Explaining the Decline in Measured TFP Growth

Philippe Aghion

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Joseph Schumpeter

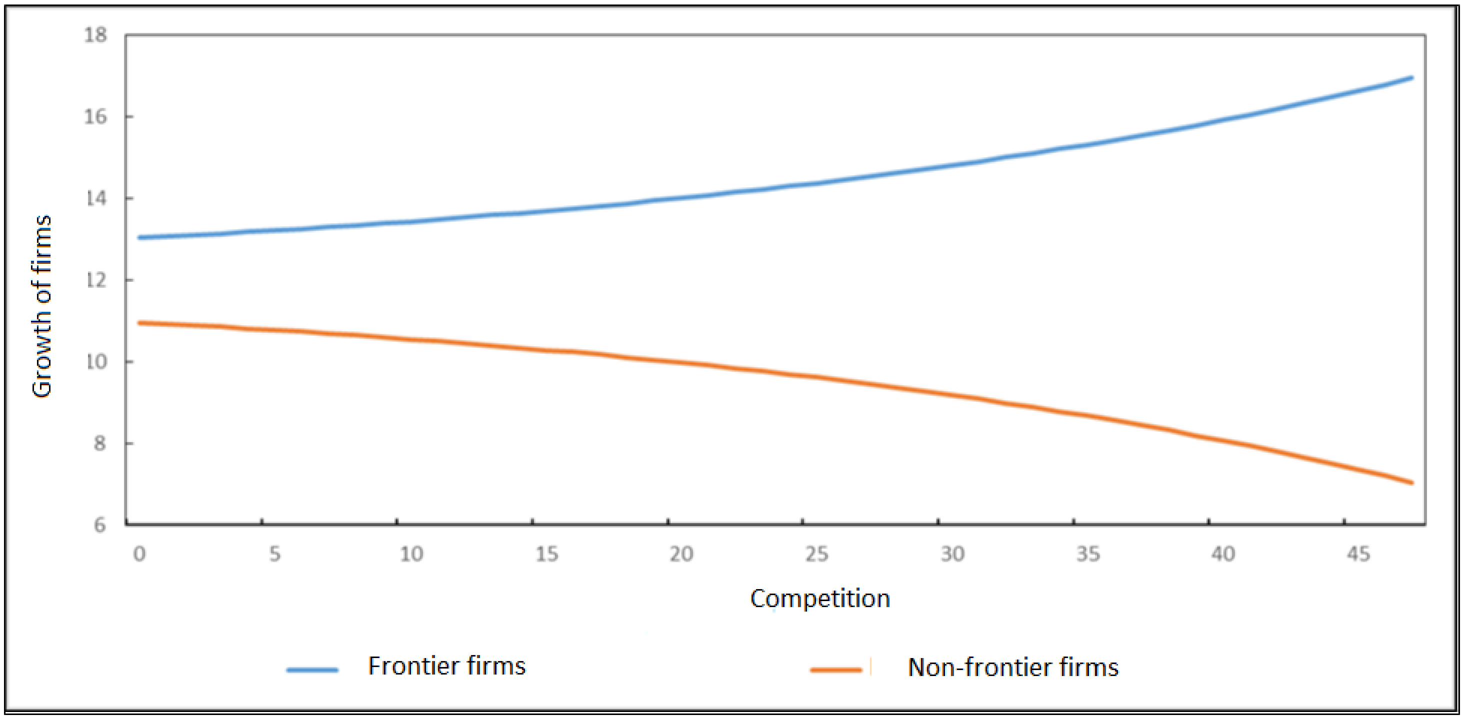
Schumpeterian growth theory

- Long-run growth driven by innovations
- Innovations result from entrepreneurial activities motivated by prospect of innovation rents
- Creative destruction: new innovations displace old technologies

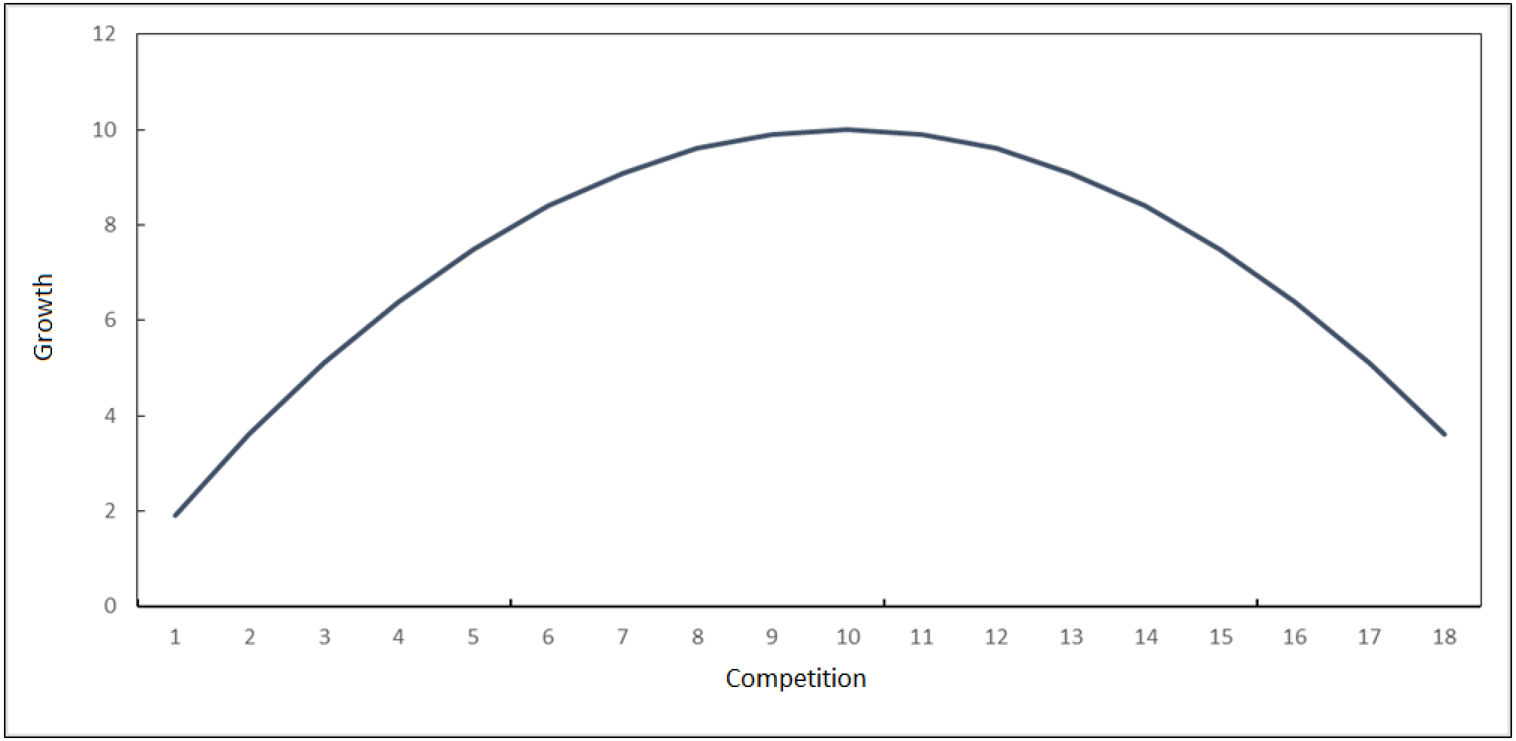
Growth enigmas

- Competition and innovation
- The debate on secular stagnation

Competition, growth and distance to frontier

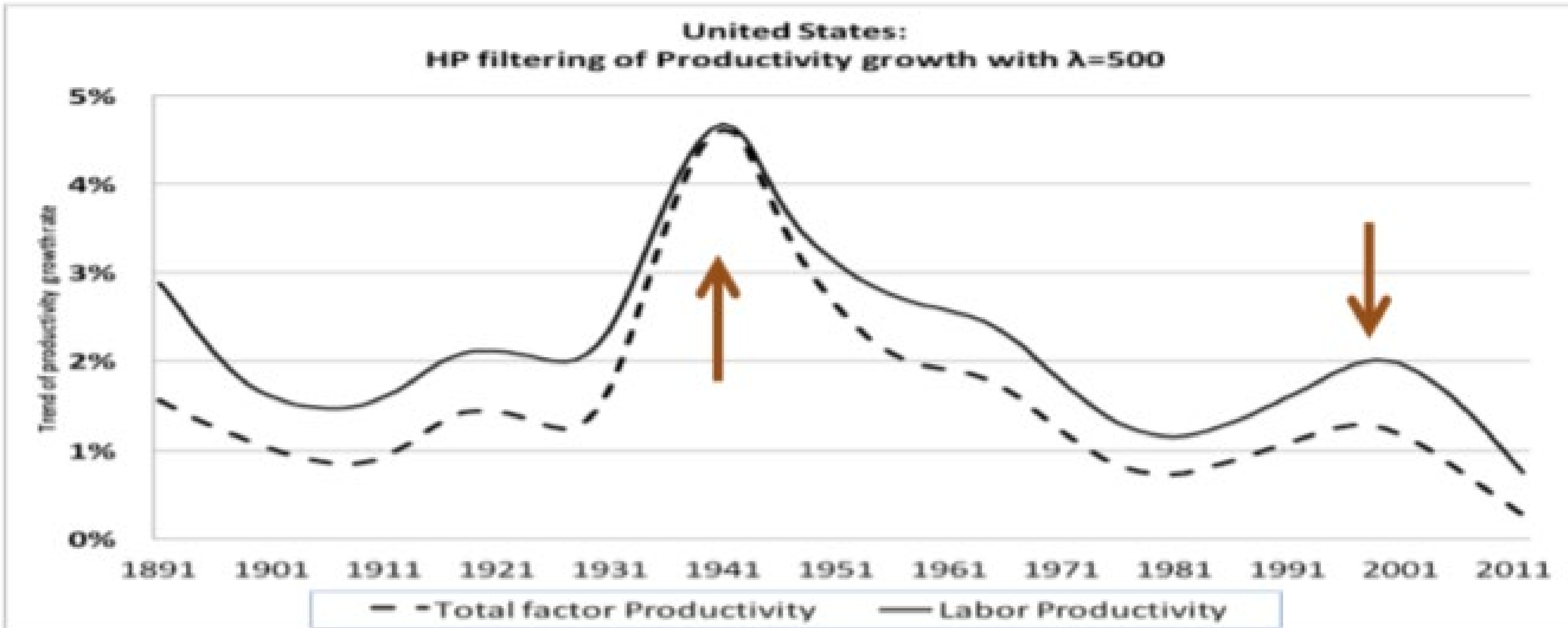


Competition and growth: the inverted-U relationship



Growth enigmas

- Competition and innovation
- **The debate on secular stagnation**



Source: Bergeaud, Cette and Lecat (2016) Long term productivity project - www.longtermproductivity.com

- Robert Gordon proposed that the age of great innovations is past (fruit tree metaphor)

Candidate explanations

- Ideas harder to find
- Measurement
- Reallocation
- Super-star firms

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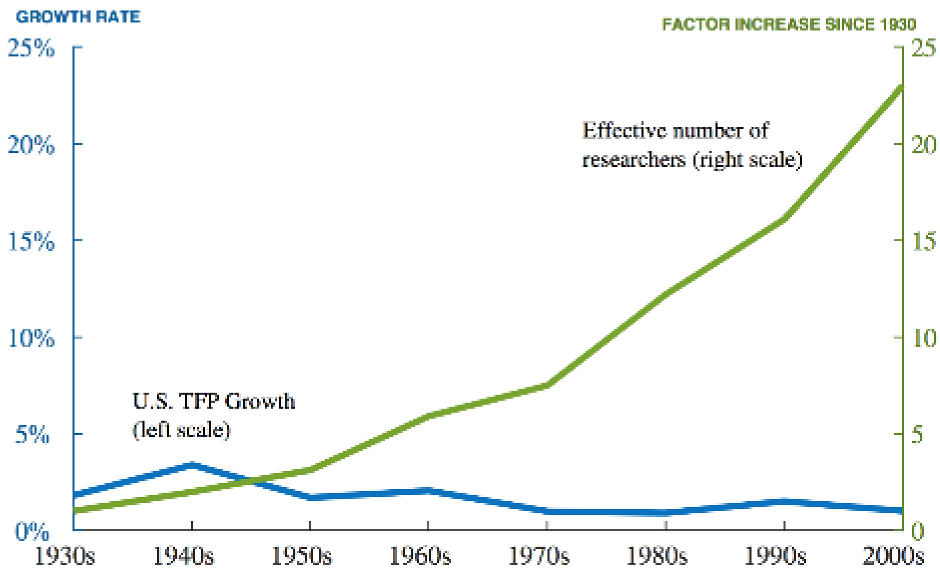
Are Ideas Getting Harder to Find?

N. Bloom, C. Jones, J. Van Reenen, M. Webb

COLLÈGE
DE FRANCE
1530

Economic growth e.g. 2% or 5% = Research productivity ↓ (falling) × Number of researchers ↑ (rising)

Figure 1: Aggregate Data on Growth and Research Effort



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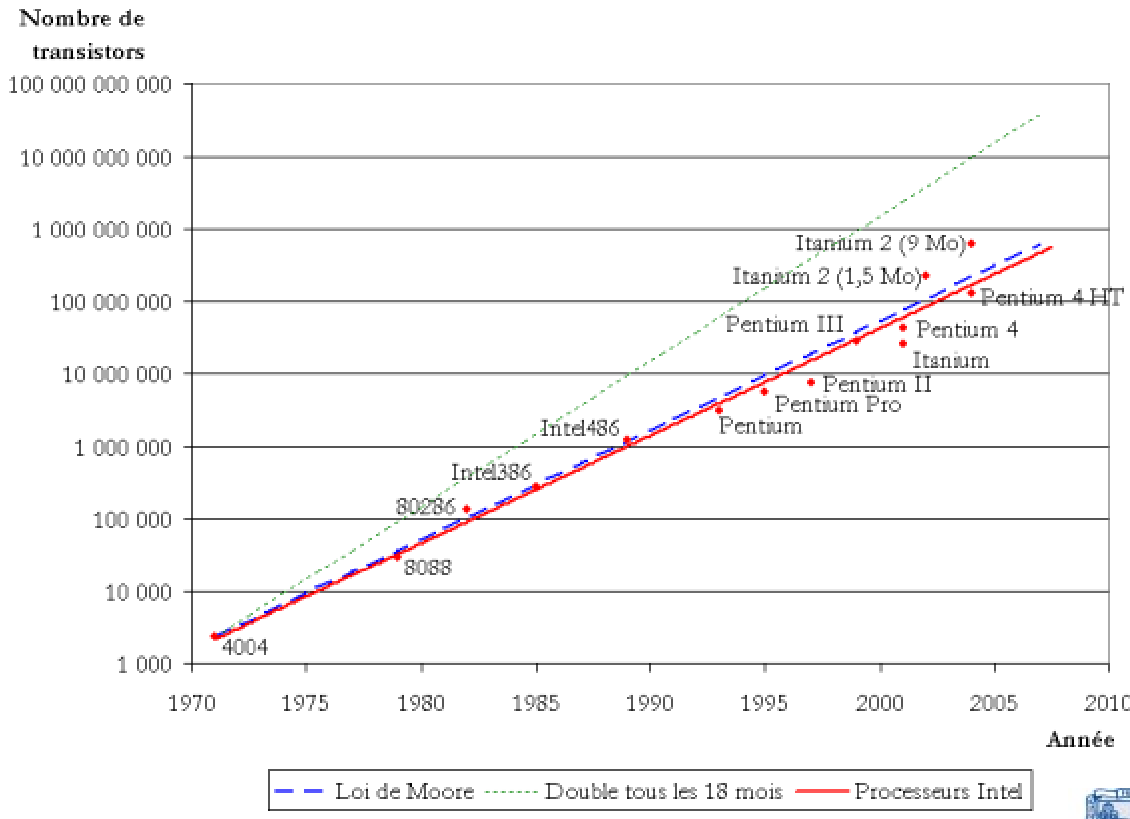
- **Moore's law** : « The number of transistors on a silicium chip doubles every two years »

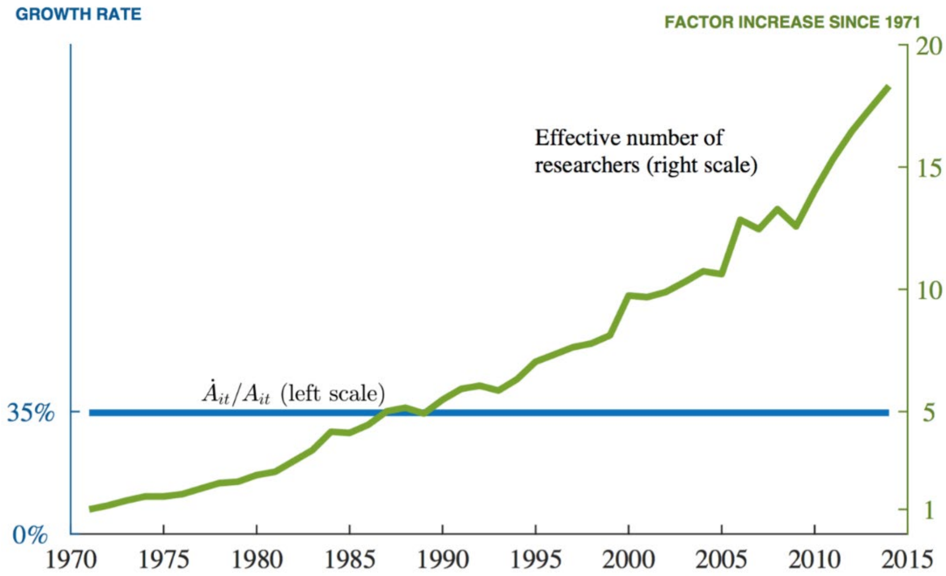


Moore’s law

Economic growth = Research productivity × Number of researchers

e.g. 2% or 5% | ↓ (falling) | ↑ (rising)

Figure 4: Data on Moore’s Law

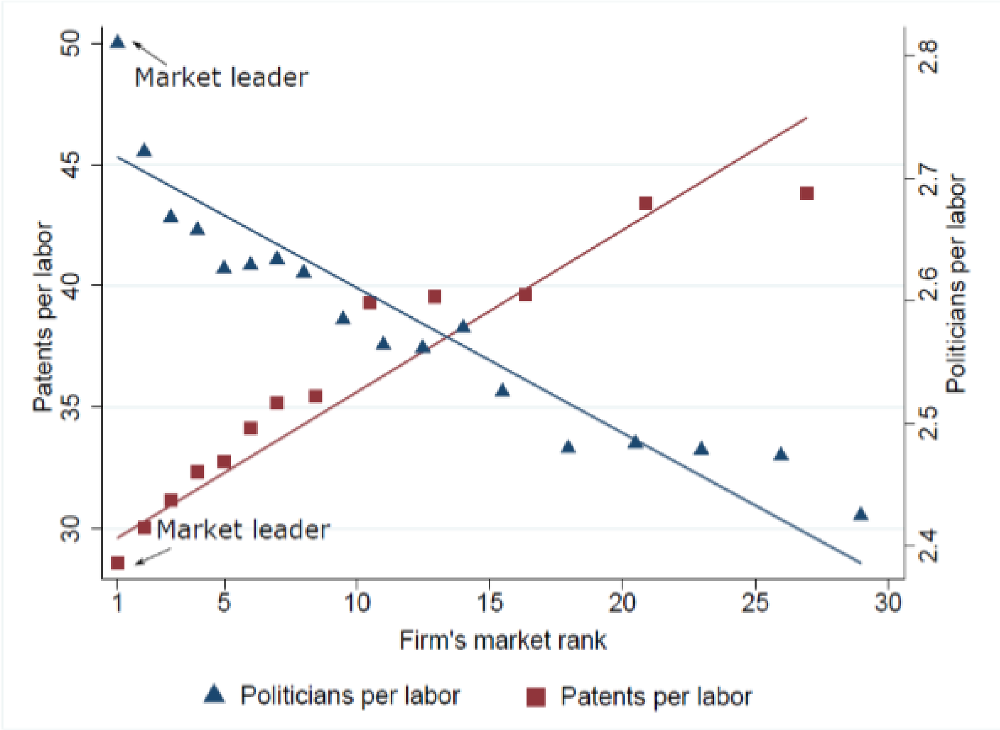


- Moore’s law requires increasing number of researchers over time
- Number of researchers to double number of transistors per chip is 18 times higher today than in the early 1970s

Questions

- Even research directed at semi-conductors involves dimensions other than changing the density of transistors
  $\longrightarrow$ add new features to the chip, make the chip less expensive, add multiple cores,...
- Variety of products within narrow category of semiconductors has increased over time
  $\longrightarrow$ research effort must be deflated by a measure of product variety

- How much of the apparent decreasing returns to R&D are truly technological?
- R&D expenditures can be put to other uses, including entry deterrence (Sutton)
- Larger firms tend to patent less and to lobby more



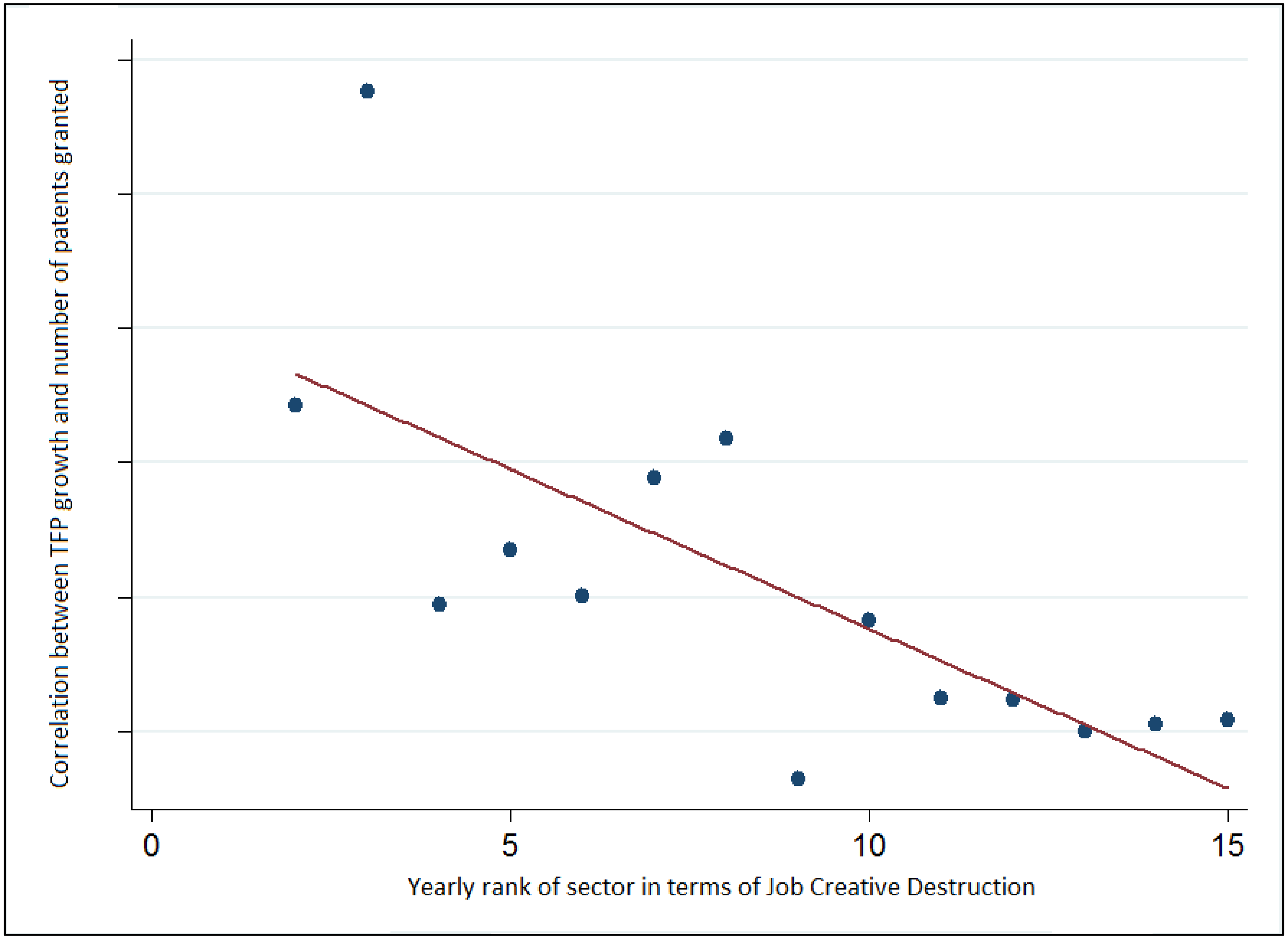
Market leader
Market leader
Patents per labor
Politicians per labor
Firm's market rank
50
45
40
35
30
2.8
2.7
2.6
2.5
2.4
1
5
10
15
20
25
30
Politicians per labor
Patents per labor

Candidate explanations

- Ideas harder to find
- **Measurement**
- Reallocation
- Super-star firms

Missing Growth from Creative Destruction

Philippe Aghion (College de France & LSE) Antonin Bergeaud (LSE)
Timo Boppart (IIES) Pete Klenow (Stanford) Huiyu Li (FRB SF)

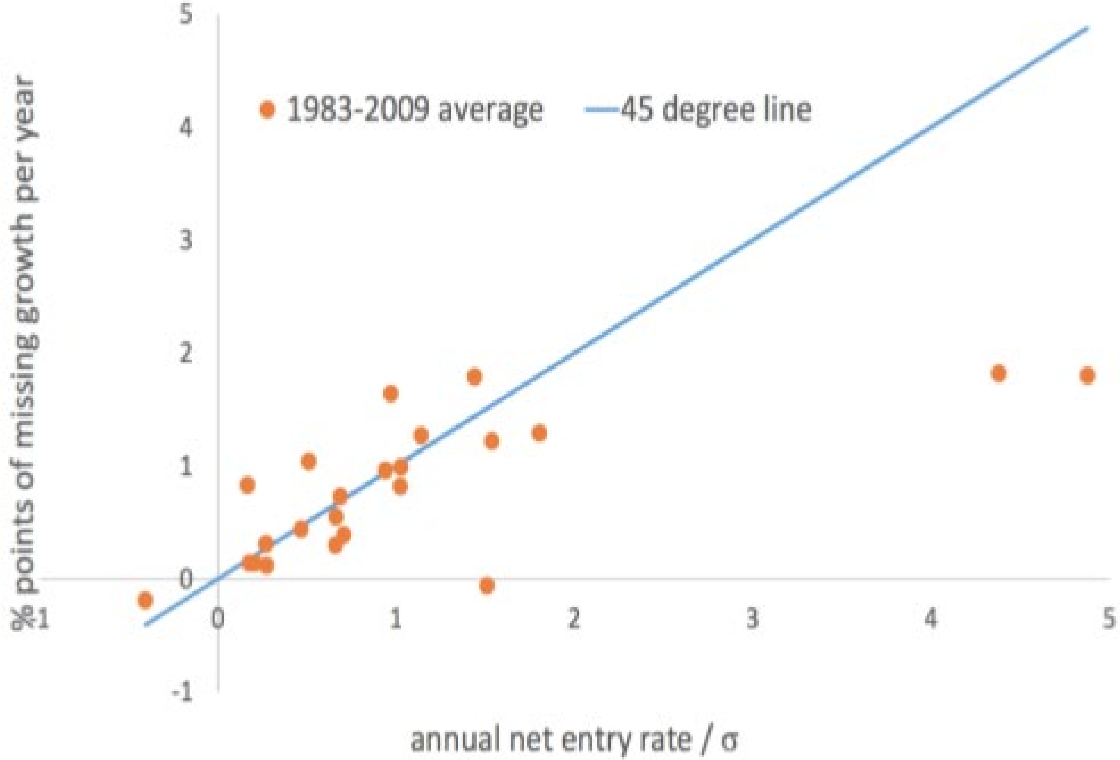

Correlation between TFP growth and number of patents granted
0
5
10
15
Yearly rank of sector in terms of Job Creative Destruction

Numerical example

- 80% of items: 4% inflation (no innovation)
- 10% of items: -6% inflation (innovation w/o CD)
- 10% of items: -6% inflation (CD)
- True inflation = 2%, True growth = 2%
- Imputation for CD= $\frac{8}{9}$. 4% + $\frac{1}{9}$. (-6%)= 2.9%
- Measured growth = 1.1%, Missing Growth = 0.9%

% points per year

	Missing	Measured	"True"
1983–2013	0.64	1.87	2.51
1983–1995	0.66	1.80	2.46
1996–2005	0.55	2.68	3.23
2006–2013	0.74	0.98	1.72



1983-2009 average
45 degree line
% points of missing growth per year
annual net entry rate / σ
5
4
3
2
1
0
-1
-1
0
1
2
3
4
5

Candidate explanations

- Ideas harder to find
- Measurement
- **Reallocation**
- Super-star firms

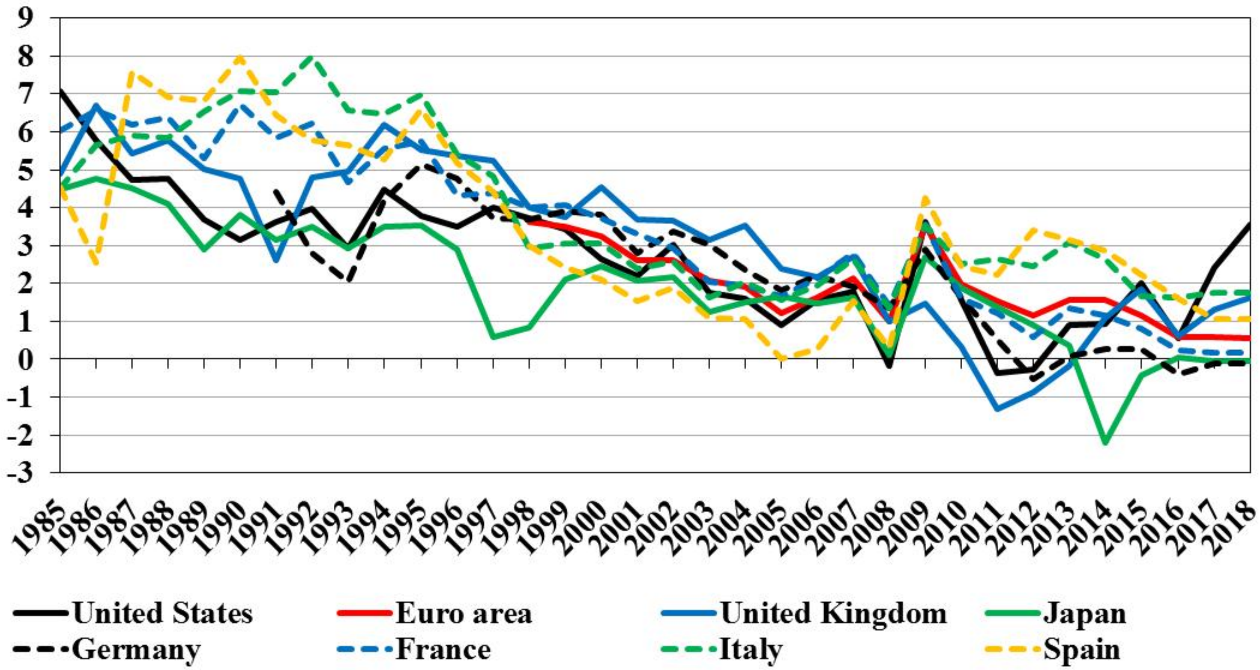
The Inverted-U Relationship Between Financial Development and Productivity Growth

P. Aghion, A. Bergeaud, G. Cette, R. Lecat and H. Manghin

Motivation: a general productivity slowdown …

Real long-term interest rate (In %) - 10-year sovereign bonds

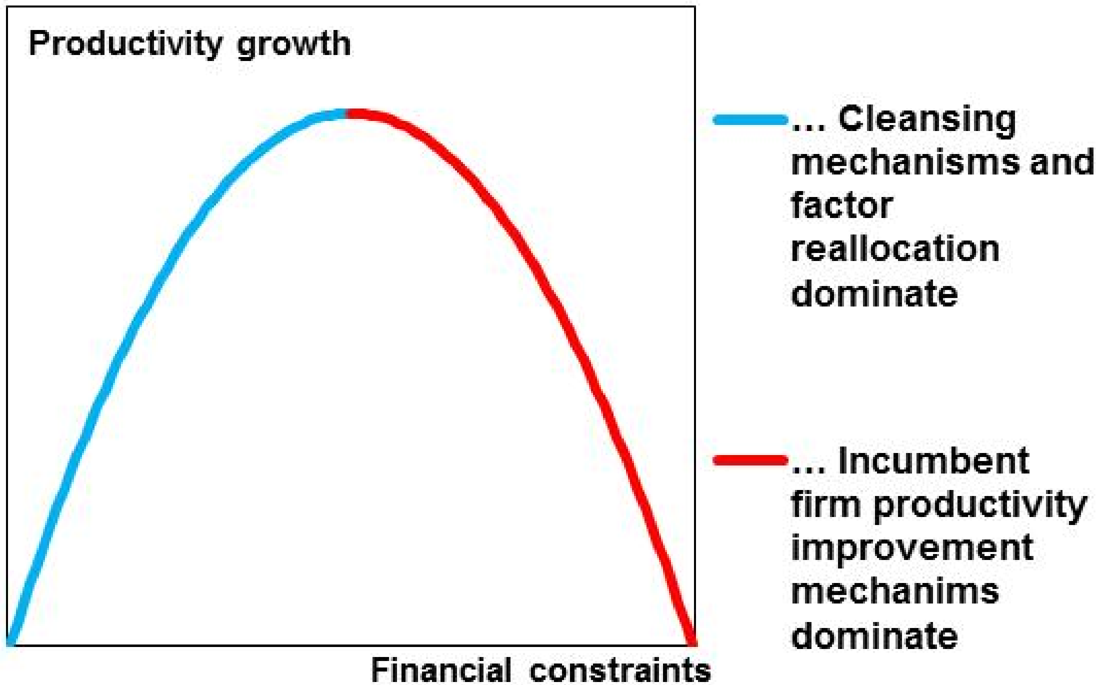
Source: OECD



- Long term real interest rate decline in all areas since the mid-1980s
- Which relationship with the productivity slowdown?

The story

- Decrease in interest rates allowed inefficient incumbents to remain on the market
- This in turn may have discouraged potentially more efficient firms (innovators) to enter the market
- Similar reallocation effect as in Acemoglu et al (2018).


Productivity growth
Financial constraints
… Cleansing mechanisms and factor reallocation dominate
… Incumbent firm productivity improvement mechanims dominate

Data

- Our main source of data comes from FiBEn. FiBEn is a large French firm-level database constructed by the Bank of France and based on fiscal documents, including balance sheet, and contains detailed information on firms' activities and size.
- Data on firms’ *cotations* by the Bank of France

Cotation system

- Banque de France’s Cotation system
- We rank firms into three categories:
  - Category A: ratings 3++ to 4+
  - Category B: ratings 4 and 5+
  - Category C: ratings 5 to P

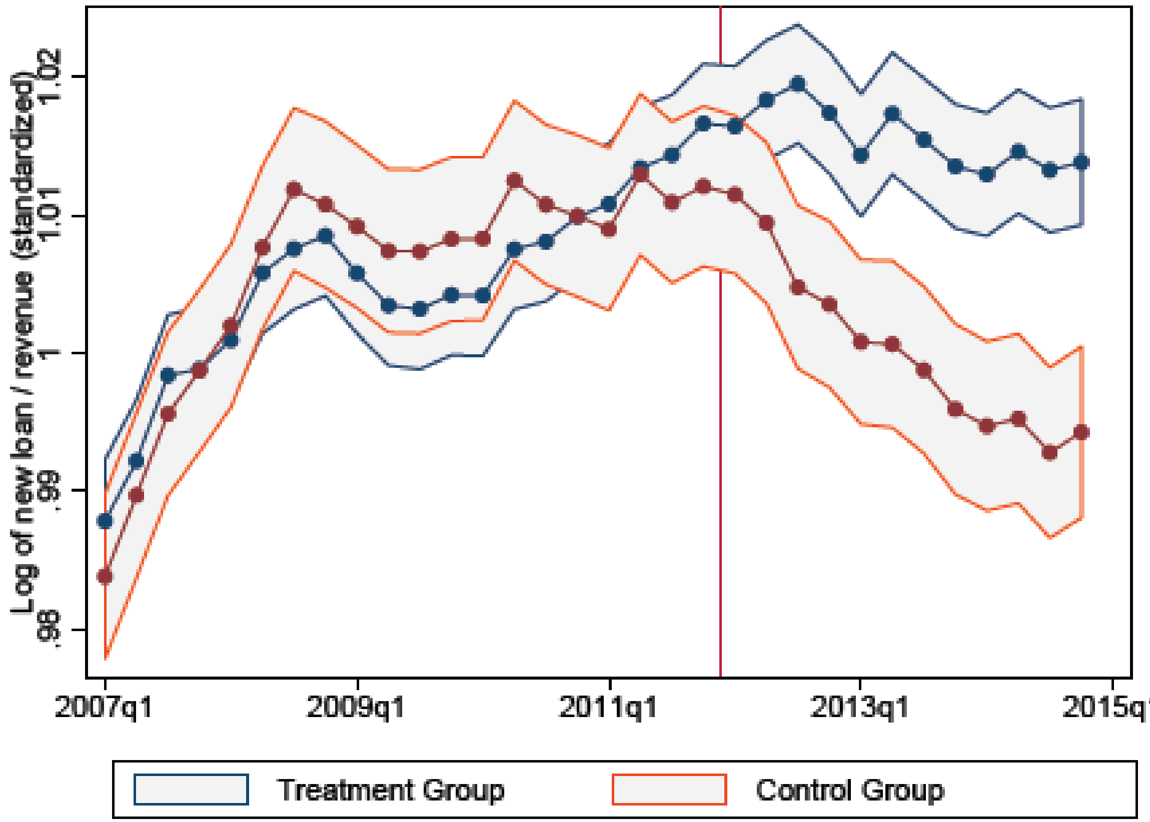
Causality

- We use the Eurosystem’s Additional Credit Claims (ACC) program as an instrument
- In the Euro Area, banks can pledge corporate loans as collateral in their refinancing operations with the ECB as long as these loans are of sufficient quality

Causality

- ACC extended the eligibility criterion to include firms rated 4 in Banque de France's Cotation
- ACC program was announced in December 2011 and implemented in February 2012.

The ACC instrument



- Treatment group: rating = 4 ; control group : rating = 5+ in 2011
- Prior to the ACC, the evolution of the value of new loans were not significantly different for firms rated 4 and 5+ in 2011.
- **The trends became significantly different from the ACC in 2012: financial constraints became lower for rating = 4 than for rating = 5+**
- **The ACC has modified the credit supply to firms with rating = 4**

Findings

- Firms rated *4* experience higher productivity growth following ACC, compared to firms rated *5+*
- Firms rated *4* experience lower exit rates following ACC, particularly those with lowest productivity

Financial constraints and productivity growth

$$g_{i,t} = \beta_1(Treated_i \times (postACC)_t) + X_{i,t}\gamma + \delta Treated_i \times t + \nu_i + \nu_{s,t} + \varepsilon_{i,t},$$

Dependent variable	TFP growth						
	All	RZ, high	RZ, low	All			
Treated×(post ACC)	1.066***	1.277**	0.750	0.518	0.136	0.415	-0.355
	(0.402)	(0.519)	(0.637)	(0.509)	(0.601)	(0.351)	(0.596)
$Log\,(L_{t-1})$	3.728***	2.009***	6.448***	3.882***	3.764***	4.085***	2.928***
	(0.369)	(0.446)	(0.653)	(0.493)	(0.403)	(0.393)	(0.518)
R^2	0.141	0.139	0.144	0.160	0.143	0.134	0.156
Observations	86,885	54,434	32,451	45,524	72,558	83,540	45,413

Notes: TFP growth is given in percentage. Columns 1 and 2 test our hypothesis while columns 3 to 7 act as placebos. Columns 4 and 5 replace the variable (post ACC) by a dummy for t being larger than respectively 2006 and 2010, columns 6 and 7 consider two different groups of rating (respectively 3 and 4^+ and 5^+ and 5). All regressions have individual, rating trend and year×sector fixed effects. Firm clustered standard errors are reported in parentheses.

- **TFP growth increases for firms that benefited from the eligibility shock** (col.1)
- It is valid **only for firms that are in sectors with strong dependance on external financing** (col. 2-3)
- Placebo tests (col. 4-7) support the fact that no other ratings effect is at play

Financial constraints and exit

$$E_{i,t} = \beta_1(Treated_i \times (postACC)_t) + \beta_2 Treated_i + X_{i,t-1}\gamma + \nu_{s,t} + \varepsilon_{i,t}.$$

Dependent variable	Default					
	All	All	Low Prod.	High Prod.	Low Prod. High RZ	Low Prod. Low RZ
(Rating = 4)	-0.011***	-0.010***	-0.013***	-0.009***	-0.013***	-0.013**
	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)	(0.005)
(Rating = 4)×(post ACC)	-0.007***	-0.006**	-0.012**	-0.004	-0.015**	-0.008
	(0.002)	(0.002)	(0.005)	(0.003)	(0.007)	(0.007)
Low Prod.		0.016***				
		(0.001)				
Fixed Effects	$s \times t$	$s \times t$	$s \times t$	$s \times t$	$s \times t$	$s \times t$
R^2	0.009	0.011	0.016	0.010	0.011	0.023
Observations	86,025	86,025	26,376	59,644	16,455	9,901

- **Default risk decreased for firms which were hit by the eligibility shock** (col. 1-3)
- This effect is **stronger for low-productivity firms** (col. 4-5)

Candidate explanations

- Ideas harder to find
- Measurement
- Reallocation
- **Super-star firms**

A Theory of Falling Growth and Rising Rents

Philippe Aghion (LSE)   Antonin Bergeaud (BdF)

Timo Boppart (IIES)   Peter J. Klenow (Stanford)

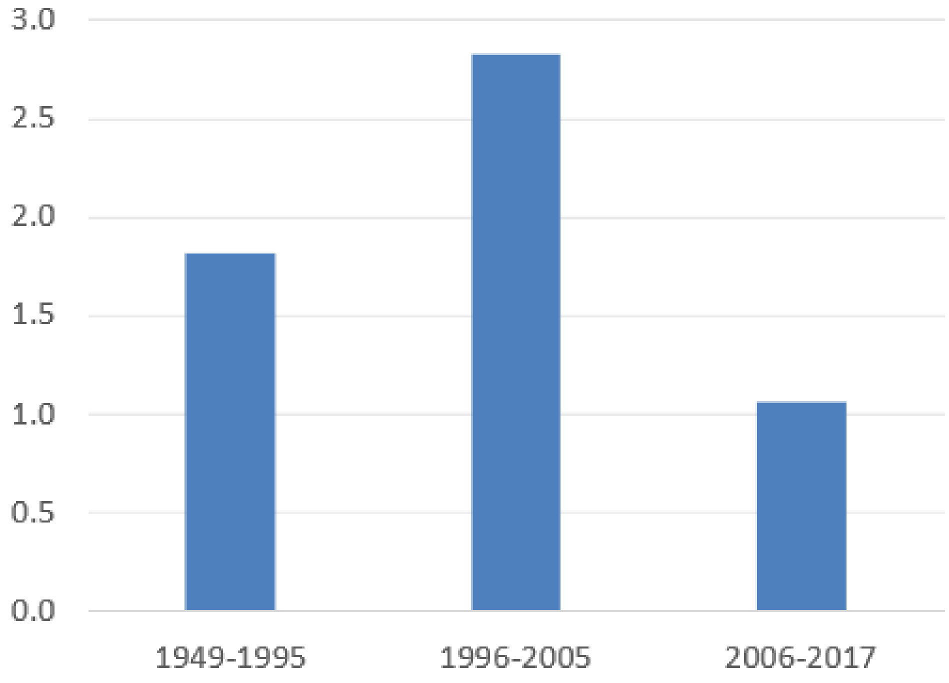
Huiyu Li (Fed SF)[1]

Motivation

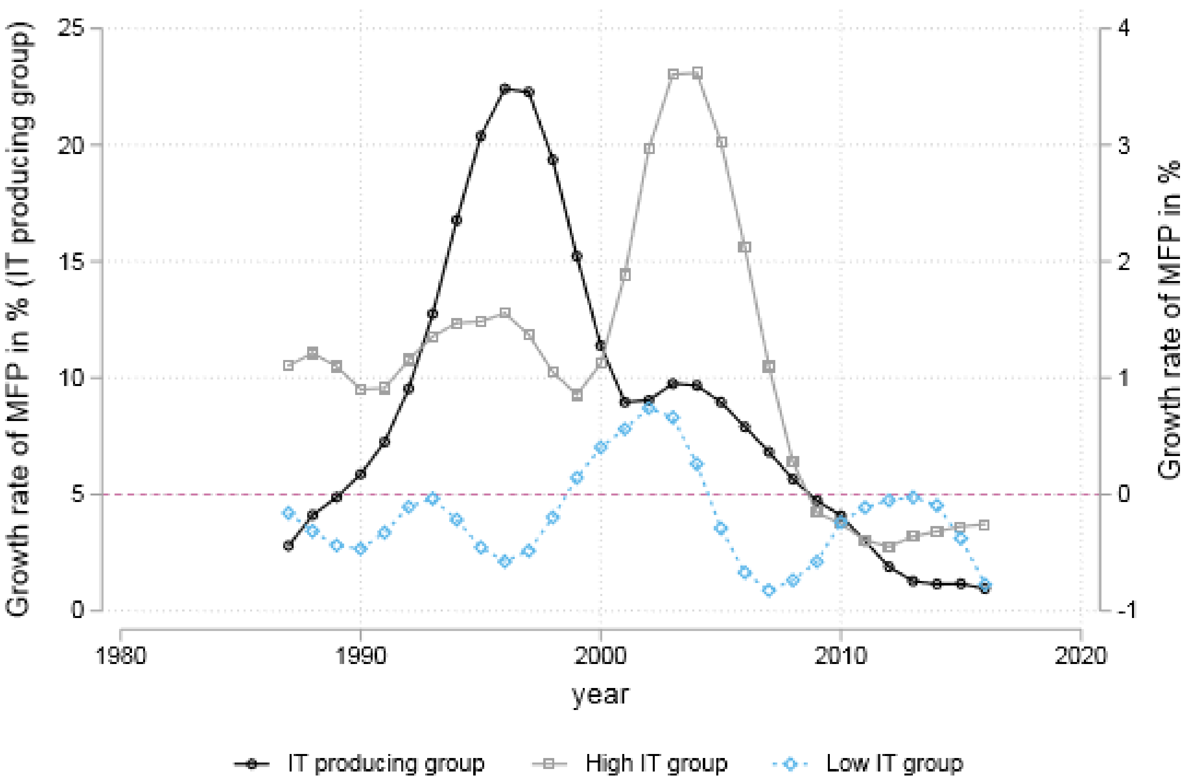
The U.S. economy over the past 30+ years is characterized by the following patterns:

1. Falling "long run" growth (after a burst of growth)
2. Falling labor share (due to composition)
3. Rising concentration

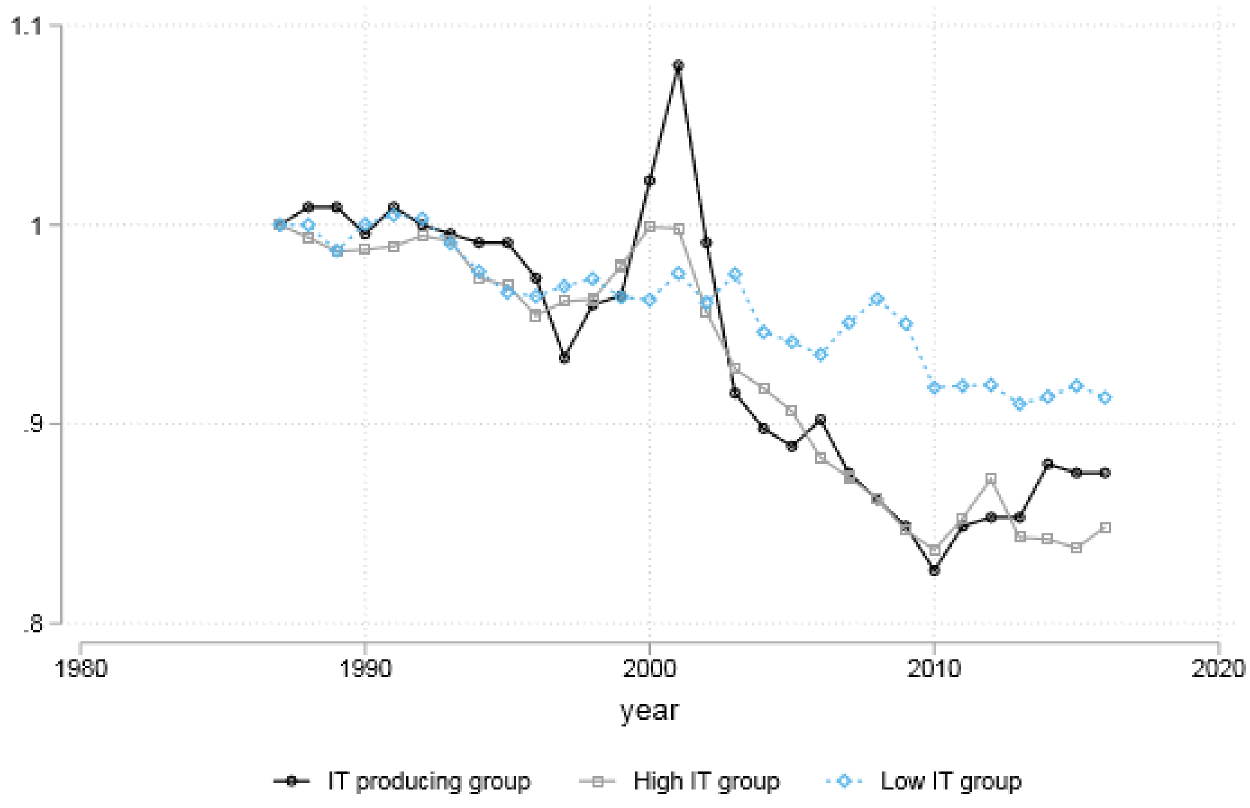
Rise and Decline in TFP Growth



TFP Growth by IT intensity



Labor share by IT intensity

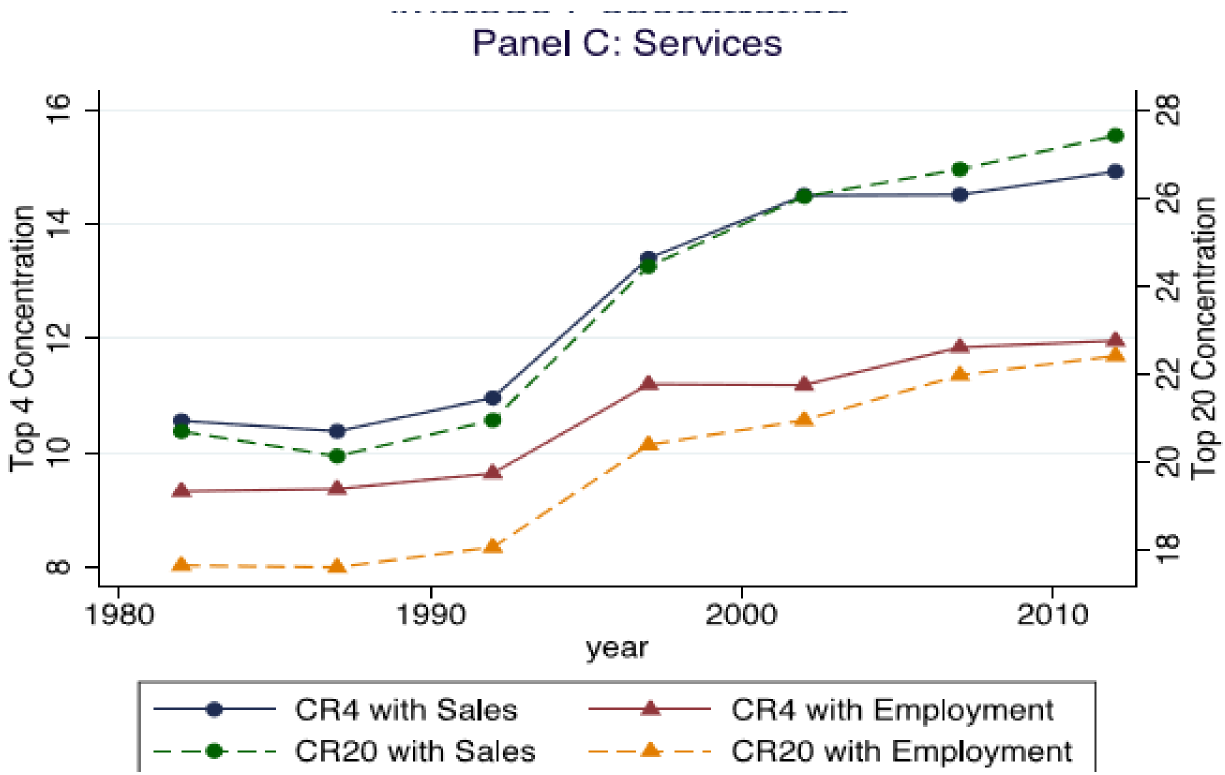


Declining Labor Share (mostly due to composition)

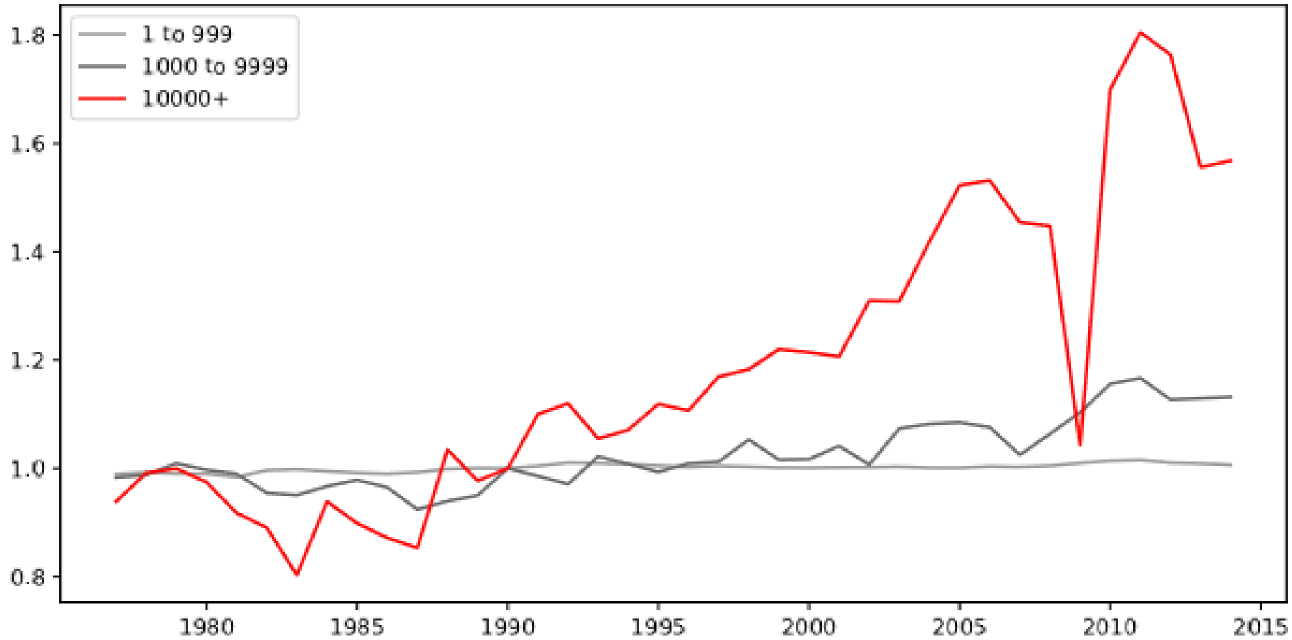
Cumulative change over specified period (ppt)

	1982–2012 MFG	1982–2012 RET	1982–2012 WHO	1982–2012 SRV	92–12 FIN	92–07 UTL
$\Delta \frac{\text{Payroll}}{\text{Sales}}$	-7.01	-0.79	0.19	-0.19	3.25	-1.89
within	-1.19	3.74	4.01	2.43	6.29	0.58
between	-4.97	-4.03	-4.38	-0.44	-3.62	-2.39

Rising Concentration in Services



Rising Establishments per Firm



Source: U.S. Census Bureau's *Business Dynamics Statistics*

Our story (1)

- Final good produced with continuum of intermediate inputs

Production side

Final output is competitively produced according to

$$Y = \exp\left(\int_0^1 \log\left[q(i)y(i)\right]di\right),$$

where intermediates differ in quality $q(i)$ and price $p(i)$.

Resulting demand:

$$y(i) = \frac{YP}{p(i)},$$

where P is the price index.

Our story (2)

- Each input producer has a quality on each specific line, which changes endogenously over time due to innovations.
- In addition to quality there is time-invariant efficiency advantage of some firms over other firms
- Namely, a small subset of firms (call them super-star firms) have lower production costs for any quality level, e.g. because of better network access or accumulated social capital.

Our story (3)

- Input producers expand through creative destruction on new product lines, i.e. by innovating upon existing producers on those lines
- However, running n lines involves a overhead cost C(n) which is increasing and convex in n

Our story (4)

- IT revolution induces a downward shift in the convex overhead cost of running n lines
- Super-star firms will expand at the expense of non-super star firms
- R&D investment and entry by non-super-star firms will be partly discouraged

Firm heterogeneity

There are J firms.

Exogenous, permanent differences in the level of process efficiency across firms.

Endogenous, evolving differences in the level of product-specific quality across firms.

Process efficiency

Process efficiency across firms:

share ϕ with high productivity φ^H
share $1-\phi$ with low productivity φ^L

Production of product i by firm j is linear in labor

$$y(i,j) = \varphi(j) \cdot l(i,j)$$

Productivity differential $\Delta = \dfrac{\varphi^H}{\varphi^L} > 1$

Market structure

Bertrand competition within each product line $i \in [0, 1]$.

In each line i the leading firm $j(i)$ sets

$$p(i, j(i), j'(i)) = \frac{q(i, j(i))}{q(i, j'(i))\varphi(j'(i))} w,$$

where $j'(i)$ indexes the next highest quality firm.

We assume $\gamma > \Delta$ so the highest quality producer is active.

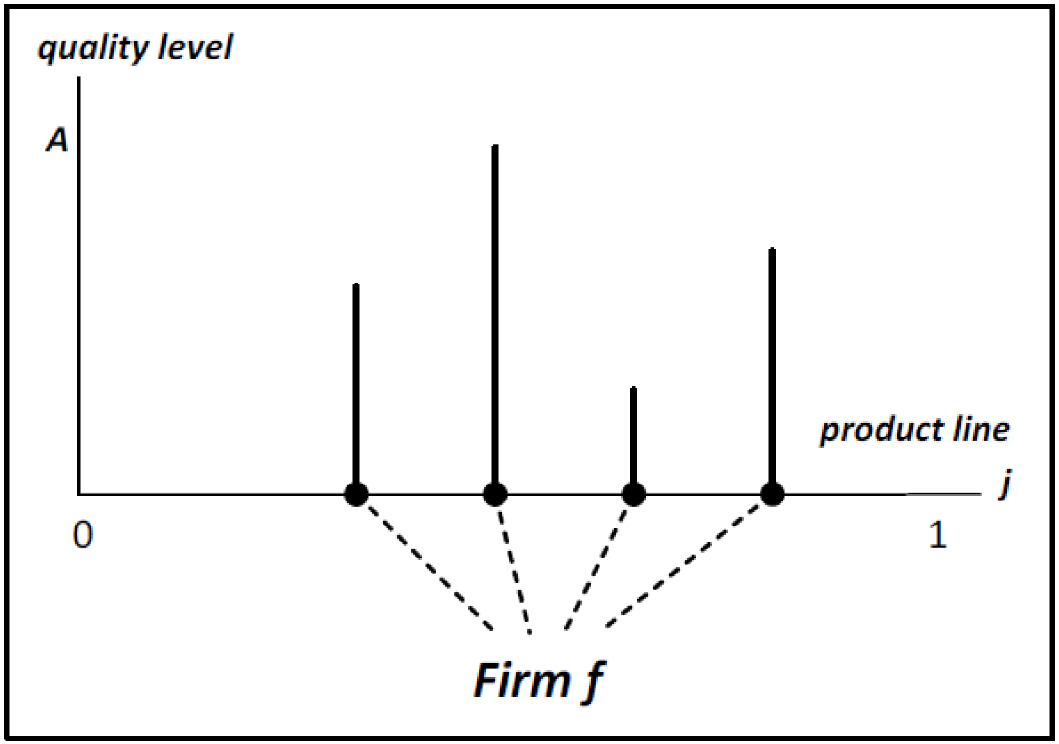
Price is constrained by the second-best quality.

Markup

Markup is endogenously determined by the relative quality and process efficiency of the best and second-best firms.

The markup factor $\mu(i) = \dfrac{p(i, j(i), j'(i))}{w/\varphi(j(i))}$ is given by

$$\mu(i, j(i), j'(i)) = \begin{cases} \gamma, & \text{if type of } j = \text{type of } j' \\ \gamma\Delta, & \text{if } j = H\text{-type}, j' = L\text{-type} \\ \gamma/\Delta, & \text{if } j = L\text{-type}, j' = H\text{-type} \end{cases}$$


quality level
A
product line
j
0
1
Firm f

Boundary of the firm

Per-period overhead cost for firm j with $n(j)$ products

$$\psi_o \cdot \frac{1}{2} n(j)^2 \cdot Y$$

Convexity yields a well-defined boundary of the firm.

High productivity firms operate more lines but not all lines.

Profits

Period profits of an H-type firm producing in $n(j)$ lines and facing a share $s(j)$ of H-type competitors:

$$\Pi(j) = \left[n(j)s(j)\left(1 - \frac{1}{\gamma}\right) + n(j)[1 - s(j)]\left(1 - \frac{1}{\Delta\gamma}\right) - \psi_o \frac{1}{2} n(j)^2\right] Y$$

Period profits of an L-type firm producing in $n(j)$ lines and facing a share $s(j)$ of H-type competitors:

$$\Pi(j) = \left[n(j)s(j)\left(1 - \frac{\Delta}{\gamma}\right) + n(j)[1 - s(j)]\left(1 - \frac{1}{\gamma}\right) - \psi_o \frac{1}{2} n(j)^2\right] Y$$

Firm problem

Each firm decides how much to invest in R&D, $x_t(j)$, to maximize the net present value of its profits.

This leads to an endogenous rate of "creative destruction" z_{t+1} and is the source of growth.

For ease of exposition, we will only formally specify the firm problem in steady state here.

$$z_{t+1} = \int_0^J x_t(j)\, dj$$

Steady state

Definition

A steady state is an equilibrium in which the fraction of lines served by high productivity firms $S^\star \in (0,1)$ and the interest rate $r^\star$ are both constant over time.

Steady state implies that the fraction of high productivity competitors faced is identical across firms, $s(j) = S^\star$.

In the following we analyze the steady state.

We are particularly interested in how the steady state changes as ψ_o, the scale of overhead costs, decreases.

Firm problem in steady state

For H-type and L-type firms, respectively:

$$v_H(n) = \max_{n'} \{\pi_H(n, S^\star) - [n' - n(1 - z^\star)]\, \psi_c + \beta v_H(n')\}$$

$$v_L(n) = \max_{n'} \{\pi_L(n, S^\star) - [n' - n(1 - z^\star)]\, \psi_c + \beta v_L(n')\}$$

A steady state is a combo of $(n_H^\star,\, n_L^\star,\, S^\star,\, z^\star)$ such that

$$\phi J n_H^\star = S^\star, \text{ and } (1-\phi) J n_L^\star = (1 - S^\star),$$

and the policy functions fulfill

$$f_H\left(n_H^\star\right) = n_H^\star, \text{ and } f_L\left(n_L^\star\right) = n_L^\star.$$

Steady state characterization

$(S^\star, z^\star, n_H^\star, n_L^\star)$ can be determined analytically from

$$\psi_c = \frac{1 - S^\star/\gamma - (1 - S^\star)/(\gamma\Delta) - \psi_o n_H^\star}{1/\beta - 1 + z^\star}$$

$$\psi_c = \frac{1 - S^\star\Delta/\gamma - (1 - S^\star)/\gamma - \psi_o n_L^\star}{1/\beta - 1 + z^\star}$$

$$\phi J n_H^\star = S^\star$$

$$(1 - \phi) J n_L^\star = 1 - S^\star$$

Steady state effect of lower ψ_o on concentration

Proposition

$S^\star$ rises monotonically as ψ_o falls.

Intuition:
A larger size gap $n_H^\star - n_L^\star$ is needed to yield a given difference in their marginal overhead costs.

Steady state effect of lower ψ_o on the labor income share

The labor income share within high and low productivity firms is monotonically *increasing* in $S^\star$.

Intuition: with a higher $S^\star$ a producer is more likely to face a high productivity competitor → lower markup.

However, the between effect goes in the opposite direction (increasing $S^\star$ tends to decrease the labor income share).

Overall effect: the aggregate labor share is decreasing in $S^\star$ (and therefore falls when ψ_o falls) as long as $S^\star > 1/2$.

Steady state effect of lower ψ_o on the growth rate

Two opposing effects as ψ_o falls:

Marginal value of innovating on an additional line determines the rate of creative destruction and growth.

Direct effect: lower $\psi_o \rightarrow$ higher incentive to innovate.

GE effect: as $S^\star$ increases $\rightarrow$ expected markup within a product line decreases.

For a range of parameter values the GE effect dominates and growth slows as ψ_o falls.

Transition dynamics after a decrease in ψ_o

Initially, as S has not increased yet, incentive to do R&D increases.

And static process efficiency gains are realized during the transition as S increases.

Both effects will contribute to a burst of growth during the transition.

The theory predicts

- Rising concentration
- A decline in the labor income share (driven by composition as opposed to a decline within firms)
- A fall in TFP growth after an initial burst

Conclusion

- Super-star story appears to best fit the evidence
- More optimistic story as it suggests a role for policy in stopping the growth decline
  - Regulate M&A
  - Ease data access
  - Break up policy?

Conclusion

- Need to adapt institutions to technological revolutions!