A Quantitative Theory of Relationship Lending

Kyle Dempsey (Ohio State)
Miguel Faria-e-Castro (FRB St. Louis)

June, 2023
SED, Cartagena

What are the macro effects of relationship lending?

Fact: lending relationships are important in many loan markets ▸ figure

- price dispersion, sourcing persistence, "lifecycle" of spreads

Model: (i) multiple lenders + sourcing adjustment costs $\implies$ relationships
(ii) financial frictions interact with implied imperfect competition

Estimate: directly estimate key demand parameters on Y-14Q micro-data

Validate: model matches lender switching, price evolution moments from data

Applications: equilibrium effects of changes in relationship strength / duration, impacts on aggregate dynamics

- Experiments (for now): financial crises (GFC 08); confidence crises (SVB 23); monetary policy transmission

Preview of key mechanisms and findings

▸ literature

Borrowers care which banks charge which prices $\implies$ **2-tier demand**

1. **bank level:** bank j's relationship intensity, spread over average IR
2. **aggregate:** joint distribution of relationships and spreads

Banks internalize relationship formation $\implies$ **dynamic pricing**

- relationships induce heterogeneous actions *beyond financial conditions*

Key outcome: stark changes to net worth dynamics, plays out in several ways:

- *life cycle:* young / early relationship banks price below market
- *bank level:* expend relationship capital to smooth out shocks
- *aggregate:* slow moving net worth $\rightarrow$ impact depends on shock

Stationary model overview

Time is discrete and infinite, $t = 0, 1, 2, \ldots$

1. **rep. borrower:** demands loans *from all banks* to finance production
2. **heterogeneous banks:** finance loans subject to "standard" frictions
   - differentiation through relationship intensity $\Longrightarrow$ **market power**

Loan market: endogenous joint dist. of prices q and relationships s, $\mu(q, s)$

- *exogenous:* risk free rate $\overline{r} = \overline{q}^{-1} - 1$, wage $\overline{w}$, deposit price $\overline{q}^d$

Banks' problem

States: net worth n, customer capital s, return shock z

$$
\begin{aligned}
V(n,s,z;\mu) \quad &= \max_{q,e,n',\ell',d',s'} e + \overline{q}\pi\mathbb{E}_{z'}\left[V(n',s',z';\mu)\right] \\
\text{subject to:} & \\
\text{[budget]} \quad & q\ell' + \psi(e) \leq n + z + \overline{q}^d d' \\
\text{[net worth dynamics]} \quad & n' = \ell' - d' \\
\text{[capital requirement]} \quad & \chi q\ell' \leq q\ell' - \overline{q}^d d' \\
\text{[loan demand]} \quad & \ell' = \ell'(q,s) \\
\text{[relationship formation]} \quad & s' = \rho_q \frac{q\ell'}{L'(\mu)} + \rho_s s
\end{aligned}
$$

- Relationship intensity as dynamic endogenous state (Gourio and Rudanko, 14)
- Affects loan pricing ▸ details on loan pricing

Representative firm / borrower and loan demand

DRS production + working capital constraint on wages $\implies$ loan demand

Borrow (in principle) from all banks $j \in [0, 1]$, choose sourcing given:

- q_j: loan price offered by j (implies interest rate $r(q_j)$)
- s_j: (relative) relationship with $j \rightarrow$ weighted average of past loan shares
- $\mu(q, s)$: joint distribution of prices and habits
    - borrower does not internalize current loan choices on $\{s'\}$, μ'

      $\implies$ "external" in the spirit of Ravn, Uribe, and Schmitt-Grohe (06)

Loan *share* adjustment subject to quadratic costs with level ϕ

- aggregate contraction not "costly by construction"

Borrower problem with relationships and adjustments

$$W(\mathcal{L};\mu) = \max_{n,L',\mathcal{L}'=\{\ell'(q,s)\}} \underbrace{zn^{\alpha} - \overline{w}n}_{\text{op. profits}} + \underbrace{L' - \int \ell(q,s)\mathrm{d}\mu(q,s)}_{\text{borrowing, net repayments}}$$

$$\underbrace{-\frac{\phi}{2}L'\int\left(\frac{q\ell'(q,s)}{L'} - 1 - (s-S)\right)^2 \mathrm{d}\mu(q,s)}_{\text{adjustment costs}} + \overline{q}\mathbb{E}\left[W(\mathcal{L}';\mu')\right]$$

subject to:

[working cap.] $L' \geq \kappa\overline{w}n$

[sourcing] $\int q\ell'(q,s)\mathrm{d}\mu(q,s) \geq L'$

2-part equilibrium loan demand system

1. Bank-specific loan demand

$$\underbrace{\frac{q\ell'(q,s;\mu)}{L'(\mu)}}_{\text{relative loan demand}} = 1 + \underbrace{(s-S)}_{\text{relationship shifter}} - \underbrace{\frac{\overline{q}}{\phi}(r(q)-R(\mu))}_{\text{elasticity} \times \text{IR spread}}$$

2. Aggregate loan demand

$$L'(\mu) = \kappa\overline{w}\left[\frac{\alpha z/\overline{w}}{1+\kappa\left(\overline{q}\tilde{R}(\mu)-1\right)}\right]^{\frac{1}{1-\alpha}}$$

$$\underbrace{\tilde{R}(\mu)}_{\text{“effective” IR}} = \underbrace{R(\mu)}_{\text{avg. IR}} + \underbrace{\mathbb{C}_{\mu}(r,s)}_{\text{cov. term}} - \underbrace{\frac{1}{2}\frac{\overline{q}}{\phi}\mathbb{V}_{\mu}(r)}_{\text{var. term}}$$

Equilibrium

A **stationary recursive competitive equilibrium** in this model consists of:

- loan demand functions $\ell'(q, s; \mu)$ and $L'(\mu)$;
- bank policies $g_q(n, s, z; \mu)$ and $g_d(n, s, z; \mu)$;
- distribution of prices and relationships $\mu(q, s)$; and
- distribution of bank states $m(n, s, z; \mu)$

which satisfy (i) borrower optimality; (ii) bank optimality; (iii) stationarity of bank state distribution m given policies g; and (iv) consistency of distributions m and μ given policies g:

$$\mu(q, s) = \int \mathbf{1}\left[q = g_q(n, s, z; \mu)\right] m(\mathrm{d}n, s, \mathrm{d}z) \text{ for all } q, s$$

Strategy for quantifying the model

1. **externally assign** subset of parameters
   - risk-free rate $\bar{r}$ = 2%, CR χ = 8%, bank failure rate $1 - \pi$ = 0.72%

2. **directly estimate** key relationship parameters ϕ, ρ_s, and ρ_q
   - ϕ: Y-14Q measurements + model-implied demand curve + IV for supply
   - ρ_s, ρ_q: use results above to measure s, estimate accumulation process

3. **internally calibrate** 4 remaining parameters to bank financing / pricing and aggregate debt moments internal calibration

Goal: tie our hands on ϕ, ρ_s, and ρ_q using semi-structural approach on micro data (2), then match other key features of banking industry (3).

Estimating ϕ: bank-specific demand curves

▸ details

Idea: estimate model-implied demand on Y-14Q data

$$\frac{\ell_{fbt}}{L_{ft}} = \underbrace{\alpha_{fb} + \alpha_t + \Gamma X_{bt}}_{\text{FEs and controls}} + \underbrace{\beta(r_{fbt} - r_{ft})}_{\text{spread term}} + \underbrace{u_{fbt}}_{s \text{ term}}$$

- ℓ_{fbt}: firm f loans from bank b at time t
- r_{fbt}: interest rate

Issue: instrument for spread term (simultaneity).

Solution: follow Khwaja and Mian (08), estimate

$$r_{fbt} - r_{ft} = \gamma_{ft} + \gamma_{bt} + v_{fbt}$$

- use $\hat{\gamma}_{bt}$ to instrument spread term
- measures pure credit supply shock

firm unit	TIN [1]	ISL [2]
$\hat{\beta}$, spread	-12.22*** (3.91)	-11.39* (5.90)
N obs.	119,394	406,054
implied $\hat{\phi}$	0.081	0.087

- TIN: individual firm
- ISL: Ind.-Size-Location
- $\hat{\phi} = -\overline{q}/\hat{\beta}$, $\overline{q}$ consistent with $\overline{r} = 2\%$ (ann.)

▸ magnitudes

Estimating ρ_s and ρ_q: bank-level dynamics

Idea: use residuals $\hat{u}_{fbt}$ to proxy s_{fbt}, then estimate law of motion via OLS:

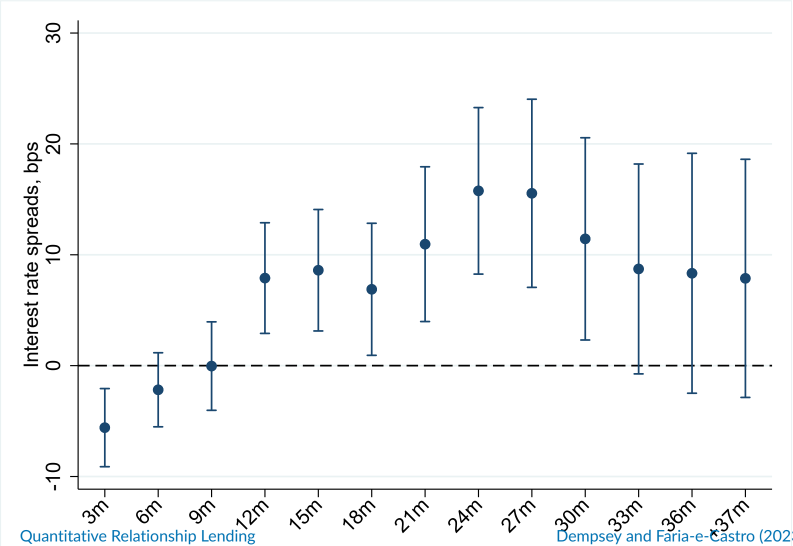
$$\hat{u}_{fbt} = \alpha_{fb} + \alpha_t + \underbrace{\rho_q \frac{\ell_{fbt}}{L_{ft}}}_{\text{loan term}} + \underbrace{\rho_s \hat{u}_{fbt-1}}_{\text{lag term}} + \nu_{fbt}$$

firm unit	TIN [1]	ISL [2]
$\hat{\rho}_q$, lending	0.72*** (0.00)	0.75*** (0.00)
$\hat{\rho}_s$, persistence	0.24*** (0.00)	0.19*** (0.00)
N obs.	90,547	286,361

▸ magnitudes

Data: relationship lifecycle

▸ data construction ▸ Ioannidou and Ongena (2010 JF)

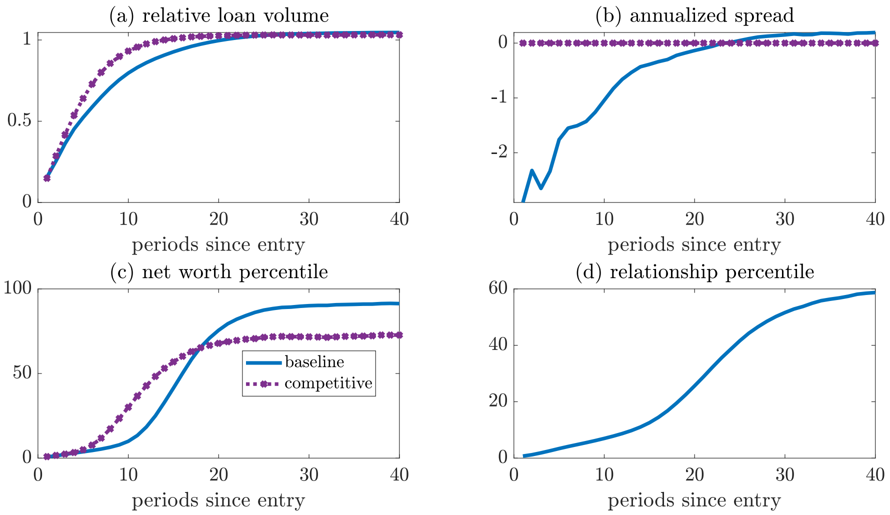


Exercise: match similar loans in Y-14Q, compare terms for switching and non-switching

1. "honeymoon:" upon switching banks, firms pay lower interest rates
2. "holdup:" over time with bank, firms end up paying higher rates

▸ back to intro ▸ "tighter" matching

Model validation: relationship lifecycle in the model



Additional facts on relationships and banking

Fact 1: Loan spreads widen over relationship (above)

- pronounced life cycle, $\approx$ 3-5 years to reach avg. n, s, loan volume

Fact 2: Switching lenders is relatively infrequent ▸ details

- empirically, switches account for $\approx$ 3% (40%) of total (new) loans
- model: measure switch as $\max\left\{\frac{q\ell'}{L'} - s, 0\right\} > 0$, share = 7.3%

Fact 3: Loan markets are highly concentrated ▸ details

- median loan market Herfindahl index $\approx$ 30%; model much lower ▸ details
- *issue:* distribution of banks fairly compressed ▸ distributions

Pricing outcomes across model variants

		baseline	competitive	% diff rel to base
effective IR (pp, ann.)	$\tilde{R}$	4.69	3.24	-31.0
$=$ average rate	R	4.53	3.24	-28.5
$+$ covariance term	$\mathbb{C}_{\mu}(r, s)$	0.08	-	-
$+$ variance term	$\mathbb{V}_{\mu}(r)$	-0.01	-	-
loan-weighted avg. IR	$\overline{R}_L$	4.59	3.24	-29.6
loan volume	L'	0.296	0.300	1.4

Higher effective IR, mostly driven by average rate.

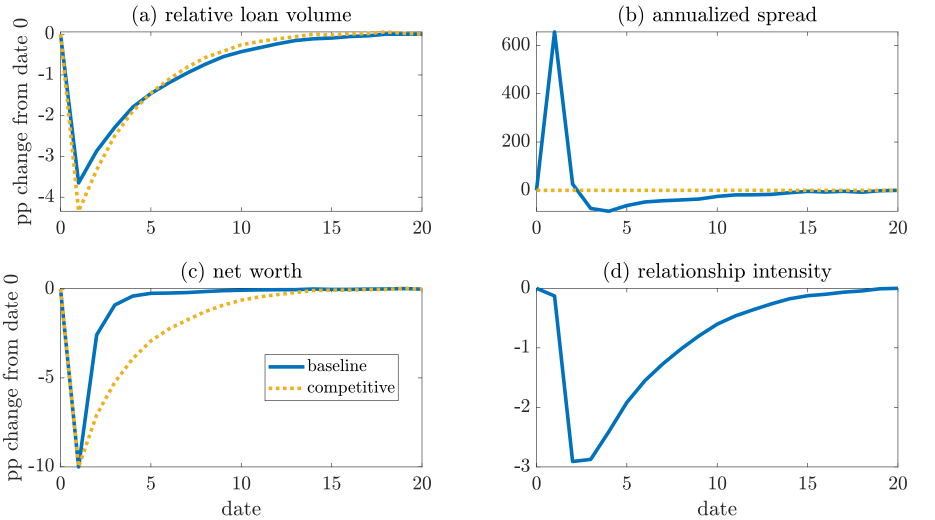
Banking industry moments across model variants

	baseline	competitive	% diff rel. to base
average net worth	0.029	0.027	-3.7
standard deviation, net worth	0.005	0.005	1.3
standard deviation, relationships	0.176	-	-
correlation, net worth and spread	0.10	0.00	-100.0
correlation, relationships and spread	0.12	-	-
correlation, net worth and relationships	0.97	-	-

- high corr. between n and s transmits to spreads, tempered by persistent z shocks
    - ρ_q critical for this effect
- more competitive model $\implies$ less net worth on average ("franchise value effect")

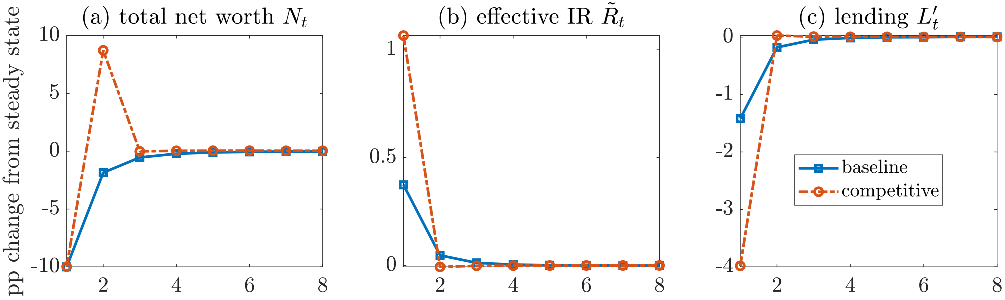
Idiosyncratic shock to net worth of one bank

▸ s shock



Experiment: wipe out 10% of n at date 1 at bank with $(n, s) = (\bar{n}, \bar{s})$ from indicated economy

Dynamic experiment 1: aggregate bank net worth shock



Shock: wipe out 10% of net worth at each bank

- more persistent drag on net worth, interest rates, lending and dividends
- why? mute price response on impact to preserve CC for future

Idiosyncratic vs. aggregate shocks to net worth

Idiosyncratic shock: *individual banks* recapitalize faster in our baseline model than the competitive model

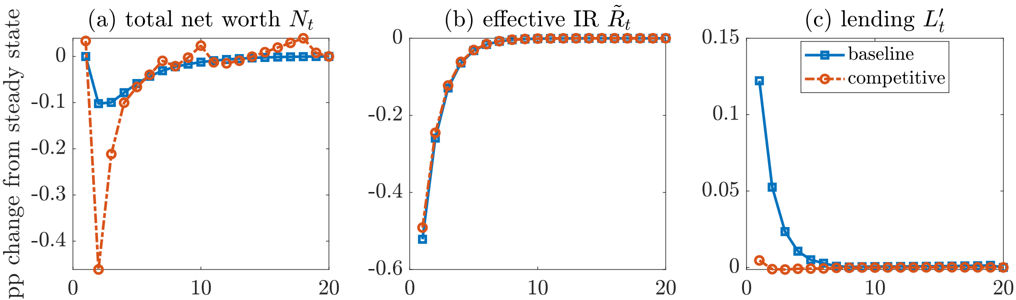
Aggregate shock: *banking sector* recpaitalizes more slowly

Why do net worth responses across models "switch" when moving from idiosyncratic to aggregate shocks?

- less n, more elastic lending in competitive case (no individual IR margin)
- widespread spread hikes push up R, limit "price punishment" in baseline
- drop in L' makes it less costly for banks to maintain loan share
- combined: the dynamic cost of hurting relationships looms relatively large

Dynamic experiment 2: real interest rate shock

▸ TFP shock



Shock: drop $\bar{r}$ from 2% to 0%, persistence of $\rho_{\bar{q}} = 0.5$

- allows substitution into external financing, $\downarrow$ need for internal funds $\Rightarrow n \downarrow$
- strongest response in baseline model $\rightarrow$ implications for MP transmission?

Conclusion and future directions

Model: imperfect competition via relationships + financial frictions

- CC $\implies$ today's pricing decisions affect tomorrow's loan demand
- frictions $\implies$ banks can expend CC to smooth shocks
- aggregate demand depends on joint distribution of prices and relationships

Quantitative analysis: estimate demand parameters using micro-data

- **cross-section:** endogenous life cycle, corr. b/w net worth, markups, CC
- **dynamics:** sluggish recovery, muted impact, greater persistence

On deck: hone in on validation, then study dynamics and implications for financial stability

Thank you!

What we contribute to the literature

▸ Full ▸ back

We combine insights from 2 main literatures:

1. **financial accelerator / banking frictions:** e.g. BGG (99), Kiyotaki and Moore (97), Corbae and D'Erasmo (21)
   - novel competition structure with long-horizon pricing
   - heterogeneous bank "block" integrates with economy-wide loan market
2. **customer capital / habits:** e.g. Gourio and Rudanko (14), Ravn et al (06)
   - banks internalize habit formation, relationships pin down demand elasticity

towards a quantitative framework with credit market relationships.

- **empirics:** e.g. Rajan and Petersen (94), Atkeson et al. (19), Drechsler et al. (17)
  - **examples:** asymmetric information (Berger & Udell (1995), Berlin & Mester (1999)), hold-up costs (Ioannidou & Ongena, (2010)), imperfect competition: (Petersen & Rajan (1995))
- **equilibrium models:** e.g. Boualam (18), ...

Banks' loan pricing Euler equation slide:bank-problem-mainback

$$\underbrace{\Pi_t + \overbrace{\bar{q}\pi\rho_q\mathbb{E}_t\sum_{i=1}^{\infty}(\bar{q}\pi(\rho_q+\rho_s))^i\Pi_{t+i}}^{\text{"}\rho\text{ term"}}}_{\text{discounted lifetime net profits}} = \underbrace{\overbrace{\epsilon^{-1}(q\ell', q)}^{\text{"}\phi\text{ term"}} \times \frac{\bar{q}}{q_t}\pi\mathbb{E}_t\left[(\psi^{-1})'(e_{t+1})\right]}_{\text{excess return (from today's market power)}}$$

$$\text{where } \Pi_t = \underbrace{\frac{\bar{q}}{q_t}\pi\mathbb{E}_t\left[\left(\psi^{-1}\right)'(e_{t+1})\right]}_{\text{loan return}} - \underbrace{\left(\psi^{-1}\right)'(e_t)}_{\text{funding cost}} + \underbrace{\lambda_t(1-\chi)}_{\text{SV ease cap. req.}}$$

- Π_t: date t flow (economic) profits
- "fixed" CC ($\rho_q \to 0$) $\implies$ static only $\implies$ ρ term $\to 0$ ▸ monopoly
- no CC ($\phi \to 0$) $\implies$ perfect competition $\implies$ ϕ term and ρ term $\to 0$ ▸ competitive

Evolution of bank distribution

Let the distribution of banks over states be denoted $m(x)$. This distribution evolves according to

$$T^* m(n', s') = \pi \int \mathbf{1}\left[n' = z' g_\ell(n,s) + g_a(n,s), s' = (1-\rho) g_q(n,s) g_\ell(n,s) + \rho s\right] f(z') dm(n,s)$$

for continuing firms and

$$T^* m(x) = (1-\pi)\overline{m}(x),$$

where $\overline{m}(x)$ is the distribution of entering banks (0 net worth, 0 customer capital)

Back

Competitive model

▸ Back

- borrowers are indifferent about loan sourcing: care only about L'

$$L'(R) = \kappa w \left[\frac{\alpha / w}{1 + \kappa(\overline{q}R - 1)} \right]^{\frac{1}{1-\alpha}}$$

Note that this is the same as baseline with $R = \tilde{R}$

- banks choose ℓ' taking $q = 1/R$ as given:

$$\begin{aligned}
V(n, z) \quad &= \quad \max_{e, \ell', d'} e + \overline{q}\pi\mathbb{E}\left[V\left(n', z'\right)\right] \\
\text{subject to: [budget]} \quad & \quad q\ell' + \psi(e) \leq n + z + \overline{q}^d d' \\
\text{[net worth dynamics]} \quad & \quad n' = \ell' - d' \\
\text{[capital requirement]} \quad & \quad \overline{q}^d d' \leq (1 - \chi) q\ell'
\end{aligned}$$

Pure monopolist model

Back

Market power but no notion of customer capital

- aggregate demand same as competitive model (or baseline with $R = \tilde{R}$)

$$L'(R) = \kappa w \left[\frac{\alpha / w}{1 + \kappa(\overline{q}R - 1)} \right]^{\frac{1}{1-\alpha}}$$

- banks choose $q = 1/R$ taking $L'(q)$ as given:

$$\begin{aligned}
V(n, z) \quad &= \quad \max_{e,q,L',d',\delta'} e + \overline{q}\pi\mathbb{E}\left[V\left(n', z'\right)\right] \\
\text{subject to: [budget]} \quad & \quad qL' + \psi(e) \leq n + z + \overline{q}^d d' \\
\text{[net worth dynamics]} \quad & \quad n' = L' + a \\
\text{[capital requirement]} \quad & \quad \overline{q}^d d' \leq (1 - \chi) qL' \\
\text{[market power]} \quad & \quad L' = L'(q)
\end{aligned}$$

Interpreting the magnitudes of ϕ and ρ

back to ϕ back to ρ

	eqm policies	10% lending cut
adj. costs, median (n, s) bank (pp of lending)	0.004	0.370
adj. costs, aggregate (pp of total lending)	0.019	0.321

Adjustment costs on the order of

- 2 bps of total lending at equilibrium policies
- 32 bps of total lending with a 10% cut to these lending policies

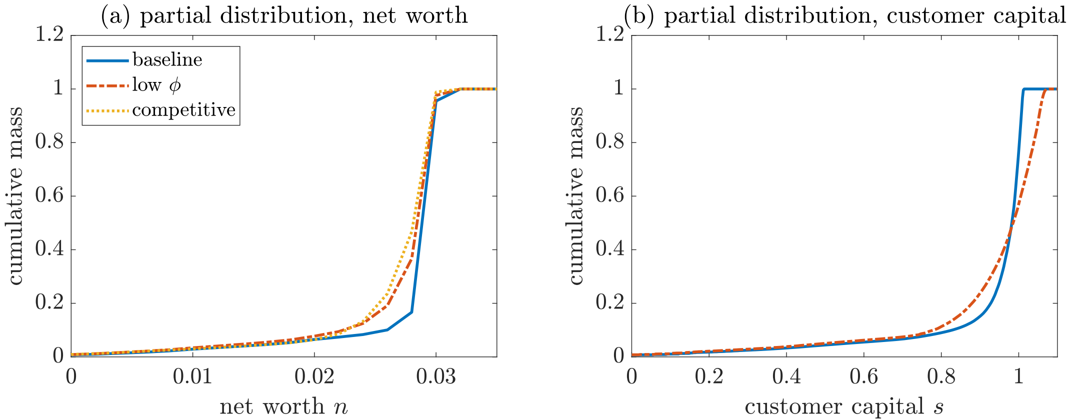
Summary of calibration

▸ back

	Description	Value	Target / Reason	Data	Model
Panel A: Externally Assigned Parameters					
$\bar{q}$	discount factor	0.9951	annualized risk-free rate = 2%		
χ	capital requirement	8%	Basel regulation		
π	bank survival rate	0.9928	quarterly bank exit rate = 0.72%		
$\overline{w}$	wage	1	normalization		
ν	deposit liquidity premium	0.0004	annualized liq premium = 17 bps, $\overline{q}^d = \overline{q}(1+\nu)$		
α	returns to scale	0.75	profit share 20% - 30%		
Panel B: Directly Estimated Parameters					
ϕ	lending share adj. costs	0.084			
ρ_s	persistence of relationships	0.21	averages of estimates		
ρ_q	lending effect on relationships	0.74			
Panel C: Internally Calibrated Parameters					
κ	working capital constraint	0.958	business debt to GDP ratio	71.5%	71.4%
$\bar{\psi}$	equity issuance cost curvature	0.0094	gross equity issuance / NW	1.1%	1.1%
ρ_z	persistence, net worth shocks	0.262	net dividend payouts / NW	5.8%	6.6%
σ_z	std. dev., net worth shocks	0.0026	average net interest margin	3.3%	2.7%
			average bank leverage	91.5%	91.0%

Distributions across models

back

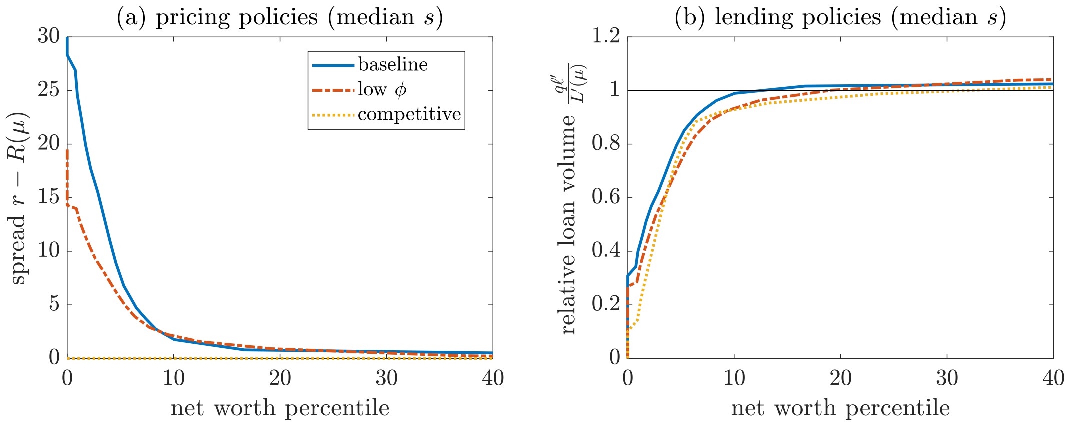


All models have lots of compression in both net worth and customer capital

- low ϕ: more dispersion in both n (to left) and s distributions
- low ρ_q: harder to build up s $\implies$ more mass to left

Policies by net worth

back

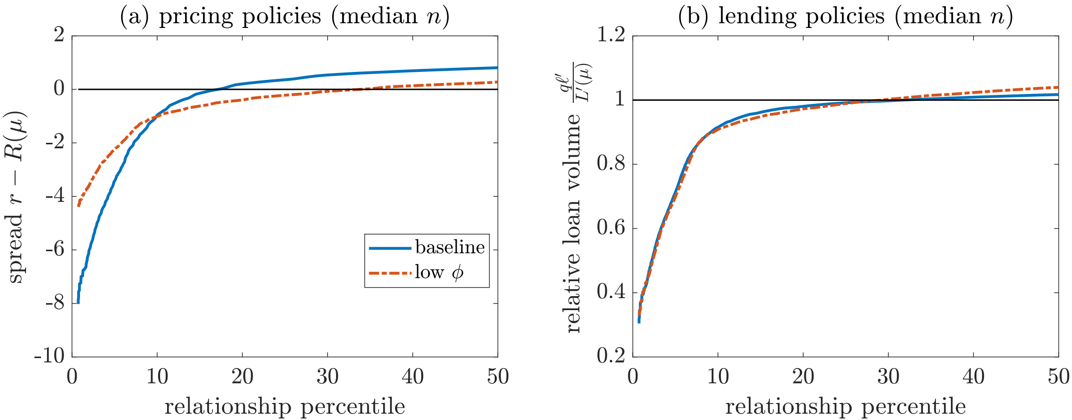


Low $n \implies$ price "above market" to cut loan supply when net worth falls

- effect strongest in least competitive models (high ϕ, low ρ_q)

Policies by relationship intensity

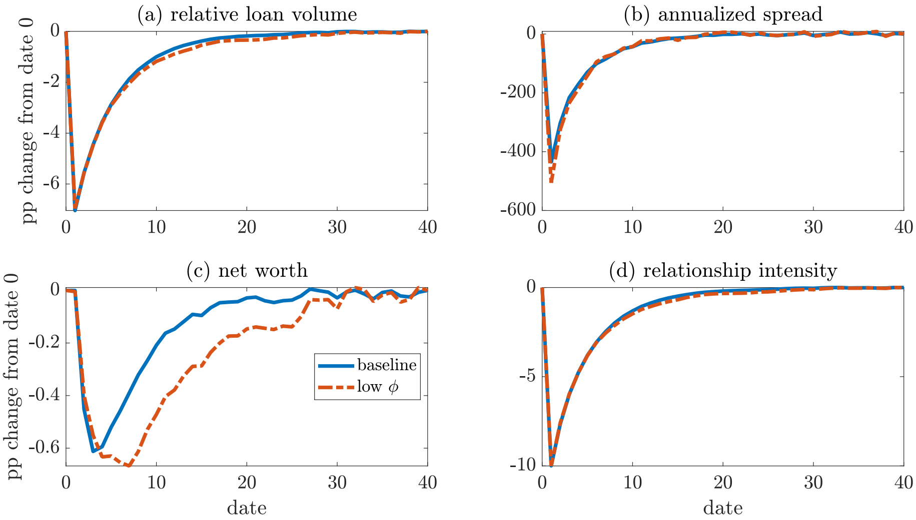
▸ back



- banks with no existing relationships need to price to attract
- doesn't immediately translate into loan volume given demand system

An idiosyncratic shock to a bank's relationship

▸ back to n shock



Experiment: wipe out 10% of s at date 1 at bank with $(n, s) = (\bar{n}, \bar{s})$ from indicated economy

Procedure: switching vs. non-switching loans

back

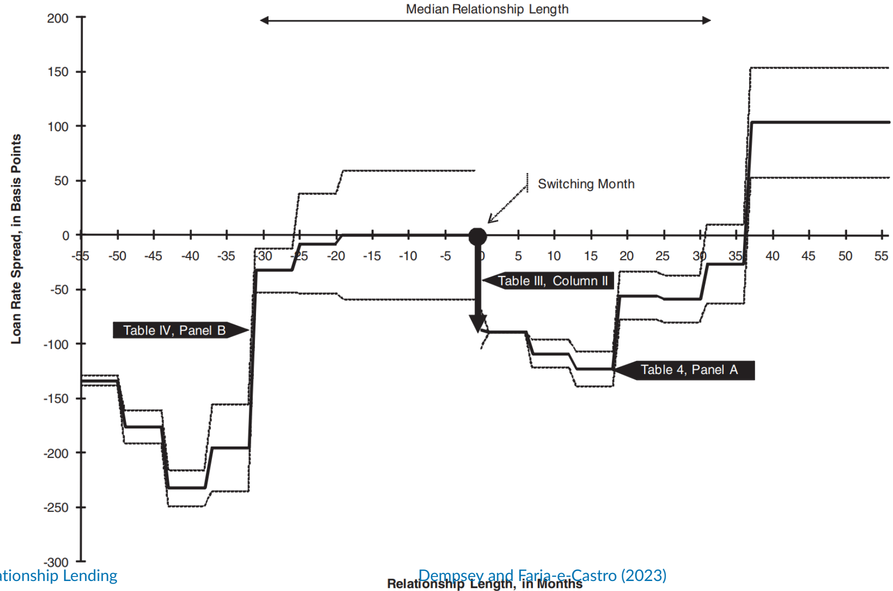
Goal: match switching vs. non-switching loans on a set of observables and compare spreads, following Ioannidou and Ongena (2010)

1. **identify switches:** new loan from bank j from whom firm i has not borrowed in past $N = \{4, \mathbf{8}, 12\}$ quarters (may overstate: unbalanced panel, 1$ M threshold, loan sales)
2. **form matched pairs:** match switching and non-switching loans on: (i) quarter; (ii) bank; (iii) quarter of origination; (iv) loan maturity; (v) loan size (percentile); (vi) default probability (vigintile); (vii) loan type; (viii) variable v. fixed IR
   - *robustness*: tighter matching on loan size, default probability, and add: (ix) NAICS 2; (x) firm size (percentile); and (xi) firm HQ CBSA
   - *tradeoff*: tightness of matching vs sample size
   - more non-switches than switches $\implies$ resample non-switches to pair each switch
3. **compare spreads:** for each matched pair k, regress

$$\text{spread}_{kt} = \sum^{Q} \alpha_q \mathbf{1}[t = q] + \varepsilon_{kt} \text{ where } q \text{ is time since switch}$$

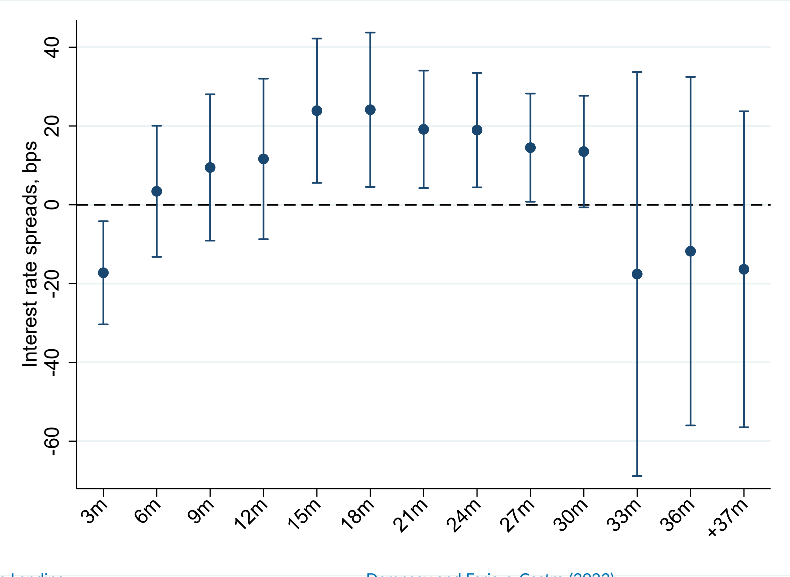
Ioannidou and Ongena (2010 JF) Figure 4

back



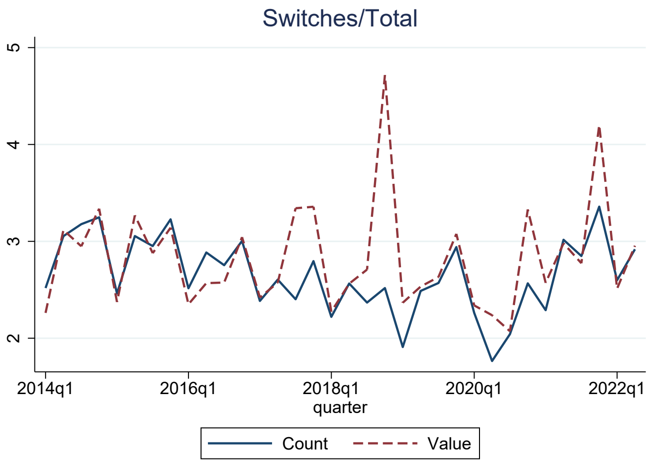
Spreads after switching: tighter matching criterion

back



Fact 1: switching is infrequent

back



Source: Y-14Q. Switches defined in terms of number of loans.

Loan is a switch if it's (i) new and (ii) from a bank with which the firm has had no relationship in past 3 years

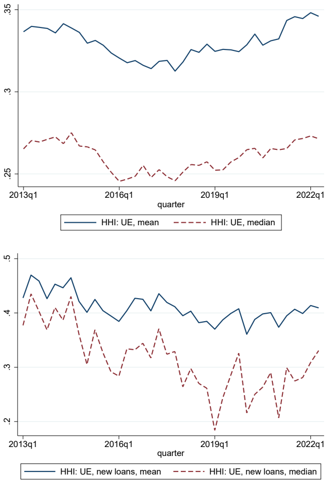
- definition follows Ioannidou & Ongena (2010)

Nature of the data $\Longrightarrow$ likely an upper bound:

- unbalanced panel: do not observe loans w/ balance < \$1M
- no small firms or small banks, where switching is less likely

Fact 2: loan markets are concentrated

▸ back



Compute Herfindahl-Hirschman Indices for local lending markets

- loan market defined as CBSA-quarter pair k
- The HHI is defined as

$$HHI_k = \sum_{i=1}^{N_k} \mu_{i,k}$$

  where N_k is the number of banks present in market k and $\mu_{i,k}$ is the market share of bank i

- The DOJ considers an industry with a HHI above 0.18 to denote a "highly concentrated industry"

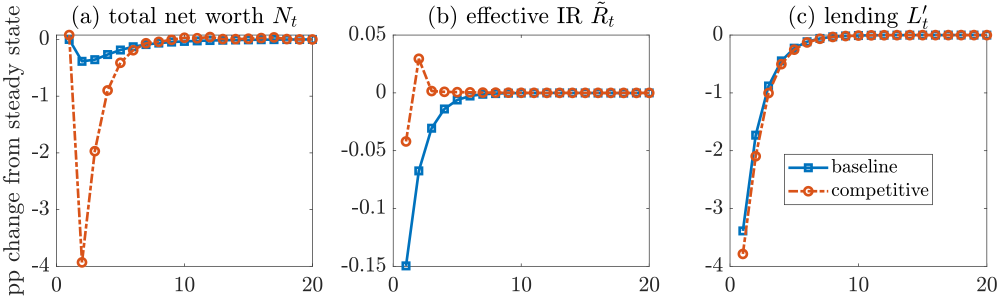
Estimation details for ϕ

▸ back

Data: Y-14Q, schedule H.1

- Focus on new loans only (originated in the last 8 quarters)
- Criteria for inclusion:
  - Non-syndicated
  - Non-missing TIN with US address
  - Not in NAICS 52 (finance) or 92 (government)
  - Loan has non-negative interest rate and committed exposure
- Three definitions of a "firm":
  1. Baseline: TIN
  2. Degryse et al. (2019): ISLT, quarter $\times$ CBSA $\times$ size decile $\times$ 3-digit NAICS
- All standard errors are clustered at the BHC level
- X_{bt} are bank controls: size, leverage, loans/assets, deposits/liabs., liquidity

Dynamic experiment 2: aggregate TFP shock



Shock: 1% drop in TFP, persistence $\rho_z = 0.5$

- drop in demand for loans $\implies$ net worth drops in both cases
- competitive: $n \downarrow$ causes constraints to bind and rates overshoot
- baseline: banks "fight" against drop by lowering rates further