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:
  - Focus is on either screening or matching decisions, not tradeoffs between the two.
Borrowers:

- Continuum of types: \( \omega \in [0, 1] \) with CDF \( F(\cdot) \).
- Risk neutral and endowed with 1 unit of effort each period.
- Type \( \omega \) 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.
Simplified intermediation environment:
- All lenders endowed with 1 unit of time each period.
- $\pi$ units to matching $\Rightarrow$ get match with probability $\pi$.
- $1 - \pi$ units to screening $\Rightarrow$ discover $\omega$ 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.
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.
Stage 2: Production

- Matched borrowers exert production effort.
  - If \( \omega \)'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 \( \omega \)'s project fails, then borrowed capital is lost.
- Probability \( \mu \) of exogenous separation at the end of this stage.
Decisions - Borrowers

- Optimization problem if financed:

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

- Yields the following strategy:

\[
e(\omega, R) = \begin{cases} 
0 & \text{if } R > \theta(\omega) - c \\
1 - \frac{c}{\theta(\omega) - R} & \text{if } R \leq \theta(\omega) - c
\end{cases}
\]

- \(e(\omega + \varepsilon, R) \geq e(\omega, R)\) with \(>\) for at least some \(R\).

- Probability of capital destruction = \(1 - e(\omega, R)\).
Decisions - Lenders

Aggregate state variables \((S)\):

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

Beliefs about available borrowers \(= \psi(\omega)\)
Decisions - Unmatched Lenders

\[
U(S, \psi) = \max_{\pi} \left\{ (1 - \pi) \beta U(S_{+1}, \psi_{+1}) + \pi (1 - \pi) \text{payoff}_{\text{inform}} + \pi^2 \text{payoff}_{\text{uninform}} \right\}
\]

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

\[
\text{payoff}_{\text{inform}} = \int_0^1 J(\omega, V(\omega), S, \psi) \psi(\omega) d\omega
\]

\[
\text{payoff}_{\text{uninform}} = \frac{1}{1 + r(S)} - \beta \mu U(S_{+1}, \psi_{+1}) + \beta (1 - \mu) \int_0^1 J(\omega, V_{+1}(\omega), S_{+1}, \psi_{+1}) \psi(\omega) d\omega
\]
Decisions - Matched and Uninformed Lenders

\[
X(S, \psi) = \max_{R} \int_{\eta(R)}^{1} \left( 1 - \frac{c}{\theta(\omega) - R} \right) R \underbrace{\psi(\omega)}_{\text{beliefs}} d\omega
\]

subject to

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

\[
\eta(R) = \arg \min_{n \in [0,1]} \left| \theta(n) - c - R \right|
\]

highest type that defaults with certainty
Decisions - Matched and Informed Lenders

\[ J(\omega, \nu, S, \psi) = \max_{a, R, \nu+1} \left\{ (1-a) \beta U(S+1, \psi+1) + a \times payoff_{accept} \right\} \]

subject to

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

borrower utility eqn and p/c

\[ S+1 = \Gamma(S), \ \psi+1 = \Psi(S+1) \]

\[ payoff_{accept} = \left\{ \begin{array}{ll}
\text{expected repayment} & \\
\left(1 - \frac{c}{\theta(\omega) - R}\right) R - (1 + r(S)) & \\
\text{cost of funds} & \\
+ \beta \mu U(S+1, \psi+1) & \\
\text{PDV if separated} & \\
+ \beta (1-\mu) J(\omega, \nu+1, S+1, \psi+1) & \\
\text{PDV if not separated}
\end{array} \right. \]
Distributions

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

- Distribution of available borrowers:

  \[
  \psi(\omega) \overset{eq/m}{=} \frac{N(\omega)f(\omega)}{\int_0^1 N(h)dF(h)}
  \]

  where

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

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

  \[
  \phi(\omega) = N(\omega) \Pi^2
  \]
Capital Market

- Capital demand:

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

- Capital supply:

\[ KS_{+1} = KS - KD \]

\[ + (1 - \delta) \left[ \int_0^1 e(\omega, R(\omega)) R(\omega) \lambda(\omega) dF(\omega) \right. \]

\[ + \int_{\eta(R)}^1 e(\omega, R) \overline{R} \phi(\omega) dF(\omega) \]

- 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 \( \{a, \pi, R, \overline{R}, \nu_+\} \), 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 \( K_{+1}, \lambda, \) and \( \phi \).
  - Functional equations for \( V \) and \( V_u \).
  - Consistency of beliefs.
**Existence of Equilibrium**

- **Proposition:** If $\mu$ 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 $\zeta$ such that $a(\omega) = 1$ IFF $\omega \geq \zeta$. 
Consider a steady state "planner" who:

- Holds the entire capital base.
- Faces the same intermediation technologies and time constraints as the decentralized economy.
- Chooses $\Pi$, $\xi$, and $\mathcal{R} \equiv \{R(\cdot), \bar{R}\}$ 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 $\beta$ 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 $\xi_{mkt} > \xi^*$. 
Exernalities

- 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.
  - $\Pi$ enters the informed problem as the rematching probability for lenders who break their matches.
  - Higher $\Pi$ 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 $\downarrow \zeta_{mkt}$.

- 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 $\zeta_{mkt} > \zeta^*$, we have $\frac{d\Pi_{mkt}}{d\tau} < 0$ and $\frac{d\zeta_{mkt}}{d\tau} < 0$. 
A Numerical Example

Functional forms:

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

\[ \theta(\omega) = y_0 + y_1 \omega^\alpha \]

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_0 )</td>
<td>1</td>
<td>Normalization</td>
</tr>
<tr>
<td>( y_1 )</td>
<td>2.05</td>
<td>Ratio of net business loans to GDP</td>
</tr>
<tr>
<td>( \alpha )</td>
<td>0.5</td>
<td>Productivity dispersion (Dziczek et al, 2008)</td>
</tr>
<tr>
<td>( \beta )</td>
<td>0.99</td>
<td>Annualized risk-free rate = 4%</td>
</tr>
<tr>
<td>( \mu )</td>
<td>0.14</td>
<td>Extent of repeated lending (Bharath et al, 2009)</td>
</tr>
<tr>
<td>( \delta )</td>
<td>0.13</td>
<td>Ratio of financial sector value added to GDP</td>
</tr>
<tr>
<td>( c )</td>
<td>0.285</td>
<td>Capacity utilization rate</td>
</tr>
</tbody>
</table>
### Steady State Comparison

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MARKET</th>
<th>PSEUDO</th>
<th>K-MAX</th>
<th>W-MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lending Intensity ($\Pi$)</td>
<td>0.4309</td>
<td>0.4214</td>
<td>0.3634</td>
<td>0.3637</td>
</tr>
<tr>
<td>Informed Cutoff ($\zeta$)</td>
<td>0.4901</td>
<td>0.4591</td>
<td>0.3667</td>
<td>0.3770</td>
</tr>
<tr>
<td>Amount of Informed Credit</td>
<td>0.4044</td>
<td>0.4269</td>
<td>0.4827</td>
<td>0.4750</td>
</tr>
<tr>
<td>Amount of Uninformed Credit</td>
<td>0.1169</td>
<td>0.1083</td>
<td>0.0743</td>
<td>0.0753</td>
</tr>
<tr>
<td>Average Type Financed</td>
<td>0.6578</td>
<td>0.6534</td>
<td>0.6399</td>
<td>0.6432</td>
</tr>
<tr>
<td>Average Delinquency Rate</td>
<td>0.3426</td>
<td>0.3416</td>
<td>0.3388</td>
<td>0.3201</td>
</tr>
<tr>
<td>Aggregate Welfare</td>
<td>75.100</td>
<td>76.972</td>
<td>79.634</td>
<td>80.551</td>
</tr>
</tbody>
</table>

Note: Pseudo problem fixes the rematching probabilities for informed lenders at the constrained efficient values.
Effect of Tax on Steady State

- Lending intensity
- Informed cutoff
- Market size
- Avg delinquency rate
- Production
- Welfare
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

Employment Ratios for Commercial Banks: \( \frac{M}{M+S} \)

(Preliminary estimates constructed using BLS Occupational Employment Statistics)