Evergreening

Miguel Faria-e-Castro[1] Pascal Paul[2] Juan Sánchez[1]

[1]Federal Reserve Bank of St. Louis

[2]Federal Reserve Bank of San Francisco

PEJ 2022 @ Universidade dos Açores

July 2022

The views expressed herein are solely those of the authors and do not necessarily reflect the views of the Federal Reserve Banks of San Francisco and St. Louis, the Board of Governors of the Federal Reserve, or the Federal Reserve System. These slides have been screened to ensure that no confidential bank or firm-level data have been revealed.

Motivation

Evergreening:

- Idea that banks revive a loan close to default by granting further credit to the same firm
- Potentially contributes to keeping less-productive firms alive & depressing aggregate TFP
- "Zombie"-lending is typically associated with low-capitalized banks during depressions

Research Questions:

1. Is evergreening a general feature of financial intermediation?
2. Can we find empirical evidence even for the U.S. over the recent past?
3. What are the aggregate/macroeconomic consequences?

This Paper

1. **Static Model**
   - Small deviation from benchmark model: "relationship banking"
   - Better terms to firms with $+$ legacy debt, $-$ productivity
   - Importance of legacy debt varies with bank capital
2. **Empirics**
   - Low-capitalized banks under-report firms' risk of default
   - Also lend relatively more to underreported borrowers
   - Explained by $+$ debt share & $-$ productivity firms, consistent with theory
3. **Dynamic Model**
   - Embed static model mechanism into dynamic heterogeneous-firm model
   - Economy features relatively larger firms, more debt, lower spreads, lower TFP

Literature

- **Empirical Evidence on Zombie Lending & Evergreening**
  - Japan: Peek & Rosengren (2005); Caballero, Hoshi & Kashyap (2008)
  - Eurozone: Schivardi, Sette & Tabellini (2020); Blattner, Farinha & Rebelo (2020); Acharya, Eisert, Eufinger & Hirsch (2019); Acharya, Crosignani, Eisert & Eufinger (2020); Bonfim, Cerqueiro, Degryse & Ongena (2022).
  - Cross-country: McGowan, Andrews & Millot (2018), Banerjee & Hofmann (2018)

  Here: Exploit regulatory environment to document lending distortions among U.S. banks.

- **Models of Zombie Lending & Evergreening**
  - Static: Rajan (1994); Puri (1999); Bruche & Llobet (2014); Acharya, Lenzu, Wang (2021)
  - Dynamic: Hu & Varas (2021); Tracey (2021)

  Here: Evergreening to avoid firm default; dynamic model to study aggregate implications.

Static Model

Firm Problem

▸ Firm Problem Solution

2 periods

- Firm has pre-existing liability b and productivity z
- Borrows new debt Qb' to invest k' today, produces tomorrow (NPV>0)
- Defaults on b at the start iff $V(z,b;Q)<0$; Q offered before default decision
- No default in the 2nd period, new lending risk-free

$$V(z,b;Q)=\max_{b',k'} Qb'-b-k'+\beta^f[z(k')^\alpha-b']$$
$$\text{s.t. } b'\leq\theta k'$$

- **Result**: there exists a $Q^{\min}(z,b)$ such that firm defaults if $Q<Q^{\min}$
- **Result**: investment k' satisfies: $MPK=\frac{1+\theta\beta^f}{\beta^f}-\frac{\theta}{\beta^f}Q$

Economy I: Competitive Lenders

- Continuum of deep-pocketed, risk-neutral, competitive lenders with $\beta^k > \beta^f$
- Equilibrium contract of competitive lenders satisfies

$$Q = \begin{cases} \beta^k & \text{if } \beta^k \geq Q^{\min}(z, b) \\ 0 & \text{otherwise} \end{cases}$$

- Equilibrium allocation (b^c, k^c, V^c) satisfies

$$MPK = \frac{1 + \theta \beta^f}{\beta^f} - \frac{\theta}{\beta^f} \beta^k, \forall z, b$$

- Interest rates and MPK equalized across all non-defaulting firms

Economy II: Relationship Banking

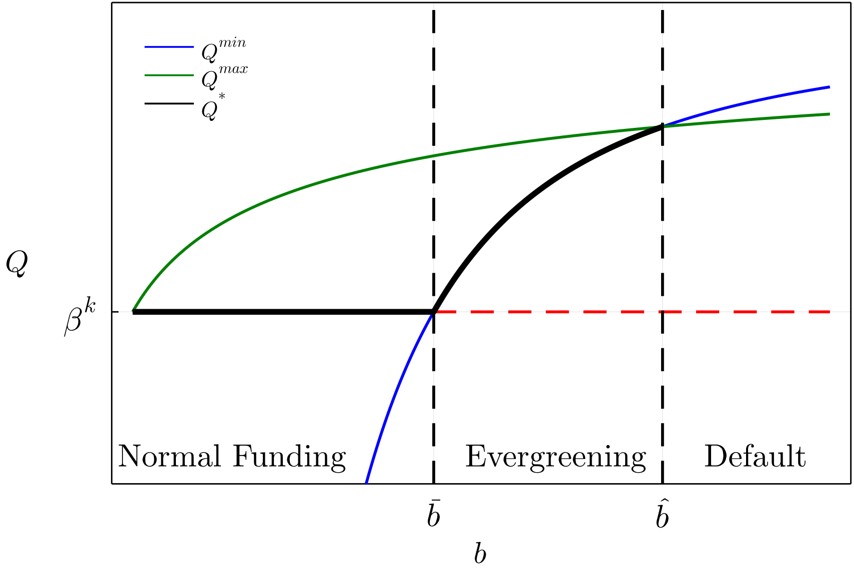
▸ Bank Problem Solution

- Lender owns pre-existing liability b, lost in default
- Firm has outside option of new lender, $Q \geq \beta^k$
- Bank problem:

$$W = \max_{Q \geq \beta^k} \mathbb{I}[V(z,b,Q) \geq 0] \times \left[b - Qb'(z,Q) + \beta^k b'(z,Q)\right]$$

- $Q \uparrow$ implies trade-off:
  - + Reduce firm's likelihood of default, increase chance of recovering b
  - - Less surplus extracted from new contract $b'(\beta^k - Q)$

Bank Problem

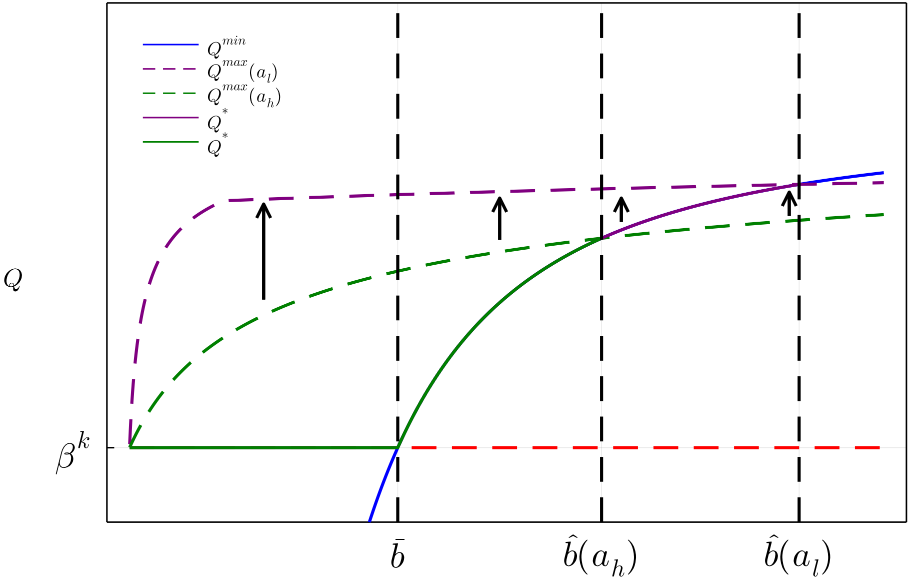


Results & Extension

- In ”evergreening region”:
  1. Q increasing in b
  2. Q decreasing in z
- “Worse” fundamentals (low z, high b) $\Rightarrow$ higher Q
- **Extension**: evergreening region expands when bank capital is low.
  - Bank pays regulatory cost φ if earnings fall under $\bar{e}$
  - Profits from other business lines under the limit $a < \bar{e}$ with probability p_o

$$\text{expected cost} = p_0 \varphi \max \left\{ 0, \bar{e} - \underbrace{a}_{\text{other profits}} - \mathbb{I}[V \geq 0]b) \right\}$$

Extension: Bank Capital



Empirical Strategy

Identification & Data

- **Identification Approach**
  - Theory: banks (i) take into account legacy debt and (ii) steer firm default
  - Identify credit supply effects by considering multiple banks lending to the same firm
  - Differentiate importance of legacy debt by bank capital and risk reporting
  - Focus on loans that banks may prefer to evergreen (w/. underreported risk)
  - **Result**: Low-cap. banks lend more to underreported borrowers ($+$debt, $-$product.)
- **Data**
  - Corporate loans of Y-14Q data, covers large BHCs, sample: 2014:Q4 - 2020:Q4
  - Loan-level panel with quarterly updates on universe of loan facilities $>$\$1 million
  - Detailed information about features of credit arrangement, including risk assessments

Risk Reporting

- **Observed Risk Measures:**
  - One-year probability of default (PD), loss given default, ... ▸ Definition
  - Use PD since it is borrower-specific $\rightarrow$ comparable across banks ▸ Evidence
- **Risk Reporting & Bank Capital:**
  - For firm i and bank j, define PD-Gap$_{i,j,t} = PD_{i,j,t} - \overline{PD}_{i,k,t}$ where $k \neq j$
  - Do low-capital banks systematically report lower risk measures?
  - Similar to Plosser & Santos (2018), estimate for bank j and firm i

$$\text{PD-Gap}_{i,j,t} = \beta Capital_{j,t-1} + \gamma X_{j,t-1} + \alpha_{i,t} + \kappa_j + u_{i,j,t}$$

  - Result: $\beta^{***} > 0 \rightarrow$ Low-capitalized banks systematically underreport ▸ Details
  - Underreported loans more "valuable" from a regulatory perspective

PDs, Bank Capital, and Credit Supply

- Do low-capital buffer banks lend relatively more to underreported firms?
  - Need to account for potential links between bank-firm selection and firm demand

- Following Khwaja and Mian (2008), estimate regression for firm i & bank j:

$$\frac{L^k_{i,j,t+2} - L^k_{i,j,t}}{0.5 \cdot (L^k_{i,j,t+2} + L^k_{i,j,t})} = \alpha^k_{i,t} + \beta_1 \text{Capital}_{j,t} + \beta_2 \text{Low-PD}^k_{i,j,t} + \beta_3 \text{Low-PD}^k_{i,j,t} \times \text{Capital}_{j,t} + \gamma X_{j,t} + u^k_{i,j,t}$$

- $\text{Low-PD}_{i,j,t} = 1$ if $\text{PD-Gap}_{i,j,t} < 0$; k distinguishes rate-types
- Further restrict sample to firms with non-guaranteed term loans only
- Sample: low- vs. high capital buffer episodes

Credit Supply - Low Capital Buffer Period

▸ Coefficients ▸ Interest Rates

- Lowering capital leads to a relative increase in credit from low- vs. high-PD banks
- Results strengthen with additional fixed effects

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.18	0.17	0.95**	1.13***	1.68**	
	(0.30)	(0.34)	(0.40)	(0.40)	(0.64)	
Low-PD		0.63	5.46***	5.92***	6.82**	5.24**
		(1.30)	(1.89)	(1.86)	(2.58)	(2.25)
Capital × Low-PD			-1.29***	-1.64***	-1.63**	-1.14**
			(0.36)	(0.35)	(0.63)	(0.41)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.51	0.54	0.54	0.54	0.54	0.57
Observations	6,977	4,674	4,674	4,188	3,617	4,649
Number of Firms	683	495	495	455	396	491
Number of Banks	29	27	27	26	27	24

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank. Sample: 2018:Q1-2020:Q2.

Sample Splits & Further Evidence

Sample Splits: results driven by firms with

- low productivity
- large legacy debt
- low payout/profit rates

▸ Sample splits

Further Evidence & Robustness

- Results weaker during "high capital buffers" period
- Significant effects on total debt and investment at the firm level
- Results not explained by low-capital banks favoring safer borrowers (or other bank characteristics)
- Results robust to alternative FE, including credit lines

▸ Further evidence

Dynamic Model

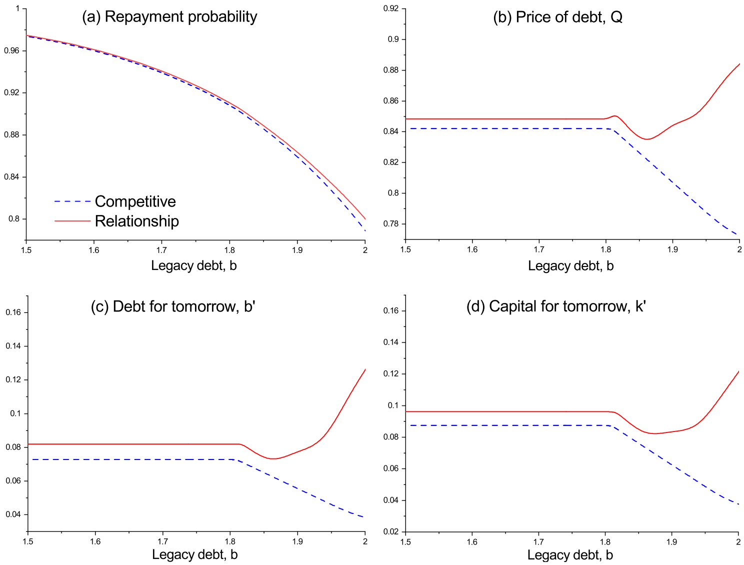
Dynamic Model

▸ Timing & Firm Problem ▸ Lending ▸ Equilibrium Definition

- Based on Hopenhayn (1992), Hennessy & Whited (2005), Gomes & Schmid (2010)
- Firms heterogeneous with respect to productivity, capital, and debt
- Time discrete and infinite $t = 0, 1, \ldots, \infty$
- Endogenous entry and exit of firms
- Firm problem: static version + equity issuance cost & default shocks
- Firm productivity follows AR(1) in logs
- Two ways of closing the model:
  1. Constant entry, elastic labor $\Rightarrow$ economy as a small industry
  2. Elastic entry, constant labor $\Rightarrow$ general equilibrium

Dynamic Model: Policy Functions

▸ Calibration ▸ Model Fit



Impact of introducing relationship lending

TFP Decomposition

	Δ % with const. entry	Δ % with const. labor
Firm level (Averages)		
Market Leverage	1.76	0.68
Interest rate	-4.67	-1.17
Size	5.10	1.46
Productivity	-0.15	-0.01
Exit rate	-4.81	-0.25
Aggregates		
Debt	10.94	0.78
Capital	10.93	0.78
Labor	8.94	0.00
Output	8.94	0.12
Wage	0.00	0.12
Measured TFP	-0.58	-0.13
Number of firms	5.55	-0.67

TFP Decomposition

$$Y = \underbrace{\left(\frac{1}{S}\right)^{1-\alpha-\eta}}_{\text{avg. firm size}} \times \overbrace{\mathbb{E}[z^{\frac{1}{1-\alpha-\nu}}]^{1-\alpha-\eta}}^{\text{selection}} \times \underbrace{\frac{Y}{Y*}}_{\text{static misallocation}} \times \overbrace{K^{\alpha}N^{1-\alpha}}^{\text{factor qtys.}}$$

Ratio	% Δ CLE constant entry to RLE	% Δ CLE constant labor to RLE
Output	8.561%	0.117%
Factors	9.143%	0.248%
Capital	3.321%	0.248%
Labor	5.822%	0.000%
MTFP	-0.581%	-0.132%
Size	-0.633%	-0.134%
Selection	-0.030%	-0.003%
Static Misallocation	0.082%	0.005%

How are subsidized firms different?

Subsidized vs. Non-subsidized Firms in the RLE (medians)

	Non-subsidized	Subsidized	Δ %
Capital	0.761	0.989	29.9%
Productivity	1.071	0.934	-12.8%
Profits/sales	0.103	0.006	-94.4%
Debt	0.792	1.028	29.9%
Interest rate	6.502	10.209	57.0%
Probability of survival	0.961	0.897	-6.7%

- Larger & more indebted
- Less profitable & productive
- **Actually pay higher interest rates, on average!**
  - $\Rightarrow$ across-firm interest rate
  - Subsidized vs. Zombie Firms

Conclusion

- **Small modifications to standard model generate incentives to evergreen**
  - Offer better terms to firms with $+$ pre-existing borrowings and $-$ productivity
  - Induces firms to borrow and invest more, may generate misallocation
- **Document evergreening behavior by large U.S. banks**
  - Low capitalized banks distort PDs & lend relatively more to underreported firms
  - Effect driven by larger loans and less productive firms, consistent with theory
- **Embed mechanism into dynamic model of industry equilibrium**
  - Equilibrium: less productivity, larger firms, more debt, lower rates
  - Subsidized firms are large, indebted, low productivity firms; may pay higher rates!

Appendix

Static Model: Solution to the Firm Problem ▸ Back

- Optimal borrowing b':

$$b' = \begin{cases} 0 & \text{if } Q < \beta^f \\ [0, \theta k'] & \text{if } Q = \beta^f \\ \theta k' & \text{if } Q > \beta^f \end{cases}$$

- Optimal investment k:

$$\alpha z (k')^{\alpha - 1} = \frac{1 - \theta(Q - \beta^f)}{\beta^f} (= MPK)$$

- Given interest rate Q, solution to the firm's problem characterized by set of functions

$$b'(z, Q), k'(z, Q), V(z, Q, b)$$

  - b', k', V increasing in z, Q
  - V decreasing in b

Bank Problem: Solution ▸ Back

- Let $Q^{\max}(z,b)$ denote maximum Q for which bank lends; $W(z,b;Q^{\max}) = 0$
- Bank's optimal policy is then given by

$$Q = \begin{cases} \beta^k & \text{if } Q^{\min}(z,b) < \beta^k < Q^{\max}(z,b) \\ Q^{\min}(z,b) & \text{if } \beta^k < Q^{\min}(z,b) < Q^{\max}(z,b) \\ 0 & \text{otherwise} \end{cases}$$

- Properties: (i) $Q^{\max} > \beta^k$ iff $b > 0$; (ii) $\frac{\partial Q^{\max}}{\partial b} > 0$; (iii) $\frac{\partial Q^{\max}}{\partial z} < 0$

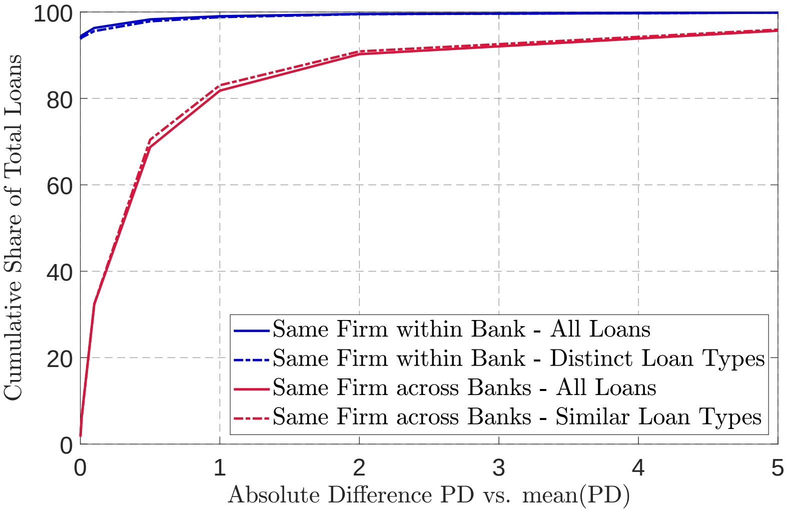
PD Definition

Back

Over the course of the **next year**, probability that loan is in default. A loan has defaulted if either one or both of the following events have taken place: (1) the bank considers that the obligor is **unlikely to pay its credit obligations to the banking group in full**, without recourse by the bank to actions such as realizing security (if held); and (2) the obligor is past **due more than 90 days on any material credit obligation** to the banking group.

Firm PD Dispersion

Back



Risk Reporting and Bank Capital

Back

- Do low-capital buffer banks systematically report lower risk measures?
- Similar to Plosser & Santos (2018), estimate for bank j and firm i

$$\text{PD}_{i,j,t}/\text{PD-Gap}_{i,j,t} = \beta Capital_{j,t-1} + \gamma X_{j,t-1} + \alpha_{i,t} + \kappa_j + u_{i,j,t}$$

- $PD_{i,j,t}$ is weighted by used credit at the bank-firm level
- $Capital_{j,t-1}$ is buffer over common Tier 1 requirement Details

- **Coefficient of interest**
  - $\beta = 0$: private info $\rightarrow$ risk measures more accurate, not linked to capital
  - $\beta < 0$: downward-biased PDs $\rightarrow$ lower RWA $\rightarrow$ raise capital ratio
  - $\beta > 0$: overall risk perception low $\rightarrow$ low PDs & low capital ratio $\rightarrow$ controls: κ_j, $X_{j,t-1}$
  - $\beta > 0$: systematic underreporting of credit risk exposure by low-capitalized banks

Risk Reporting and Bank Capital

Capital Changes | Interaction Effects | Back

- Low-capital buffer banks systematically underreport their credit risk exposure
- Low-capital buffer banks are more likely to underreport PDs relative to other banks

	(i) PD	(ii) PD	(iii) PD	(iv) PD-Gap	(v) PD-Gap	(vi) PD-Gap
Capital	0.10***	0.06**	0.10***	0.10**	0.08***	0.11***
	(0.04)	(0.03)	(0.03)	(0.04)	(0.02)	(0.03)
Fixed Effects						
Firm $\times$ Time	✓	✓				
Synd. $\times$ Time			✓			
Time				✓	✓	✓
Bank		✓	✓		✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Portfolio Risk Controls		✓	✓		✓	✓
R-squared	0.8	0.8	0.7	0	0.01	0.01
Observations	412,537	401,790	57,186	419,060	407,362	58,447
Number of Firms	12,189	12,065	2,844	12,489	12,347	2,914
Number of Banks	32	32	31	32	32	31

Bank controls: ROA, dep/assets, income gap, ln(assets). Portfolio risk controls: RWA/assets, weighted portolio PD. Standard errors clustered by bank. Sample: 2014:Q4-2020:Q4.

Capital Definitions

Back

- **Total Capital = CET1 + Add. Tier 1 + Tier 2**

- **CET1** $\rightarrow$ most ”costly” for banks
  - Common stock
  - Stock surplus
  - Retained earnings
  - Minority interest
  - Accumulated other comprehensive income

- **Add. Tier 1**
  - Preferred stock (perpetual, callable after min. 5Y)

- **Tier 2**
  - Loan loss provisions
  - Subordinated debt (maturity $>=$ 5Y)

Capital Requirements and Violations

Back

- **Requirements**
  - Capital Buffer = Capital Type - Required Capital
  - Capital Types: CET1, Tier 1, or Total Capital
  - Required Capital = Minimum (CET1, Tier 1, or Total) + CCB
  - CCB = Capital Conservation Buffer = GSIB + SCB + CCyB
  - GSIB = Surcharge for GSIBs (from 2017:Q1, bank-specific)
  - SCB = Stress Capital Buffer (since 2016:Q1, bank-specific from 2020:Q4)
  - CCyB = Counter-cyclical capital buffer (not used so far)
- **Penalties for Violations**
  - CCB requirement:
    - limitations on dividend payouts, share buybacks, executive bonuses
  - Minimum requirement ("Prompt Corrective Action"):
    - stricter supervision, forcing the bank to issue capital, restrictions on asset growth, pulling the bankffs license

Standardized vs. Internal Ratings-Based Approach

Back

Capital Ratio = Capital Type / Risk-Weighted Assets

- **Standardized Approach**
  - 100% risk-weight for corporate loans
  - Banks' own risk-assessments do not enter
- **Advanced Internal Ratings-Based Approach**
  - Banks own risk-measures determine risk-weights (PD, EAD, LGD, ECL, Maturity factors)
  - Banks can choose to apply the advanced internal ratings-based-approach
  - Pre-2020: required for $>$\$250b assets or $>$\$10b in foreign exposure
  - Post-2020: required for GSIBs & $>$\$700b assets or $>$\$75b cross.-jur.-activity
  - Compare to standardized approach and apply the one with higher risk-weighted assets

Risk-Reporting and Bank Capital

Back

- $y_{i,j,t+2} - y_{i,j,t} = \beta \Delta Capital_{j,t-1} + \gamma X_{j,t-1} + \alpha_{i,t-1} + \kappa_j + u_{i,j,t+2}$

	(i) PD	(ii) PD	(iii) PD	(iv) PD-Gap	(v) PD-Gap	(vi) PD-Gap
Capital	0.09***	0.08***	0.12**	0.10***	0.09***	0.12***
	(0.03)	(0.03)	(0.05)	(0.03)	(0.03)	(0.04)
Fixed Effects						
Firm × Time	✓	✓				
Synd. × Time			✓			
Time				✓	✓	✓
Bank		✓	✓		✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
Portfolio Risk Controls		✓	✓		✓	✓
R-squared	0.59	0.59	0.51	0.00	0.00	0.00
Observations	313,556	304,914	29,894	320,869	311,300	31,509
Number of Firms	10,018	9,912	1,855	10,309	10,150	1,949
Number of Banks	32	32	30	32	32	30

Standard errors clustered by bank. Sample: 2014:Q4-2020:Q4.

Risk-Reporting and Bank Capital

Back

- Correlation stronger for riskier credit

	PD	PD	PD	PD	PD	PD
Capital × log(Loan)	-0.00					-0.00
	(0.01)					(0.01)
Capital × log(Assets)		-0.03***				-0.01
		(0.01)				(0.01)
Capital × mean(PD)			0.08***			0.06**
			(0.02)			(0.03)
Capital × Syndicated				0.12***		0.06**
				(0.02)		(0.03)
Capital × Public					-0.06***	-0.05*
					(0.02)	(0.03)
Fixed Effects						
Bank × Time	✓	✓	✓	✓	✓	✓
Firm × Time	✓	✓	✓	✓	✓	✓
R-squared	0.8	0.74	0.8	0.8	0.8	0.74
Observations	412,537	253,417	412,537	373,996	412,537	224,954
Number of Firms	12,189	8,599	12,189	11,889	12,189	8,318
Number of Banks	32	32	32	32	32	32

$PD_{i,j,t} = \beta Capital_{j,t-1} \times X_{i,j,t} + \alpha_{i,t} + \kappa_{j,t} + u_{i,j,t}$. mean(PD) denotes average PD of a firm across banks. Standard errors clustered at the bank-firm level. Sample: 2014:Q4-2020:Q4.

Supply - Interest Rates

▸ Back

- Similar results for changes in interest rates: $i^k_{i,j,t+2} - i^k_{i,j,t}$

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	-0.00	-0.00	-0.01*	-0.01**	-0.01**	
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	
Low-PD		0.01**	-0.02**	-0.02**	-0.03**	-0.03***
		(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Capital × Low-PD			0.01***	0.01***	0.01***	0.01***
			(0.00)	(0.00)	(0.00)	(0.00)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.88	0.89	0.89	0.88	0.87	0.91
Observations	6,538	4,399	4,399	3,944	3,416	4,368
Number of Firms	652	474	474	433	379	470
Number of Banks	29	27	27	26	27	24

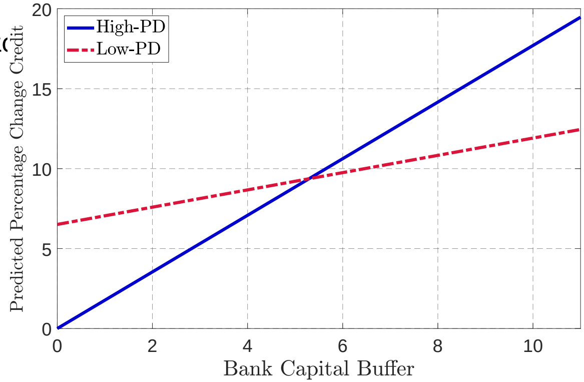
Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Interest rates are weighted by used credit and changes are winsorized at the 1% tails. Standard errors clustered by bank. Sample: 2018:Q1-2020:Q2.

Interpretation Regression Coefficients

▶ Back

- Raising capital, a firm that borrows from two banks (one high-PD and one low-PD) receives relatively less credit from the low-PD bank (β_3 = difference in slopes)

- At low capital, switc e in credit (vice versa)



Based on estimates $\beta_1 = 2.27$, $\beta_2 = 9.86$, $\beta_3 = -2.16$, constant=0. Range bank capital buffers in 2019:Q4: 1.66 to 10.19.

Credit Supply during COVID-19

Back

- Effects similar for COVID-19 crisis

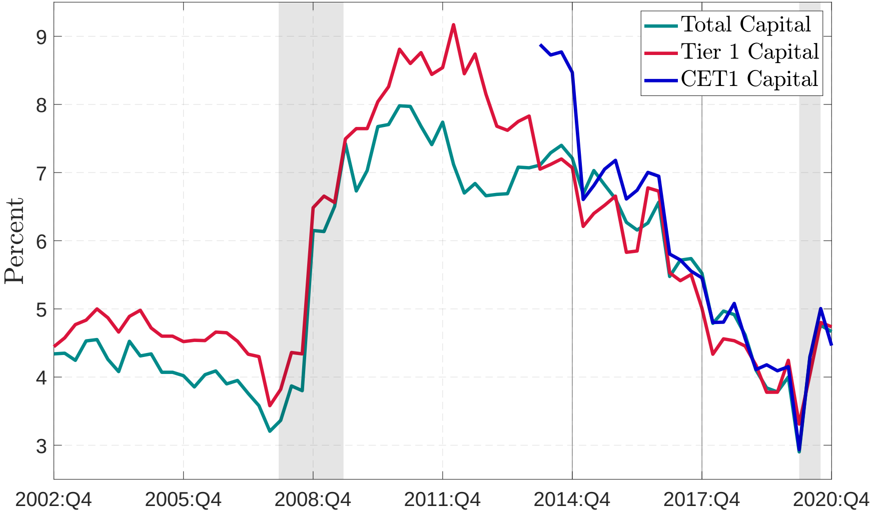
	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.78	0.96	1.77*	2.27**	3.80***	
	(0.59)	(0.70)	(0.86)	(0.92)	(1.04)	
Low-PD		2.63*	6.51**	9.86***	11.56***	8.29**
		(1.51)	(2.74)	(2.93)	(2.70)	(3.44)
Capital × Low-PD			-1.23*	-2.16***	-2.19**	-1.43**
			(0.63)	(0.68)	(0.78)	(0.68)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.53	0.53	0.53	0.53	0.55	0.55
Observations	892	667	667	612	510	663
Number of Firms	412	309	309	286	240	307
Number of Banks	24	23	23	21	23	21

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank. Sample: 2019:Q4-2020:Q2.

Bank Capital Buffers

Bank Capital Ratios & Requirements

Back



Median across Y-14 banks at each date.

Credit Supply - High Capital Buffers

Back

- Effects not present during period of high capital buffers

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	-0.17	0.09	0.10	-0.19	0.40	
	(0.29)	(0.25)	(0.32)	(0.36)	(0.52)	
Low-PD		0.88	0.92	-1.22	-1.16	5.22**
		(0.80)	(1.87)	(2.37)	(4.12)	(2.18)
Capital × Low-PD			-0.01	0.26	0.27	-0.62
			(0.38)	(0.44)	(0.71)	(0.39)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.54	0.55	0.55	0.56	0.55	0.58
Observations	10,309	6,606	6,606	6,135	3,160	6,535
Number of Firms	835	581	581	551	307	574
Number of Banks	32	26	26	26	25	23

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank. Sample: 2014:Q4-2017:Q4.

Credit Supply - Low Capital Buffers excluding COVID

▸ Back

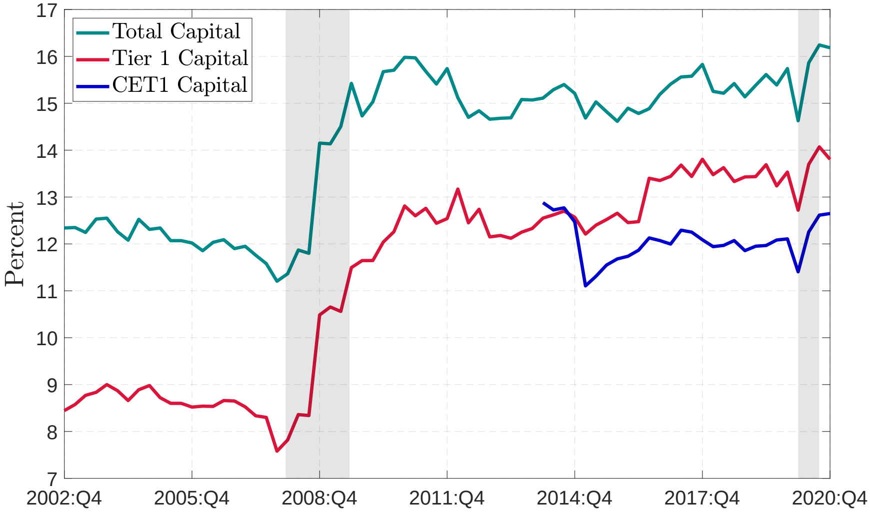
- Similar results during period of low capital buffers excluding COVID

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	-0.20	-0.18	0.58	0.85*	1.09	
	(0.34)	(0.42)	(0.48)	(0.47)	(0.76)	
Low-PD		0.04	4.98**	4.95*	5.96*	3.71
		(1.38)	(2.39)	(2.53)	(3.23)	(2.89)
Capital $\times$ Low-PD			-1.27***	-1.54***	-1.55**	-0.93
			(0.43)	(0.46)	(0.69)	(0.54)
Fixed Effects						
Firm $\times$ Rate $\times$ Time	✓	✓	✓			✓
Firm $\times$ Rate $\times$ Syn. $\times$ Time				✓		
Firm $\times$ Rate $\times$ Pur. $\times$ Time					✓	
Bank $\times$ Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.5	0.53	0.53	0.53	0.52	0.56
Observations	5,292	3,477	3,477	3,097	2,663	3,456
Number of Firms	606	422	422	386	335	420
Number of Banks	28	25	25	25	24	23

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank.
Sample: 2018:Q1-2019:Q4.

Bank Capital Ratios

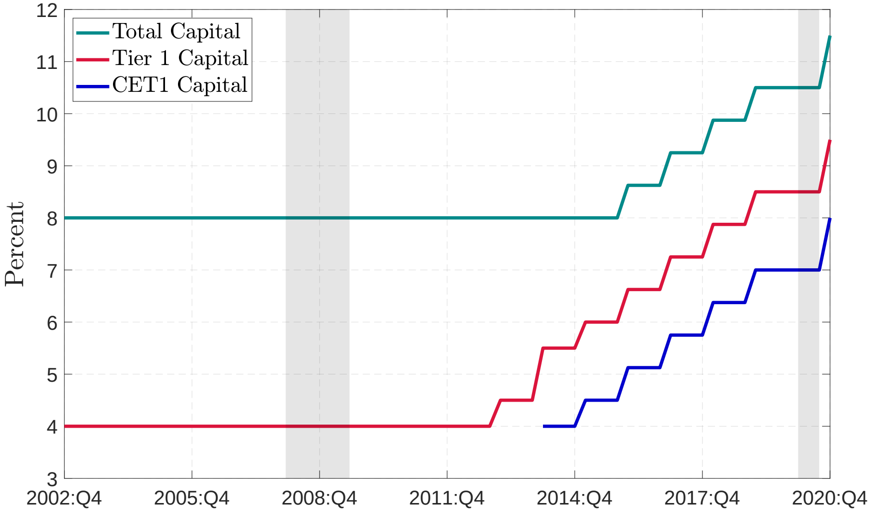
▸ Back



Median across Y-14 banks at each date.

Bank Capital Requirements

▸ Back



Median across Y-14 banks at each date.

Credit Supply - Probability of Default ▸ Back

- Results not explained by low-capital banks favoring safer borrowers

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.07	0.11	0.07	0.13	0.36	
	(0.37)	(0.35)	(0.35)	(0.30)	(0.40)	
PD		-0.11	-0.27*	-0.27**	-0.21	-0.28
		(0.10)	(0.14)	(0.12)	(0.13)	(0.17)
Capital × PD			0.05	0.04	-0.01	0.05
			(0.04)	(0.04)	(0.03)	(0.05)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.5	0.51	0.51	0.52	0.51	0.54
Observations	9,930	7,263	7,263	6,348	5,701	7,251
Number of Firms	969	754	754	674	606	752
Number of Banks	29	27	27	27	27	26

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank.
Sample: 2018:Q1-2020:Q2.

Credit Supply - Low-PD Interactions

Back

- Results remain when controlling for interactions of all bank controls & Low-PD

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.28	0.30	1.18*	1.29**	2.04**	
	(0.33)	(0.30)	(0.65)	(0.60)	(0.80)	
Low-PD		-23.52	29.03	20.58	68.99	44.40
		(58.28)	(71.36)	(87.25)	(72.53)	(63.60)
Capital × Low-PD			-1.62*	-1.93**	-2.23**	-1.69*
			(0.83)	(0.86)	(0.98)	(0.89)
Fixed Effects						
Firm × Rate × Time	✓	✓	✓			✓
Firm × Rate × Syn. × Time				✓		
Firm × Rate × Pur. × Time					✓	
Bank × Time						✓
Bank Controls & Interactions	✓	✓	✓	✓	✓	
R-squared	0.54	0.54	0.54	0.54	0.54	0.57
Observations	4,674	4,674	4,674	4,188	3,617	4,649
Number of Firms	495	495	495	455	396	491
Number of Banks	27	27	27	26	27	24

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets, and each of these interacted with Low-PD. Standard errors clustered by bank. Sample: 2018:Q1-2020:Q2.

Credit Supply - Omitting Firm Fixed Effects ▸ Back

- Results robust to omitting firm fixed effect

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.13	0.54**	0.92***	1.05***	1.14***	
	(0.17)	(0.24)	(0.29)	(0.31)	(0.29)	
Low-PD		-0.07	2.37*	2.97**	2.85**	2.93**
		(0.97)	(1.22)	(1.22)	(1.29)	(1.07)
Capital $\times$ Low-PD			-0.66**	-0.81***	-0.73***	-0.65**
			(0.24)	(0.18)	(0.26)	(0.25)
Fixed Effects						
Rate $\times$ Time	✓	✓	✓			✓
Rate $\times$ Syn. $\times$ Time				✓		
Rate $\times$ Pur. $\times$ Time					✓	
Bank $\times$ Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.01	0.02	0.02	0.02	0.03	0.05
Observations	84,274	8,033	8,033	7,529	7,996	8,022
Number of Firms	15,258	1,135	1,135	1,093	1,133	1,135
Number of Banks	31	27	27	27	27	27

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors two-way clustered by bank and firm. Sample: 2018:Q1-2020:Q2.

Credit Supply - Credit Lines (committed)

Back

- Results robust to including (committed) credit lines

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Capital	0.15	0.13	0.36**	0.45**	0.61**	
	(0.13)	(0.14)	(0.17)	(0.19)	(0.26)	
Low-PD		0.34	2.20**	2.61***	3.07***	1.81*
		(0.50)	(0.82)	(0.81)	(1.08)	(0.96)
Capital $\times$ Low-PD			-0.50***	-0.68***	-0.66**	-0.44**
			(0.18)	(0.21)	(0.27)	(0.19)
Fixed Effects						
Firm $\times$ Rate $\times$ Time	✓	✓	✓			✓
Firm $\times$ Rate $\times$ Syn. $\times$ Time				✓		
Firm $\times$ Rate $\times$ Pur. $\times$ Time					✓	
Bank $\times$ Time						✓
Bank Controls	✓	✓	✓	✓	✓	
R-squared	0.6	0.63	0.64	0.63	0.63	0.64
Observations	21,712	15,152	15,152	11,193	10,233	15,146
Number of Firms	1,881	1,315	1,315	1,075	918	1,314
Number of Banks	30	28	28	27	28	27

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors two-way clustered by bank and firm. Sample: 2018:Q1-2020:Q2.

Credit Supply - Alternative Fixed Effects

Back

- Results robust to replacing firm fixed effect

	(i)	(ii)	(iii)	(iv)
Capital	1.02***	0.86***	0.73**	0.77**
	(0.25)	(0.29)	(0.34)	(0.36)
Low-PD	2.78*	2.60*	2.38	1.27
	(1.35)	(1.44)	(1.45)	(1.33)
Capital × Low-PD	-0.77***	-0.78**	-0.75**	-0.75**
	(0.25)	(0.29)	(0.31)	(0.30)
Fixed Effects				
Time	✓			
Location × Time		✓		
Location × Industry × Time			✓	
Location × Industry × Size × Time				✓
Bank Controls	✓	✓	✓	✓
R-squared	0.01	0.09	0.29	0.42
Observations	8,033	5,822	5,388	3,536
Number of Firms	1,135	833	736	570
Number of Banks	27	27	27	26

Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Location-FE: State of headquarters. Standard errors two-way clustered by bank and firm. Sample: 2018:Q1-2020:Q2.

Effects at the Firm-Level

Back

- Do these effects persist at the firm-level, affecting total debt and investment?
  - When firms experience a credit reduction, they may switch to other banks or nonbanks
  - Lending cuts may not affect firm investment if other resources, like cash-holdings, used instead
- Estimate regression for firm i:

$$\frac{y_{i,t+1} - y_{i,t-1}}{0.5 \cdot (y_{i,t+1} + y_{i,t-1})} = \alpha_i + \tau_{k,t-1} + \beta_1 \widetilde{\text{Capital}}_{i,t-1} + \beta_2 \widetilde{\text{Low-PD}}_{i,t-1} + \beta_3 \widetilde{\text{Low-PD} \times \text{Capital}}_{i,t-1} + \gamma X_{i,t-1} + u_{i,t-1}$$

- Firm outcomes: y is either total debt or fixed assets ("investment")
- Weighted regressors: $\widetilde{\text{Capital}}_{i,t-1} = \sum_{j=1}^{J} \text{Capital}_{j,t-1} \times \text{Term Loan}_{i,j,t-1}/\text{Debt}_{i,t-1}$
- Fixed effects: firm-FE α_i and industry-time-FE $\tau_{k,t-1}$

Effects at the Firm-Level

▸ Back

- Firms are unable to substitute credit supply changes $\rightarrow$ total debt affected

- In turn, credit supply changes translate into firm investment adjustments

	Δ Total Debt		Investment	
	(i)	(ii)	(iii)	(iv)
Capital	0.14***	2.62**	-0.17***	2.08***
	(0.04)	(1.03)	(0.01)	(0.75)
Low-PD		6.11		9.25***
		(4.37)		(3.33)
Capital × Low-PD		-3.55***		-1.50**
		(0.86)		(0.62)
Fixed Effects				
Firm	✓	✓	✓	✓
Time × Industry	✓	✓	✓	✓
Firm Controls	✓	✓	✓	✓
R-squared	0.4	0.4	0.39	0.39
Observations	82,204	82,204	74,926	74,926
Number of Firms	13,861	13,861	12,081	12,081
Number of Banks	37	37	37	37

Firm controls: cash, net income, tangible assets, liabilities (all relative to assets), ln(assets), public-firm-indicator, term loans/debt, unused credit/debt. Standard errors clustered by main-bank and firm. Sample: 2016:Q3-2020:Q4.

Credit Supply - Sample Splits with Credit Lines

Back

- Effects driven by $-$prod., $+$debt, $-$payout firms $\rightarrow$ consistent with theory

	(i) Low Prod.	(ii) High Prod.	(iii) Large Loans	(iv) Small Loans	(v) Low Payout	(vi) High Payout
Capital	0.55	-0.12	0.67	2.22	0.45*	0.26
	(0.36)	(0.18)	(0.50)	(1.45)	(0.24)	(0.27)
Low-PD	3.29**	0.82	7.01**	6.12	2.23**	1.37
	(1.23)	(1.24)	(2.63)	(4.34)	(1.04)	(1.18)
Capital $\times$ Low-PD	-0.70**	-0.03	-1.44***	-2.24	-0.48*	-0.20
	(0.30)	(0.32)	(0.41)	(1.36)	(0.28)	(0.30)
Fixed Effects						
Firm $\times$ CL $\times$ Rate $\times$ Time	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
R-squared	0.65	0.66	0.63	0.5	0.63	0.64
Observations	4,307	4,281	1,672	1,642	3,462	3,442
Number of Firms	560	487	197	225	470	455
Number of Banks	27	27	27	19	27	27

Prod.: net income/assets. Loan size: loan amount. Payout: payout/assets. Splits above/below median of pooled sample. Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank. Sample: 2018:Q1-2020:Q2.

Credit Supply - Sample Splits

Extended Sample | back

- Theory: banks try to steer firms close to default $\rightarrow$ $-$prod., $+$debt, $-$payout firms

	(i) Low Prod.	(ii) High Prod.	(iii) Large Loans	(iv) Small Loans	(v) Low Payout	(vi) High Payout
Capital	3.39***	0.54	1.77	1.22	2.91***	0.85
	(1.06)	(0.73)	(1.08)	(0.96)	(0.71)	(1.14)
Low-PD	15.23**	8.83*	13.61***	8.49	15.22***	6.92
	(6.57)	(4.46)	(4.30)	(8.31)	(4.00)	(4.82)
Capital $\times$ Low-PD	-3.20***	-0.81	-2.77***	-1.02	-2.26***	-1.29
	(1.02)	(1.06)	(0.85)	(1.22)	(0.68)	(0.80)
Fixed Effects						
Firm $\times$ Rate $\times$ Time	✓	✓	✓	✓	✓	✓
Bank Controls	✓	✓	✓	✓	✓	✓
R-squared	0.56	0.64	0.51	0.69	0.67	0.52
Observations	632	618	549	547	520	500
Number of Firms	116	103	104	88	103	106
Number of Banks	24	20	22	20	24	23

Prod.: net income/assets. Loan size: loan/firm debt. Splits above/below median of pooled sample. Bank controls: ROA, dep/assets, income gap, ln(assets), unused credit/assets. Standard errors clustered by bank. Sample: 2018:Q1-2020:Q2.

Further Evidence & Robustness ▸ back

- **COVID-19 & High Capital Buffers**
  - Effects similar for COVID crisis, but not present with high capital buffers ▸ Details
- **Effects at the Firm Level**
  - Effects translate into total debt & investment changes at the firm level ▸ Details
- **Transmission Channel**
  - Results not explained by low-capital banks favoring safer borrowers ▸ Details
  - ... or the transmission working through other bank characteristics ▸ Details
- **Fixed Effects & Credit Lines**
  - Results robust to omitting or replacing firm fixed effect ▸ Details
  - ... and including credit lines into loan sample ▸ Details

Dynamic Model: Timing

Back

Within each period t:

1. Firm productivity z realized
2. Lending contract Q is offered, depending only on curren states (z, b, k)
3. Firm draws preference shocks $\varepsilon^P, \varepsilon^D \sim$ extreme value, chooses to default or not
4. Non-defaulting firms invest, produce, repay debt, and borrow
5. Entrants pay cost of entry
6. Firms invest, produce, repay, borrow, and pay dividends

Dynamic Model: Firm Problem ▸ Back

- Value given Q and realization for the extreme-value shocks

$$V_0(z,b,k,\varepsilon^P,\varepsilon^D;Q) = \max\left\{V^P(z,b,k;Q)+\varepsilon^P, 0+\varepsilon^D\right\}$$

- $\varepsilon^P - \varepsilon^D \equiv \varepsilon$ distributed logistic with scale parameter κ, thus

$$\text{Prob of Repayment} : \mathcal{P}(z,b,k;Q) = \frac{\exp\left[V^P(z,b,k;Q)/\kappa\right]}{1+\exp\left[V^P(z,b,k;Q)/\kappa\right]}$$

$$\text{Expected Value} : \mathcal{V}(z,b,k;Q) = \mathbb{E}_{\varepsilon^P,\varepsilon^D} V_0(z,b,k,\varepsilon^P,\varepsilon^D;Q) = \kappa\log\left\{1+\exp\left[V^P(z,b,k;Q)/\kappa\right]\right\}$$

- Firm value of repayment:

$$V^P(z,b,k;Q) = \max_{b',k',n} div - \mathbb{I}[div<0][e_{con}+e_{slo}\times div] + \beta^f \mathbb{E}_{z'}[\mathcal{V}(z',b',k')|z]$$

$$\text{s.t. } div = zk^\alpha n^\eta - wn - k' + (1-\delta)k + Qb' - b - c_f$$

$$b' \leq \theta k'$$

Dynamic Model: Solution to the Firm Problem ▸ Back

- FOC for capital:

$$\mathbb{E}_{z'}\left\{\mathcal{P}(z',b',k')\left(\beta^f\frac{1+\mu(div')}{1+\mu(div)}\right)[\pi_k(z',k')-\theta]\right\}=1-\theta Q.$$

- $\pi_k(z',k')$ is the MPK next period
- Relationship between offered Q and the MPK when borrowing constraint binds
- $\uparrow Q$ associated with *future* MPK $\downarrow$
- Constraint binds when

$$Q[1+\mu(div)]-\beta^f\mathbb{E}_{z'}\left\{\mathcal{P}(z',b',k')[1+\mu(div')]\right\}>0$$

Competitive and Relationship Lending ▸ back

- $\mathcal{P}(s; Q)$ is probability of repayment and $s = (z, b, k)$
- **Competitive Lending**: Free-entry for lenders $\Rightarrow$ zero-profit condition, implying

$$Q^{comp}(s) = \beta^k \mathbb{E}_{z'}[\mathcal{P}(z', b'(s; Q^{comp}(s)), k'(s; Q^{comp}(s))]$$

- **Relationship Lending**: Lender can choose Q, subject to participation constraint

$$\max_Q W(s; Q) = \mathcal{P}(s; Q)\left[b - Qb'(s; Q) + \beta^k \mathbb{E}_{z'}[W(z', b'(s; Q), k'(s; Q))|z]\right]$$

$$\text{s.t.} \qquad V(s; Q) \geq V(s; Q^{new})$$

Dynamic Model: Entrants & Industry Equilibrium ▸ Back

- Large pool of entrants may pay cost κ to enter and start producing next period.
- We assume that each entrant is endowed with κ units of physical capital
- The value that they obtain is given by

$$V^E(w) = \int_{\underline{z}}^{\tilde{z}} \frac{V(z, 0, \kappa; w)}{\tilde{z} - \underline{z}} \mathrm{d}z.$$

Stationary Industry Equilibrium ▸ Back

Given an arbitrary interest rate function Q, a SIE consists of

1. Policy functions $(k, b')(z, b, k)$ and value functions $V(z, b, k)$
2. Equilibrium wage w
3. Mass of entrants m
4. Stationary distribution $\lambda(z, b, k)$

such that:

1. Policies and values solve the firm's problem given (Q, w)
2. Wage is such that the free-entry condition is satisfied
3. Mass of entrants is such that the market for labor clears
4. λ satisfies its law of motion

$$\lambda(z', b', k') = \sum_{z,b,k} \Pr(z'|z)\mathbb{I}[b^p(z, b, k) = b']\mathbb{I}[k^p(z, b, k) = k']\mathcal{P}[V(b, z, k)]\lambda(z, b, k)$$
$$+\mathrm{m} \times \Pi^e_z(z')\mathbb{I}[b' = 0]\mathbb{I}[k' = 0]$$

Parameter values ▸ Back

Parameter	Description	Value	Source/Reason
ω	Cost of entry	1.118	Normalize $w = 1$
ρ_z	TFP persistence	0.767	Gomes 2001, Gourio & Miao 2010
σ_u	TFP volatility	0.109	Gomes 2001, Gourio & Miao 2010
e_{slope}	Equity issuance cost	0.2	Hennessy & Whited 2007
δ	Depreciation rate	0.10	Standard
α	Production, capital share	0.32	Standard
η	Production, labor share	0.48	Standard
β^k	Lender discount rate	0.97	Standard, real rate of 3%
ψ_1	Recovery value	0.35	Kermani & Ma 2020
β^f	Borrower discount factor	0.884	Internally calibrated
$\mathbf{c}$	Fixed cost	0.055	Internally calibrated
κ	Logistic distr., scale	0.225	Internally calibrated
$\tilde{z}$	TFP distr. for entrants	1.147	Internally calibrated
$\underline{k}$	Initial capital	0.805	Internally calibrated
θ	Constraint parameter	1.040	Internally calibrated
e_{con}	Fixed cost of issuing equity	0.010	Internally calibrated

Data Moments and Model Fit ▸ Back

Moment	Source	Data	Model
Market leverage (median)	Y-14/Compustat	0.63/0.57	0.59
Debt over fixed assets (median)	Y-14/Compustat	1.09/1.20	1.04
Investment rate (aggregate)	Y-14/Compustat	0.104/0.14	0.116
Interest rate spread (median)	Y-14	3.46%	4.22%
Exit rate	Hopenhayn 2018	9.0%	8.3%
Size at entry (relative to mean)	Lee & Mukoyama 2015	0.60	0.57
Size at exit (relative to mean)	Lee & Mukoyama 2015	0.49	0.39
TFP at entry (relative to mean)	Lee & Mukoyama 2015	0.75	0.88
TFP at exit (relative to mean)	Lee & Mukoyama 2015	0.64	0.86

Subsidized Firms vs. Zombie Firms ▸ back

Zombie firm definition from Favara, Minoiu, and Perez-Orive (2022):

- Leverage above median
- Interest coverage ratio below 1
- Negative net income

Model: 5.8% vs. 5.7% in the data.