A Quantitative Analysis of Bank Lending Relationships

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What are the macro effects of relationship lending?

Large empirical and theoretical literatures on **relationship lending** in banking

- information advantage of banks (Diamond 91; Petersen & Rajan 94; Berger & Udell 95)
- "informational lock-in" (Sharpe 90, Rajan 92)
- matters for macroprudential policy, monetary transmission... (Couaillier et al 23)

Data: lender switching is infrequent ($<$ 3.5% of total loan volume). Rates from new lenders start out favorable (5-10 bps *below* market), become less favorable (5-10 bps *above*).

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What are the consequences of relationship lending...

1. ...for banks across the industry (pricing, capital, risk,...)?
2. ...for how the economy responds to aggregate shocks (financial crises, TFP,...)?

This paper

Model: multiple lenders $+$ loan sourcing adjustment costs $\implies$ relationships

- banks internalize relationship formation $\Rightarrow$ dynamic pricing
- to banks, financial and relationship capital are complements

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- adjustment costs consistent with 4.1% long run reduction in credit

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Quantitative: lending relationships meaningfully alter aggregate dynamics, e.g.

- **amplifies negative *supply* shocks:** 36% *larger* drop in lending on impact
- **dampens negative *demand* shocks:** 22% *smaller* drop in lending on impact

What we contribute to the literature

We combine insights from 2 main literatures:

1. **financial accelerator/banking frictions:** Kiyotaki & Moore 97; BGG 99; Corbae D'Erasmo 21
   - novel competitive structure with long-horizon pricing
2. **customer capital / habits:** Ravn et al 06; Gourio & Rudanko 14; Gilchrist et al 17
   - banks internalize habit formation, relationships interact with financial constraints

towards a quantitative framework with credit market relationships.

- **empirics:** e.g. Rajan & Petersen 94; Drechsler, Savov & Schnabl 17; Atkeson et al 19
- **equilibrium models:** e.g. Boualam 18
- existing literature on bank customer capital mostly focused on the **liability** side
  - Egan, Hortacsu & Matvos 17; Drechsler, Savov & Schnabl 17; Li, Loutskina & Strahan 23

Outline

Model

- Banks: dynamic pricing and relationships
- Borrowers: sourcing loans across banks

Quantitative Analysis

- Mapping the model to the data
- Cross-section and model mechanics
- Validation
- Aggregate dynamics

Conclusion and Future Directions

Environment and markets

Time is discrete and infinite, $t = 0, 1, 2, \ldots$, and there are 2 types of agents:

- continuum of identical firms $i \in [0, 1]$ that hire inputs and borrow to produce
- continuum of heterogeneous banks $j \in [0, 1]$ fund loans w/ deposits and equity
- banks exit (and are replaced) at rate $1 - \pi$, face equity issuance costs, capital req.

Agents interact in imperfectly competitive **lending markets**

- firms form persistent relationships with banks that are costly to adjust

  $\Longrightarrow$ **differentiation:** care not only about loan terms, but also relationship intensity

Partial equilibrium: risk-free rate $\bar{r}$, wage $\bar{w}$, rental rate (user cost) of capital $\bar{uc}$, and deposit price $\bar{q}^d$ taken as given

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Banks' problem

$$
\begin{aligned}
V(n,s,z;\mu) \quad &= \quad \max_{q,e,n',\ell',d',s'} \psi(e) + \overline{q}\mathbb{E}_{z'}\left[\mathcal{V}(n',s',z';\mu)\right] \\
\text{subject to : [budget constraint]} \quad & \quad q\ell' + e \leq n + z + \bar{q}^d d' \\
\text{[net worth dynamics]} \quad & \quad n' = \ell' - d' \\
\text{[capital requirement]} \quad & \quad \chi q\ell' \leq q\ell' - \bar{q}^d d' \\
\text{[adjust for exit]} \quad & \quad \mathcal{V}(n,s,z;\mu) = (1-\pi)\psi(n) + \pi V(n,s,z;\mu) \\
\text{[loan demand]} \quad & \quad \ell' = \ell'(q,s;\mu) \\
\text{[relationship formation]} \quad & \quad s' = \rho_q \frac{q\ell'}{L'(\mu)} + \rho_s s
\end{aligned}
$$

$\mu(q,s)$ is the joint distribution of interest rates and relationships (consistency!)

Dynamic loan pricing

special cases

Define the net period return on a dollar loan

$$\Pi_t = \underbrace{\frac{\overline{q}}{q_t}\mathbb{E}_t\left[\frac{\psi'(e_{t+1})}{\psi'(e_t)}\right]}_{\text{loan return}} - \underbrace{1}_{\text{funding cost}} + \underbrace{\lambda_t(1-\chi)}_{\text{shadow value CR}}$$

The bank's optimal choice is given by

$$\underbrace{\Pi_t + \overbrace{\overline{q}\pi\rho_q\mathbb{E}_t\sum_{i=0}^{\infty}(\overline{q}\pi(\rho_q+\rho_s))^i\Pi_{t+1+i}}^{\text{dynamic relationships}}}_{\text{discounted lifetime net profits}} = \underbrace{\overbrace{\phi\frac{q}{\overline{q}}\frac{q\ell'}{L'}}^{\text{inverse elasticity}} \times \frac{\overline{q}}{q_t}\mathbb{E}_t\left[\psi'(e_{t+1})\right]}_{\text{excess return (from today's market power)}}$$

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Borrowers and loan demand

Working capital constraint motivates borrowing (Christiano, Eichenbaum & Evans 05)

Continuum of identical firms $\implies$ focus on representative borrower

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 $j \to$ weighted average of past loan shares
- $\mu(q, s)$: joint distribution of prices and relationships
  - borrower does not internalize current loan choices on $\{s'\}$, μ'
  - "external habits" in the spirit of Ravn, Schmitt-Grohe & Uribe 06
  - borrower doesn't care about bank's "name," j, $\implies$ recursive formulation

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

Borrower problem

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

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

subject to:

[working cap.] $\quad L' \geq \kappa(\overline{w}n + \overline{uc}k)$

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

2-part equilibrium loan demand system

▸ eqm definition

1. Bank-specific loan demand

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

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2. Aggregate loan demand

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

$$\underbrace{\tilde{R}(\mu)}_{\text{“effective” IR}} = \underbrace{R(\mu)}_{\text{average}} + \underbrace{\mathbb{C}_{\mu}(r,s)}_{\text{covariance}} - \underbrace{\frac{1}{2}\frac{\beta}{\phi}\mathbb{V}_{\mu}(r)}_{\text{variance}}$$

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Strategy for quantitative analysis

1. **externally assign** subset of “standard” macro parameters ▸ details

2. **directly estimate** key relationship parameters ϕ, ρ_s, and ρ_q

3. **internally calibrate** the rest to match bank financing and pricing moments

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

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Compare baseline to 3 alternatives in cross-section and aggregate dynamics

1. competitive ($\phi \to 0$)
2. low elasticity ($\uparrow \phi$)
3. low punishment ($\downarrow \rho_q$, with ρ_s adjusted up to keep S constant)

Estimating model-implied demand to retrieve ϕ

▸ sample details

[model] $$\frac{q\ell'(q,s;\mu)}{L'(\mu)} = 1 + (s - S) - \frac{\overline{q}}{\phi}[r(q) - R(\mu)]$$

[data] $$\frac{\ell_{fbt}}{L_{ft}} = \underbrace{\alpha_{ft} + \alpha_b + \Gamma X_{bt}}_{\text{FEs and controls}} + \underbrace{\zeta(r_{fbt} - r_{ft})}_{\text{spread term}} + \underbrace{u_{fbt}}_{s\text{ term}}, f = \text{firm}, b = \text{bank}$$

Issue 1: data: Need quantities and prices $\rightarrow$ use **FR Y-14Q** (Schedule H.1)

- quarterly, loan-level, detailed information on loan facilities $> \$1$M
- covers top 30-40 BHCs, 2013:Q1-2022:Q2

Issue 2: simultaneity: follow Amiti & Weinstein 18, estimate $r_{fbt} - r_{ft} = \gamma_{ft} + \gamma_{bt} + v_{fbt}$, (use $\hat{\gamma}_{bt}$ to instrument spread term, “pure” credit supply shock)

Estimating ϕ: results

	(1)	(2)	(3)	(4)
$r_{fbt} - r_{ft}$	-13.9***	-30.0***	-11.9***	-25.3***
	(4.0)	(3.7)	(1.7)	(7.9)
Firm identifier	TIN	TIN	ISL cell	ISL cell
Observations	57,833	57,731	221,674	221,637
Model	OLS	IV	OLS	IV

- TIN: tax identification number (individual firm)
- ISL: industry/size/location cell (Degryse et al. 19)
- IV specifications (2) and (4) $+$ 2% annualized interest rate $\implies \hat{\phi} \in [0.03, 0.04]$

Estimating ρ_s and ρ_q: approach and results

s terms subsumed into residual $u_{fbt} \implies$ use $\hat{u}_{fbt}$ to proxy s_{fbt}, estimate LoM via OLS:

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

Generated regressor: need to boostrap standard errors

	(1)	(2)
$\hat{\rho}_q$	0.77***	0.79***
	(0.01)	(0.01)
$\hat{\rho}_s$	0.18***	0.14***
	(0.01)	(0.01)
Firm identifier	TIN	ISL cell
Observations	36,651	132,290
R-squared	0.91	0.89

Internally calibrated parameters

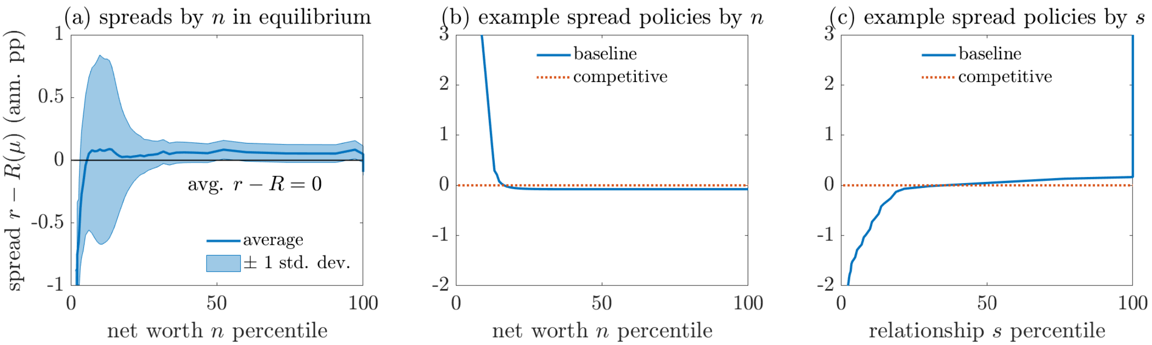
	Description	Value	Target / Reason	Data	Model
κ	Working capital constraint	0.750	Business debt to GDP ratio	71.5%	71.6%
$\overline{\psi}$	Equity issuance costs	0.267	Gross equity issuance / NW	1.1%	1.5%
ρ_z	Persistence of net worth shocks	0.446	Average net interest margin	1.8%	1.3%
σ_z	Variance of net worth shocks	0.005	Average bank leverage	87.7%	87.7%

- Net worth shock: $z_t = \rho_z z_{t-1} + \sigma_z \epsilon_t^z$
- Equity issuance costs: $\psi(e) = \begin{cases} e & \text{if } e \geq 0 \\ e(1+\overline{\psi}) & \text{if } e < 0 \end{cases}$

Outline

Equilibrium pricing policies

other specifications



Low $n \implies$ price "above market:" expend relationship capital to build financial capital

Low $s \implies$ price "below market:" sacrifice profits today to build for future

Financial and relationship capital are complements

details

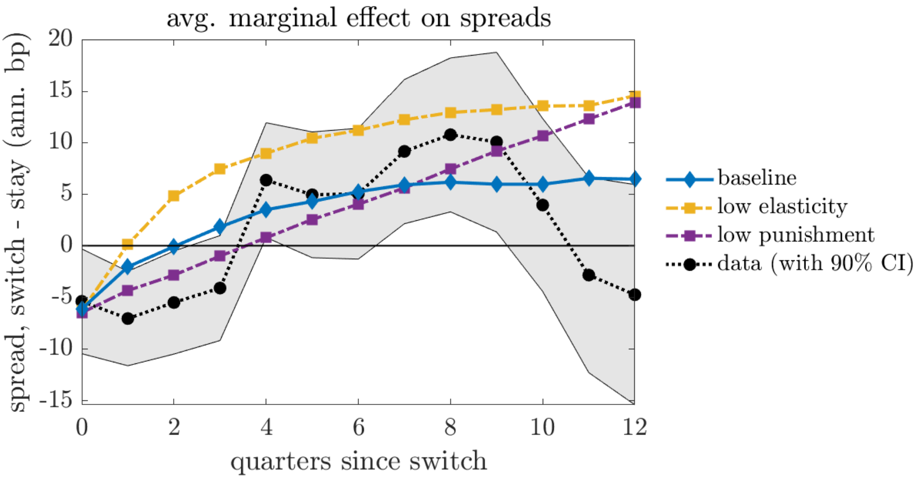
Pricing and industry outcomes across model variants

		baseline	comp.	low elas.	low pun.
			$\phi \to 0$	$\uparrow \phi$	$\downarrow \rho_q$
		(1)	(2)	(3)	(4)
effective interest rate (pp, ann.)	$\tilde{R}(\mu)$	3.08	1.94	4.34	3.65
$=$ average interest rate	$R(\mu)$	3.05	1.94	4.26	3.21
$+$ covariance term	$\mathbb{C}_\mu(r, s)$	0.04	-	0.09	0.48
$+$ variance term	$\mathbb{V}_\mu(r)$	-0.01	-	-0.01	-0.04
average net worth		0.087	0.077	0.075	0.076
coefficient of variation, net worth		0.28	0.70	0.22	0.38
coefficient of variation, relationships		0.16	-	0.15	0.48
correlation, net worth and relationships		0.84	-	0.86	0.78
correlation, relationships and spread		0.10	-	0.17	0.38

Outline

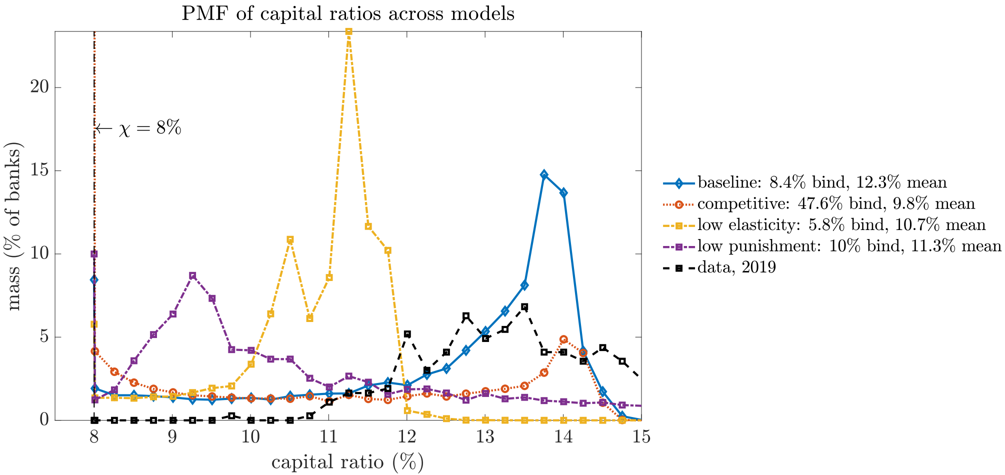
Validation: spreads over a relationship, model vs. data

▸ data



Key insight: baseline comes closest to full trajectory over life of relationship

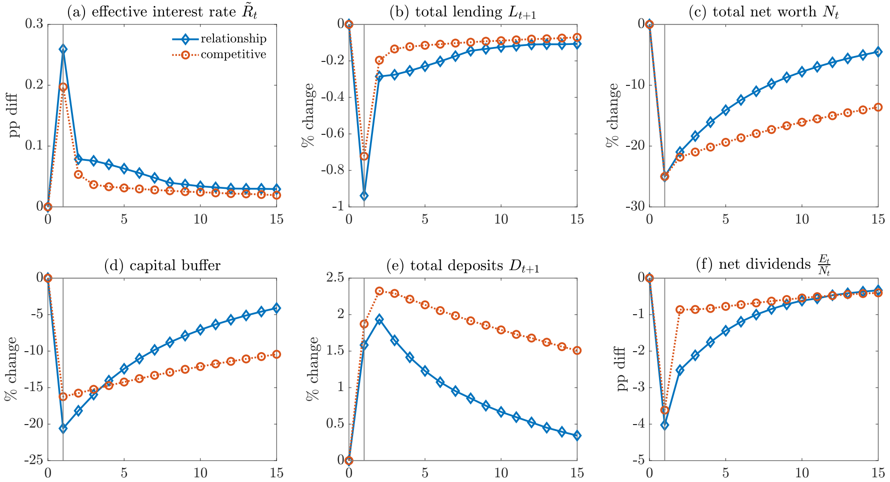
Validation: capital buffers, model vs. data



Key insight: balance franchise value alongside ability to self-insure

Outline

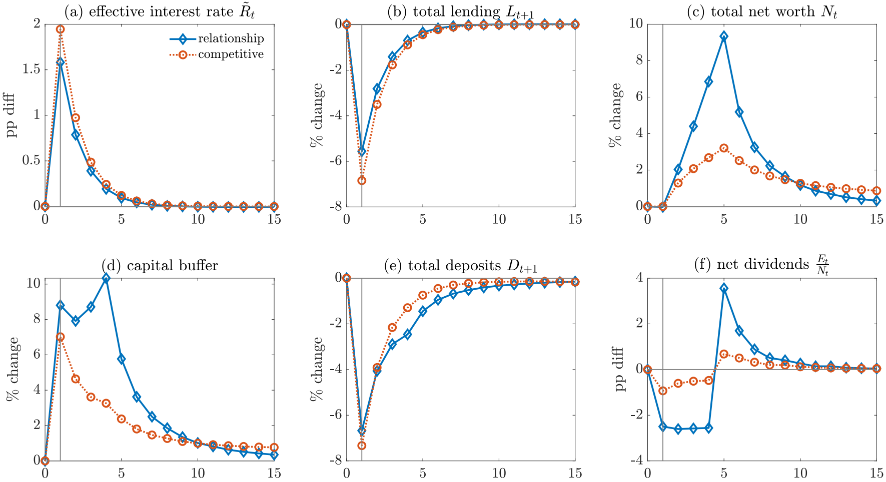
Financial crisis: destroy 25% of net worth at each bank



Relationships imply a sharper contraction on impact (36% larger drop in loan volume)

...but faster recapitalization (capital buffer half life 7 vs 20 periods).

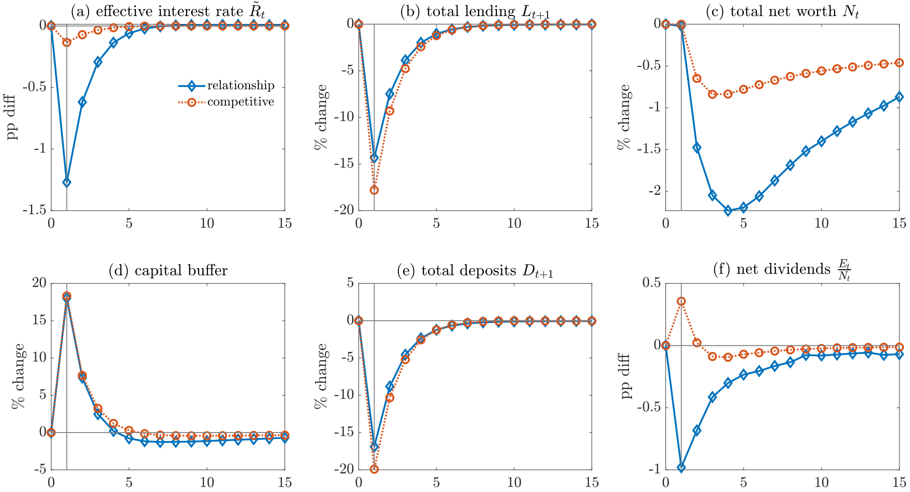
Funding squeeze: persistent rise in deposit rates



Stronger capital buffers, relationship building / maintenance

$\Longrightarrow$ weaker pass-through of rate increase (79% vs 97%).

Drop in TFP: negative credit demand shock



Opportunity to build relationships dampens demand-driven contraction.

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Conclusion and future directions

Aggregative, quantifiable, micro-disciplined model of lending relationships

- relationships $\implies$ today's pricing decisions affect tomorrow's loan demand
- frictions $\implies$ banks account for relationships in optimal responses to shocks
- estimate on micro data to discipline key novel relationship parameters
- validate against relationship pricing patterns, capital buffers
- differs relative to competitive benchmark in patterns of real outcomes vs financial stability in the wake of aggregate shocks

Where next?

- **financial stability:** entry and exit, endogenous crises and aggregate shocks
- **market structure:** concentrated (Canada) vs unconcentrated (US) banking industries
- **empirics:** Y-14 is the place we'd *least* expect to see this!

Outline

Appendix

Outline

Dynamic Loan Pricing: special cases

back

1. **Fixed Relationship Intensity:** $\rho_q = 0$, "local monopolist"

$$\Pi_t = \epsilon^{-1}(q\ell', q) \times \frac{\beta\pi}{q_t}\mathbb{E}_t\left[\psi'(e_{t+1})\right]$$

2. **Perfect Competition:** $\epsilon^{-1} = \rho_q = 0$

$$\Pi_t = 0$$

Equilibrium

▸ back ▸ details on distribution

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 distribution m given policies g; and (iv) consistency of distributions m and μ given g:

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

Evolution of bank distribution

back

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)

Summary of calibration

back

	Description	Value	Target / Reason	Data	Model
Panel A: Externally Assigned Parameters					
$\overline{r}_{\text{ann}}$	Annualized risk-free rate	2%	Quarterly discount price $\overline{q} = (1+\overline{r}_{\text{ann}})^{-\frac{1}{4}}$		
ν_{ann}	Deposit liquidity premium	0.17%	Quarterly deposit price $\overline{q}^d = (1+\overline{r}_{\text{ann}} - \nu_{\text{ann}})^{-\frac{1}{4}}$		
χ	Capital requirement	8%	Current US bank regulation		
π	Bank survival rate	0.9928	Quarterly bank exit rate of 0.72%		
α	Capital share	0.38	Profit share of 5%, capital share of 0.4		
η	Labor share	0.57	Profit share of 5%, labor share of 0.6		
$\overline{w}$	Wage rate	4.41	Normalization		
$\overline{uc}$	Ann. user cost of capital	9%	2% interest plus 7% depreciation rate		
$\overline{A}$	Aggregate TFP	1	Normalization		
Panel B: Directly Estimated Parameters					
ϕ	Lending share adj. costs	0.0362	Average of estimates		
ρ_q	Mkt. share impact on rels.	0.782	Average of estimates		
ρ_s	Persistence, relationships	0.159	Average of estimates		
Panel C: Internally Calibrated Parameters					
κ	Working capital constraint	0.755	Business debt to GDP ratio	71.5%	71.6%
$\overline{\psi}$	Equity issuance cost curvature	0.11	Gross equity issuance / NW	1.1%	1.1%
ρ_z	Persistence of net worth shocks	0.262	Net dividend payouts / NW	5.8%	3.7%
σ_z	Variance of net worth shocks	0.00264	Average net interest margin	1.8%	1.5%
			Average bank leverage	92.0%	91.5%

Calibration (I): externally set parameters

back

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$\overline{A}$	Aggregate TFP	1	Normalization

Competitive model

▸ back

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

$$L'(R) = \kappa w \left[\frac{A\left(\frac{\alpha}{\overline{\overline{uc}}}\right)^{\alpha}\left(\frac{\eta}{\overline{\overline{w}}}\right)^{\eta}}{1+\kappa(\beta R - 1)} \right]^{\frac{1}{1-\alpha}}$$

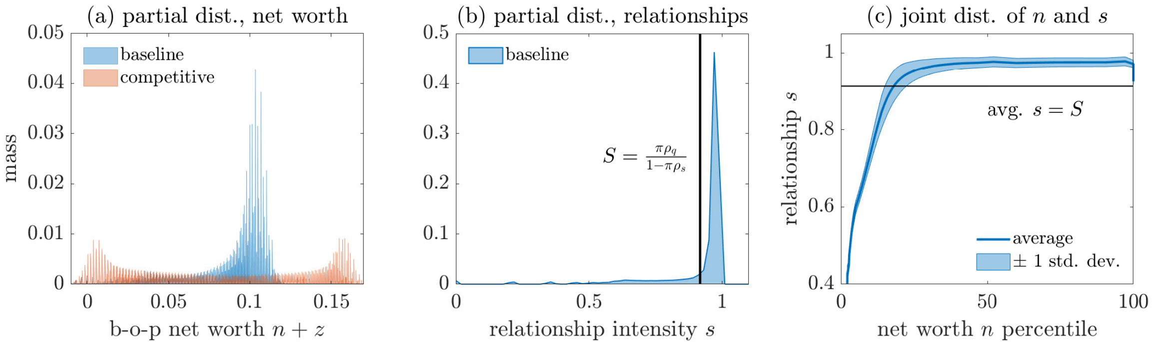
  Note that this is the same as baseline with $R = \tilde{R}$

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

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

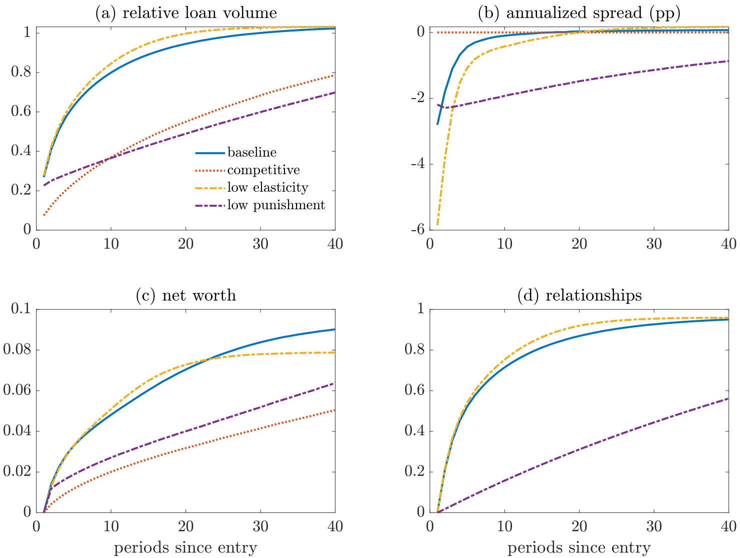
Distributions

▸ back



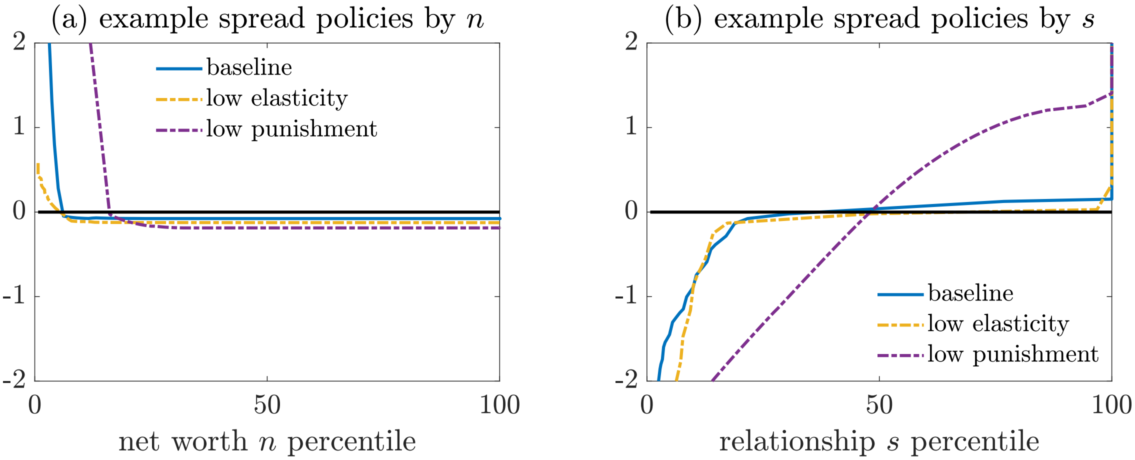
Relationship life cycle

▸ back



Policy functions: other specifications

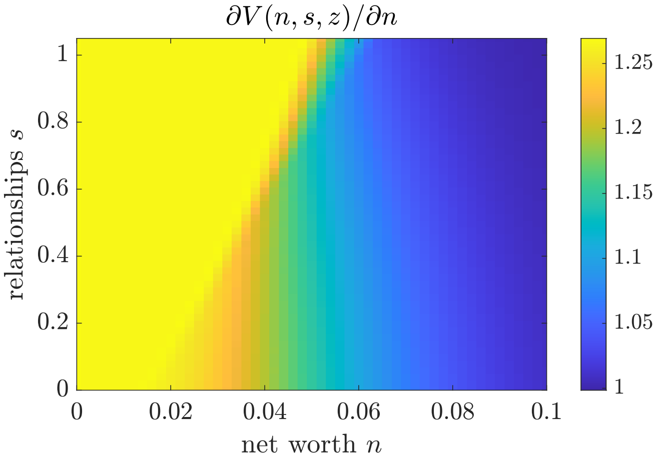
back



- Low elasticity: higher ϕ
- Low punishment: lower ρ_q

Complementarity of financial and customer capital

back



- Net worth valuable when customer capital is high
- Customer capital valuable when net worth is high

Outline

FR Y-14Q details

back

Data: FR Y-14Q, schedule H.1

- Focus on new loans only (originated in the last 4 quarters)
- Criteria for inclusion:
  - Non-syndicated
  - US dollars
  - Non-missing TIN with US address
  - Not in NAICS 52 (finance) or 92 (government)
  - Loan has positive interest rate and committed exposure
- Three definitions of a “firm”:
  1. Baseline: TIN
  2. Degryse et al 19: ISL, CBSA $\times$ size decile $\times$ 3-digit NAICS

FR Y-14Q details

▸ back

- Time period: 2013Q1-2022Q2
- 3.361 million distinct loans
- 242,568 distinct firms
- 41 distinct BHCs

Procedure: switching vs. non-switching loans

back

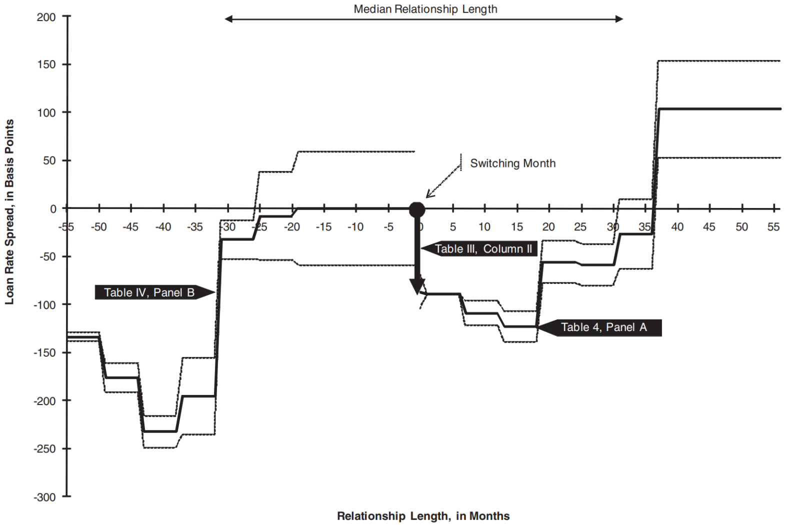
Goal: match switching vs. non-switching loans on a set of observables and compare spreads, following Ioannidou and Ongena (2010)

1. **identify switches:** new loan from bank j from whom firm i has not borrowed in past $N = 4$ 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 (percentile); (vii) loan type; (viii) variable v. fixed IR
   - more non-switches than switches $\implies$ resample non-switches to pair each switch
3. **compare spreads:** for the sample of matched pairs k, regress

$$\text{spread}_{kt} = \sum_{q=1}^{13} \alpha_q \mathbf{1}[\tau_{kt} = q] + \varepsilon_{kt} \text{ where } \tau_{kt} \text{ is time since origination}$$

Ioannidou and Ongena (2010 JF) Figure 4

back



Data on switching

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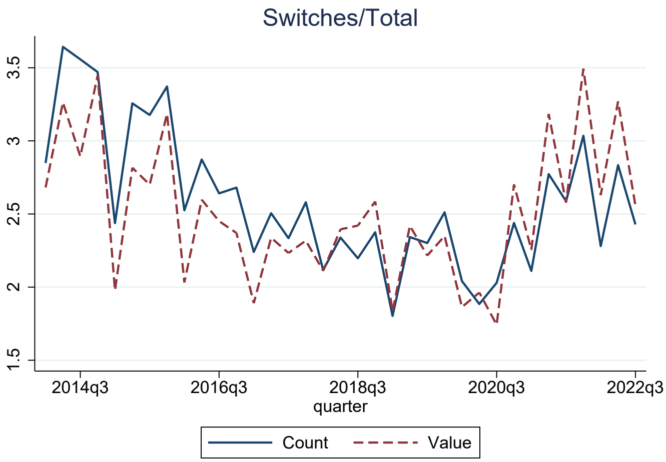


Source: Y-14Q. Switches defined in terms of number of loans.

Loan is a switch if it is new and from a bank with which the firm has had no relationship in past year

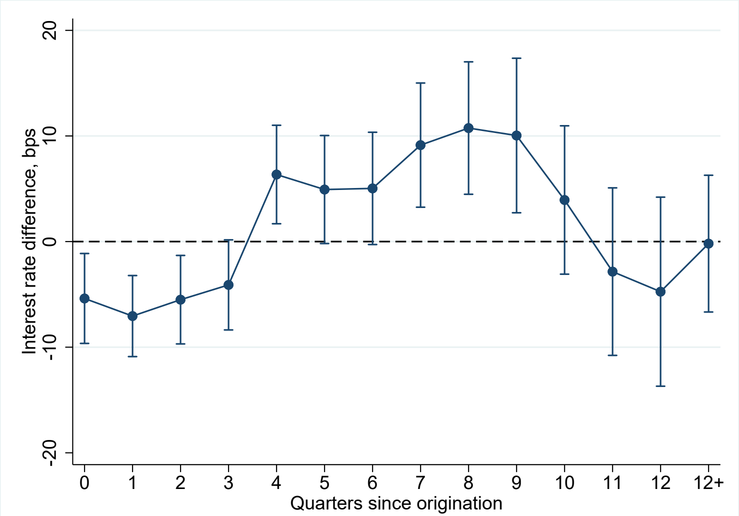
- definition follows Ioannidou & Ongena (2010)

Nature of data $\implies \sim$ *upper* bound:

- unbalanced panel: do not observe loans w/ balance < $1M
- no small firms or small banks, where switching is less likely
- loans may enter/exit panel for many reasons

Data: relationship life cycle

procedure details | 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