A Quantitative Theory of Relationship Lending

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What are the macro effects of relationship lending?

- Large literature on **relationship lending** in banking
  - Information advantage of banks (Diamond 91; Petersen & Rajan 94; Berger & Udell 95)
  - "Informational lock-in" (Sharpe 90, Rajan 92)
  - Price dispersion and sourcing persistence
  - Matters for macroprudential policy, monetary transmission... (Couaillier et al 23)

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- **What are the macroeconomic consequences of relationship lending?**
  1. For the dynamics of individual relationships
  2. For the distribution of banks in the economy (interest rates, capital, risk...)
  3. For how the economy responds to aggregate shocks

This Paper

1. **Quantitative Model of Relationship Lending**
    - Multiple lenders and sourcing adjustment costs give rise to "relationships"
    - 2-tier demand system, amenable to direct estimation
    - Banks internalize relationship formation $\Rightarrow$ dynamic pricing
    - Financial frictions interact with motives to manage customer capital

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3. **Model Results**
   - Relationship lending generates interest rate dispersion, provides insurance for banks
   - Banks offer teaser, below-market rates to lock in customers and then extract surplus
   - Customer capital and financial capital are **complements**
   - Relationship lending generates sluggish recoveries from financial crises

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 competition structure with long-horizon pricing
    - heterogeneous bank "block" integrates with economy-wide loan market
2. **customer capital / habits:** Ravn et al 06; Gourio & Rudanko 14; Gilchrist et al 17
    - banks internalize habit formation, relationships pin down demand elasticity

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

Outline

Environment and Markets

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

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- Two types of agents:
  - A continuum of identical firms $i \in [0, 1]$ that hire inputs and borrow to produce
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- **Partial equilibrium**: risk-free rate $\bar{r}$, wage $\bar{w}$, user cost of capital $\bar{uc}$, and deposit price $\bar{q}^d$ taken as given

Banks' problem

States: net worth n, relationship intensity s, return shock z

$$V(n, s, z; \mu) = \max_{q,e,n',\ell',d',s'} \psi(e) + \beta\pi\mathbb{E}_{z'}\left[V(n', s', z'; \mu)\right]$$

subject to:

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

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

Dynamic Loan Pricing

Define the net period return on a dollar loan

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

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The bank's optimal choice is given by

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

$\epsilon^{-1}(q\ell', q)$ is the inverse elasticity of loan demand ▸ special cases

Borrowers and Loan Demand

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

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- 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

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    - "external habits" in the spirit of Ravn, Schmitt-Grohe & Uribe 06
- **Loan *share* adjustment** subject to quadratic costs with level ϕ

Representative borrower problem

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

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

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

1. Bank-specific loan demand

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

2-part equilibrium loan demand system

1. Bank-specific loan demand

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2. Aggregate loan demand

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

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

Equilibrium

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:

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

Outline

Strategy for quantifying the model

(I) **externally assign** subset of “standard” macro parameters

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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).

Calibration (I): externally set parameters

	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	4.41	Normalization
$\overline{uc}$	Ann. user cost of capital	9%	2% interest plus 7% depreciation rate
$\overline{A}$	Aggregate TFP	1	Normalization

Calibration (II): estimating ϕ

‣ sample details

Goal: estimate model-implied demand to retrieve ϕ

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

Need data on quantities and prices of credit.

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FR Y-14Q (Schedule H.1)

- Regulatory dataset maintained by the Federal Reserve for stress testing
- Quarterly loan-level panel on universe of loan facilities $> \$1$M
- Covers top 30/40 BHCs, 2013:Q1-2022:Q2
- Detailed information on features of credit facilities

Calibration (II): estimating ϕ

With data on quantities and prices, we can estimate

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

$$f = \text{firm}, \quad b = \text{bank}, \quad t = \text{quarter}$$

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Classic **simultaneity problem**: follow Amiti & Weinstein 18 and estimate

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

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

Calibration (II): estimating ϕ

$$\frac{\ell_{fbt}}{L_{ft}} = \alpha_{ft} + \alpha_b + \Gamma X_{bt} + \zeta(r_{fbt} - r_{ft}) + u_{fbt}$$

	(1)	(2)	(3)	(4)
$\hat{\zeta}$	-14.084***	-30.932***	-12.191***	-26.505***
	(4.121)	(3.928)	(1.767)	(7.998)
Firm identifier	TIN	TIN	ISL cell	ISL cell
Observations	57,346	57,245	218,866	218,827
Model	OLS	IV	OLS	IV
Implied $\hat{\phi}$	0.070	0.033	0.082	0.038

- TIN: tax identification number (individual firm)
- ISL: industry/size/location cell (Degryse et al. 19)

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

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- **Generated regressor**: need to boostrap standard errors

Calibration (II): estimating ρ_s and ρ_q

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

	(1)	(2)
$\hat{\rho}_q$	0.771***	0.791***
	(0.012)	(0.005)
$\hat{\rho}_s$	0.178***	0.141***
	(0.011)	(0.005)
Firm identifier	TIN	ISL cell
Observations	36,651	132,290
R-squared	0.91	0.89

Calibration (III): internally set parameters

- Net worth shock: $z_t = \rho_z z_{t-1} + \sigma_z \epsilon_t^z$
- Equity issuance costs:

$$\psi(e) = \begin{cases} e & \text{if } e \geq 0 \\ e(1+\overline{\psi}) & \text{if } e < 0 \end{cases}$$

	Description	**Value**	**Target / Reason**	**Data**	**Model**
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%

Outline

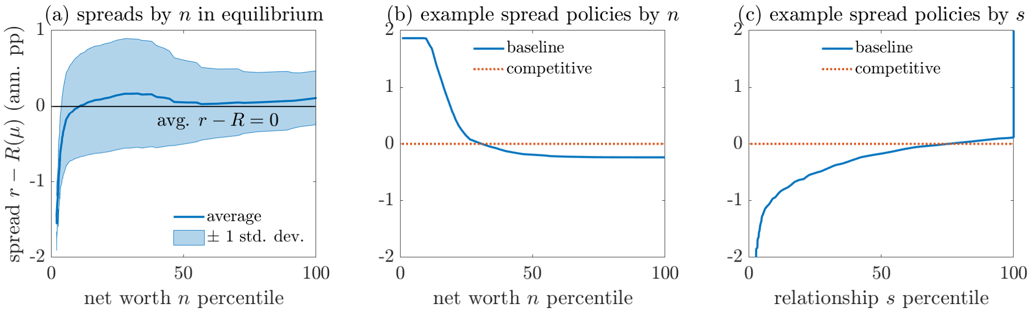
Quantitative Analysis

Compare two economies:

1. Baseline, with estimated $\hat{\phi}$
2. Perfectly competitive economy, with $\phi = 0$

Policy functions

▸ other specifications



Policy functions

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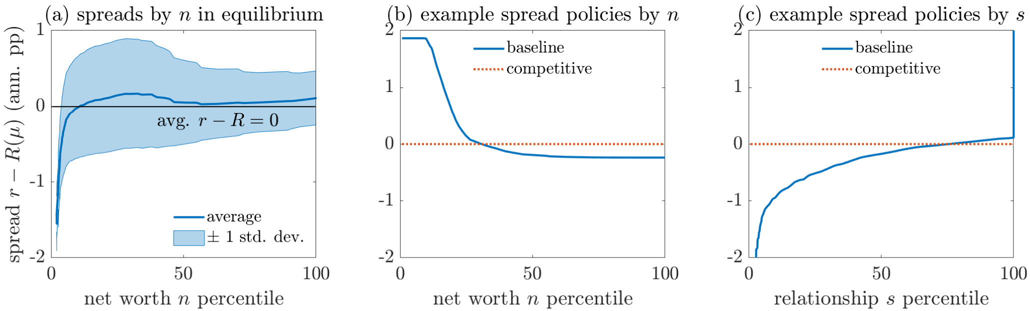

- Low $n \implies$ price "above market' $\implies s \downarrow$ so that $n \uparrow$

Policy functions

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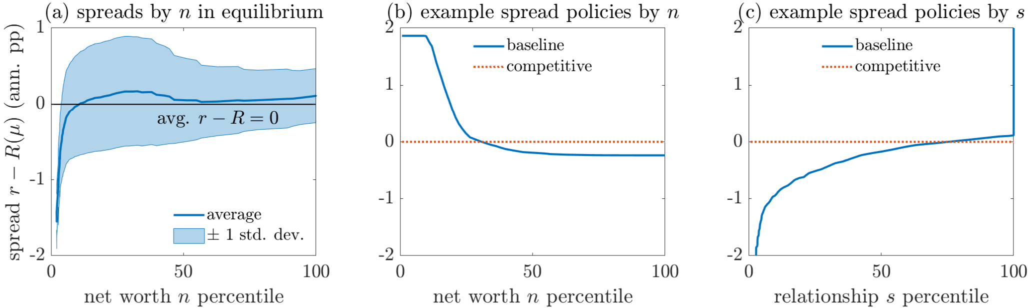
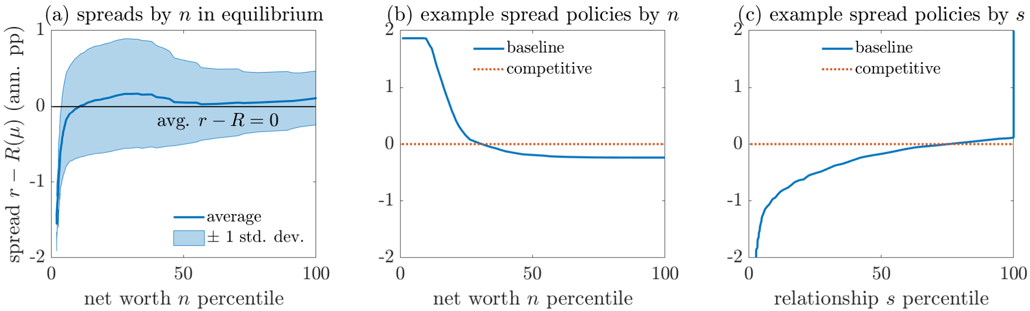


- Low $n \implies$ price "above market' $\implies s \downarrow$ so that $n \uparrow$
- Low $s \implies$ price "below market" $\implies n \downarrow$ so that $s \uparrow$

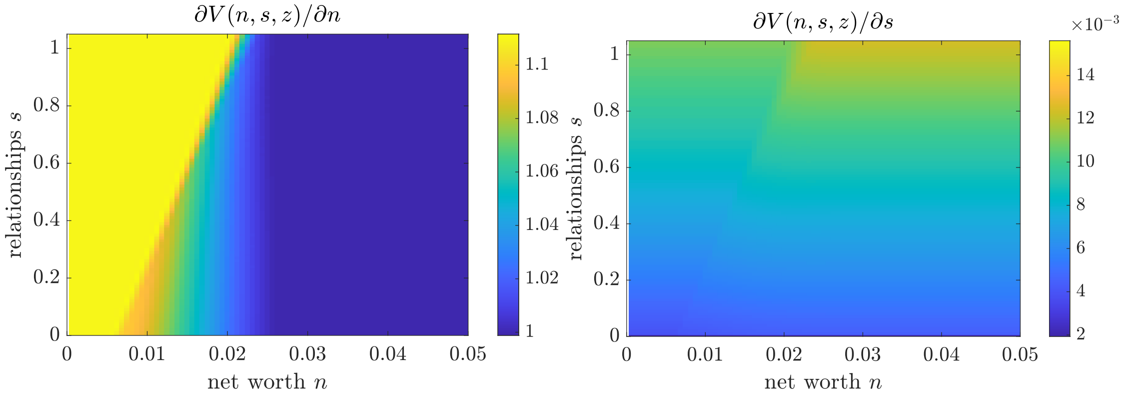
Policy functions

other specifications



- Low $n \implies$ price "above market' $\implies s \downarrow$ so that $n \uparrow$
- Low $s \implies$ price "below market" $\implies n \downarrow$ so that $s \uparrow$
- **Financial and relationship capital are complements**

Complementarity of financial and customer capital



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

Pricing outcomes across model variants

other specifications

		level	
		(i) baseline	(ii) comp.
effective IR (pp, ann.)	$\tilde{R}(\mu)$	3.29	2.16
$=$ average rate	$R(\mu)$	3.26	2.16
$+$ covariance term	$\mathbb{C}_\mu(r, s)$	0.05	-
$+$ variance term	$\mathbb{V}_\mu(r)$	-0.01	-
loan-weighted avg. IR		3.28	2.15
loan volume	$L'(\mu)$	0.26	0.27

- higher effective IR, mostly driven by average rate
- covariance term raises rate, dispersion term attenuates

Banking industry moments across model variants

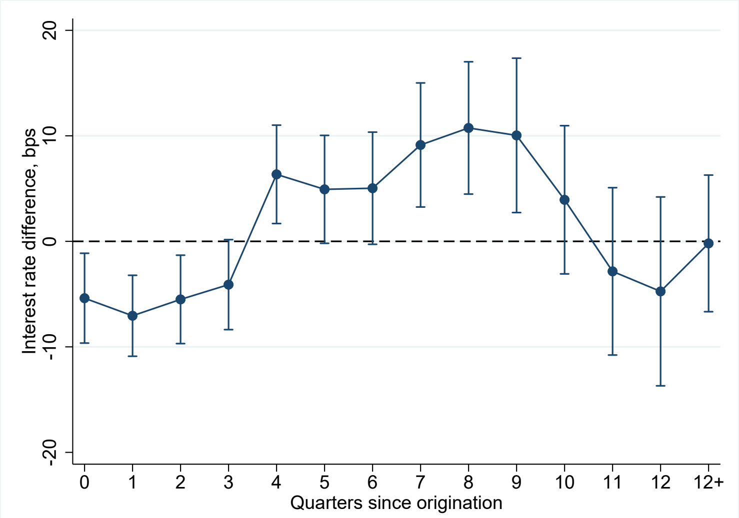
other specifications

	level	
	(i) baseline	(ii) comp.
average net worth	0.023	0.022
std dev, net worth	0.005	0.010
std dev, relationships	0.143	-
corr, net worth and spread	0.002	-
corr, relationships and spread	0.123	-
corr, net worth and relationships	0.795	-
share of switches (pp)	1.34	4.15

- more competitive model $\Longrightarrow$ less net worth on average distributions
  - franchise value effect vs. (s, n) complementarity
- weak negative correlation between spreads and net worth bank lifecycle
  - financial constraints vs. (s, n) complementarity

Data: relationship lifecycle

▸ procedure details ▸ Ioannidou and Ongena (2010 JF)

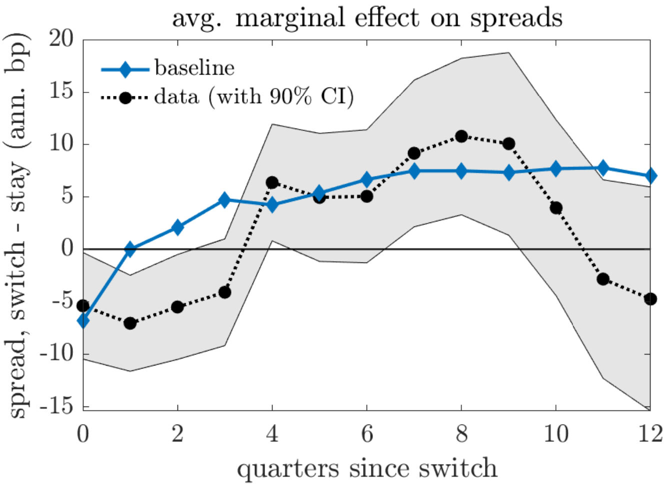


Exercise: match similar loans in Y-14Q, compare terms for switching and non-switching

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

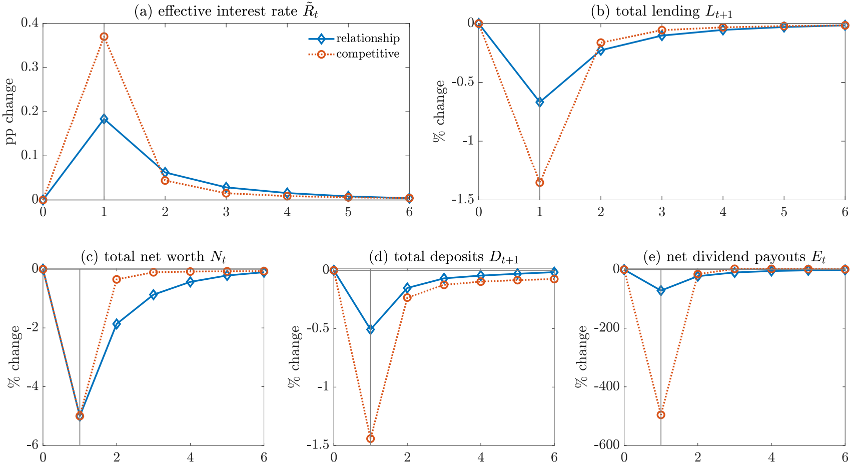
Validation: relationship lifecycle in the model

▸ other specifications



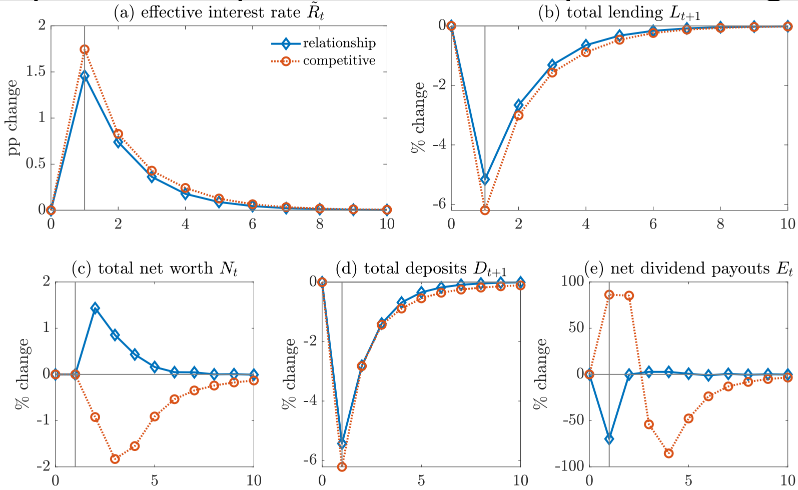
Model also matches share of switching loans in the data ▸ data on switching

Dynamic experiment 1: destroy 5% of net worth at each bank



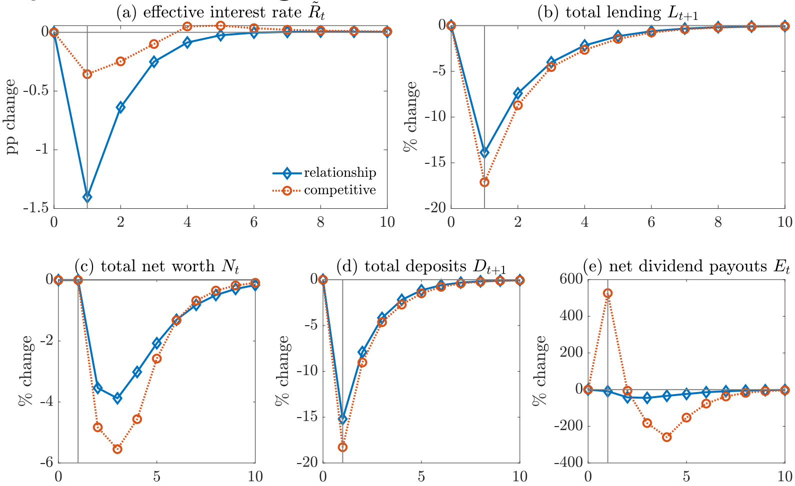
- competitive economy: standard financial accelerator
- baseline economy: CC concern moderates rise in R_t, slows recapitalization

Dynamic experiment 2: persistent rise in deposit funding costs



- competitive economy: banks lend less and reduce their size
- baseline economy: CC sustains lending, deposits substituted for capital

Dynamic experiment 3: negative credit demand shock



- competitive economy: banks lend less, reduce size, little impact on R_t
- baseline economy: banks lower rates to sustain lending

Outline

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

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Quantitative analysis: estimate demand parameters using micro-data

- **cross-section:** endogenous life cycle, corr. b/w net worth, markups, CC
- **dynamics:** sluggish recovery from financial crises, greater persistence
- implications for interplay between monetary policy and financial stability

Thank you!

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Outline

Appendix

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:** $\epsilon^{-1} = \rho_q = 0$

$$\Pi_t = 0$$

Outline

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%

Competitive model

back

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

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

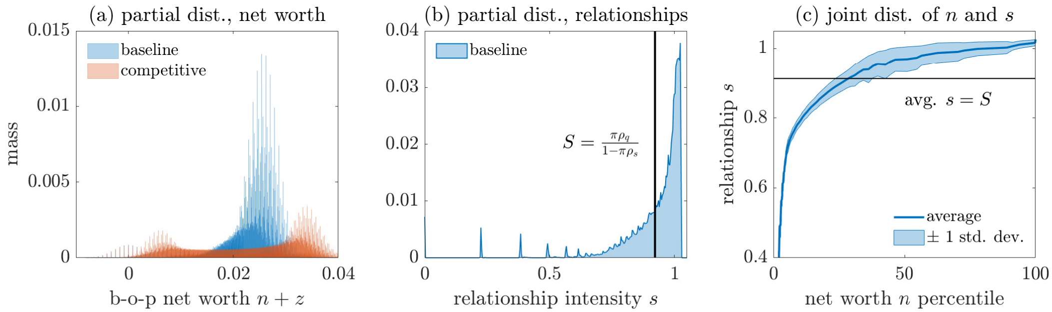
  Note that this is the same as baseline with $R = \tilde{R}$

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

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

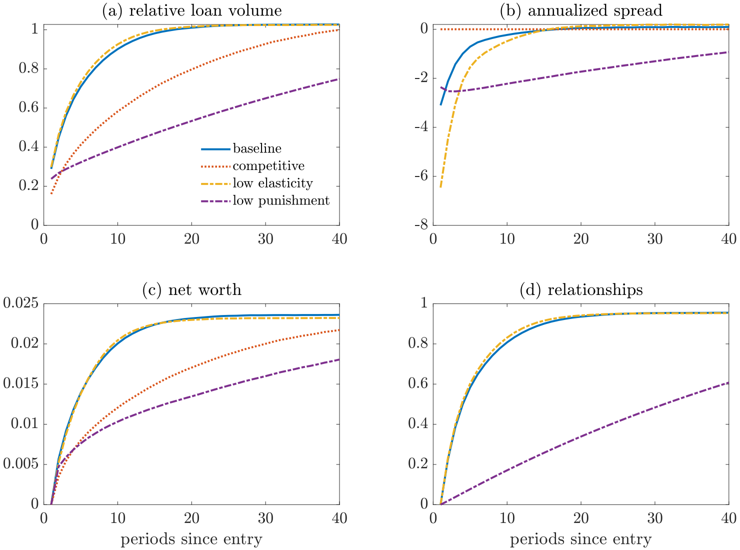
Distributions

back



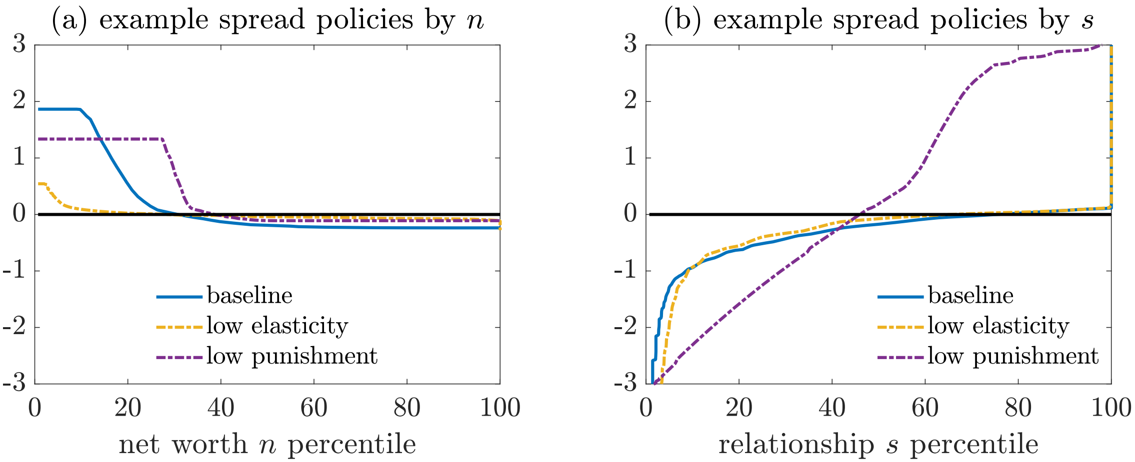
Bank lifecycle

back



Policy functions: other specifications

back



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

Pricing outcomes across model variants

▸ back

		level			
		(i) baseline	(ii) comp.	(iii) low elas.	(iv) low pun.
effective IR (pp, ann.)	$\tilde{R}(\mu)$	3.29	2.16	4.52	3.81
$=$ average rate	$R(\mu)$	3.26	2.16	4.44	3.36
$+$ covariance term	$\mathbb{C}_{\mu}(r, s)$	0.05	-	0.10	0.49
$+$ variance term	$\mathbb{V}_{\mu}(r)$	-0.01	-	-0.02	-0.05
loan-weighted avg. IR		3.28	2.15	4.51	3.76
loan volume	$L'(\mu)$	0.26	0.27	0.25	0.25

Banking industry moments across model variants

back

	level			
	(i) baseline	(ii) comp.	(iii) low elas.	(iv) low pun.
average net worth	0.023	0.022	0.022	0.023
std dev, net worth	0.005	0.010	0.004	0.008
std dev, relationships	0.143	-	0.128	0.412
corr, net worth and spread	0.002	-	0.068	0.306
corr, relationships and spread	0.123	-	0.191	0.391
corr, net worth and relationships	0.795	-	0.765	0.894
share of switches (pp)	1.34	4.15	0.86	2.96

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

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

Procedure: switching vs. non-switching loans

back

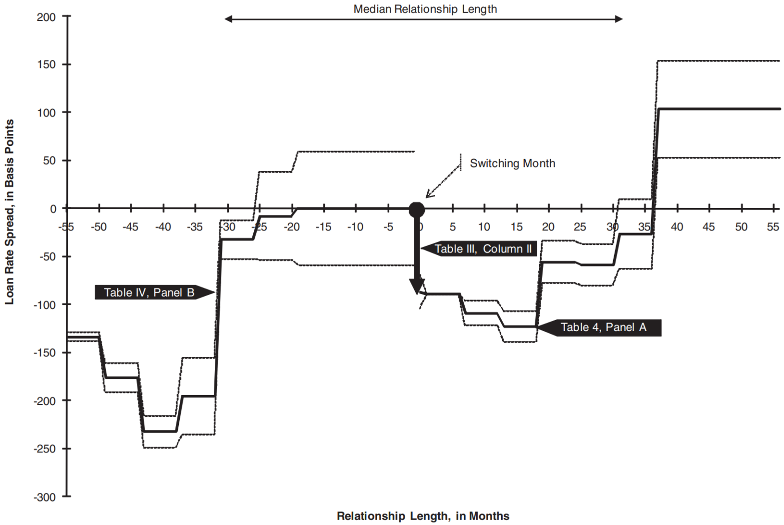
Goal: match switching vs. non-switching loans on a set of observables and compare spreads, following Ioannidou and Ongena (2010)

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

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

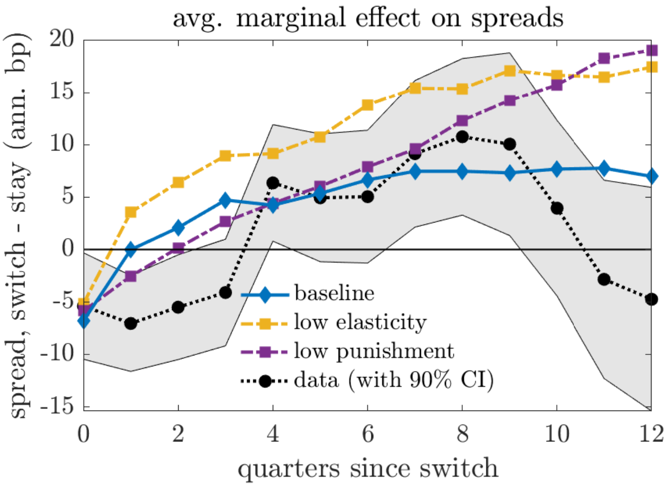
Ioannidou and Ongena (2010 JF) Figure 4

back



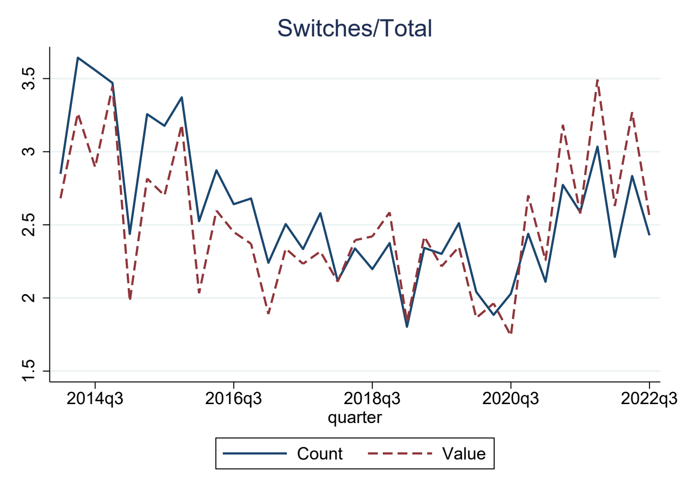
Validation: relationship lifecycle in the model

back



Data on switching

back



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 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
- loans may enter/exit panel for many reasons