Financing Constraints, Firm Dynamics and Innovation

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Motivation (1)

- The process of firm entry, growth and exit is largely driven by technological progress.
  - New entrants adopt technologies at the frontier and are more productive than existing units.
  - Firms that successfully innovate grow, while unsuccessful ones shrink and disappear.
- These dynamics determine aggregate productivity growth.
- Do financial factors matter? If yes, how? directly (lack of finance to invest in innovation) or indirectly (affecting entry-exit and competition)?

Motivation (2)

A recent paper by Hsieh and Klenow (2012) compares life cycle profile of manufacturing plants in USA, Mexico and India:

Figure 4: Employment Growth over the Life-Cycle

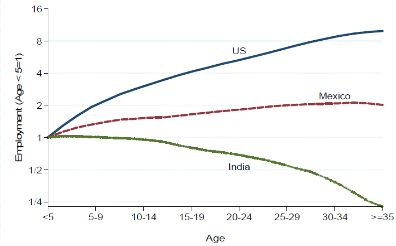
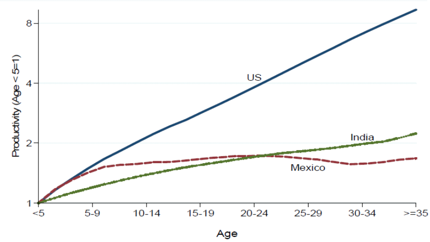


Figure 6: Productivity Over the Life-Cycle



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- Correlation, not a proof of causation. So I need a model.

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- Link with empirical data: in a previous paper, I show that in my dataset R&D to introduce new products is more risky (it generates more volatility in profits) that the other types of R&D.

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    - ... but also the downside risk (firms that do not innovate remain profitable for longer time)
    - When innovation has a downside risk, the more financing frictions (or other barriers that raise entry costs), the less innovation and aggregate productivity in the industry.

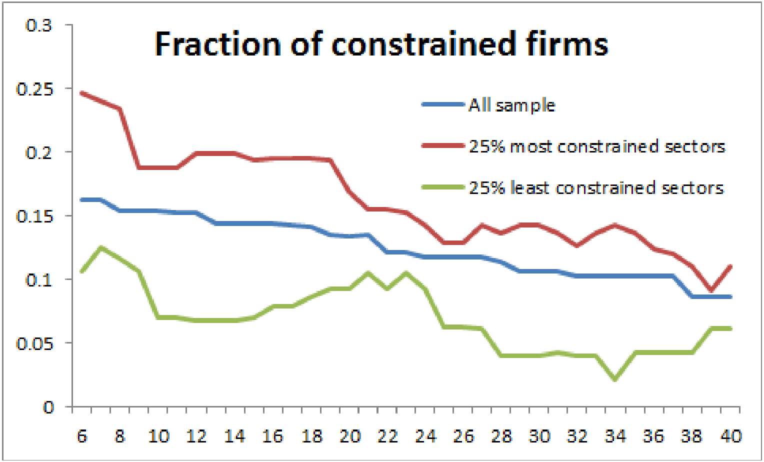
Empirical data

- Construct a survey measure of financing constraints.
- Calculate the percentage of financially constrained firms in each 4 digit manufacturing industry
- Create two groups:
  - The 25% four digit sectors with most constrained firms, called the "Constrained" group,
  - The 25% four digit sectors with least constrained firms, called the "Unconstrained" group.
- Calculate age profile of innovation and productivity.

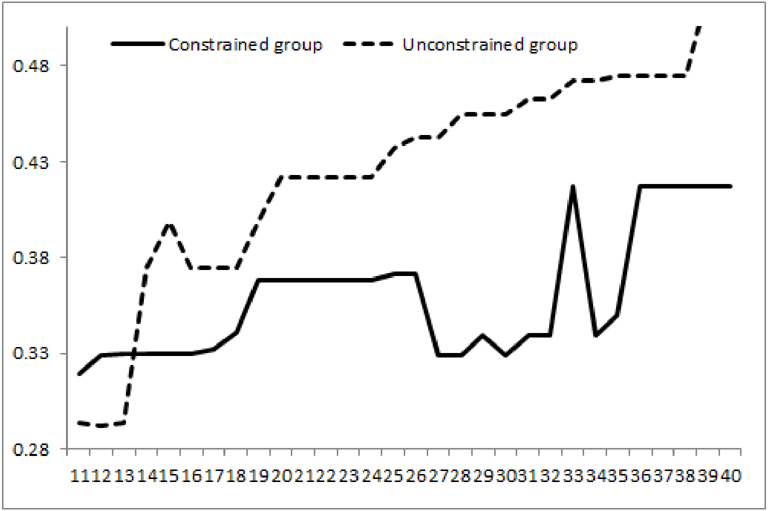
group composition

2 digit sector	n. obs.	% of firms in "Constrained" group	% of firms in "Unconstr." group
Food and Drinks	960	74%	13%
Textiles	1150	26%	25%
Shoes and Clothes	551	38%	62%
Wood Furniture	343	36%	21%
Paper	379	37%	28%
Printing	457	51%	37%
Chemical, Fibers	614	43%	34%
Rubber and Plastic	717	21%	0%
Non metallic products	823	37%	7%
Metals	614	35%	19%
Metallic products	1183	61%	15%
Mechanical Products	2031	22%	30%
Electrical Products	522	21%	10%
Television and comm.	303	4%	0%

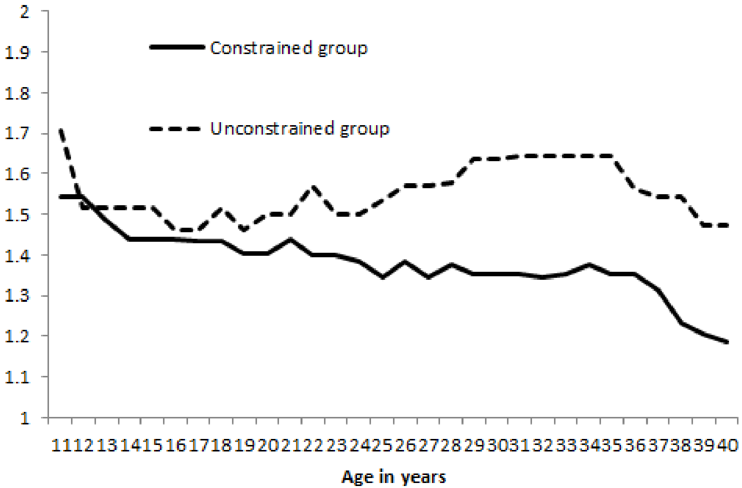
Fraction of constrained firms over age



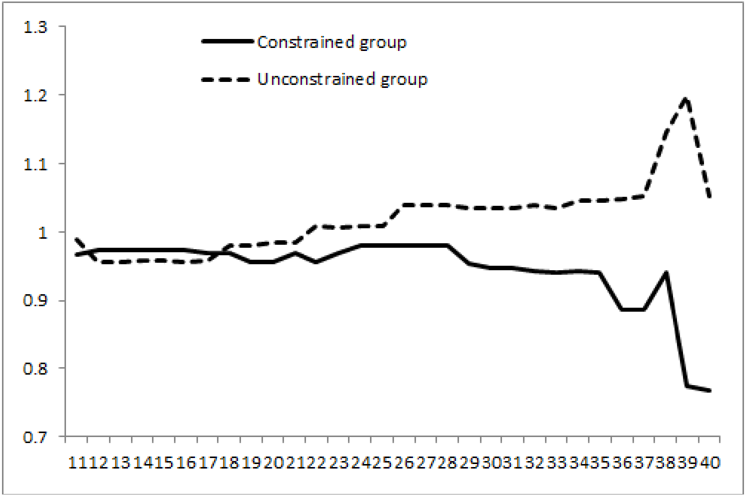
Percentage of innovating firms (doing R&D)



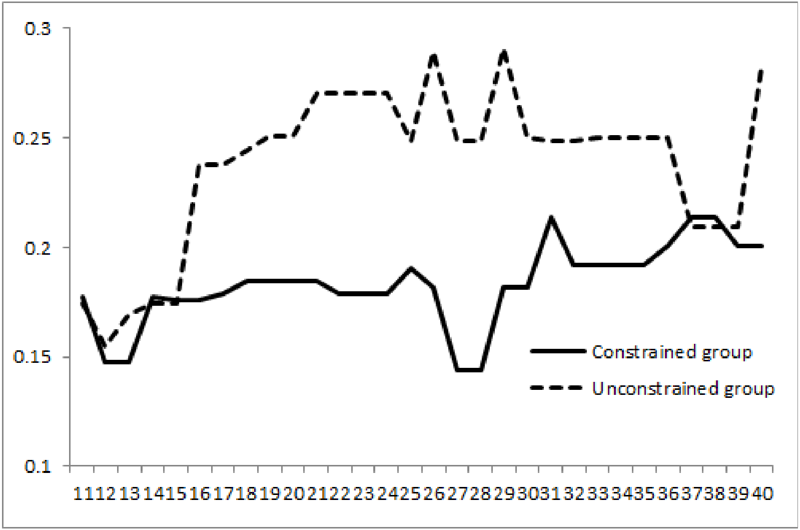
Total factor productivity conditional on age



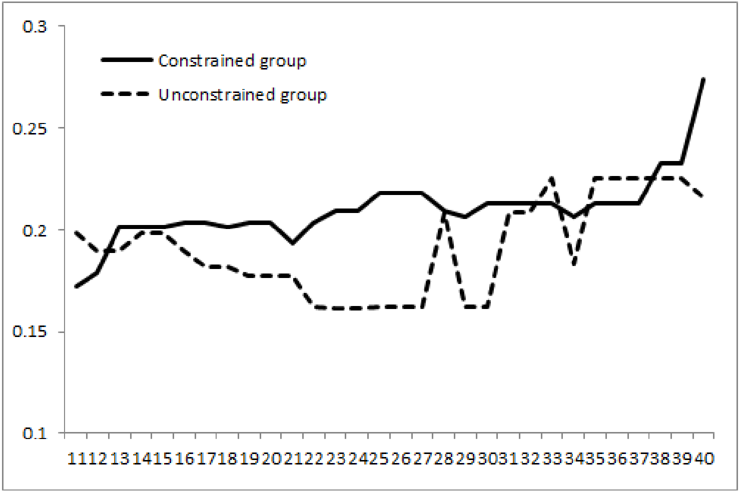
Total Factor productivity conditional on age, relative to TFP conditional on age in the 2 digit sector.



Percentage of firms doing R&D to introduce new products over age.



Percentage of firms doing R&D to improve current products or productive processes.



The model

- Each firm in an industry uses labour (wage=1) to produce a variety $w \in \Omega$ of a consumption good.
- Consumers preferences for the varieties in the industry are C.E.S. with elasticity $\sigma > 1$.
- One-off fixed cost to enter S^C
- Per-period fixed costs of production F

Demand

The C.E.S. price index P_t is then equal to:

$$P_t = \left[\int_w p_t(w)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}$$

The associated quantity of the aggregated differentiated good Q_t is:

$$Q_t = \left[\int_w q_t(w)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}$$

The overall demand for the differentiated good Q_t is generated by:

$$Q_t = AP_t^{1-\eta}$$

Profit function

Profits for a generic firm with productivity ν_t :

$$\pi_t\left(v_t, \varepsilon_t\right) = \frac{\left(\sigma - 1\right)^{\sigma-1}}{\sigma^{\sigma}} A P_t^{\sigma-\eta} v_t^{\sigma-1} - F_t$$

$$F_t = F + \varepsilon_t$$

ε_t follows an I.I.D. process. It implies that sometimes profits $\pi_t\left(\nu_t, \varepsilon_t\right)$ are negative.
The marginal cost of production is equal to $1/\nu_t$.

Innovation - 1

- Marginal productivity at the frontier grows at the gross rate $g > 1$. Labour cost grows at the same rate (simplifying assumption)$\rightarrow$marginal production cost $1/\nu_t$ for a firm depends on its technology level relative to frontier.
- New firms start with technologies close to the frontier.
  - If they do not innovate: with probability ξ^{NI} they keep up with the frontier (relative productivity ν_t remains constant), otherwise ν_t depreciates at the rate g (obsolescence).

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  - If they do not innovate: with probability ξ^{NI} they keep up with the frontier (relative productivity ν_t remains constant), otherwise ν_t depreciates at the rate g (obsolescence).
  - If they innovate, with probability ξ^{I} they get to the frontier, otherwise ν_t depreciates at the rate g^{fail}

Innovation - 2

- Type 1 Embodied (risky) innovation: $g^{fail} > g$:

$$\overbrace{(v_{t+1} = 1)}^{\substack{\text{Innovation}\\\text{succeeds}}} > \overbrace{\left(v_{t+1} = \frac{v_t}{g}\right)}^{\substack{\text{Does not}\\\text{innovate and}\\\text{depreciates}}} > \overbrace{(v_{t+1} = \frac{v_t}{g^{fail}})}^{\substack{\text{Innovation}\\\text{fails}}}$$

- Type 1 Disembodied innovation: $g^{fail} \leq g$:

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Timing and Financing frictions

- Budget constraint:

$$a_t = R\left(a_{t-1} - I_{t-1}K\right) + \pi_t\left(v_t, \varepsilon_t\right) \tag{1}$$

- I_{t-1} is an indicator function that is equal to 1 if the firm decided to innovate in period $t-1$.
- Firms need to pay in advance the fixed costs of production F and of innovation K :
- Continuation is feasible only if:

$$a_t \geq F \tag{2}$$

- Innovation is feasible only if:

$$a_t \geq F + K \tag{3}$$

Value functions

Value function today conditional innovating:

$$V_t^{UP}\left(a_t,\varepsilon_t,v_t\right)=-K+\frac{1-\delta}{R}$$
$$\left\{\begin{array}{c}\xi^I E_t\left[V_{t+1}\left(a_{t+1},\varepsilon_{t+1},1\right)+\pi_{t+1}\left(\varepsilon_{t+1},1\right)\right]+\left(1-\xi^I\right)\\ E_t\left[V_{t+1}\left(a_{t+1},\varepsilon_{t+1},\frac{v_t}{g^{fail}}\right)+\pi_{t+1}\left(\varepsilon_{t+1},\frac{v_t}{g^{fail}}\right)\right]\end{array}\right\}$$

Likewise, the value function conditional on not innovating is:

$$V_t^{NOUP}\left(a_t,\varepsilon_t,v_t\right)=\frac{1-\delta}{R}$$
$$\left\{\begin{array}{c}\xi^{NI}E_t\left[V_{t+1}\left(a_{t+1},\varepsilon_{t+1},v_t\right)+\pi_{t+1}\left(\varepsilon_{t+1},v_t\right)\right]\\ +\left(1-\xi^{NI}\right)E_t\left[V_{t+1}\left(a_{t+1},\varepsilon_{t+1},\frac{v_t}{g}\right)+\pi_{t+1}\left(\varepsilon_{t+1},\frac{v_t}{g}\right)\right]\end{array}\right\}$$

Policy functions

The firm innovates and chooses $I_t(a_t, \varepsilon_t, v_t) = 1$ if both the following conditions are satisfied:

$$V_t^{UP}(a_t, \varepsilon_t, v_t) > V_t^{NOUP}(a_t, \varepsilon_t, v_t)$$

$$a_t \geq F + K$$

Given the innovation decision, the value of the firm at time t is:

$$V_t(a_t, \varepsilon_t, v_t) = \tag{4}$$

$$1(a_t \geq F)\left\{\max\left[V_t^{UP}(a_t, \varepsilon_t, v_t), V_t^{NOUP}(a_t, \varepsilon_t, v_t), 0\right]\right\} \tag{5}$$

Entry decision

- Every period there is free entry. New potential entrants, with endowment a_0, can learn their type v_0 after having paid an initial cost S^C.
- Once they learn their type v_0 (drawn from an initial uniform distribution), they decided whether or not to start activity.
- The free entry condition:

$$\int_{\underline{v}}^{\overline{v}} \max\left\{E^{\varepsilon_0}\left[V_0\left(a_0, v_0, \varepsilon_0\right)\right], 0\right\} f\left(v_0\right) dv_0 - S^C = 0 \qquad (6)$$

Calibration with risky innovation

Matched parameters				
	Value	Moment to match	Data	Model
A	5610	Aggregate sales		
δ	0.03	employment share of exiting firms	8.2%	8%
r	1.02	average real interest rate	2%	2
F	0.2	average ratio fixed costs/labour costs	0.3	0.22
$\overline{v}$	1	normalized to 1.	n.a.	n.a.
$\underline{v}$	0.969	Cross sect. std. of firm average profits/added v.	0.084	0.036
S^C	0.6	mean profits/added value	0.036	0.031
ξ	0.3	avg. of time series vol of profits/added value	0.092	0.088
ρ	0.2	fraction of negative profits	0.21	0.21
g	1.0035	average yearly decline in profits/sales	3%	3%
K	0.02	average r&d/added value	3%	2%
ξ^{NI}	0.5	average age of firms	24	26.7
ξ^{I}	0.1	% of innovating firms (r&d to intr. new products)	13%	13%
a_0	0.4	% of firms going bankrupt every period	0.5%	0.5%

Calibration with risky innovation (2)

Other parameters		
η	1.5	
σ	4	
g^{fail}	g^3	benchmark (sensitivity analysis)

Simulate several industries

With different degrees of financing frictions

Constrained : $a_0 = 0.21$, fraction of firms going bankrupt every period=1.5%

Benchmark: $a_0 = 0.4$,fraction of firms going bankrupt every period=0.5%

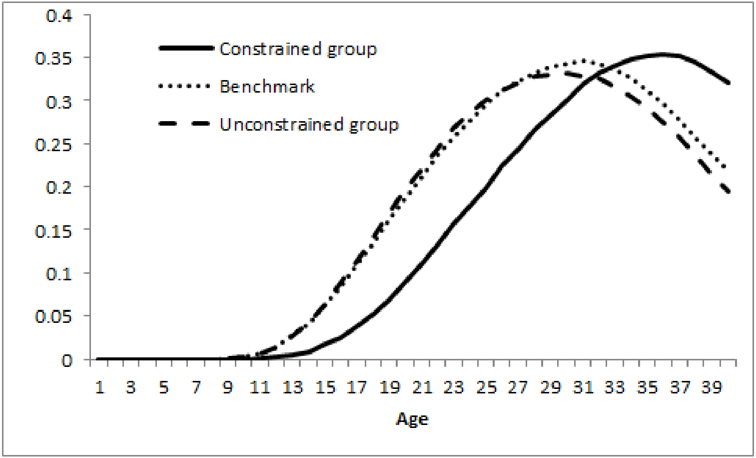
Unconstrained : $a_0 = 2$,fraction of firms going bankrupt every period=0.005%

With different types of innovation

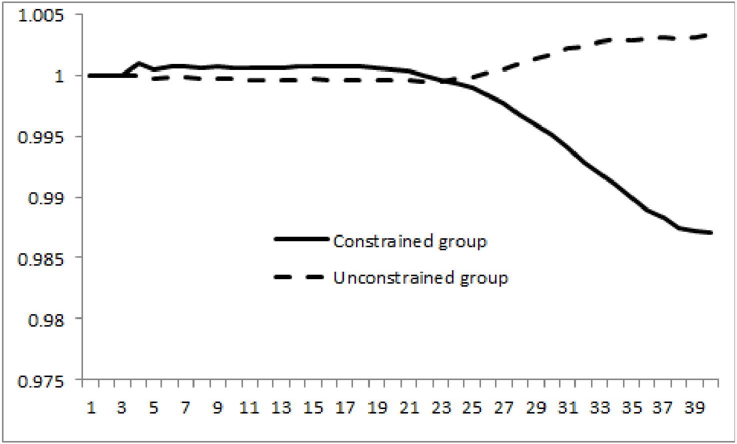
Embodied (risky) innovation: $g^{fail} = 1.0105$

Disembodied (no downside risk) innovation: $g^{fail} = 1$

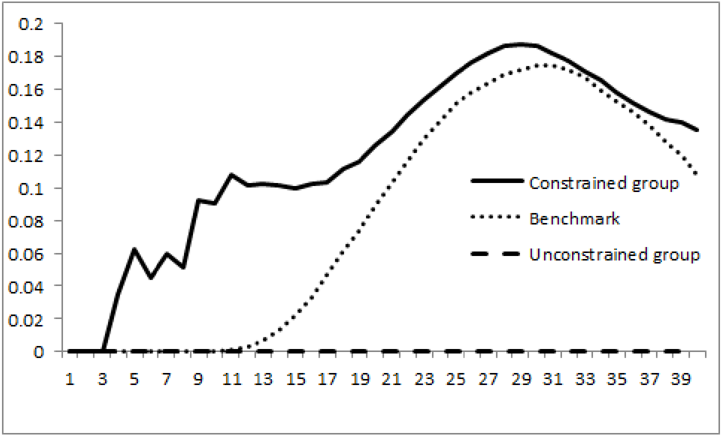
Fraction of innovating firms in three industries conditional on age, RISKY INNOVATION



Productivity conditional on age, relative to the benchmark case, RISKY INNOVATION



Fraction of innovating firms in three industries conditional on age, "SAFE" INNOVATION



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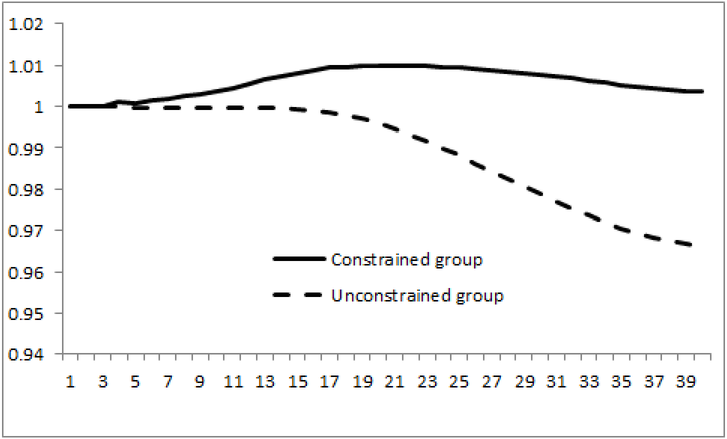
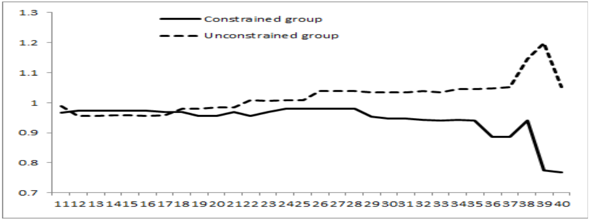
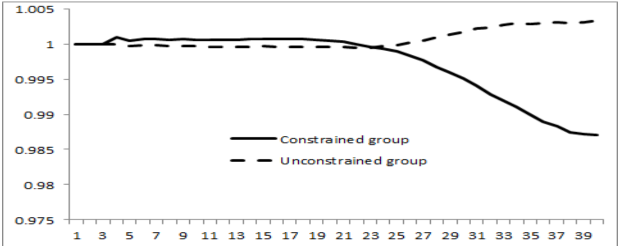


Productivity conditional on age, comparison.

Empirical data



Risky Innovation



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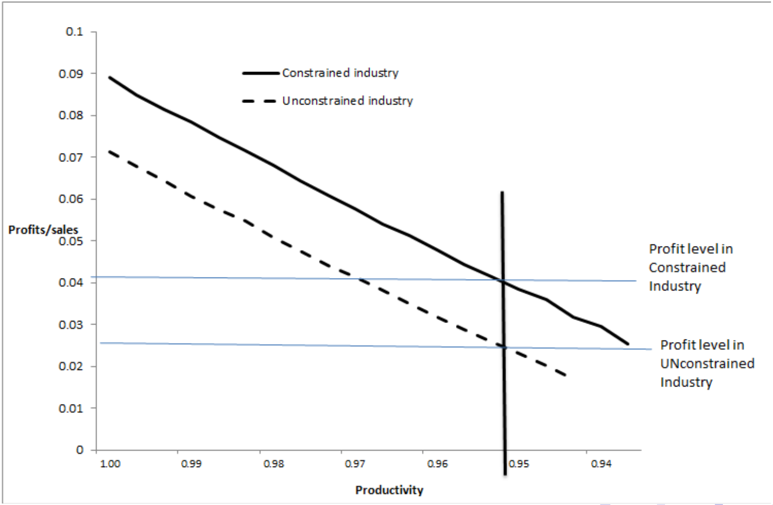
- When innovation is risky, the downside risk also matters.
- Less Financing frictions→more firms survive→more competition→ profits decrease for all productivity levels. Firms have less to loose. (because if innovation fail, they can always exit and cut further losses), they start to innovate earlier.

Conclusions

- In a calibrated model with heterogenous firms, potentially the most important effect of financing frictions on innovation is the indirect competition effect.
- Such effect is ambiguous and it depends on the nature of innovation.
- Preliminary empirical analysis is consistent with a negative effect of financing frictions on innovation because of downside innovation risk.

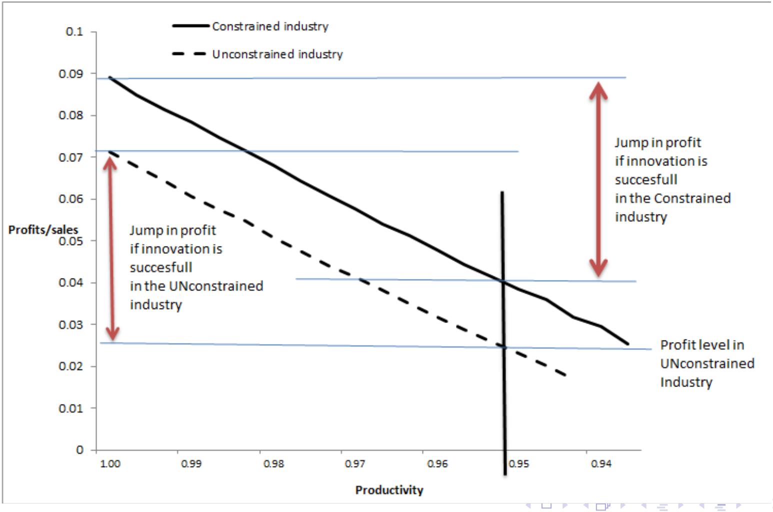
Graphical intuition of the result - 1

First step: consider profit levels at a certain productivity level, in the two industries



Graphical intuition of the result - 2

If there is no downside risk, the upside is what matters, and this is larger in the Constrained industry



Graphical intuition of the result - 3

With downside risk, the potential maximum fall in profits also matters, and this is larger in the Constrained industry