

Banking crises and investments in innovation

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Motivation

Real effects of banking crises

- Large output losses (Laeven & Valencia, 2012) and longer 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)

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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 disproportionately affect investments in innovation

Outline of the model and empirical results

Theoretical Framework

- Growth model with a banking sector subject to crises
- Channel to explain longer-term effect of banking crises → composition of investment

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Empirics

- Industry-level data on R&D around 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'Araccia 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, 2001, 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

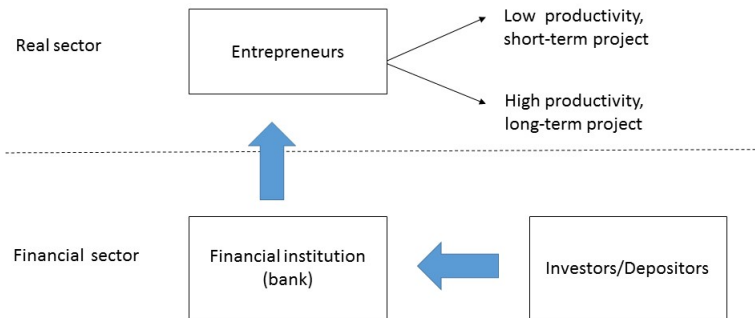


Figure: The economy

Real sector

- Aghion et al. (2010)

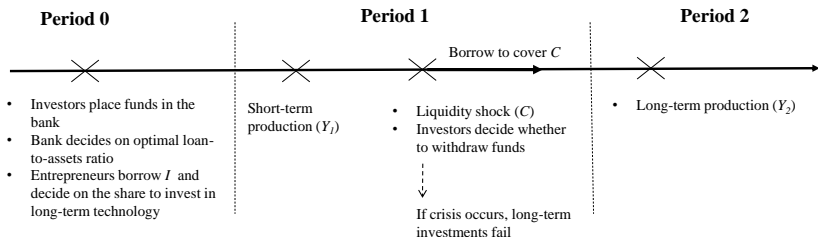


Figure: Timing of the real sector

Financial sector and bank runs

<u>Assets</u>	<u>Liabilities</u>
I (loans to real sector)	D (deposits)
M (cash reserves)	E (equity)

Figure: Balance Sheet of the Bank

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Figure: Balance Sheet of the Bank

- Period 1 demand for liquidity coming from both sides of the balance sheet:

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

- C is noisy (global games equilibrium selection argument)

Equilibrium

Proposition 1 There exists a unique Bayesian Nash Equilibrium in which a bank run occurs whenever $C > C^*$:

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

Lemma 1: The share of investment in the long-term technology is monotonically increasing in the credit supply.

Proposition 2: The loans-to-assets ratio in the banking sector increases monotonically with bank leverage.

OLG model

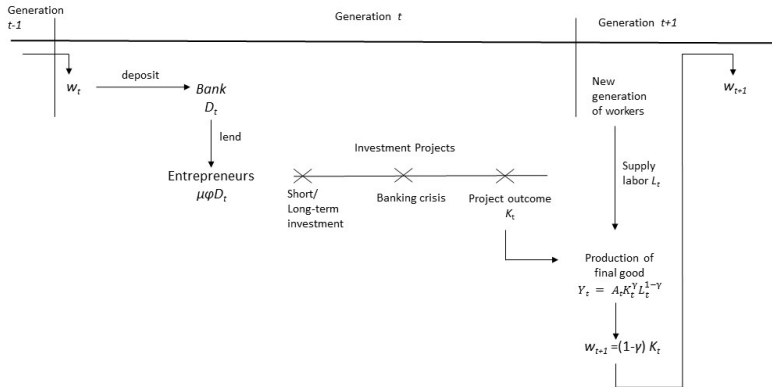


Figure: Timing of the real sector

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 \rightarrow higher share of high-productivity investment
- (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
- (iii) Tighter credit conditions after the banking crisis \rightarrow lower share of investment in the high productivity technology, 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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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

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

- $\Delta R\&D_{ic} = R\&D_{post-crisis} - R\&D_{pre-crisis}$
- $ExtDep_i$: 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

Data

- Industry level data on R&D and Total investment: 29 two- and three-digits manufacturing industries (OECD ANBERD, STAN)
- Industry-level measure of dependence on external finance: 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

$$\Delta R\&D_{ic} = \alpha_i + \mu_c + \beta_1 \text{ExtDep}_i * \text{Bank}_c + \beta_2 \text{Size}_{ic} + \epsilon_{ic}$$

	$\Delta R\&D = (R\&D_{postcrisis} - R\&D_{precrisis})$		Panel estimations	
	(1)	(2)	(3)	(4)
ExtDep*Bank	-0.0187*** (0.0058)	-0.0152*** (0.0053)		
ExtDep*Bank*Crisis			-0.0104*** (0.0028)	-0.0115*** (0.0034)
Size _{t-3}	0.274 (0.600)	-0.346 (0.389)	-0.368*** (0.101)	-0.658*** (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

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Share of R&D in Total Investment

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ExtDep*Bank*Crisis			-0.0056** (0.0025)	-0.0047* (0.0024)
Size _{t-3}	-0.0962 (0.153)	0.0916 (0.510)	0.263** (0.105)	0.0243 (0.0243)
Observations	234	234	4,415	4,415
R-squared	0.333	0.320	0.712	0.888
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Banking crises vs balance sheet effects

	<i>R&D</i>		<i>R&D/TI</i>	
	(1)	(2)	(3)	(4)
ExtDep*Bank*Crisis	-0.00943*** (0.00264)	-0.0112*** (0.00330)	-0.00617** (0.00285)	-0.00441** (0.00209)
ExtDep*Bank*Recession	-0.00246 (0.00626)	0.00181 (0.00737)	-0.0242*** (0.00765)	-0.00414 (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

	<i>R&D growth</i>				<i>R&D/TI</i>			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ExtDep	-0.014*** (0.0039)	-0.0096*** (0.0030)	-0.0088*** (0.0029)	-0.0044 (0.0034)	-0.0064** (0.0027)	-0.0096*** (0.0029)	-0.011*** (0.0032)	-0.0096** (0.0039)
Tangible	-0.0001 (0.0005)				-0.0000 (0.0002)			
Small		-0.00907** (0.00364)				0.0047 (0.003)		
Durable			-0.0103* (0.0059)				0.0002 (0.0055)	
Intensity				-0.0113* (0.0066)				0.0078 (0.0057)
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:

- Identify a new channel through which banking crises can impact long-run growth

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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.

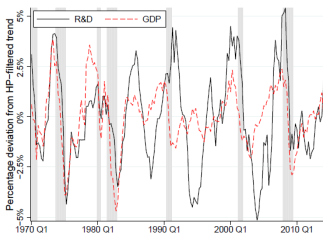
Policy implications:

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

Thank you!

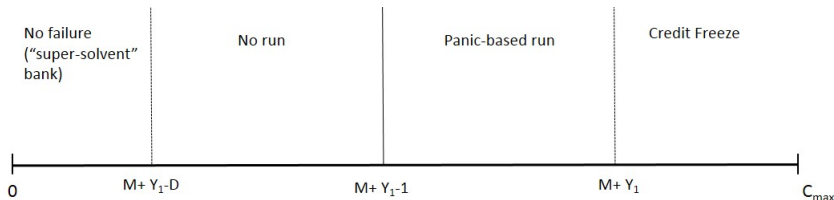
Motivating evidence

- 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:

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

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:

$$\text{Prob}(C < C^* | x^*) rD = D,$$

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

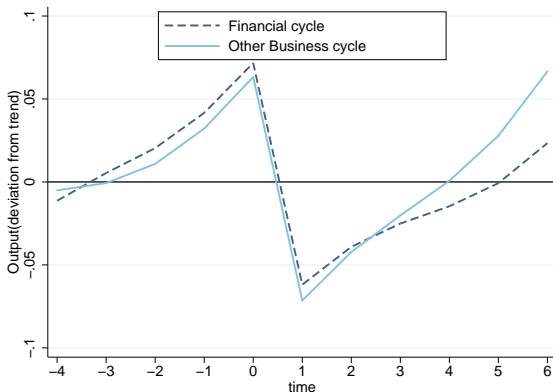


Figure: Dynamics of GDP around recessions