Borrowing Constraints, Banks' Time-Horizons and Industry Evolution

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Motivation

Stylized Facts

External finance plays a fundamental role for a multitude of firm dimensions:

- investment decisions (Fazzari et al., 1988)
- inventory demand (Kashyap et al., 1994)
- R&D decisions (Hall, 2002)
- wage dynamics (Michelacci and Quadrini, 2009)
- asset management (Campello et al., 2010)

A generalized lack of external finance has been attributed to:

- transition toward market-based financial systems (Dosi, 1990)
- impatience of the banking industry (Deeg and Hardie, 2016)
- misalignment between shareholders and managers (Dawid et al., 2018)

Stylized Facts

But which firms are more affected by limited access to external finances?

Firm's age (years)	Whole sample: Number of observations	Whole sample: Size: mean (median)	Non-financially constrained (NFC): Number of observations (percentage of age class)	Non-financially constrained (NFC): Size: mean (median)	Mildly financially constrained (MFC): Number of obs. (percentage of age class)	Mildly financially constrained (MFC): Size: mean (median)	Highly financially constrained (HFC): Number of observations (percentage of age class)	Highly financially constrained (HFC): Size: mean (median)
0–4	53,351	1.679	15,184	1.643	27,463	1.891	10,704	1.184
		(0.525)	(28.5)	(0.433)	(51.5)	(0.654)	(20.1)	(0.373)
5–10	66,094	3.094	23,450	3.732	34,666	3.019	7,978	1.539
		(0.838)	(35.5)	(0.827)	(52.4)	(0.984)	(12.1)	(0.409)
11–20	79,780	6.204	37,469	7.097	36,339	5.703	5,715	3.573
		(1.522)	(47.0)	(1.639)	(45.5)	(1.651)	(7.5)	(0.497)
21–30	44,706	8.799	24,174	9.554	18,364	8.492	2,168	2.976
		(2.552)	(54.1)	(2.665)	(41.1)	(2.757)	(4.8)	(0.599)
>31	25,817	21.682	14,278	22.184	10,059	18.999	1,480	35.067
		(3.945)	(55.3)	(4.369)	(39.0)	(4.127)	(5.7)	(1.239)
Total	269,748	6.458	118,975	7.867	132,615	5.437	30,998	3.472
		(1.231)	(44.1)	(1.450)	(49.2)	(1.270)	(11.5)	(0.421)

Figure 1: Source: Bottazzi et al. (2014)

Stylized Facts

And even more importantly, how is firms' growth affected?

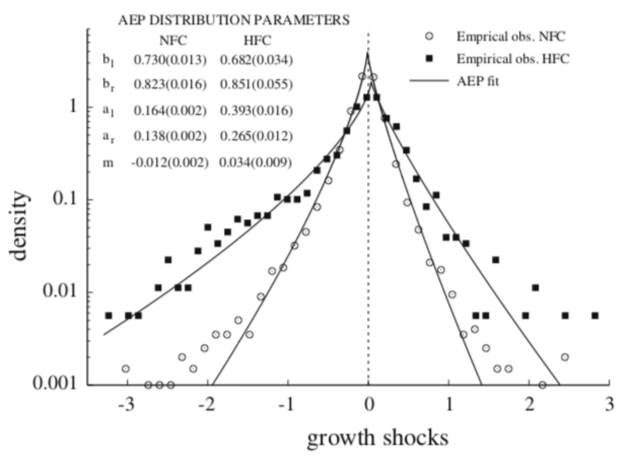

Figure 2: Source: Bottazzi et al. (2014)

Literature

Notwithstanding the large body of empirical evidence discussing this issue, previous models of industry dynamics have been focusing on the roles of:

- Stochastic firm growth or productivity (Bottazzi and Secchi, 2006; Alfarano et al., 2012);
- Learning and market selection equilibrium (Jovanovic, 1982; Ericson and Pakes, 1995)
- Learning and market selection disequilibrium (Dosi et al., 1995, 2017; Amendola and Gaffard, 2006)

But they overlooked the relation of firm and industry dynamics with credit markets.

To our knowledge only some equilibrium models of firm dynamics and credit are present (Cooley and Quadrini, 2001; Albuquerque and Hopenhayn, 2004).

Aim of the paper

Model how credit markets characteristics:

- access to external finance (i.e. credit constraints)
- patience of the banking sector (i.e. time-horizon)

might affect firm dynamics and industry evolution:

- productivity
- concentration and competitiveness
- firm size and firm growth distributions

Sneak preview of the results

Under tighter credit constraints scenarios:

- the industry is farther from the technology frontier
- there is a trade-off between productivity and profitability
- the industry is more concentrated
- firm growth rates are more volatile
- average and median firm tends to be older and bigger

When the banking industry is short-term oriented:

- more industry concentration
- lower adoption of new technologies

The Agent-Based Model

What is an ABM?

A tool to model economies where agents

- are boundedly rational
- interact directly in non-trivial network connections
- might be persistently heterogeneous

A bottom-up approach that allows one to:

- model behavioural rules
- match statistical regularities

No analytical solution. Need to rely on MonteCarlo simulations.

Industry demand

The industry demand (d) is an exogenous stochastic process, whose random sequence is fixed and generated before the model runs.

Industry demand is modelled as a logistic function, to take into account the industry life cycle (Klepper, 1997)

$$d_t = \frac{\eta}{1 + (\frac{\eta - d_0}{d_0})e^{-\xi t}} + \varepsilon_t \tag{1}$$

Timeline of the events

1. Entry of new firms
2. Technical change
3. Adoption process (planning)
4. Expansion process (planning)
5. Determination of production and labour requirements (planning)
6. Determination of wages and prices (WS-PS model)
7. Computation of costs (planning)
8. Demand for credit and allocation of credit
9. Allocation of demand for goods
10. Balance sheets operations
11. Exit of bankrupt firms

Entry and exit

Entry depends on the excess demand in the industry and is specified via a Poisson process $\mathcal{P}_t$ with average success rate that depends on the size of the imbalance

$\mathbb{E}[\mathcal{P}_t] = \lambda(D_{t-1} - S_{t-1})$.

$$E_t = \begin{cases} 0 & \text{if } D_{t-1} - S_{t-1} \leq 0 \\ \mathcal{P}_t & \text{if } D_{t-1} - S_{t-1} > 0 \end{cases} \tag{2}$$

Bankrupt firms exit if net-worth is negative or if market shares are too low. The number of firms is determined as:

$$N_t = N_{t-1} + E_t - X_t \tag{3}$$

Technical change

In the Amendola and Gaffard (2006) tradition, there is a set of available technologies $\mathcal{J}_t$ characterized by:

- productivity in production $\alpha_F(j)$
- productivity in construction $\alpha_C(j)$
- the time to build the technology $\tau(j)$
- the sunk cost of the technology $\bar{c}(j)$

Technical change is a two-step process, in the Nelson and Winter (1982) traditions:

1. Bernoulli draw $\mathcal{F}(\rho)$ tells whether an innovation happens
2. a Beta distribution draw tells the gain $\mathcal{B}(a, b)$

Formally:

$$\alpha_F(j) = \mathcal{F}(\rho) \cdot [\alpha_F(j-1) + \mathcal{B}(a, b)] \tag{4}$$

Adoption process

Assumptions:

- Adopting a new technology is costly in terms of labour allocated to installing the technology;
- the payback period is set as a multiple k of the time τ required to install the new technology;
- k and τ are the same for all technologies.

Decision:

$$AD_{i,t} = \begin{cases} 1 & \text{if } \left(\frac{w_{t-1}}{\alpha_F(j_i)} - \frac{w_{t-1}}{\alpha_F(j)}\right) k\tau \geq \left(\frac{w_{t-1}}{\alpha_C(j)}\right) \hat{q}_{i,t}\tau \\ 0 & \text{if } \left(\frac{w_{t-1}}{\alpha_F(j_i)} - \frac{w_{t-1}}{\alpha_F(j)}\right) k\tau < \left(\frac{w_{t-1}}{\alpha_C(j)}\right) \hat{q}_{i,t}\tau \end{cases} \tag{5}$$

Rationale: apply if lower cost for production (saving cost of labour) is larger than cost of installation of the new technology.

Expansion process

Assumptions:

- Expanding the productive capacity is also costly in terms of labour allocated to build up the new capacity;
- the payback period is set as a multiple k of the time τ required to install the new technology;
- expanding the productive capacity also involves a sunk cost $\bar{c}$.

Decision:

$$EX_{i,t} = \begin{cases} 1 & \text{if } \left(d^e_{i,t+1} - \hat{q}_{i,t}\right) p_{i,t-1} k\tau \geq \left(\frac{w_{t-1}}{\alpha_C(j)}\right) (d^e_{i,t+1} - \hat{q}_{i,t})\tau + \bar{c} \\ 0 & \text{if } \left(d^e_{i,t+1} - \hat{q}_{i,t}\right) p_{i,t-1} k\tau < \left(\frac{w_{t-1}}{\alpha_C(j)}\right) (d^e_{i,t+1} - \hat{q}_{i,t})\tau + \bar{c} \end{cases} \tag{6}$$

Rationale: expand if higher profit from expected additional sales are larger than cost of capacity expansion.

Credit market

Demand for credit is determined by pecking order theory:

$$b_{i,t} = \begin{cases} 0 & \text{if } NW_{i,t} \geq C^{pr}_{i,t} + C^{in}_{i,t} \\ C^{pr}_{i,t} + C^{in}_{i,t} - cash_{i,t} & \text{if } NW_{i,t} < C^{pr}_{i,t} + C^{in}_{i,t} \end{cases} \tag{7}$$

The bank might decide to reject credit (credit rationing) to a firm according to:

$$\theta^{CR}_{i,t} = 1 - \frac{1}{1 + exp\left(-\varphi \sum_{n=1}^{d} \frac{ROA_{i,n}}{d}\right)} \quad \text{with } \varphi \geq 0 \text{ and } d \geq 1 \tag{8}$$

The rationing function

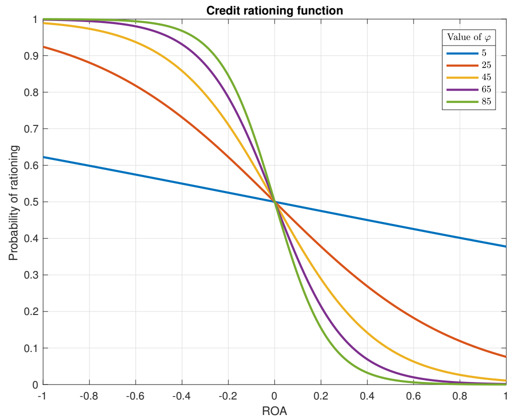

Figure 3: Credit rationing function for 5 different values of φ.

Individual demand

Market shares are determined by price competition:

$$sh_{i,t} = sh_{i,t-1}\left[1 + \psi\left(\frac{\bar{P}_t - P_{i,t}}{P_t^{Max} - P_t^{min}}\right)\right] \tag{9}$$

Individual demand is therefore:

$$d_{i,t} = sh_{i,t}d_t \tag{10}$$

Results

Comparisons

We'll compare two archetypical situations:

- no credit constraint
- presence of credit constraint

in controlled environment where between scenarios

- parameters are equal
- RNG are equal

We begin by showing outcome from a single run and then we show also statistical significance results from 100 MC simulations.

Parametrization

Parameter	Meaning	Value
M	MonteCarlo simulations	100
T	TimePeriods of each M	400
μ	mark-up	0.3
λ	entry scaling	1
ρ	prob. of tech change	0.9
a	a of the Beta distribution	5
b	b of the Beta distribution	2
$\bar{c}$	fixed cost	1
τ	time to build	8
k	payback period multiplier	1
φ	patience degree (nonlinearity)	20
d	patience degree (smoothing)	5
r	interest rate on debt	0.01
θ	debt repayment	0.1
η	S-shaped demand capacity	30
ξ	S-shaped demand smoothness	0.03

Table 1: Baseline parametrization of the model.

Demand and Supply

Dynamics of industry life cycle models. Supply follows demand by construction.

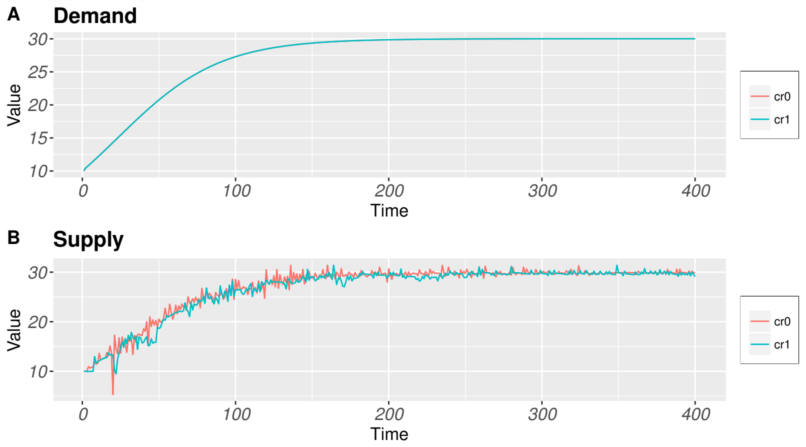

Figure 4: Industry demand (top) and industry supply (bottom).

Concentration and population

Credit constraints increase concentration and decrease the number of firms in the industry and increase market concentration.

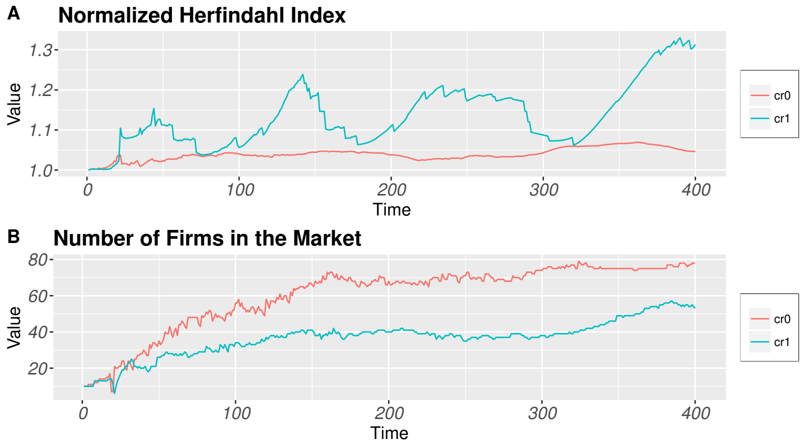

Figure 5: Herfindahl-Hirschman Index (top) and number of firms in the industry (bottom).

Profitability

Profitability (ROA) is higher in the selection phase, when rationing constraints are binding.

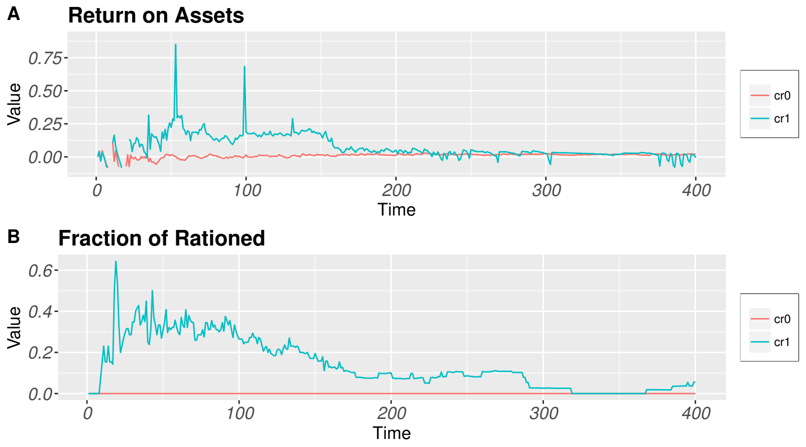

Figure 6: Return on assets (top) and fraction of credit rationed firms (bottom).

Firms Size

Firms are larger in size (also employees).

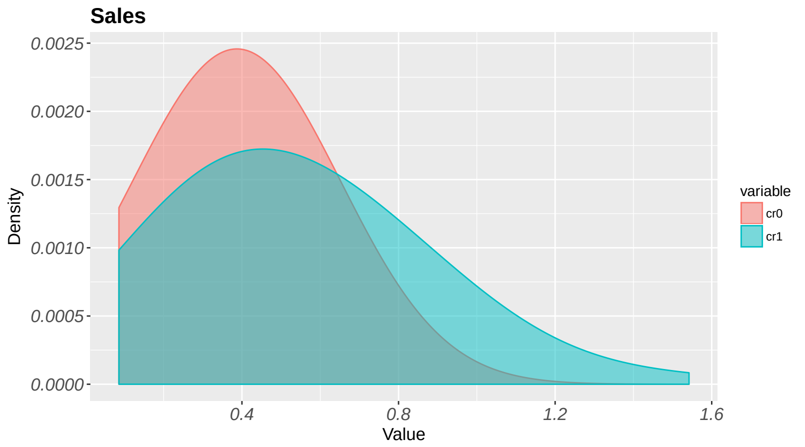

Figure 7: Distribution of firm sizes in the scenarios without (red) and with credit rationing (blue) under gradual adjustments

Nevertheless, under industry productivity is lower (and real wages as well)

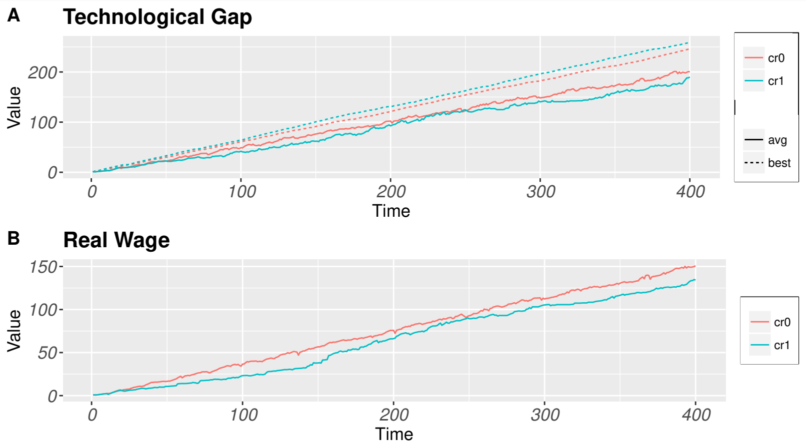

Figure 8: Productivity (top) and real wage (bottom).

Firm growth rates

Firm growth process is more volatile as the tails get fatter.

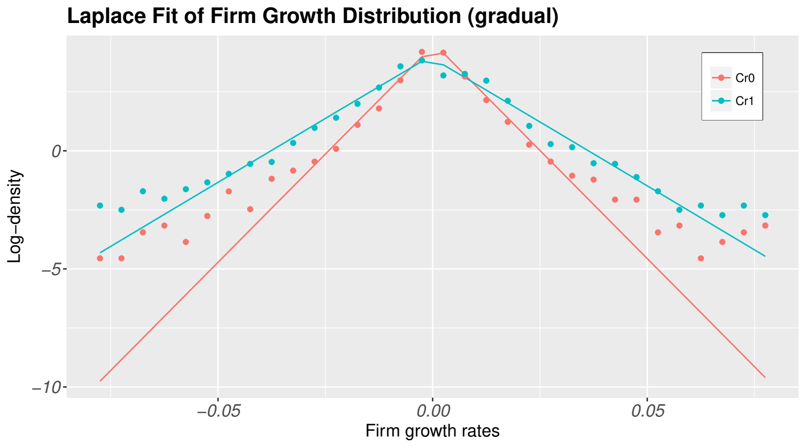

Figure 9: Firm growth rates distributions together with an exponential-power fit

Comparison

All in all, box-plots and simple t-tests suggest statistical significance is present for most of the variables.

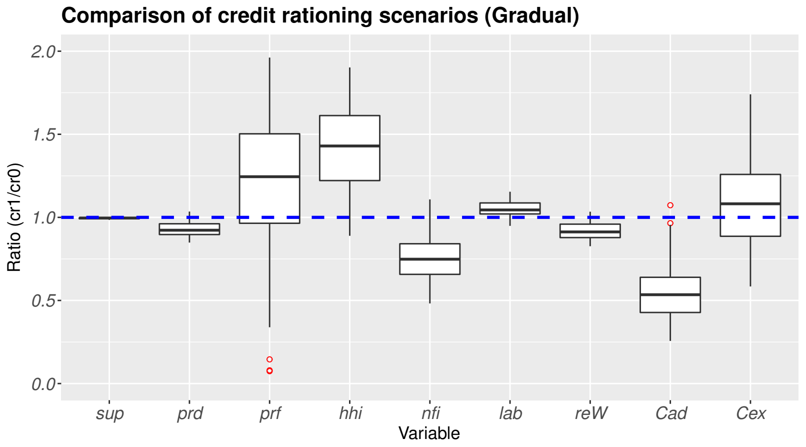

Figure 10: Boxplot of the main variables. Ratio between non-rationing and rationing scenario (100 MC).

Transmission Mechanisms

Which firms get rationed?

Larger firms are less likely to be rationed.

	Dependent variable:	
	rationed	rationed
	logit	*RE-logit*
	(1)	(2)
sales	−3.077***	−3.075***
	(0.109)	(0.109)
debt to sales	−0.000***	−0.000**
	(0.000)	(0.000)
Constant	−0.048	−0.049
	(0.068)	(0.068)
Observations	14609	14609
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 2: Regression of rationing dummy variable on firms characteristics.

Which firms survive?

Rationed firms are less likely to survive.

	Dependent variable:	
	rationed	rationed
	logit	*RE-logit*
	(1)	(2)
sales	1.906***	1.899***
	(0.308)	(0.308)
rationed	0.167	−240.242***
	(4.204)	(0.420)
debt to sales	−0.000	−0.000*
	(0.000)	(0.000)
Constant	2.924***	2.925***
	(0.207)	(0.207)
Observations	14609	14609
Note:	*p<0.1; **p<0.05; ***p<0.01	

Table 3: Logit regression of survival dummy variable on firms characteristics

Discussion

All in all we find that there is an important trade-off. Limited access to finance:

- on one side it generates higher profitability and concentration;
- on the other it lowers innovation and productivity.

This has important policy implications. Credit constraints:

- are not necessarily a negative instrument, since they fasten market selection;
- but they have negative drawbacks as they reduce the rate of technical change.

These two points contrast the standard view according to which higher rents (e.g. monopoly power given by patent protection) induce higher innovation.

Additional Experiments

The effects of lumpiness

Lumpiness affects the growth shocks. Growth rates become more volatile in the non-rationing scenario and less volatile in the rationing scenario.

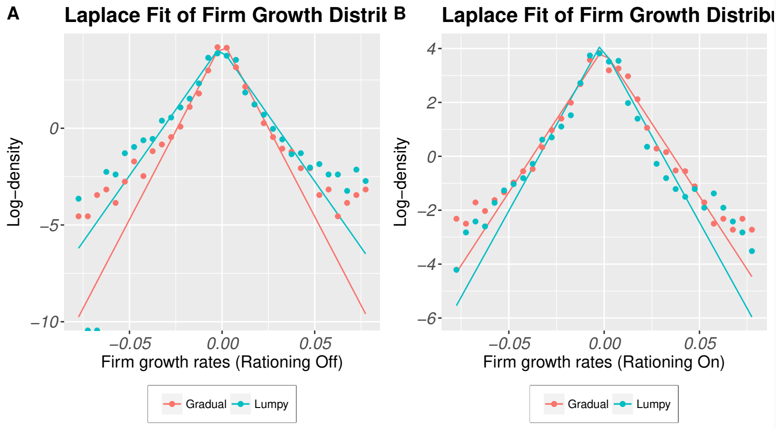

Figure 11: Firm growth rates distributions according to the type of adjustment in technology and expansion

The role of patience

Patience of the banking sector increases competition as well as the rate of innovation.

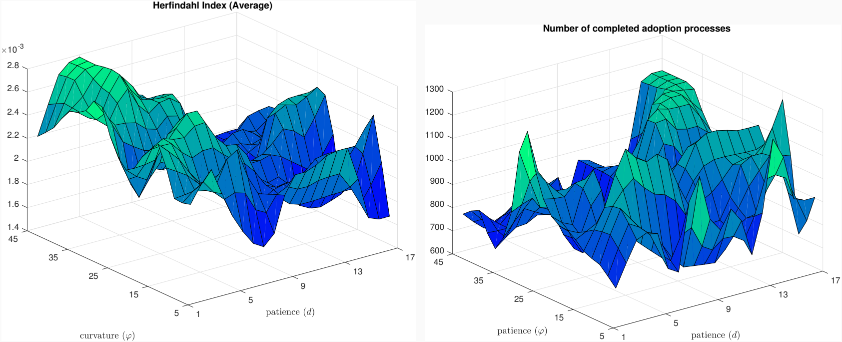

Figure 12: Effects of the parameters on Herfindahl-Hirschman Index (left) and on the number of completed adoption processes (right).

Summary of the results

Under tighter credit constraints scenarios:

- the industry is farther from the technology frontier
- there is a trade-off between productivity and profitability
- the industry is more concentrated
- firm growth rates are more volatile
- average and median firm tends to be older and bigger

When the banking industry is short-term oriented:

- more industry concentration
- lower adoption of new technologies

Thanks for the attention.

Questions?

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