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*) after $\sim$ 1 year.

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

Estimate (directly) model-implied demand system to recover key relationship parameters

- adjustment costs consistent with 5.6% long run reduction in credit

Validate against “relationship life cycle” pricing patterns, capital buffer distribution

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

- **amplifies negative *supply* shocks:** 88 bp *larger* drop in lending on impact
- **dampens negative *demand* shocks:** 5.8 pp *smaller* drop in lending on impact
- *important*: very different than standard / static market power!

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
   We add: novel competitive structure with long-horizon pricing
2. **customer capital / habits:** Ravn et al 06; Gourio & Rudanko 14; Gilchrist et al 17
   We add: banks internalize habits, 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 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 $\overline{r}$, wage $\overline{w}$, rental rate (user cost) of capital $\overline{uc}$, and deposit price $\overline{q}^d$ 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

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

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Borrowers and loan demand

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

Continuum of identical firms $\implies$ focus on <u>representative borrower</u>

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 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

$$
\begin{aligned}
W(\mathcal{L};\mu) \quad = \quad & \max_{n,k,L',\mathcal{L}'=\{\ell'(q,s)\}} \underbrace{Ak^{\alpha}n^{\eta} - \overline{w}n - \overline{uc}k}_{\text{operating profits}} + \underbrace{L' - \int \ell(q,s)\mathrm{d}\mu(q,s)}_{\text{borrowing, net repayments}} \\
& - \underbrace{\frac{\phi}{2}L' \int \left(\frac{q\ell'(q,s)}{L'} - 1 - (s-S)\right)^2 \mathrm{d}\mu(q,s)}_{\text{loan share adjustment costs}} + \overline{q}\mathbb{E}\left[W(\mathcal{L}';\mu)\right]
\end{aligned}
$$

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

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

2. Aggregate loan demand

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

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

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Strategy for quantitative analysis

1. **externally assign** subset of "standard" macro parameters ▸ details
2. **directly estimate** key relationship parameters ϕ and ρ_q using FR-Y14Q data
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).

Compare baseline to 4 alternatives in cross-section and aggregate dynamics

- 3 "nested:" competitive ($\phi \to 0$), low elasticity ($\uparrow \phi$), low punishment ($\downarrow \rho_q$)
- fixed relationship: s a permanent type drawn from baseline

Estimating model-implied demand to retrieve ϕ and ρ_q

▸ sample details

Plug law of motion for relationships into bank-specific demand curve:

$$\frac{\ell_{f,b,t}}{L_{f,t}} = 1 - S_{f,t} - \frac{\bar{q}}{\phi}(r_{f,b,t} - r_{f,t}) + \rho_q \frac{\ell_{f,b,t-1}}{L_{f,t-1}} + \rho_s s_{f,b,t-1}$$

f is firm, b is bank, $L_{f,t} = \sum_b \ell_{f,b,t}$, $r_{f,t} = \sum_b \frac{\ell_{f,b,t}}{L_{f,t}} r_{f,b,t}$.

1. unobserved heterogeneity $\rightarrow$ firm-time (controls $S_{f,t}$) and bank FEs, bank controls
2. $s_{b,f,t-1}$ not directly measurable $\rightarrow$ use *length of relationship* $\tau_{f,b,t}$ as control, calibrate ρ_s internally (tight relationship to NIMs)
3. simultaneity $\rightarrow$ instrument for bank-specific credit supply shocks following Amiti and Weinstein (2018): estimate $r_{f,b,t} - r_{f,t} = \gamma_{f,t} + \gamma_{b,t} + v_{f,b,t}$, use $\hat{\gamma}_{b,t}$ as IV

Estimating ϕ and ρ_q: results

	(1)	(2)	(3)	(4)
spread, $r_{fbt} - r_{ft}$	-12.9***	-19.4***	-7.9***	-9.9**
	(1.6)	(2.7)	(0.8)	(4.0)
lagged loan share, $\ell_{f,b,t-1}/L_{f,t-1}$	0.62***	0.57***	0.56***	0.53***
	(0.01)	(0.01)	(0.01)	(0.01)
Firm identifier	TIN	TIN	ISL cell	ISL cell
Observations	74,121	60,332	259,972	229,764
Model	OLS	IV	OLS	IV

Standard errors in parentheses, clustered at the BHC level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

- TIN: tax ID number (individual firm); ISL: industry/size/location cell (Degryse et al. 19 – expands sample given reliance on multi-bank firms)
- average IV specs (2) and (4) $+$ 2% ann. IR $\implies$ $\hat{\phi} = 0.068$ and $\rho_q = 0.548$

Internally calibrated parameters

	Description	Value	Target / Reason	Data	Model
κ	Working capital constraint	0.755	Business debt to GDP ratio	71.5%	71.5%
ρ_s	Persistence of relationships	0.427	Average net interest margin	1.8%	1.3%
$\overline{\psi}$	Marginal equity issuance cost	0.750	Gross equity issuance / NW	1.1%	1.9%
ρ_z	Persistence of net worth shocks	0.450	Net dividend payouts / NW	5.8%	1.1%
σ_z	Std. dev. of net worth shocks	0.006	Average bank leverage	87.7%	87.4%

- Net worth shock: $z_t = \rho_z z_{t-1} + \sigma_z \epsilon_t^z$
- Equity issuance costs: $\psi(e) = e$ if $e \geq 0$, $\psi(e) = (1 + \overline{\psi})e$ if $e < 0$
- ρ_s consistent with $1 - S = 0.056$, key for NIM

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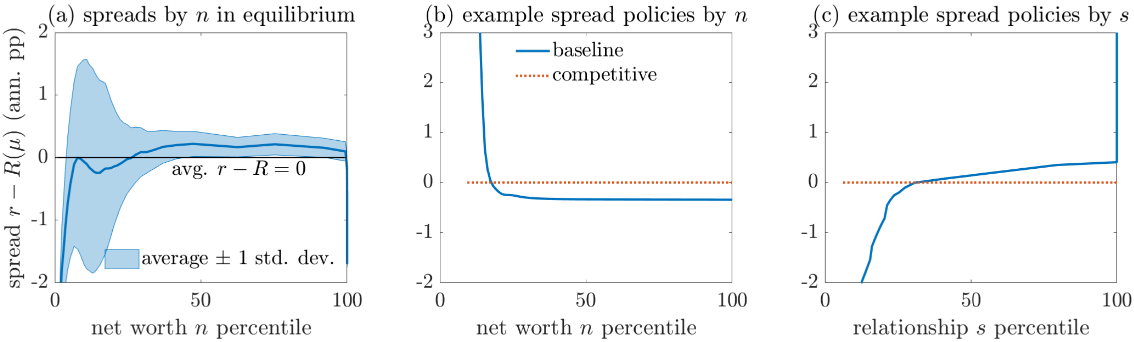
Equilibrium pricing

▸ 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. $\phi \to 0$	low elas. $\phi \uparrow$	low pun. $\rho_q \downarrow$	fixed rel. $\bar{s}$
		(i)	(ii)	(iii)	(iv)	(v)
effective interest rate (pp, ann.)	$\tilde{R}(\mu)$	3.65	2.03	4.71	4.39	3.61
$=$ average interest rate	$R(\mu)$	3.55	2.03	4.54	3.75	3.60
$+$ covariance term	$\mathbb{C}_\mu(r, s)$	0.10	-	0.18	0.68	0.04
$+$ variance term	$\mathbb{V}_\mu(r)$	-0.01	-	-0.02	-0.05	-0.02
loan volume	$L'(\mu)$	0.68	0.72	0.65	0.66	0.68
average net worth		0.090	0.096	0.079	0.078	0.104
coefficient of variation, net worth		0.33	0.77	0.28	0.41	0.30
coefficient of variation, relationships		0.24	-	0.22	0.48	0.24
correlation, net worth and relationships		0.89	-	0.89	0.76	-0.05
correlation, relationships and spread		0.59	-	0.70	0.90	0.66
correlation, net worth and spread		0.35	-	0.46	0.48	-0.60

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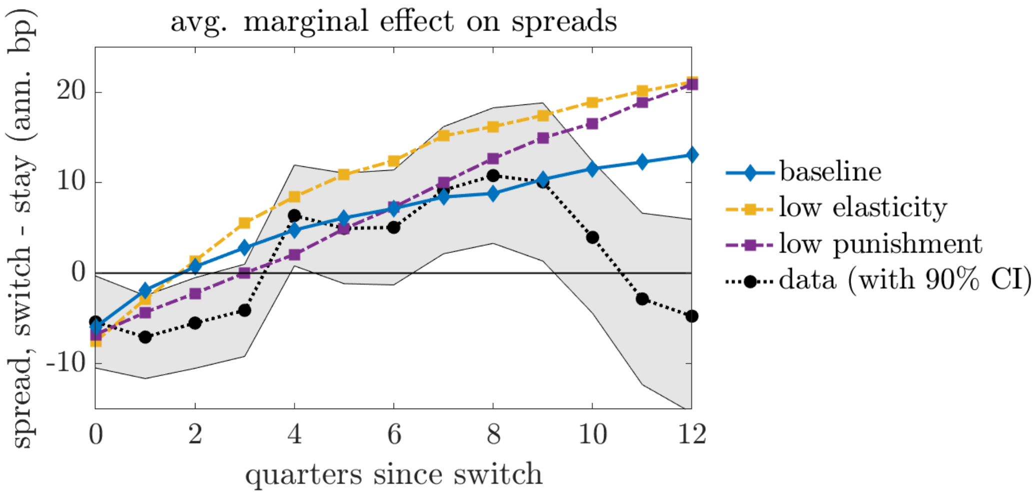
Validation: spreads over a relationship, model vs. data

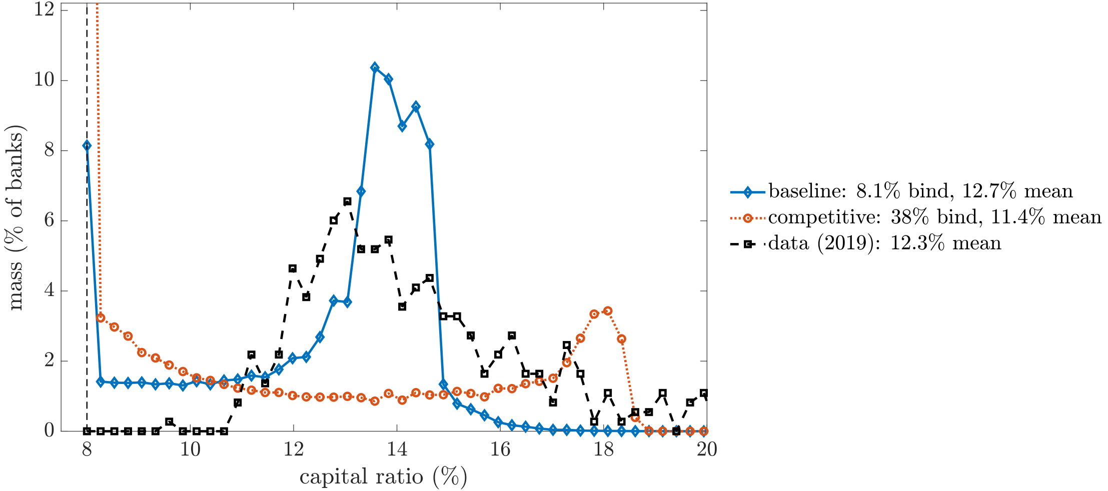
▸ data



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

Validation: capital buffers, model vs. data

▸ alternate models



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

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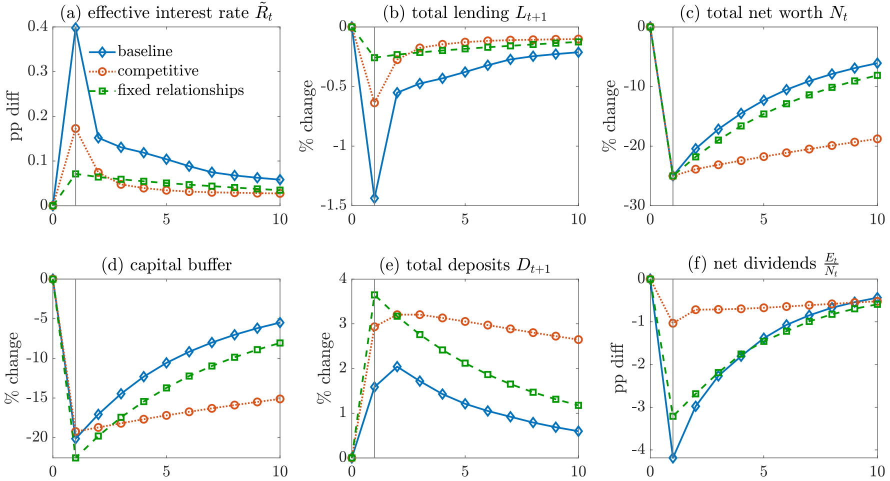
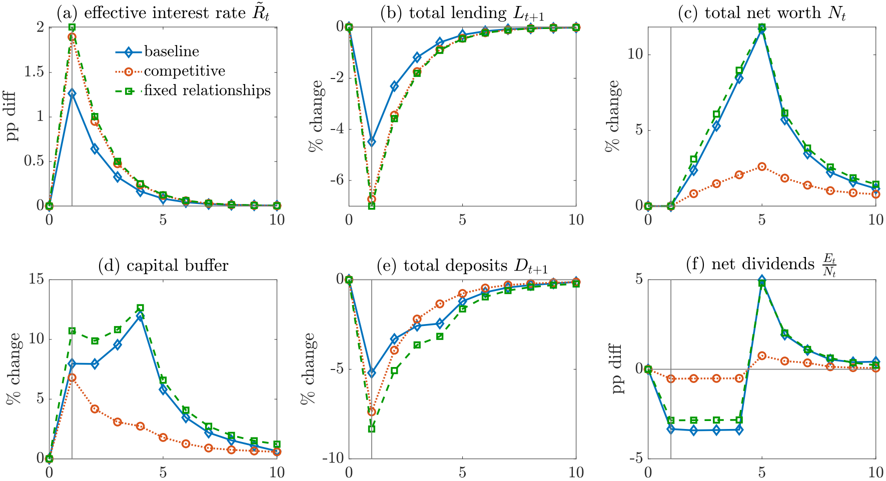
Financial crisis: destroy 25% of net worth at each bank



Relationships exacerbate contraction on impact (88 bp larger drop in loan volume rel. to competitive), but speed recapitalization (capital buffer half life 6 vs 16 quarters).

Fixed relationship case: larger capital buffers (high franchise value) dampen shock.

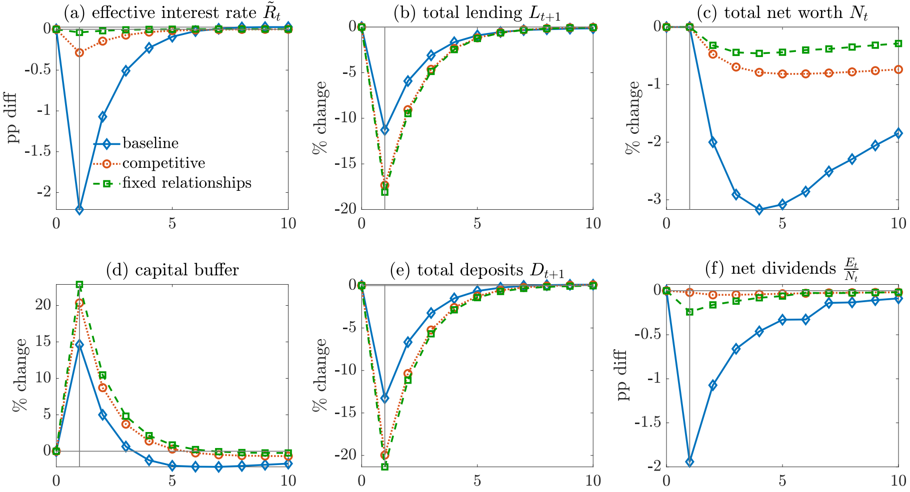
Funding squeeze: persistent rise in deposit rates



Stronger capital buffers, relationship maintenance $\implies$ weaker rate pass-through (64% vs 91%).

Fixed relationship case more like competitive: despite market power, dynamics absent

Drop in TFP: negative credit demand shock



Opportunity to build relationships dampens demand-driven contraction.

Outline

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 novel relationship parameters
- validate against relationship pricing patterns, capital buffers
- differs relative to competitive and static market power alternates 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

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Model

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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)

Externally calibrated parameters

back

	Description	Value	Target / Reason
$\overline{r}_{\text{ann}}$	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	3.78	Normalization
$\overline{uc}$	Ann. user cost of capital	9%	2% interest plus 7% depreciation rate
$\overline{A}$	Aggregate TFP	1	Normalization

Competitive model

back

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

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

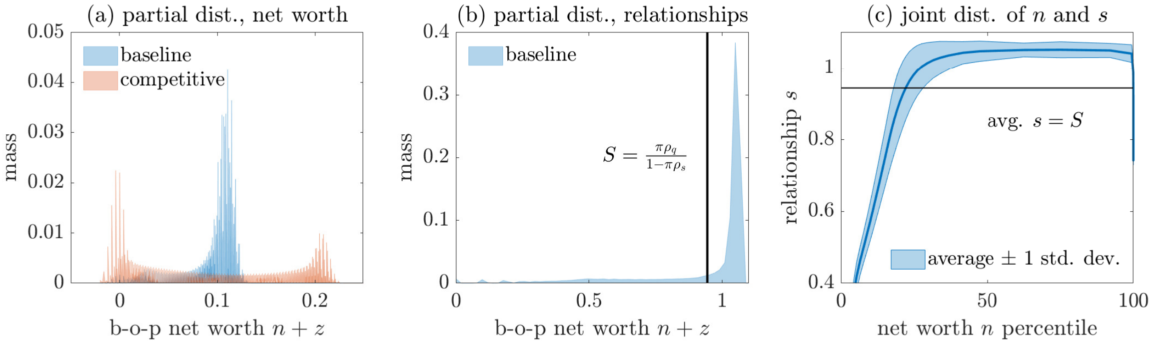
  Note that this is the same as baseline with $R = \tilde{R}$

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

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

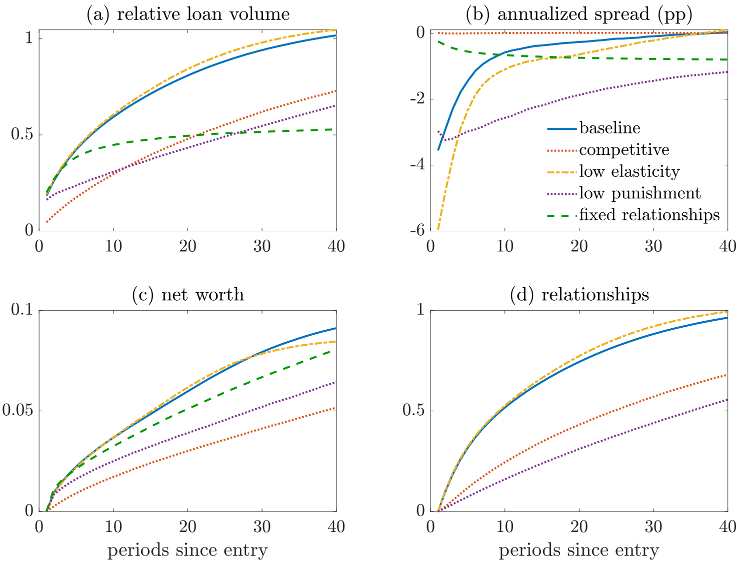
Distributions

▸ back



Relationship life cycle

▸ back



Policy functions: other specifications

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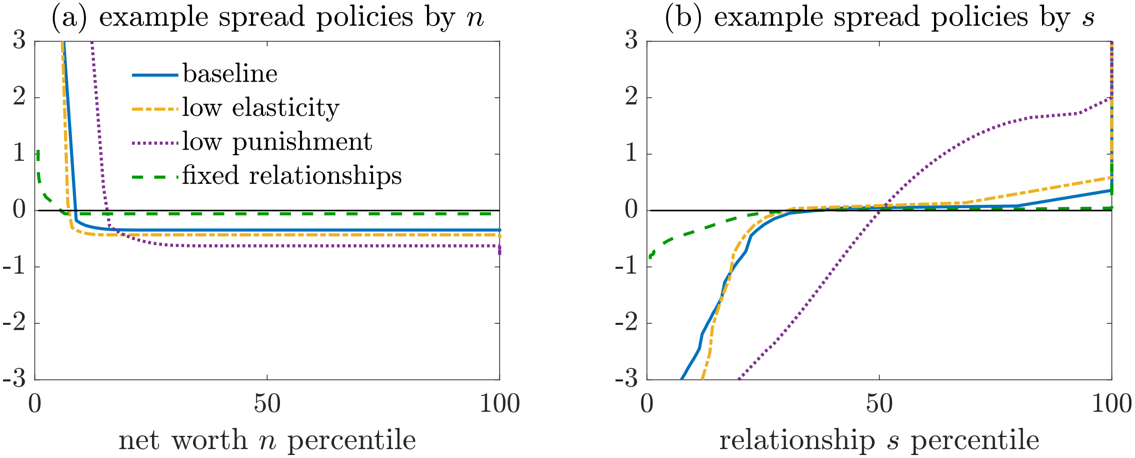
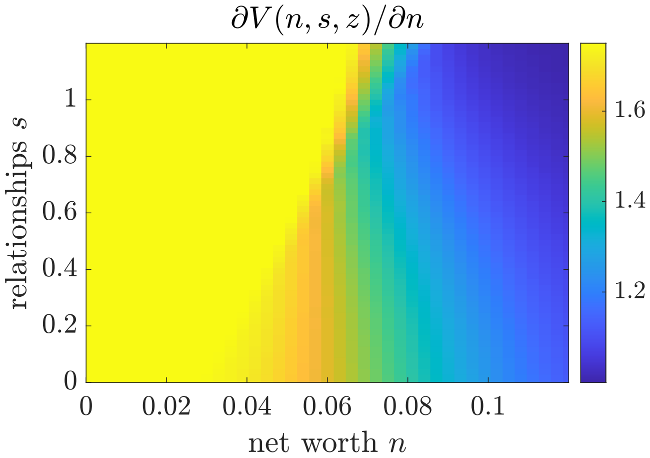


Complementarity of financial and customer capital

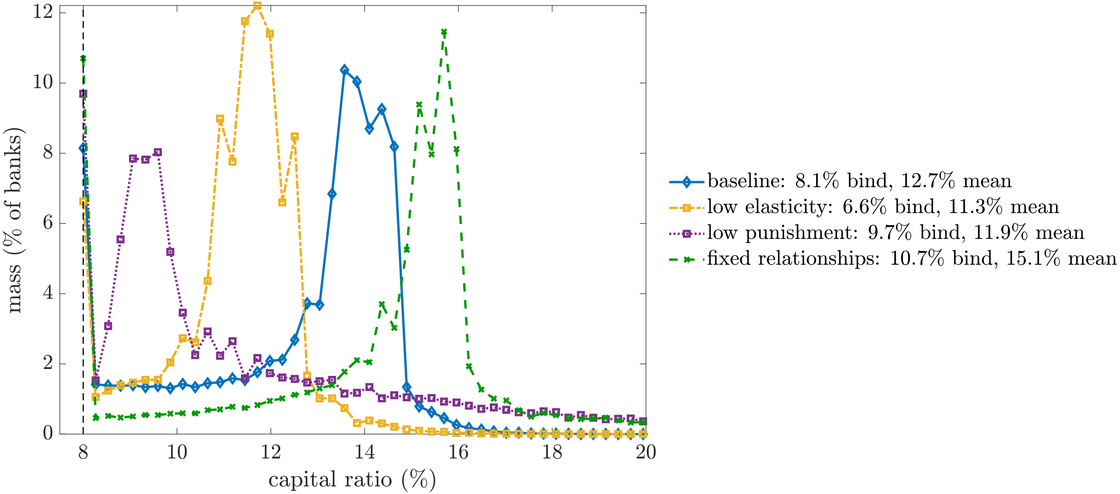
▸ back



Net worth (relationships) valuable when relationships (net worth) is high

Capital buffers in alternate models

back



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

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- Model
- Data

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

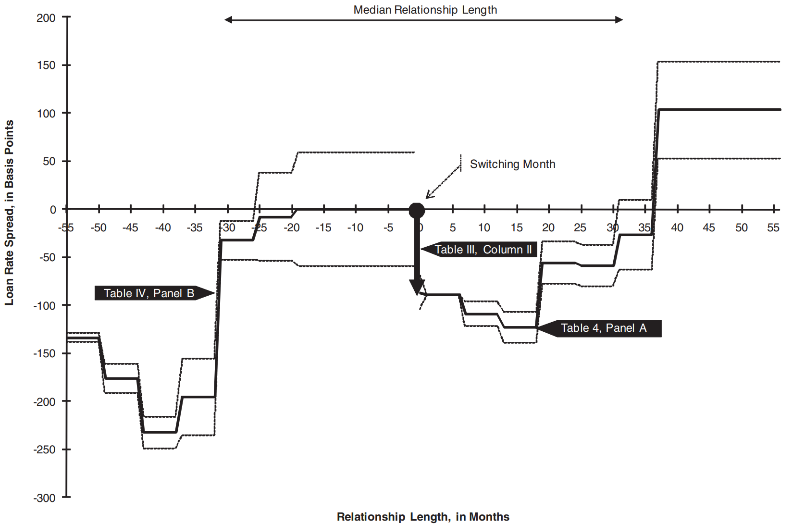
Goal: match switching vs. non-switching loans on a set of observables and compare spreads, following Ioannidou and Ongena (2010)

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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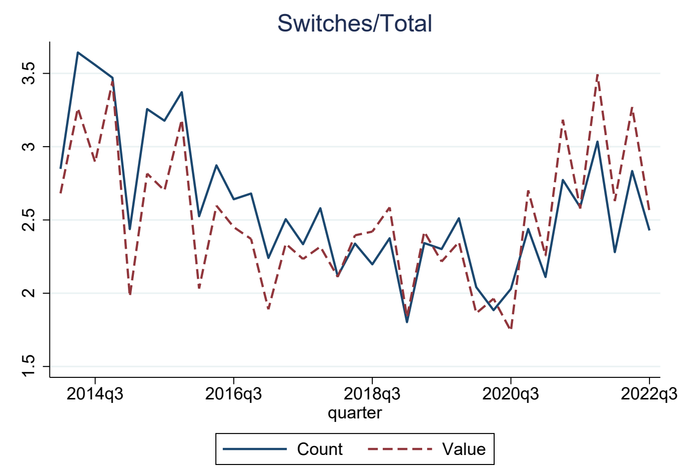


Source: Y-14Q. Switches defined in terms of number of loans.

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

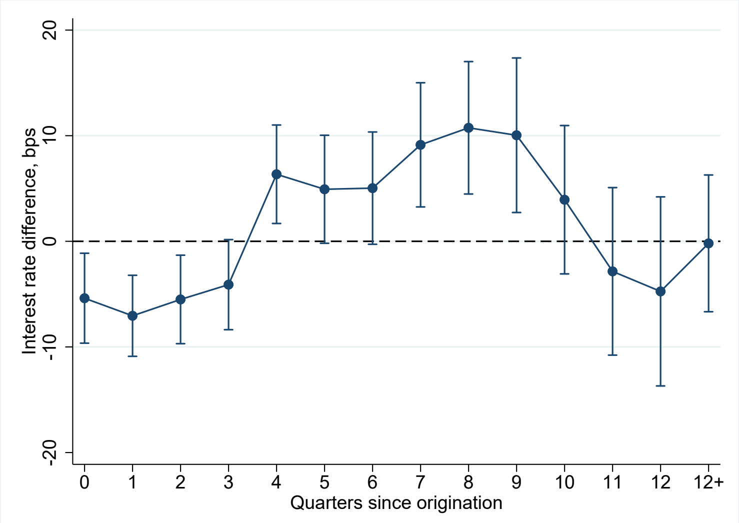
- definition follows Ioannidou & Ongena (2010)

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) ▸ back



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