Screening, Lending Intensity, and the Aggregate Response to a Bank Tax

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Research Question

- Motivating issue: How did banks contribute to the recent financial crisis?
- Revisit what banks do as lenders:
  - Due to competition, they actively attract borrowers.
  - Due to private information, they actively screen borrowers.
- Research question: Are banks efficient at allocating resources between attracting and screening? I demonstrate no.

Preview of Results

- Even without irrationality or asset prices, the market generates too much uninformed, low-quality credit.
- Key externalities from the resource allocation decision:
  - Affects the distribution of available borrowers, compelling unmatched lenders to want to attract sooner.
  - Also affects the rematching probabilities of informed lenders, giving them an incentive to be more selective.
- A mild matching tax can raise steady state output and attenuate the response to aggregate shocks.

Recent Literature

- Macroeconomics and financial fragility:
  - ex. Lorenzoni (2008), Korinek (2009)
  - Focus is on externalities through asset prices, not bank interactions.
- Microfoundations of banking:
  - ex. Cao and Shi (2001), Parlour and Rajan (2001), Direr (2008), Becsi et al (2009)
  - Focus is on either screening or matching decisions, not tradeoffs between the two.

Environment - Agents & Technologies

Borrowers:

- Continuum of types: $\omega \in [0, 1]$ with CDF $F(\cdot)$.
- Risk neutral and endowed with 1 unit of effort each period.
- Type ω can produce $\theta(\omega)$ with probability e where:
  - $\theta'(\omega) > 0$ and $\theta''(\omega) < 0$
  - $e =$ unobservable borrower effort
- Cost of exerting effort: $-c \ln(1 - e)$.
- Production requires 1 unit of external capital.

Environment - Agents & Technologies

Lenders:

- Continuum of ex ante identical, risk neutral lenders.
- Have access to capital via an interbank market.
- Cannot produce but can operate two intermediation technologies:
  - A matching technology to attract a borrower.
  - A screening technology to learn about the borrower if matched.
- Key assumptions:
  - Success rate of each technology rises with resources put into it.
  - Cannot make both technologies succeed with probability 1.

Environment - Agents & Technologies

Lenders (cont'd):

- Simplified intermediation environment:
  - All lenders endowed with 1 unit of time each period.
  - π units to matching $\Rightarrow$ get match with probability π.
  - $1 - \pi$ units to screening $\Rightarrow$ discover ω with probability $1 - \pi$.
  - How does this compare to a more general environment?
- Assume one match at a time and no "on the contract" search.
- Ex post, can classify lenders as either unmatched, matched and uninformed, or matched and informed.

Environment - Sequence of Events

Stage 1: Matching and Retention

- Unmatched lenders choose time allocation.
  - If matching not successful, then try again next period.
  - If matching is successful, then:
    - Fineness of information set depends on screening results. (*Abstract from credit ratings*).
    - Choose whether to accept or reject borrower.
    - If accept, then also choose 1-prd loan rate s.t. p/c. (*Abstract from intertemporal incentives*).
    - If reject, then revert to being unmatched.
- Matched lenders choose retention strategy and loan rate.

Environment - Sequence of Events

Stage 2: Production

- Matched borrowers exert production effort.
  - If ω's project succeeds under gross loan rate R, then:
    - Borrower consumes $\theta(\omega) - R$.
    - Lender gets R, puts $(1-\delta) R$ back into interbank market.
  - If ω's project fails, then borrowed capital is lost.
- Probability μ of exogenous separation at the end of this stage.

Decisions - Borrowers

- Optimization problem if financed:

$$\max_{e\in[0,1]} \left\{e\left[\theta\left(\omega\right)-R\right]+c\ln\left(1-e\right)\right\}$$

- Yields the following strategy:

$$e\left(\omega,R\right)=\begin{cases} 0 & \textit{if} \quad R>\theta\left(\omega\right)-c \\ 1-\frac{c}{\theta(\omega)-R} & \textit{if} \quad R\leq\theta\left(\omega\right)-c \end{cases}$$

- $e\left(\omega+\varepsilon,R\right)\geq e\left(\omega,R\right)$ with $>$ for at least some R.
- Probability of capital destruction $=1-e\left(\omega,R\right)$.

Decisions - Lenders

Aggregate state variables (S):

- Beginning of period capital base $= K$
- Borrower values
  - Value of type ω's with informed financing $= V(\omega)$
  - Value of type ω's if unmatched $= V_u(\omega)$
- Distributions
  - Proportion of type ω's with informed financing $= \lambda_{-1}(\omega)$
  - Proportion of type ω's with uninformed financing $= \phi_{-1}(\omega)$

Beliefs about available borrowers $= \psi(\omega)$

Decisions - Unmatched Lenders

$$U(S,\psi) = \max_{\pi} \left\{ \begin{array}{l} (1-\pi)\,\beta U(S_{+1},\psi_{+1}) \\ +\pi(1-\pi)\,payoff_{inform} + \pi^2 payoff_{uninform} \end{array} \right\}$$

$$s.t.\ \pi \in [0,1],\ S_{+1} = \Gamma(S),\ \psi_{+1} = \Psi(S_{+1})$$

$$payoff_{inform} = \int_0^1 \overbrace{J(\omega, V(\omega), S, \psi)}^{\text{PDV of informed match with } \omega} \overbrace{\psi(\omega)}^{\text{beliefs}} d\omega$$

$$\begin{aligned} payoff_{uninform} = & \overbrace{X(S,\psi)}^{\text{1 prd return}} - \overbrace{(1+r(S))}^{\text{cost of funds}} + \overbrace{\beta\mu U(S_{+1},\psi_{+1})}^{\text{PDV if separated}} \\ & + \underbrace{\beta(1-\mu)\int_0^1 J(\omega, V_{+1}(\omega), S_{+1}, \psi_{+1})\,\psi(\omega)\,d\omega}_{\text{PDV if not separated}} \end{aligned}$$

Decisions - Matched and Uninformed Lenders

$$X(S,\psi) \quad = \quad \max_{\overline{R}} \int_{\eta(\overline{R})}^{1} \overbrace{\left(1-\tfrac{c}{\theta(\omega)-\overline{R}}\right)\overline{R}}^{\text{expected repayment by } \omega} \; \overbrace{\psi(\omega)}^{\text{beliefs}} d\omega$$

subject to

$$\overline{R} \in [0, \theta(1) - c]$$

$$\underbrace{\eta(\overline{R})}_{\text{highest type that defaults with certainty}} = \arg\min_{n\in[0,1]} \left|\theta(n) - c - \overline{R}\right|$$

Decisions - Matched and Informed Lenders

$$J(\omega, v, S, \psi) \quad = \quad \max_{a,R,v_{+1}} \left\{ (1-a)\,\beta U\left(S_{+1}, \psi_{+1}\right) + a * payoff_{accept} \right\}$$

$$\textit{subject to}$$

$$a \in [0,1], \ R \in [0, \theta(\omega) - c]$$

$$\textit{borrower utility eqn and } p/c$$

$$S_{+1} = \Gamma(S), \ \psi_{+1} = \Psi(S_{+1})$$

$$\begin{aligned} payoff_{accept} \quad = \quad & \overbrace{\left(1 - \tfrac{c}{\theta(\omega) - R}\right) R}^{\text{expected repayment}} - \overbrace{(1 + r(S))}^{\text{cost of funds}} \\ & + \underbrace{\beta\mu U\left(S_{+1}, \psi_{+1}\right)}_{\text{PDV if separated}} + \underbrace{\beta(1-\mu)\, J\left(\omega, v_{+1}, S_{+1}, \psi_{+1}\right)}_{\text{PDV if not separated}} \end{aligned}$$

Distributions

- $N(\omega) \equiv$ proportion of type ω's in the market for a new lender

- Distribution of available borrowers:

$$\psi(\omega) \overset{eqlm}{=} \frac{N(\omega) f(\omega)}{\int_0^1 N(h)\, dF(h)}$$

where

$$N(\omega) = 1 - (1-\mu)\left[\lambda_{-1}(\omega) + \phi_{-1}(\omega)\right] A(\omega)$$

$$\lambda(\omega) = 1 - N(\omega) + A(\omega) N(\omega) \Pi (1 - \Pi)$$

$$\phi(\omega) = N(\omega) \Pi^2$$

Capital Market

- Capital demand:

$$KD = \int_0^1 \left[\lambda(\omega) + \phi(\omega)\right] dF(\omega)$$

- Capital supply:

$$\begin{aligned} KS_{+1} &= KS - KD \\ &+ (1-\delta) \left[\begin{array}{l} \int_0^1 e(\omega, R(\omega)) R(\omega) \lambda(\omega) dF(\omega) \\ + \int_{\eta(\overline{R})}^1 e\left(\omega, \overline{R}\right) \overline{R} \phi(\omega) dF(\omega) \end{array} \right] \end{aligned}$$

- Market clearing: r adjusts so that $KD = KS$.

Definition of Equilibrium

- An equilibrium is a set of lender value functions $\{J, U\}$ and sequences of borrower continuation values $\{V, V_u\}$, individual decision rules $\{a, \pi, R, \overline{R}, v_{+1}\}$, aggregate decision rules $\{A, \Pi\}$, distributions $\{\lambda, \phi\}$, capital $\{K_{+1}\}$, costs of funds $\{r\}$, and beliefs $\{\psi, \Gamma, \Psi\}$ satisfying:
  - Lender optimality.
  - Symmetry (i.e., $A = a$, $\Pi = \pi$, etc.).
  - Capital market clearing.
  - Laws of motion for K_{+1}, λ, and ϕ.
  - Functional equations for V and V_u.
  - Consistency of beliefs.

Existence of Equilibrium

- PROPOSITION: If μ is sufficiently high, then $\exists$ a unique non-trivial steady state in the class of symmetric equilibria where the borrower participation constraint doesn't bind.
- Note: exists scalar ξ such that $a(\omega) = 1$ IFF $\omega \geq \xi$.

Benchmark for Constrained Efficiency

Consider a steady state "planner" who:

- Holds the entire capital base.
- Faces the same intermediation technologies and time constraints as the decentralized economy.
- Chooses Π, ξ, and $\mathcal{R} \equiv \left\{ R(\cdot), \overline{R} \right\}$ to maximize total present discounted capital subject to aggregate feasibility.
  - $\mathcal{R}$ is now the division of output b/w consumption and capital.
  - Start with capital rather than net output in the objective function to shut down inefficiencies related to $\mathcal{R}$.
  - Can interpret this planner as a monopolist bank (who is nonetheless subject to the matching friction).

Constrained Efficiency

- PROPOSITION: If $\mu = 1$, then the decentralized equilibrium is constrained efficient.
- PROPOSITION: If $\mu \neq 1$ and β is high, then:
  1. The decentralized equilibrium is inefficient.
  2. If $\theta(\cdot)$ is concave enough, then the direction of inefficiency is $\Pi_{mkt} > \Pi^*$ and $\xi_{mkt} > \xi^*$.

Externalities

- Externality through the distribution of available borrowers:
  - Induces unmatched lenders to attract now, screen later.
  - If A adopts, then average quality of borrowers available tomorrow will fall. Therefore, B adopts.
  - If A doesn't adopt, then average quality today will be close to the unconditional average. Therefore, B adopts.
- Externality through rematching probabilities:
  - Induces informed lenders to be too selective.
  - Π enters the informed problem as the rematching probability for lenders who break their matches.
  - Higher Π means higher rematching rate which, with enough exogenous separation, outweighs the aforementioned decline in average borrower quality.

Towards a Corrective Tax

- Decrease in market inefficiency requires $\downarrow \Pi_{mkt}$ and $\downarrow \xi_{mkt}$.
- Consider the following tax on lending intensity:
  - $U(S, \psi) = \max_{\pi} \{\cdots - \tau\pi\}$.
  - Tax revenues are added back to interbank market so that all other equations are unchanged.
- PROPOSITION: Under the conditions that guarantee $\Pi_{mkt} > \Pi^*$ and $\xi_{mkt} > \xi^*$, we have $\frac{d\Pi_{mkt}}{d\tau} < 0$ and $\frac{d\xi_{mkt}}{d\tau} < 0$.

A Numerical Example

Functional forms:

$$\omega \sim U[0,1]$$

$$\theta(\omega) = y_0 + y_1 \omega^{\alpha}$$

Calibration (U.S., 1995 - 2005):

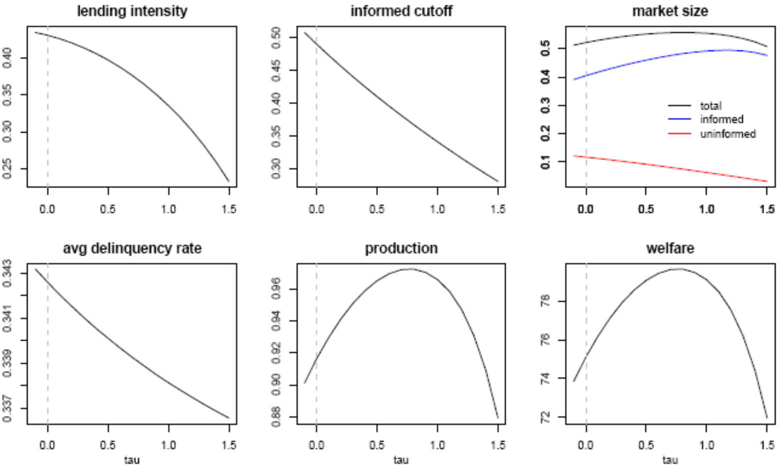
Parameter	Value	Targets
y_0	1	Normalization
y_1	2.05	Ratio of net business loans to GDP
α	0.5	Productivity dispersion (Dziczek et al, 2008)
β	0.99	Annualized risk-free rate $=$ 4%
μ	0.14	Extent of repeated lending (Bharath et al, 2009)
δ	0.13	Ratio of financial sector value added to GDP
c	0.285	Capacity utilization rate

Steady State Comparison

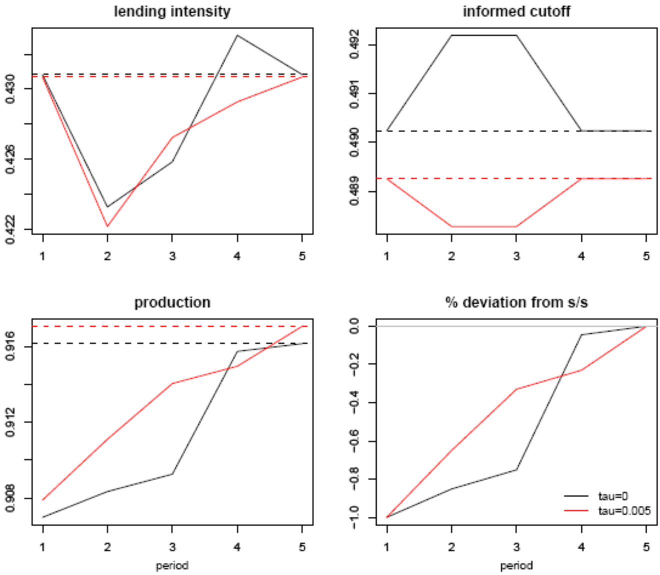
VARIABLE	MARKET	PSEUDO	K-MAX	W-MAX
Lending Intensity (Π)	0.4309	0.4214	0.3634	0.3637
Informed Cutoff (ξ)	0.4901	0.4591	0.3667	0.3770
Amount of Informed Credit	0.4044	0.4269	0.4827	0.4750
Amount of Uninformed Credit	0.1169	0.1083	0.0743	0.0753
Average Type Financed	0.6578	0.6534	0.6399	0.6432
Average Delinquency Rate	0.3426	0.3416	0.3388	0.3201
Aggregate Welfare	75.100	76.972	79.634	80.551

Note: Pseudo problem fixes the rematching probabilities for informed lenders at the constrained efficient values.

Effect of Tax on Steady State

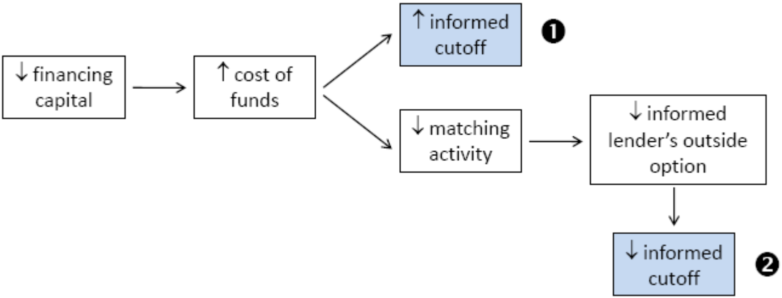


Effect of Tax on Dynamics (temp fall in project successes)



Effect of Tax on Dynamics (temp fall in project successes)

Key transmission channels for a temporary negative aggregate productivity shock:



A mild tax on matching activity strengthens (2) relative to (1), limiting the contraction of informed financing and supporting a faster return to steady state.

Conclusion

- I examine the allocation of bank resources across intermediation activities and find that it is fundamentally inefficient.
- A mild tax on lending intensity can increase steady state output and attenuate the dynamic response to aggregate shocks.

Supplementary