Banking crises and investments in innovation

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Motivation

Real effects of banking crises

- Large output losses (Laeven & Valencia, 2012)
- Financial recessions last 2.3 years, 40% longer than other recessions (Boissay et al., 2015)
- Slow recoveries: it takes on average 8 years to reach pre-crisis levels of real GDP/capita (Reinhart & Rogoff, 2014)

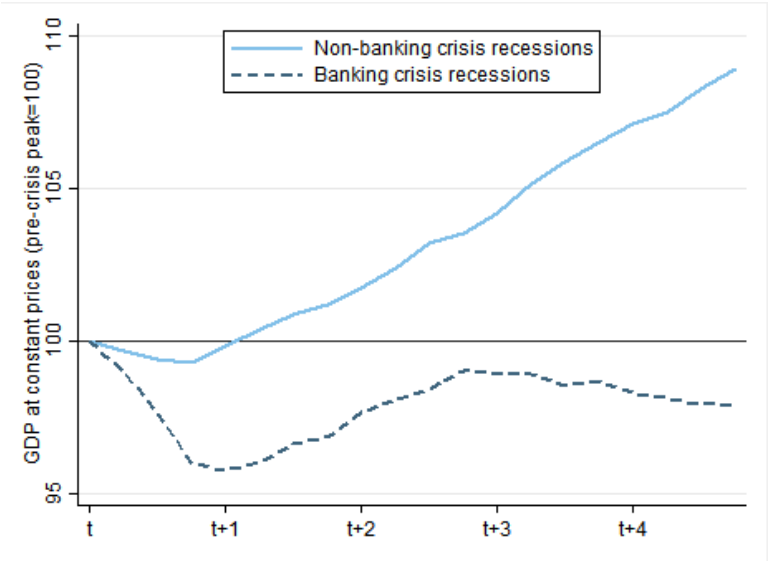

Figure: Recovery following banking crises vs non-banking crises recessions

Motivation

Short- vs long-run

- Long-run impact of financial development on growth (Levine, 2005)
- Short-run amplifying effect of credit frictions over the business cycle (Bernanke et al., 1999; Comin & Gertler, 2006)

Link between short- and long-run dynamics: innovation

- Main driver of productivity growth (Aghion & Howitt, 1999)
- Highly pro-cyclical (Barlevy, 2007; Ouyang, 2011; Aghion et al., 2010; Aghion et al., 2014): balance-sheet effects?

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New insight in this paper

- Evidence of a *supply-side channel*: worsening credit supply conditions after banking crises will disproportionally affect investments in innovation

Outline of the model and empirical results

Theoretical Framework

- Growth model with two types of investments
- Banking sector: subject to panics and crises
- Channel to explain longer-term effect of banking crises $\rightarrow$ composition of investment

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  - Post-crisis: less investment in high productivity technology → slow recovery

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Empirics

- Investments in innovation: R&D
- 13 recent banking crises episodes
- Diff-in-diff estimations: industries that depend more on bank credit reduce their share of R&D in total investment disproportionately more following episodes of banking crises.

Relation to literature

Banking crises

- Real effects of banking crises (Dell'Ariccia et al., 2008; Kroszner et al., 2007; Chava and Purnanandam, 2011; Reinhart and Rogoff, 2014; Ball, 2014; Garicano and Steinwender, 2015)
- Macro models with a financial sector (Brunnermeier and Sannikov, 2014; Boissay et al. 2015)
- Global games (Carlsson and Van Damme, 1993; Morris and Shin 1998, 2004; Goldstein and Pauzner, 2005)

Research and development

- R&D and finance (Brown et al. 2009; Ouyang, 2011; Nanda and Nicholas, 2014, Artuç & Pourpourides, 2014, Hsu et al., 2014)
- R&D as a link between short and long-term dynamics (Aghion et al., 2010; Schmitz, 2015)

Set-up

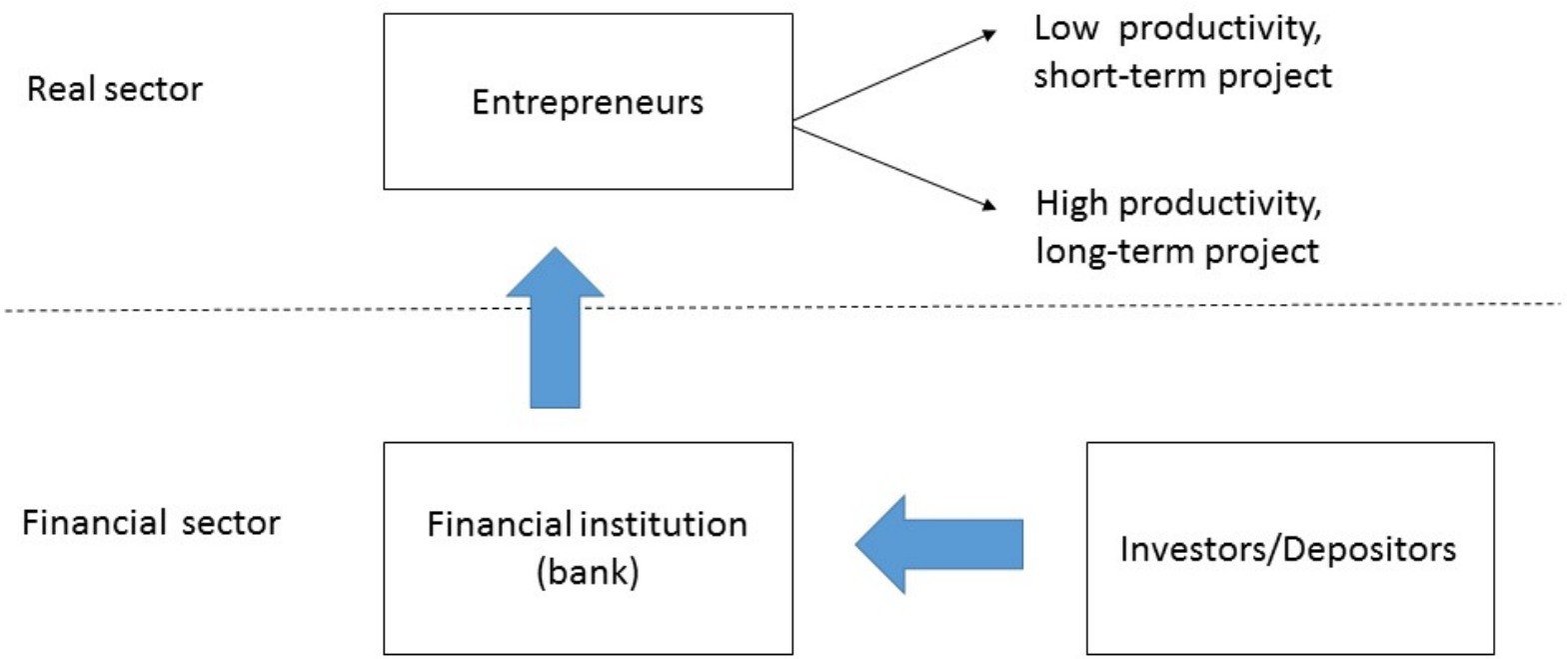

Figure: The economy

Real sector

- Aghion et al. (2010)

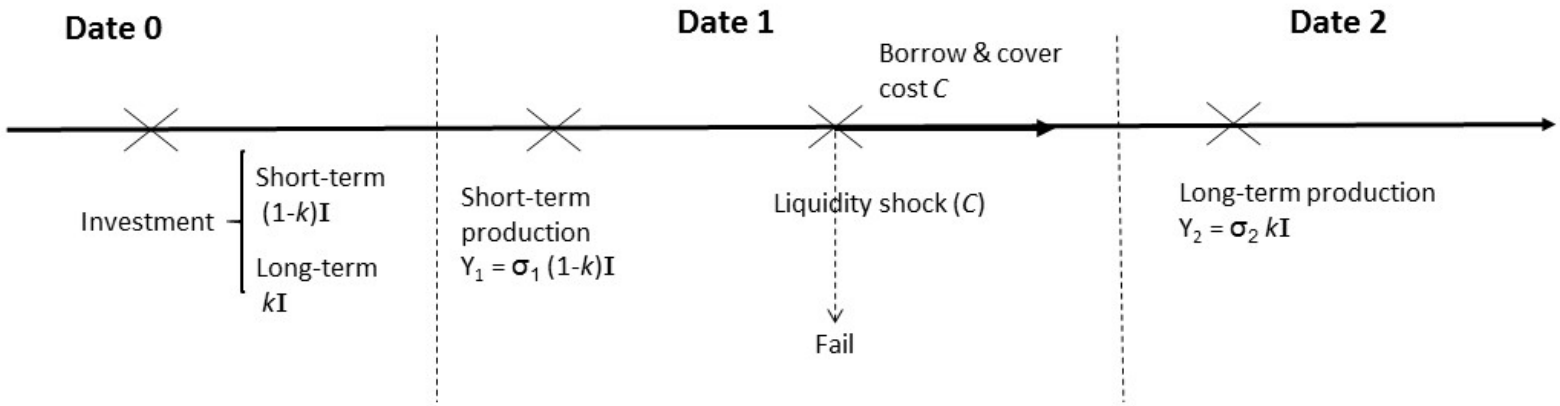

Figure: Timing of the real sector

Entrepreneurs' maximization problem

$$\pi_E(k) = (1-\alpha)\sigma_1(1-k)\mathrm{I} + e(1-\alpha)\sigma_2 k\mathrm{I},$$

Financial sector

Assets	Liabilities
I	D
M	E

Figure: Balance Sheet of the Bank

D - volume of uninsured deposits
M - amount of cash reserves
I - volume of loans to real sector
E - bank equity (exogenous and constant)

Financial sector

Assets	Liabilities
I=$\mu\phi$D	ϕD
M=$(1-\mu)\phi$D	

Figure: Balance Sheet of the Bank

- D + E= D + $\frac{E}{D}$D $\equiv \phi$D, where $\phi \equiv 1+\frac{E}{D}$ (proxy for leverage)
- μ loans-to-assets ratio of the bank
- Investors/depositors receive rD at $t = 2$, but can also withdraw at $t = 1$ and recover their initial investment D

Investors' Equilibrium

- $t = 1$ demand for liquidity:

$$\underbrace{\ell D}_{\text{Depositors}} + \underbrace{C - Y_1}_{\text{Entrepreneurs}} > M$$

- Imperfect information about C (global games):

$$x_i = C + \epsilon_i, \qquad \epsilon_i \sim U[-\epsilon, \epsilon]$$

Proposition 1 There exists a unique Bayesian Nash Equilibrium in which all depositors run on the bank when they observe a signal higher than x^* and leave their funds in the bank in $t = 1$ when they observe a signal lower than x^*. That is, the bank will be in a liquidity crunch, whenever the random shock C is higher than a threshold value, C^*, equal to:

$$C^* = M + Y_1 - \frac{D}{r}$$

▸ Proof

Bank Optimization Problem

$$\underset{\mu}{\text{Max}}$$

$$\underbrace{\lambda(\alpha\sigma_2 k\mu\phi + \alpha\sigma_1(1-k)\mu\phi - r)D}_{\text{No crisis}} + \underbrace{((1-\lambda)\alpha\sigma_1(1-k)\mu\phi + (1-\mu)\phi)D}_{\text{Crisis}}$$

given k and λ

Lemma 1: The share of the high productivity investment, k, is monotonically increasing in the loans-to-assets ratio, μ, for $\phi < \overline{\phi}$.

Proposition 2: As banks become more leveraged, their loans-to-assets ratio, μ, increases monotonically, for $\phi < \overline{\phi}$.

OLG model

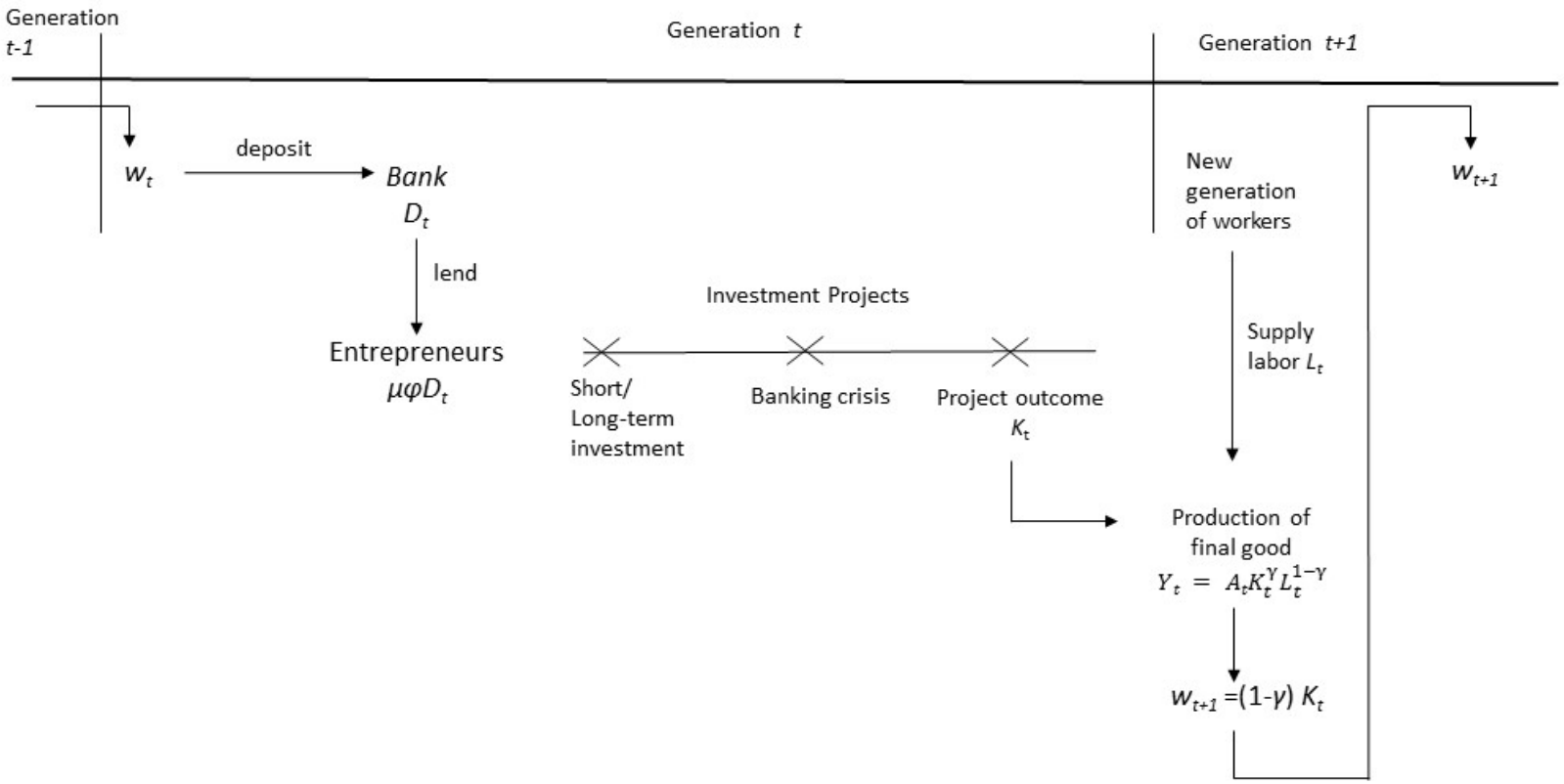

Figure: Timing of the real sector

Model dynamics

The economy experiences the following investment and growth dynamics:

Proposition 3

(i) As long as a bank run does not occur: increase in savings $\rightarrow$ more leveraged banking sector $\rightarrow$ higher loan-to-assets ratio (μ) $\rightarrow$ higher share of high-productivity investment (k).

(ii) A bank run decreases the aggregate income in the next period $\rightarrow$ lower deposits-to-equity ratio $\rightarrow$ banks tighten credit supply by decreasing their loans-to-assets ratio (μ).

(iii) Tighter credit conditions after the banking crisis $\rightarrow$ lower share of investment in the high productivity technology (k), which slows down the recovery.

▸ Simulation of the economy

Empirics

Testable implication

- Tightening credit supply that follows banking crises causes the share of R&D investment in total investment to drop

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- Tightening credit supply that follows banking crises causes the share of R&D investment in total investment to drop

Supply-side or demand-side?

- Banking crises occur at the onset or are followed by recessions (Demirguc-Kunt & Detragiache, 1998)
- Shocks to supply of credit (Iyer et al., 2014; Chava & Purnanandam, 2011)
- Differential impact on financially-dependent borrowers (Dell'Ariccia, et al., 2008; Kroszner et al., 2007; Hsu et al. 2014; Nanda & Nicholas, 2014)

Identification strategy

Rajan & Zingales's (1998) "difference-in-difference" estimations: exogenous way of differentiating between industries that depend more on external finance

$$\Delta R\&D_{ic} = \alpha_i + \mu_c + \beta_1 ExtDep_i \times Bank_c + \beta_2 Size_{ic} + \epsilon_{ic},$$

- $\Delta R\&D_{ic} = R\&D_{crisis} - R\&D_{precrisis}$
- $ExtDep_i$: industry-level measure of dependence on external finance
- $Bank_c$: country-level measure of dependence on the banking sector
- $Size_{ic}$: share of sector i R&D in total country c's R&D
- α_i, μ_c: industry and country fixed effects

Identification

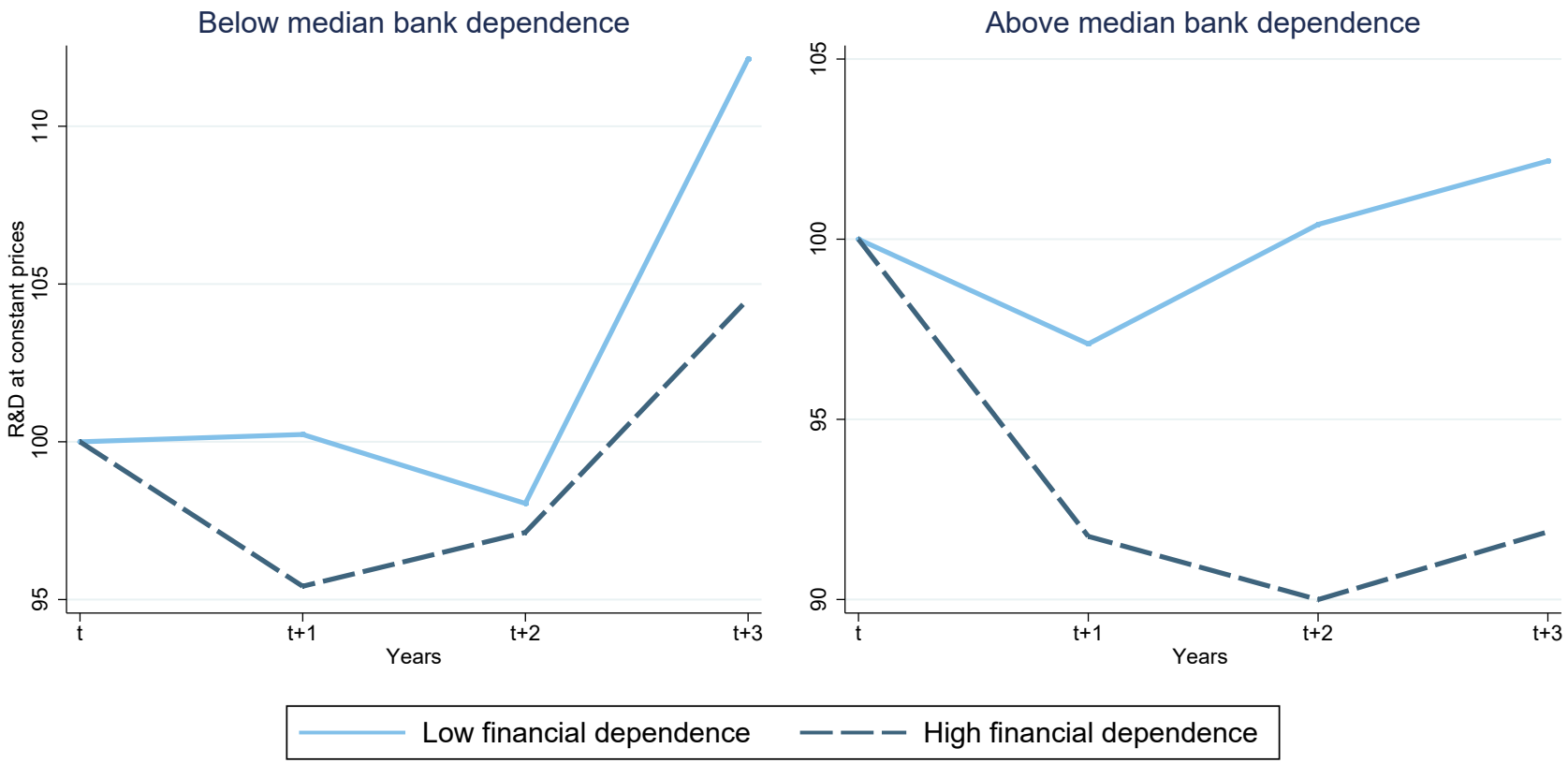

Figure: R&D investments following banking crises

Data

- Industry level data on R&D (OECD ANBERD, STAN): 29, two- and three-digits manufacturing industries
- Industry-level measure of dependence on external finance (*ExtDep*): Rajan & Zingales (1998) (Compustat- firm level data)
- Country-level measure of bank dependence: Private Credit/ Stock Market Capitalization (Levine, 2002)
- 13 systemic banking crises episodes over 1994-2012 (Laeven & Valencia, 2012)

Banking crises and investment in innovation

$$\Delta R\&D_{ic} = \alpha_i + \mu_c + \beta_1 ExtDep_i \times Bank_c + \beta_2 Size_{ic} + \epsilon_{ic}$$

	$\Delta R\&D = (R\&D_{crisis} - R\&D_{precrisis})$		Panel estimations	
	(1)	(2)	(3)	(4)
ExtDep×Bank	-0.0187***	-0.0152***		
	(0.0058)	(0.0053)		
ExtDep×Bank×Crisis			-0.0104***	-0.0115***
			(0.0028)	(0.0034)
$Size_{t-3}$	0.274	-0.346	-0.368***	-0.658***
	(0.600)	(0.389)	(0.101)	(0.230)
Observations	244	248	4,387	4,387
R-squared	0.289	0.279	0.045	0.082
Country FE	YES	YES	YES	
Industry FE	YES	YES	YES	
Year FE			YES	YES
Country-industry FE				YES

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Banking crises and investment in innovation

$$R\&D_{ict} = \alpha_i + \mu_c + \lambda_t + \beta_1 ExtDep_i \times Bank_c \times Crisis_{ct} + Share_{ic} + \epsilon_{ict},$$

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Share of R&D in Total Investment

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	(1)	(2)	(3)	(4)
ExtDep×Bank	-0.0104***	-0.0278***		
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ExtDep×Bank×Crisis			-0.0056**	-0.0047*
			(0.0025)	(0.0024)
Size$_{t-3}$	-0.0962	0.0916	0.263**	0.0243
	(0.153)	(0.510)	(0.105)	(0.0243)
Observations	234	234	4,415	4,415
R-squared	0.333	0.320	0.712	0.888
Country FE	YES	YES	YES	
Industry FE	YES	YES	YES	
Year FE			YES	YES
Country-industry FE				YES

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Banking crises vs balance sheet effects

	R&D		*R&D/TI*	
	(1)	(2)	(3)	(4)
ExtDep×Bank×Crisis	-0.00943***	-0.0112***	-0.00617**	-0.00441**
	(0.00264)	(0.00330)	(0.00285)	(0.00209)
ExtDep×Bank×Recession	-0.00246	0.00181	-0.0242***	-0.00414
	(0.00626)	(0.00737)	(0.00765)	(0.00585)
Observations	4,080	4,080	4,103	4,103
R-squared	0.049	0.089	0.730	0.881
Country FE	YES		YES	
Industry FE	YES		YES	
Year FE	YES	YES	YES	YES
Country-industry FE		YES		YES

Alternative industry characteristics

	R&D growth				*R&D/TI*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Triple interaction terms: Industry Characteristic×Bank×Crisis								
ExtDep	-0.014***	-0.0096***	-0.0088***	-0.0044	-0.0064**	-0.0096***	-0.011***	-0.0096**
	(0.0039)	(0.0030)	(0.0029)	(0.0034)	(0.0027)	(0.0029)	(0.0032)	(0.0039)
Tangible	-0.0001				-0.0000			
	(0.0005)				(0.0002)			
Small		-0.00907**				0.0047		
		(0.00364)				(0.003)		
Durable			-0.0103*				0.0002	
			(0.0059)				(0.0055)	
Intensity				-0.0113*				0.0078
				(0.0066)				(0.0057)
Country, Industry, Time Fixed effects								
Observations	3082	3545	2354	2247	3103	3558	2368	2262
R-squared	0.028	0.020	0.041	0.055	0.706	0.748	0.433	0.709

Robustness tests

- Different time pre/post crisis time frames
- Split sample analysis: banking crisis vs non banking crisis periods
- Inclusion of only countries that have experienced the 2008 GFC
- Model saturated with two-way fixed effects
- Include also countries that have not experienced systemic banking crises
- Alternative measures of financial dependence:
  - Bank dependence: Carlin & Mayer (2003) (Orbis firm level data)
  - Country measure of bank dependence to include bond market funding
- Falsification strategies: random crisis date; hypothetical crisis date in 2008 all countries

Conclusions

Theoretical model:

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Empirical findings:

- Show that industries that depend more on the banking sector reduce their R&D investments, as well as the share of R&D in total investment, disproportionately more following episodes of banking crises.

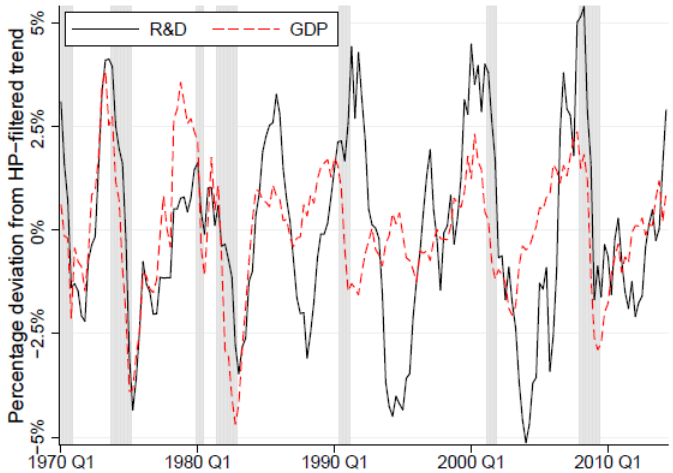
Policy implications:

- Policies that encourage R&D investment during periods of tight credit supply and in more financially constrained industries

Thank you!

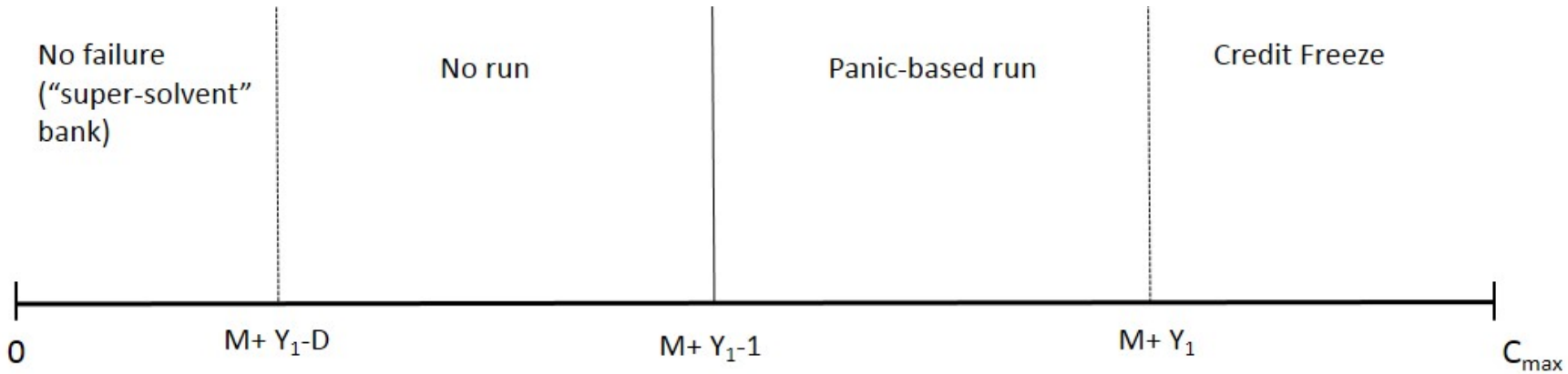
Motivating evidence

- Impact of investments in R&D investment on productivity growth:
  - Standard growth accounting framework: the elasticity of output to investments in R&D between 0.05 to 0.12 (larger than regular investment) (Guellec and van Pottelsberghe de la Potterie, 2001; Hall et al., 2010)
  - Impact of R&D is not only strongly positive, but also relatively fast: two periods in cross-country studies; 1-4 years in firm-level studies.
- Volatility of R&D:



Source: Schmitz (2014): R&D and GDP fluctuations in the United States

Proof of investors' equilibrium



2 equations determine the threshold equilibrium.

1. The number of investors who run on the bank:

$$\ell = Prob(x_i > x^* | C_1) = Prob(C_1 + \epsilon_i > x^* | C_1) = 1 - \frac{1}{2\epsilon}(x^* - C_1 + \epsilon),$$

since x_i is uniformly distributed over $[C_1 - \epsilon, C_1 + \epsilon]$.

Define C^* the threshold cost at which the bank is illiquid:

$$\ell D + C^* = M + Y_1$$

Then: $x^* = C^* - \epsilon - \frac{2\epsilon}{rD}(M + Y_1 - C^*)$

Proof of equilibrium

2. At the threshold a depositor is indifferent between withdrawing and leaving his funds in the bank:

$$Prob(C < C^*|x^*)rD = D,$$

given that C is uniform over $[x - \epsilon, x + \epsilon]$.
which is equivalent to:

$$C^* - x^* = \frac{2\epsilon}{r} - \epsilon$$

Plunging this into the first equation gives:

$$C^* = M + Y_1 - \frac{D}{r}.$$

QED

Simulation of the economy

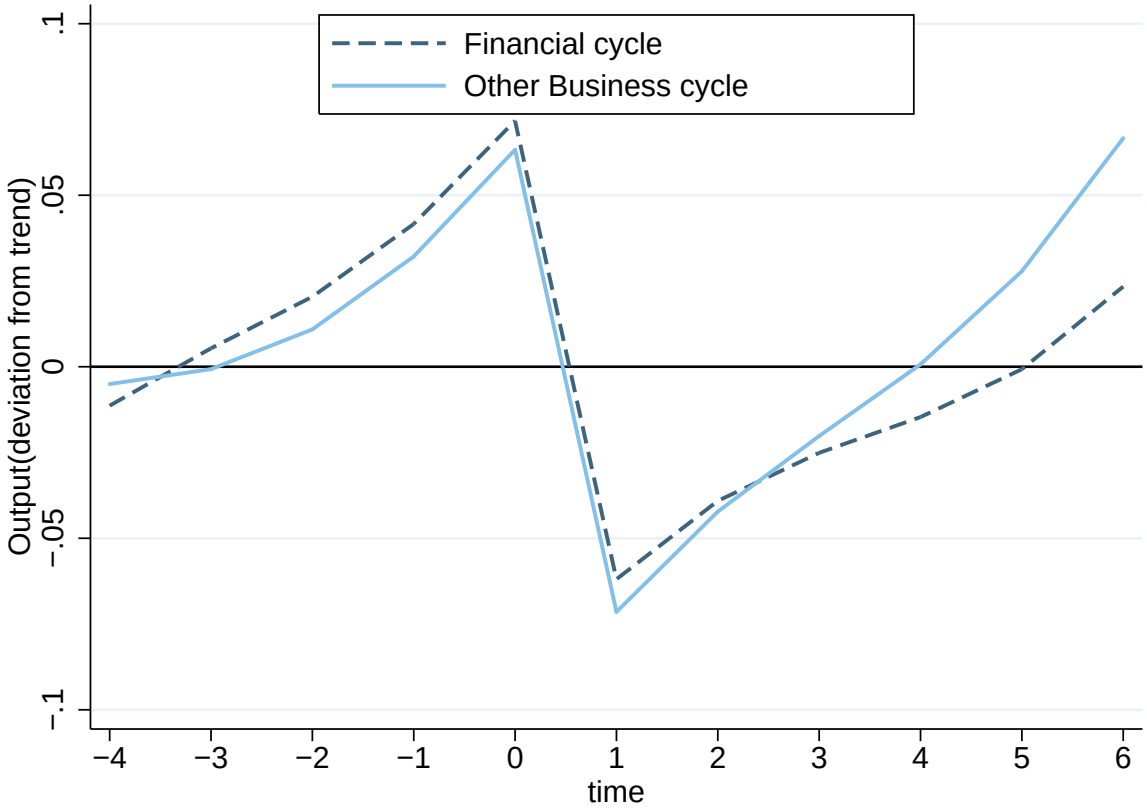


Figure: Dynamics of GDP around recessions