Information Span in Credit Market Competition

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Motivation

- Competition in credit markets is shaped by rich information structures
  - Banks' have multiple sources of information: hard v.s. soft
  - Specialized lending among banks (Blickle, Saunders, and Parlatore, 2023)

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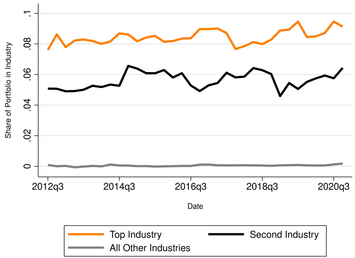

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- Revolution in big data and machine learning reshapes information landscape
  - More data can make information more precise
  - Common data makes information more correlated across agents
  - Soft information can now be recorded by objective data (it is hardened)
    - e.g., farm loans

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- **This paper**

  How is competition in credit markets affected by hardening soft information?

Results

1. Credit market competition with specialized lenders & multidimensional info
   - Two lenders each with "hard" signals used for screening
   - Specialized lender with additional "soft" signal used to set rate
   - Hard v.s. soft not about verifiability, but reflects some "sharing" features

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   - Key: Novel modeling of the recent information technology improvement
4. Technical contribution
   - Closed-form/analytical characterization of common-value auction with asymmetrically informed bidders, without black-well ordering

Model

- Borrower finances 1\$. Project of private quality θ and output

$$\begin{cases} 1+\bar{r} & \text{when } \theta = 1, \\ 0 & \text{when } \theta = 0, \end{cases}$$

  where $q \equiv \mathbb{P}(\theta = 1)$.

- Credit market: Two banks $j = A, B$ compete for the borrower
  - Banks simultaneously choose lending strategies based on their information

$$r^j \in \mathcal{R} \equiv [0, \bar{r}] \cup \underbrace{\infty}_{\text{no offer}}$$

  - If receiving two offers r^A and r^B, the borrower accepts the lower one

Information Span

- Project success needs multiple characteristics (binary) to be good; **O-ring theory**

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- Information span: scope of characteristics that soft/hard info can assess
  - Hard signal: $h^j = \mathcal{H}^j(\theta_h) \in \{H, L\}$, soft signal $s^j = \mathcal{S}^j(\theta_s) \sim \phi(s)$ (see later)
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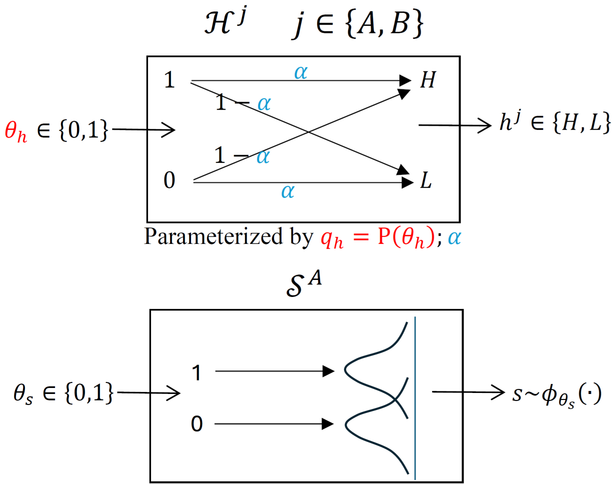
"Specialized" Information Structure



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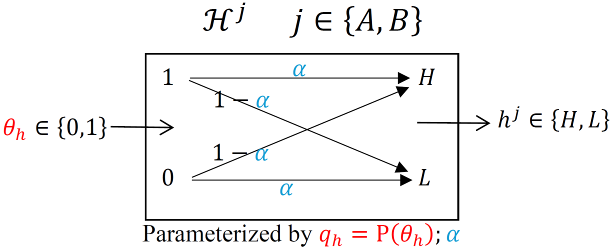

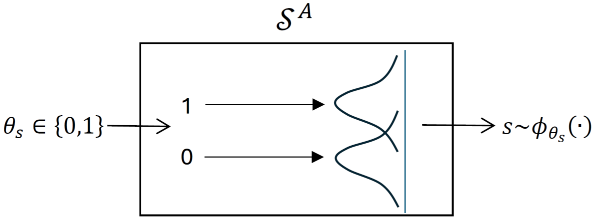

- Bank A is the specialized bank and has $\{s, h^A\}$; Bank B has $\{h^B\}$
- What if a different information structure with three potential signals? (later)

Signal Distributions

Information span is different from signal precision

- Hard signals are binary and i.i.d across lenders

$$\mathbb{P}\left(h^j = H \,|\theta_h = 1\right) = \mathbb{P}\left(h^j = L \,|\theta_h = 0\right) = \alpha$$

  - Both lenders can have access to "hard" signals
- Soft signal: directly work with posterior

$$s \equiv \mathbb{P}\left(\theta_s = 1 |\, s\right) \in [0, 1], \quad \text{p.d.f} \quad \phi(s)$$

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Assumption (Hard Info as Decisive Pre-Screening)

A lender rejects the borrower upon $h^j = L$ and is willing to participate only if $h^j = H$.

Optimal Bidding Strategies

- $p_{h^A h^B}(s) = \mathbb{P}\left(h^A, h^B, s \in ds\right)$, $\mu_{h^A h^B}(s) = \mathbb{E}\left(\theta \middle| h^A, h^B, s\right)$, $\overline{p}_{h^A h^B} = \mathbb{P}\left(h^A, h^B\right)$

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- Upon $h^A = H$ and s, Bank A chooses $r^A(s) \in [0, \bar{r}] \cup \infty$ to maximize

$$\pi^A(r,s) \equiv \underbrace{p_{HH}(s)}_{h^B=H} \underbrace{\left[1 - F^B(r)\right]}_{A \text{ wins}} \left[\mu_{HH}(s)(1+r) - 1\right] + \underbrace{p_{HL}(s)}_{h^B=L} \left[\mu_{HL}(s)(1+r) - 1\right]$$

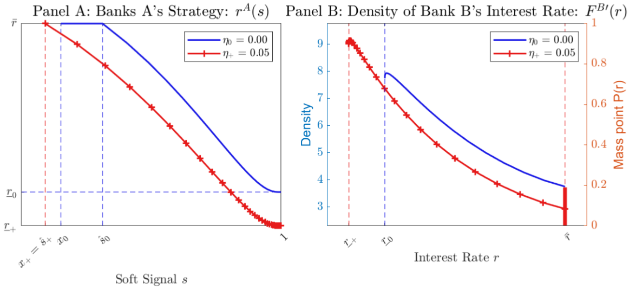
- Upon $h^B = H$, Bank B chooses $F^B(r) \equiv \Pr\left(r^B \le r\right)$ to $\max_{F^B} \int \pi^B(r)\, dF^B(r)$

$$\pi^B(r) \equiv \underbrace{\bar{p}_{HH}}_{h^A=H} \underbrace{\left[1 - F^A(r)\right]}_{B \text{ wins}} \mathbb{E}\left[\theta(1+r) - 1 \middle| r \le r^A(s), HH\right] + \underbrace{\bar{p}_{LH}}_{h^A=L} \mathbb{E}\left[\theta(1+r) - 1 \middle| LH\right]$$

Winner's Curse!

Equilibrium Strategies

- Two types of equilibria: positive-weak $\pi^B > 0$ or zero-weak $\pi^B = 0$.



- **Bank A: private-info-based pricing** (Blickle, He, Huang, and Parlatore, 2023)
  - Decreasing $r^A(s)$, withdraws upon $s < x$
- Bank B: h^B determines lending, but r^B is randomized
- That paper: this "informed undercutting" is crucial in generating *lower* rates on loans granted by specialized lenders

Credit Market Equilibrium

Proposition

In the unique equilibrium, lender $j \in \{A, B\}$ rejects borrowers upon $h^j = L$. When $h^j = H$,

1. Bank A with soft signal s offers

$$r^A(s) = \begin{cases} \min\left\{ \frac{\pi^B + \int_0^s p_{HH}(t)dt + \overline{p}_{LH}}{\int_0^s p_{HH}(t) \cdot \mu_{HH}(t)dt + \overline{p}_{LH}\overline{\mu}_{LH}} - 1, \overline{r} \right\} & \text{for } s \in [x, 1], \\ \infty, & \text{for } s \in [0, x). \end{cases}$$

   Interior $r^A(\cdot)$ is strictly decreasing (for $s \in (\hat{s}, 1]$ and $r \in [\underline{r}, \overline{r})$).

2. Bank B makes offer with prob. $F^B(\overline{r}) < 1 \, (= 1)$ if $\pi^B = 0 \, (> 0)$:

$$F^B(r) = \begin{cases} 1 - \frac{\int_0^{s^A(r)} t\phi(t)dt}{q_s}, & \text{for} \quad r \in [\underline{r}, \overline{r}), \\ 1 - \mathbf{1}_{\{\pi^B = 0\}} \cdot \frac{\int_0^{\hat{s}} t\phi(t)dt}{q_s}, & \text{for} \quad r = \overline{r}. \end{cases}$$

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Tractability: ALL signals $\{h^A, h^B, s\}$ independent conditional on success, despite of overlapping span

Increase in Information Span of Hard Signals

Fundamental characteristics

$$\theta = \overbrace{\theta_h^h \cdot \theta_s^h}^{\theta_h^h} \cdot \underbrace{\theta_s^h \cdot \theta_s^s}_{\theta_s}$$

- Overlap θ_s^h captures the span of hard information
- $\eta \equiv 1 - \mathbb{P}\left(\theta_s^h = 1\right) \uparrow$: hard information describes more characteristics.
  - Less likely to get a positive signal if $\theta = 0 \Rightarrow$ Lower Type II error
- Hard signal has information about soft signal realization s. For non-specialized Bank B

  $\Rightarrow$ Face higher soft signal for Bank A if competes

  $\Rightarrow$ Lower winner's curse

Economic Intuition

- What is $\phi(s\,|HH)$, i.e., the conditional density of s given HH where lenders compete head-to-head
  - Bank B needs to think through this as well (then integrate over $[0, s]$)
- What is it when $\eta = 0$?
  - $\phi(s\,|HH; \eta = 0) = \underbrace{\phi(s)}_{\text{uncond. dist.}} = \underbrace{q_s}_{\Pr(\theta_s=1)} \underbrace{\phi_1(s)}_{\phi(s|\theta_s=1)} + \underbrace{(1-q_s)}_{\Pr(\theta_s=0)} \underbrace{\phi_0(s)}_{\phi(s|\theta_s=0)}$
  - Empty θ_s^h so no overlap between hard and soft signals; HH carries no info for s
- When $\eta \equiv 1 - \mathbb{P}(\theta_s^h = 1) \uparrow$: hard information describes more characteristics
  - $\phi(s\,|HH; \eta) = \underbrace{\phi(s)}_{\text{uncond. dist.}} + \underbrace{\frac{2\alpha - 1}{\frac{\alpha^2}{\eta} - 2\alpha + 1}}_{\uparrow \text{ in } \eta} (\phi_1(s) - \phi_0(s))$
  - Closer to $\phi_1(s)$ so lower Type II error

Information Span and Bank Profits

Proposition (Equilibrium profits)

1. Bank B's profits are increasing in η. There is a cutoff $\hat{\eta}$ s.t.

$$\begin{cases} \pi^B = 0, & \text{for } \eta \leq \hat{\eta}, \\ \pi^B > 0, & \text{for } \eta > \hat{\eta}. \end{cases}$$

2. In a positive-weak equilibrium, the difference in bank profits decreases, i.e.,

$$\frac{d\pi^B}{d\eta} > \frac{d}{d\eta}\mathbb{E}\left[\pi^A\right]$$

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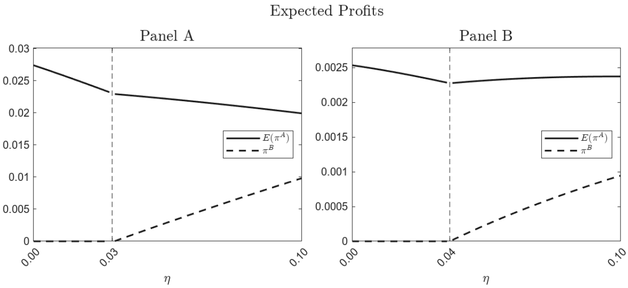

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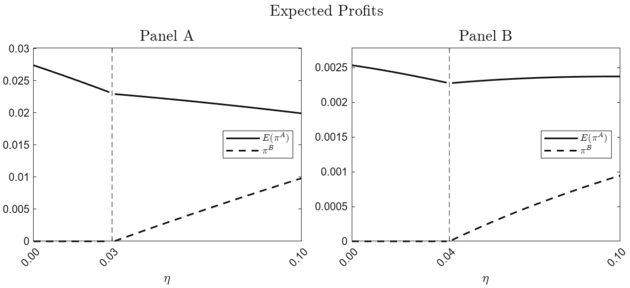
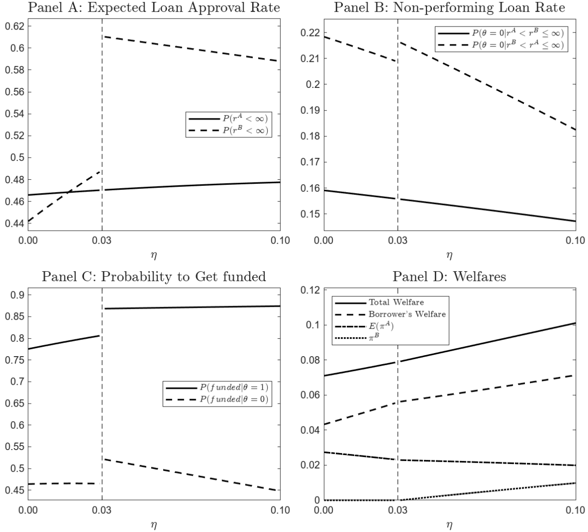


Hardening soft information levels the playing field!

Hardening Soft Information

Three effects:

- Lower Type II error based on hard signal
- Lower winner's curse for Bank B
- Better soft signals for Bank A



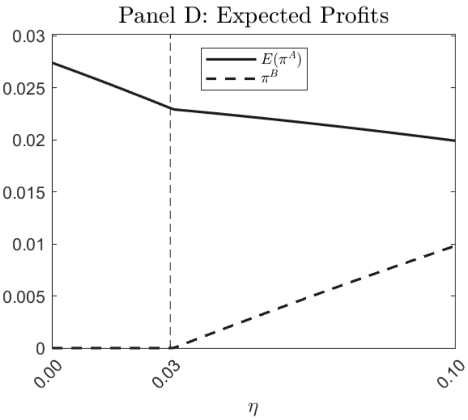
Not All Technological Advances Are Equal

Technology improvement could lead to

- Broader hard information (η)
  $\Rightarrow$ level the playing field, and may bring Pareto improvement
- More precise signals
  $\Rightarrow$ soft signal precision, clearly stronger specialized bank
  $\Rightarrow$ hard signal precision α, nonmonotone but stronger specialized bank when $\alpha \to 1$
-
- More correlated hard signals (in the paper)
  $\Rightarrow$ stronger specialized bank

Breadth (Information Span) vs. Quality (Precision)

- $\uparrow \eta$ levels the playing field



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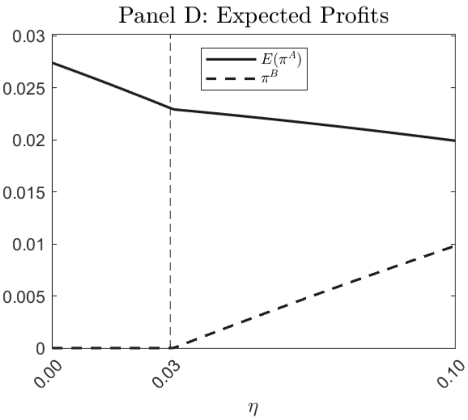

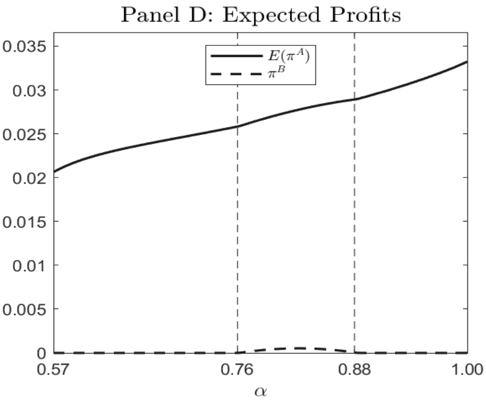

Alternative Information Structure

What if we model the information span as third signal?

- Suppose both lenders now access to signals h_s^j, $j \in \{A, B\}$ on the hardened soft fundamental θ_s^h (on top of θ_h^h and θ_s)
    - $h_s^j \in \{H, L\}$ binary, decisive, with precision $\alpha_s \in [0.5, 1]$
    - h_s^A and h_s^B can be correlated with $\rho_s^h \in [0, 1]$, as typical big-data technologies
- Our model is (almost) isomorphic to the following two cases
    - either both signals h_s^j's are perfectly correlated $\rho_s^h = 1$
    - or $\alpha_s = 1$ perfectly revealing signal
- In these two situations, h_s^j's are as if public
    - We just need to replace all distributions to be conditional on $h_s^A = h_s^B = H$
- Exactly the same mechanism as baseline, and robust to general setting

Conclusion

This paper

- Credit competition framework with different information span
  - Soft vs. hard, specialization in information...
- Technological development: soft information is being hardened
  - Broader information vs. more precise information vs. more public information
- Hardening soft information levels the playing field and increases competition
  - lower interest rates, higher approval rates, higher quality loans
  - Not the same if precision increases or signals become more public!

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Credit competition in digital disruption

- Hardening soft information: this paper
- A companion paper: highlighting we need "undercutting" to generate the empirical regularity of lower rates of loans granted by specializd lenders
- Open banking
  - He, Huang and Zhou (2023, JFE), Babina et al. (2023), Goldstein, Huang and Yang (2024)
- Collateral vs. platform cash flow and information: Huang (2023)