\sum_{i \neq j} d_j$. *Then the best response of bank i is*

$$d_i^* = \begin{cases} d_i^\tau & \text{if } d_i^\tau \geq \frac{1}{N}\sum_{j\neq i} d_j \\ \frac{1}{N}\sum_{j\neq i} d_j & \text{if } \frac{1}{N}\sum_{j\neq i} d_j \in (d_i^\tau, \hat{d}_i) \\ \hat{d}_i & \text{if } \hat{d}_i < \frac{1}{N}\sum_{j\neq i} d_j \end{cases} \tag{1}$$

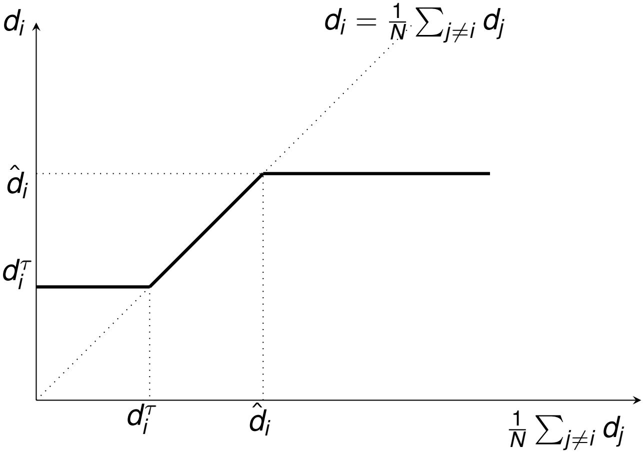


Figure: **Best Response of bank *i***

Symmetric Equilibrium

Proposition

Suppose that the difference in productivities between banks is sufficiently symmetric or that $\delta \leq \widetilde{\delta}$, and $\tau > 0$. Then, in equilibrium:

i) *Each bank issues the same quantity of digital claims, with $d_1^* = d_2^* = \cdots = d_{N+1}^* = \frac{D}{\lambda}$.*

ii) *The gross payment flows in the economy are $\alpha(N+1)\frac{D}{\lambda}$, while the net payment flows between any two banks are zero.*

iii) *For each $r \in \left[\frac{(\underline{\mu}+\delta N)f'(\frac{D}{\lambda})-(1+\tau\alpha)}{\lambda(1-\alpha)}, \frac{\underline{\mu}f'(\frac{D}{\lambda})-1}{\lambda(1-\alpha)}\right]$, there is an equilibrium in which the interest rate in the inter-bank market is given by $r_b^* = r$.*

Equilibrium Properties

- When productivities are sufficiently similar across zones, we have a symmetric equilibrium.
  - Each bank lends $\frac{D}{\lambda} > D$. Total investment $= (N+1)\frac{D}{\lambda}$.
  - This is the autarkic outcome.
- Inter-bank rate r_b clears the market in reserves.
  - Due to coordination friction, multiple equilibria with different inter-bank rates exist.
  - Prices are "sticky."
- No net bank transfers in inter-bank market or at final settlement.

Equilibrium Properties, contd.

- The symmetric equilibrium is **not efficient** in terms of production.
- We can have $\delta > 0$, so productivities are heterogeneous, sufficiently close.
  - Efficiency implies more productive regions should produce more.
- Transfer cost τ creates a friction that impedes efficiency.
- The payment function of banks affects their lending function.

Asymmetric Productivities

Proposition

Suppose that $\delta > \underline{\delta}$ and $\tau > 0$. Then, in equilibrium

i) *There exists some n^* such that, in equilibrium, banks 1 through $n^* - 1$ issue $\hat{d}_i(r_b^*)$ digital claims, banks $n^* + 1$ through $N + 1$ issue $d_i^\tau(r_b^*)$ digital claims, and $d_{n^*}^* = \frac{(N+1)D}{\lambda} - \sum_{i \neq n^*} d_i^*$.*

ii) *There are net ex post payment flows from more productive banks to less productive banks and more productive banks borrow reserves from less productive banks in the interim market.*

iii) *There is a unique market-clearing interest rate r_b^*.*

Equilibrium Properties

- Productive banks invest more than less productive banks.
  - Resources to flow from less efficient zones to more efficient ones.

- However, this equilibrium also does not attain efficiency:
  - $r_b > 0$ means that less productive banks extract some of the surplus.
  - $\tau > 0$ implies more productive banks incur transfer costs at date 4.

- Both factors reduce the incentive of more productive banks to invest.

- Aggregate investment remains $(N+1)\frac{D}{\lambda}$.

Changes in the Payments system

- Cryptocurrencies $\Longrightarrow$ decrease in the demand for cash.
  - λ decreases
- New payments technologies $\Longrightarrow$ easier to purchase from other banking systems.
  - α increases
- Permissioned ledgers $\Longrightarrow$ reduce collateral
  - Decrease in τ.

Cryptocurrencies: Change in the demand for cash

Proposition

Suppose that there is a small decrease in the demand for intermediate liquidity by merchants, λ. Then, each bank i increases its issuance of digital claims d_i. Further,

(i) *If $\delta > \underline{\delta}$, so that zones are sufficiently heterogeneous in productivity, as in Proposition 2, then the unique market-clearing interbank rate may rise or fall; that is, r_{bn}^* can be either greater or smaller than r_{bo}^*.*

(ii) *If $\delta \leq \hat{\delta}$, so that zones are approximately homogeneous in productivity, as in Proposition 1, then the range of interbank interest rates supported in equilibrium can increase or decrease.*

Intuition: Why decrease in λ can increases interbank rate

- Suppose there is a **decrease** in the demand for cash.
- Ceteris paribus, banks have to borrow less in the inter-bank market.
- All banks increase lending: $(N+1)\frac{D}{\lambda}\uparrow$.
  - However, with heterogeneous banks, this effect is greater on more productive banks.
- In equilibrium, demand for funds in inter-bank market can **increase**.
  - Leads to an increase in inter-bank rate.

New Payments Technologies

Proposition

Suppose that there is a small increase in α, the proportion of inputs purchased in foreign zones. Then,

(i) *If $\delta < \hat{\delta}$, so that zones are approximately homogeneous in productivity, each bank i continues to issue the same number of digital claims as before, $d_i = \frac{D}{\lambda}$. The range of feasible inter-bank interest rates shifts to the right.*

(ii) *If $\delta > \underline{\delta}$, so that zones are sufficiently heterogeneous in productivity, the effect on the inter-bank interest rate r_b^* is ambiguous. The aggregate number of digital claims issued in the economy remains the same. However, (a) a less productive bank i increases its issuance (b) a more productive bank j decreases its issuance.*

Intuition; Why economic integration weakly increases interbank rate

- If the payment system becomes more integrated, banks "lose control" over their liquidity management because most of the claims deposited by their local merchants and the funds through the payment system are determined by other banks.
- This increases their demand for reserves through the interbank market which weakly increases the interbank rate.
  - With homogeneous zones: the inter-bank rate weakly increases, but it has no real effect.
  - With heterogeneous zones, less productive zones **increase** investment, and more productive zones **decrease** investment.
    - Effect works through a change in the inter-bank interest rate r_b.
    - Transfer cost τ bites for more productive zones.
    - Total investment remains the same, so this is a redistribution to less efficient zones.

Change in the cost of netting payments

Proposition

Suppose that the ex post settlement cost τ decreases by a small amount. Then,

(i) *If $\delta < \hat{\delta}$, so that zones are approximately homogeneous in productivity as in Proposition 1, each bank i continues to issue the same quantity of digital claims as before, $d_i^* = \frac{D}{\lambda}$. Further, $\frac{\partial \bar{r}}{\partial \tau} = 0$ and $\frac{\partial r}{\partial \tau} > 0$, so the range of feasible interbank interest rates decreases.*

(ii) *If $\delta > \underline{\delta}$, so that zones are sufficiently heterogeneous in productivity as in Proposition 2, $r_b^{n^*} < r_b^{o*}$, then (a) a less productive bank i, that was issuing claims $\hat{d}_i^*$ in the old equilibrium, decreases its issuance (b) a more productive bank j, that was issuing claims $d_j^{\tau*}$, increases its issuance. The interbank interest rate, r_b^*, increases.*

Intuition: Why decreasing τ increases interbank rate

- If the transfer cost decreases, then this increases the profits of the most productive banks, because they are most likely to issue the most digital claims and be net payers (and thus exposed to the cost).
- This increases their incentive to issue claims which increases the demand in the interbank market and leads to a higher rate.
- The higher rate makes issuing claims marginally less attractive for less productive banks compared to lending out deposits in the interbank market.

Conclusion

- Focus on the liquidity management problem faced by strategic banks.
- Consider how the lending function of banks is affected by the payments function of banks.

- Potential technological changes to the payments system will affect the interbank rate (here the opportunity cost of real investment) and bank loan creation.
- Important to consider all these markets together.

Inter-bank Market at Date 1

Banks Objective Function

- Households in each zone have cash D, which is deposited into the local bank.
- Merchant in zone i receives digital claims equal to

$$S_i = (1-\alpha)d_i + \frac{\alpha}{N}\sum_{j\neq i} d_j.$$

- A fraction λ cash in their claims at date 3. Must receive cash (c) or claim backed by reserves (z) in exchange.
- Denote $z_i = \lambda S_i - D$.
  - If $z_i > 0$ (< 0), bank i borrows (lends) on inter-bank market.
  - Interest rate clears the inter-bank market: $\sum_{i=1}^{N} z_i = 0$.

Bank's Objective Function

- Bank *i*'s objective function is

$$\pi_i = (\mu_i f(d_i) - d_i) - \tau\alpha\Big(d_1 - \frac{1}{N}\sum_{j\neq i} d_j\Big)^+ - r_b z_i \quad (2)$$

$$\text{s.t. } z_i + D \geq \lambda\Big[(1-\alpha)d_i + \frac{\alpha}{N}\sum_{j\neq i} d_j\Big]. \quad (3)$$

- Where

$(\mu_i f(d_i) - d_i)$	Real Production
$\tau\alpha\Big(d_1 - \frac{1}{N}\sum_{j\neq i} d_j\Big)^+$	Net Payments Cost
$r_b z_i$	Interest in interbank market