IO approach to banking

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Introduction

- Up to the 60's banks (FI) were mainly absent from economic analysis with some exceptions
  - Macro models of money supply and monetary transmission
  - Some inventory and portfolio selection models in finance
    - To include some regulatory constraints or limitations
  - In general very ad-hoc approach even in these setups
- First IO approach to introduce bank is the Klein-Monti approach
  - Late 60's

Introduction - Klein Monti Approach

- Klein-Monti approach
- Banks are multi-product firms
  - Exclusive providers of both loans and deposits
  - Can have other assets and liabilities
    - Cash, interbank loans, interbank deposits reserves, equity etc.
- Operate under certain specific structures of
  - Operational costs
  - Legal constraints

Introduction - Klein Monti Approach

- These type of model focus on
  - Determination of equilibrium prices (interest rates) and quantities under a given market structure
  - Determination of equilibrium market structure under different technological or regulatory environments
    - entry barriers (natural or legal)
    - scale, scope or network economies; switching cost
    - interest rate ceilings, capital regulation etc.
- In principal these models abstract from
  - Providing a rationale for financial intermediation
  - The intertemperal dimension of banking activities
  - Informational assymetries and risk

Introduction - Klein Monti Approach

- Basicl model assumptions
  - deposits and loans are goods
    - Some agent demands them and some agent supplies them
  - Both goods are homogeneous
    - Some minimal differentiation sometimes (e.g. location)
  - banks are profit maximizers
  - banks are risk free
- The basic models can be useful
  - as building blocks of richer models
  - to give intuitions about issues orthogonal to what is left aside

Introduction - Klein Monti Approach

- Some recent models are incorporating some novel issues
  - heterogeneity in depositors and borrowers
  - (endogenous) risk
  - details regarding loan and deposit contracts
  - banks' monitoring and risk management
  - risk taking incentives
  - bank capital
  - prudential issues
  - etc.

The basic perfect competition model - Ingredients

- Static model, no uncertainty, many profit maximizing banks
- Bank take interest rates of their products as given
  - Loans L yield interest rate r_l: Loan demand $L(r_l)$, $L' < 0$
  - Deposits D yield interest rate r_d: Deposit demand $D(r_d)$, $D' > 0$
- Interbank market where banks can borrow or lend at rate r
  - r (partial equilibrium) Net Interbank borrowing position I
- Reserve regulation
  - Banks have to hold fraction ϕ of deposits as central bank reserves R
- No capital, no other (intermediation) costs

Solving the bank's problem

- Bank balance sheet imposes

$$R + L = D + I$$

- For any remuneration lower than r it is stricly optimal for banks not to keep excess reserves

$$\begin{aligned} R &= \phi D \\ I &= L - (1-\phi)D \end{aligned}$$

- Bank profits

$$\begin{aligned} \pi &= r_l L - r_d D - rI \rightarrow \pi = r_l L - r_d D - r\left[L - (1-\phi)D\right] \\ \pi &= (r_l - r)L + ((1-\phi)r - r_d)D \end{aligned}$$

- Two separate functions→Loan granting and Deposit granting

Solving the bank's problem

- Perfectly competitive banks choose quantities

$$\max_{L,D} \pi = (r_l - r)L + ((1-\phi)r - r_d)D$$

$$L = \begin{cases} \infty & \text{if } r_l > r \\ [0,\infty) & \text{if } r_l = r \\ 0 & \text{if } r_l < r \end{cases} \text{ and } D = \begin{cases} \infty & \text{if } r_d < (1-\phi)r \\ [0,\infty) & \text{if } r_d = (1-\phi)r \\ 0 & \text{if } r_d > (1-\phi)r \end{cases}$$

- In equilibrium we must have

$$r_l^* = r \text{ and } r_d^* = (1-\phi)r$$

- Equlibrium quantities are found recursively from demand side

$$L^* = L(r_l^*), D^* = D(r_d^*)$$

Relevant take-aways

- Separability of loan and deposit decisions
  - If a well functioning interbank market exists
  - We can analyze each side in isolation
- Recursivity of equilibrium quantities
  - Demand side determines equilibrium quantities
- Since 2012 in the eurosystem banks have to keep 1% of their liabilities as reserves
  - Remuneration is at a rate fixed by the ECB

Introducing intermediation costs

- Assume costs are given by an increasing and convex fucntion $C(L, D)$

$$\pi = (r_l - r)L + ((1-\phi)r - r_d)D - C(L, D)$$

- First order conditions (FOCs) imply

$$L = \left. \begin{array}{l} \frac{\partial \pi}{\partial L} = 0 \rightarrow (r_l - r) = \frac{\partial C(L,D)}{\partial L} \\ \frac{\partial \pi}{\partial D} = 0 \rightarrow (1-\phi)r - r_d = \frac{\partial C(L,D)}{\partial D} \end{array} \right\} \rightarrow L^s(r_l, r_d), D^s(r_l, r_d)$$

- Hence
    - Intermediation margins are positive
    - If $\frac{\partial^2 C(L,D)}{\partial D \partial L} \neq 0$ problem is no longer "separable"

Intermediation costs

- In the particular case with $C(L, D) = c_L L + c_D D$:

$$\begin{aligned} r_l^* &= r + c_L \\ r_d^* &= (1-\phi)r - c_D \end{aligned}$$

- Hence
  - changes in r still produce "parallel" shifts in supply schedules
  - quantities determined (recursively) as L(r*l), D(r*d)
- Brief remark
  - There is long tradition of empirical work trying to determine the importance of scale, scope and network economies in banking. Traditional banking activities may not carry very large economies of scale (if information friction is not taken into account). However, there seemto be more important scale economies in wholesale and investment banking]

Introducing bank capital (equilty/own funds/capital)

- Assume a regulatory requirement of the type $K \geq kL$
  - K equity requirement
  - k capital requirement
  - ρ opportunity cost of capital $(\rho \geq r)$
- New balance sheet constraint

$$L + R = D + I + K$$

- New bank profits

$$\pi = (r_l - r)L + ((1 - \phi)r - r_d)D - (\rho - r)K$$

Introducing bank capital (equilty/own funds/capital)

- New bank profits

$$\pi = (r_l - r)L + ((1-\phi)r - r_d)D - (\rho - r)K$$

- Choice of K

$$K = \begin{cases} \text{any } K \quad \text{if } \rho = r \rightarrow r_d^* = (1-\phi)r \text{ and } r_l^* = r \\ K = kL \text{ if } \rho > r \rightarrow r_d^* = (1-\phi)r \text{ and } r_l^* = r + k(\rho - r) \end{cases}$$

- Basel agreements on capital requirements (I, II and III) make k a function of composition and risk of bank assets
  - How exactly depends on each agreement

The monopolistic bank - Klein Monti setup

- Assume now 1 bank monopolizes deposit and loan markets

$$\pi = (r_l - r)L + ((1-\phi)r - r_d)D$$

- With well behave loand and deposit demand functions $L' < 0$, $D' > 0$
- FOCs

$$\begin{aligned} \frac{\partial \pi}{\partial r_l} &= (r_l - r)L' + L = 0 \\ \frac{\partial \pi}{\partial r_d} &= ((1-\phi)r - r_d)D' - D = 0 \end{aligned}$$

- FOCs

$$\frac{\partial \pi}{\partial r_l} = (r_l - r)L' + L = 0 \rightarrow \frac{(r_l - r)}{r_l} = \frac{1}{\varepsilon_L}, (\varepsilon_L = -\frac{r_l L'}{L})$$
$$\frac{\partial \pi}{\partial r_d} = ((1-\phi)r - r_d)D' - D = 0$$
$$\rightarrow \frac{((1-\phi)r - r_d)}{r_d} = \frac{1}{\varepsilon_D}, (\varepsilon_D = -\frac{r_d D'}{D})$$

- Lerner indexes can be understood as inverse elasticities
- If infinitely elastic demand$\varepsilon_L \rightarrow \infty, \varepsilon_D \rightarrow \infty$
- Monopolist=perfect competition

Imperfect competition models

- There are multiple imperfect competiton models
- Cournot model
  - Homogeneous goods, competition in quantities
- Salop model/Hotelling model
  - Heterogeneous goods, competition in prices
- Bertrand
  - Homogeneous goods, competition in prices

Imperfect competition models - Cournot

- Consider an oligopoly with n symmetric banks
  - Subindex i determines bank i
- Assume the following inverse demand functions
  - $L(r_l), L' < 0 \rightarrow r_l(L), r_l' < 0$
  - $D(r_d), D' > 0 \rightarrow r_d(D), r_d' > 0$
  - $L = \sum l_i, D = \sum d_i$
- Objective function of bank i (profits)

$$\pi_i = \left(r_l \left(l_i + \sum_{j \neq i} l_j \right) - r \right) l_i + \left((1 - \phi) r - r_d \left(d_i + \sum_{j \neq i} d_j \right) \right) d_i$$

Imperfect competition models - Cournot

- Each bank decides its own supply l_i, d_i
- FOCs

$$\begin{aligned} \frac{\partial \pi_i}{\partial L_i} &= 0 \rightarrow (r_l - r) + r_L' l_i = 0 \\ &= > (r_l - r)n + r_L' L = 0 \rightarrow \frac{(r_l - r)}{r_l} = \frac{1}{n\varepsilon_L} \end{aligned}$$

$$\begin{aligned} \frac{\partial \pi_i}{\partial D_i} &= 0 \rightarrow ((1-\phi)r - r_d) - r_d' d_i = 0 \\ &= > ((1-\phi)r - r_d) - r_d' D = 0 \rightarrow \frac{((1-\phi)r - r_d)}{r_d} = \frac{1}{n\varepsilon_D} \end{aligned}$$

- Note that if $n \rightarrow \infty => r_l \rightarrow r, r_d \rightarrow (1-\phi)r$

Cournot some considerations

- Limit cases are equivalent to monopoly $(n = 1)$ and perfect competition $(n \to \infty)$.
  - Small elasticities or small n widen the margins.
- In the constant-elasticity case, intermediation margins are increasing in the interbank rate r:

$$
\begin{aligned}
r_l^* &= \frac{r}{1 - \frac{1}{n\varepsilon_L}} \rightarrow \frac{dr_l^*}{dr} > 1 \\
r_d^* &= \frac{(1-\phi)r}{1 + \frac{1}{n\varepsilon_D}} \rightarrow \frac{dr_d^*}{dr} < 1 - \phi
\end{aligned}
$$

- Empirically the effects could be different specially in ST
  - Contractual inertia

Cournot some considerations

- Price setting occurs at market level subsequently to banks' quantity decisions
- In principle, explicit competition in prices seems a much closer description of reality...
- But Cournot competition could be a reduced form of a two-stage competition situation in which banks:
  - First decide on capacity (number of branches, employees, capital)
  - Second, decide on interest rates (not being able to change capacity at this stage)
  - Kreps-Scheinkman (1983, BellJ): Cournot outcomes

Bertrand competition

- Price competition is more "plausible" than quantity competition, but the plain Bertrand model has serious limitations:
  - 1. Unrealistic predictions: By standard price-cutting arguments, with a perfectly competitive interbank market, the prediction is as in (1)
  - 2. Multiplicity of equilibria: In the absence of an interbank market, having simultaneous competition in the two sides of the balance sheet poses technical problems and can produce counterintuitive results (Yanelle, 1989)
- Plain Bertrand model predictions are little robust to introducing frictions (e.g., switching or transport cost) or product differentiation
- Monopolistic competition model may be a more sensible choice

Monopolistic competition - Salop setup

- Two dates $t = 0, 1$, no uncertainty
- Measure-one continuum of depositors uniformly distributed along a circumference of unit length
  - Endowed with a unit of funds at $t = 0$
  - Wish to consume at $t = 1$
  - Incur a (unobservable) transportation cost αx when moving to a distance x
    - Implicit assumption for lecture- covered market in equlibrium-
- $n \geq 2$ banks are symmetrically located along the circumference
  - Supply deposits at a rate r_i, $i = 1, ..., n$
  - Invest the proceeds at a rate r
- Depositors can only invest in bank deposits, which obliges them to move to a bank once

Symmetric equilibrium

- All banks offer the same deposit rate $r_i = r_d$
  - No profitable unilateral deviation exists
- Each depositor chooses to deposit his funds in the bank that offers him the highest net return (interest payments - transport costs)
  - In practice they only need to check the rates offered by the two banks at each side of a depositor's location (Assumption of not too low transport costs implicit)
  - A bank's marginal depositor can be identified from such a depositor's indifference condition:
- If bank i offers r_i and its competitors offer r_d, the marginal depositorwill be at a distance x from bank i such that

$$r_i - \alpha x = r_d - \alpha(\frac{1}{n} - x) \rightarrow x = \frac{1}{2n} + \frac{r_i - r_d}{2\alpha}$$

Symmetric equilibrium

- Hence, the relevant demand for bank i has the form

$$D_i(r_i, r_d) = 2x = \frac{1}{n} + \frac{r_i - r_d}{\alpha}$$

- The bank's objective function is

$$\begin{aligned} \pi_i &= (r - r_i) Di(r_i, r_d) \\ (concave\ in\ r_i &\rightarrow) \end{aligned}$$

- FOC

$$(r - r_i)\frac{1}{\alpha} - (\frac{1}{n} + \frac{r_i - r_d}{\alpha}) = 0$$

- By symmetry: $r_i = r_d \Rightarrow r_d^* = r - \frac{\alpha}{n}$

Symmetric equilibrium

- if $\alpha \to 0$ or $n \to \infty \Rightarrow r_d^* = r$
- Equilibrium profits are increasing in α and decreasing in n

$$\pi^* = \frac{(r - r_d)}{n} = \frac{\alpha}{n^2} \to n\pi^* = (r - r_d) = \frac{\alpha}{n}$$

(individual and industry profits)

Free entry equlibrium

- Under certain analyses n is taken as given or exogenously varied
  - e.g. regulatory rules on competition
- Lets assume free entry
  - Each bank incurs a fixed cost F
  - Following entry or exit all banks reallocate to keep equidistant
  - In equilibrium n would be the integer such that

$$\pi^* = \frac{\alpha}{n^2} \geq F > \frac{\alpha}{(n+1)^2}$$

$$n \simeq n^* = \sqrt{\frac{\alpha}{F}} \text{ and } r - r_d^* \simeq \sqrt{\alpha F}$$

Free entry equlibrium

- Is the free entry equilibrium efficient?
  - Trade-off between entry costs and transport costs
- Aggregate net returns would be maximized by

$$n^{FB} = \arg\min_{n} \; nF + 2n \int_0^{\frac{1}{2n}} \alpha x dx$$

- Notice that

$$2n \int_0^{\frac{1}{2n}} \alpha x dx = \frac{\alpha}{n^2} \rightarrow FOC \;\; n^{FB} = \frac{1}{2} n^*$$

- Excess entry (banks ignore their negative impact on other banks profit)
- Possible argument for entry regulation in banking?

Effects of introducing deposit rate ceilings

- Regulatory cap (maximum) on deposit rates
  - e.g. Regulation Q in US (1933-1986)
  - but also in more recent days (Spain 2013)
- What is the effect of introducing a regulatory cap $r_d^* \leq \bar{r}$?
- Hints - prove-

$$\begin{aligned} \left.\frac{\partial \pi_i}{\partial r_i}\right|_{r_i=r_d=\bar{r}} &> 0 \\ \pi_i(r_i &= r_d = \bar{r}) > F \\ n^*(\bar{r}) &> n^* \end{aligned}$$

Effects of introducing deposit rate ceilings

- Free entry + deposit rate ceiling = bad outcomes
  - too much (extra) entry
- Why is this happening?
  - How can a constraint increase bank profits?