Market Power and Innovation in the Intangible Economy

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    United States France

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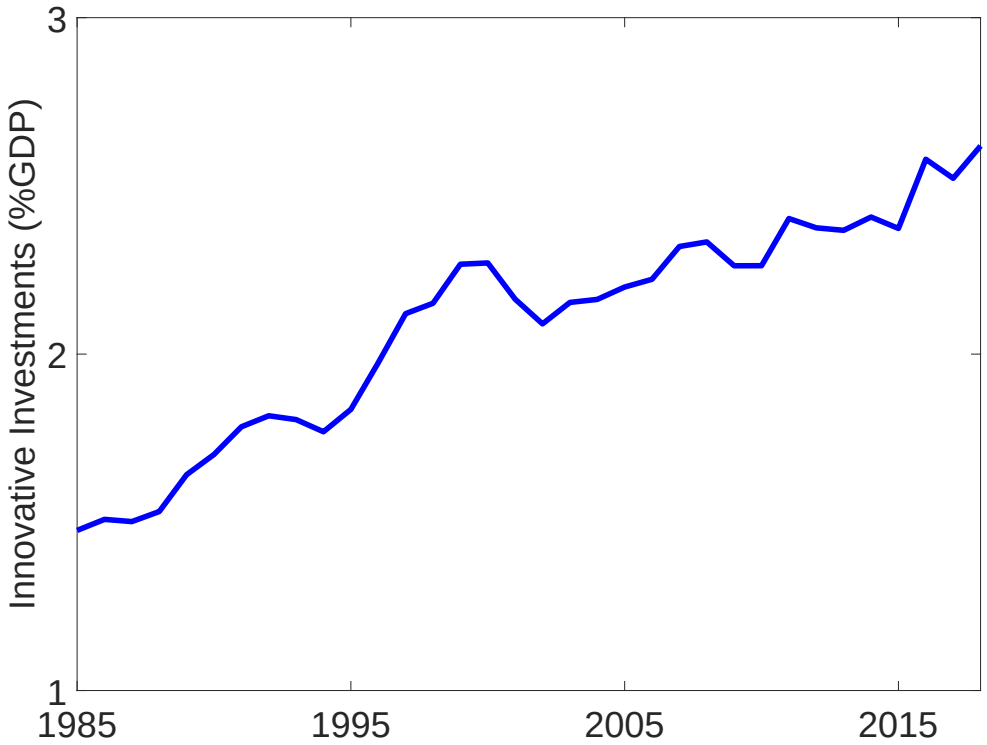
- Market power is increasing
  - Markups are increasing
  - Product market concentration is rising

    United States France

Literature Review

Productivity growth

- Ideas are getting harder to find (Bloom et al. 2017)



U.S. Investments in Intellectual Property excluding Software

Source: BEA, Fernald (FRBSF) France

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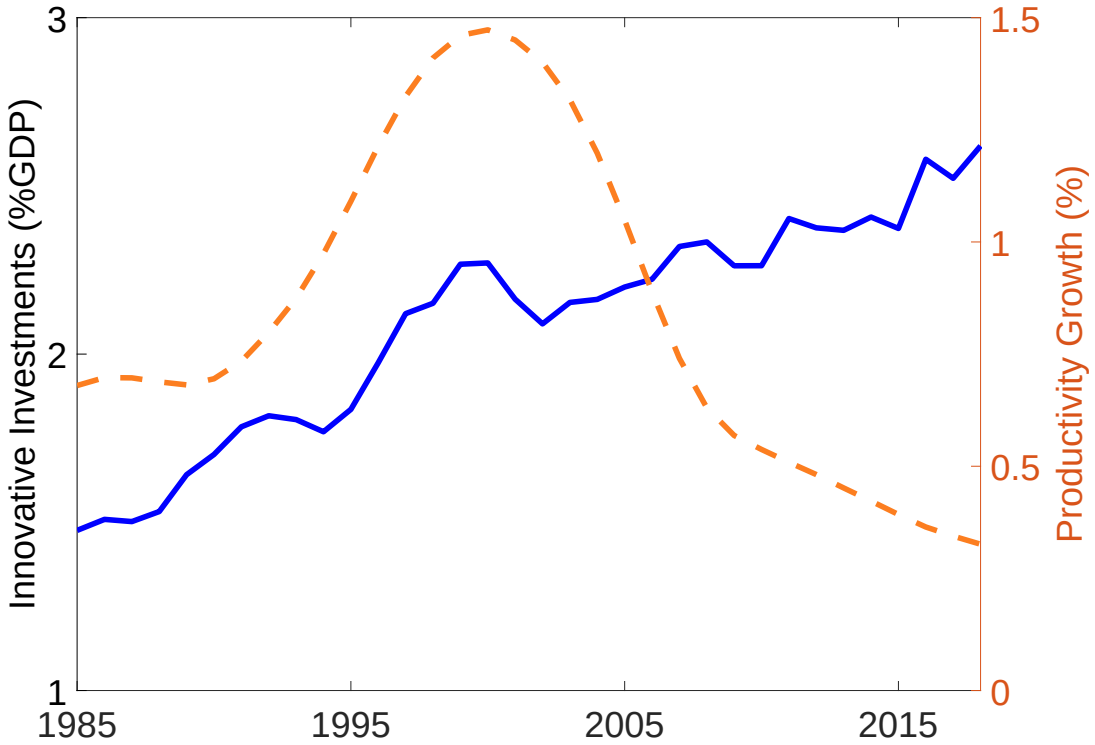

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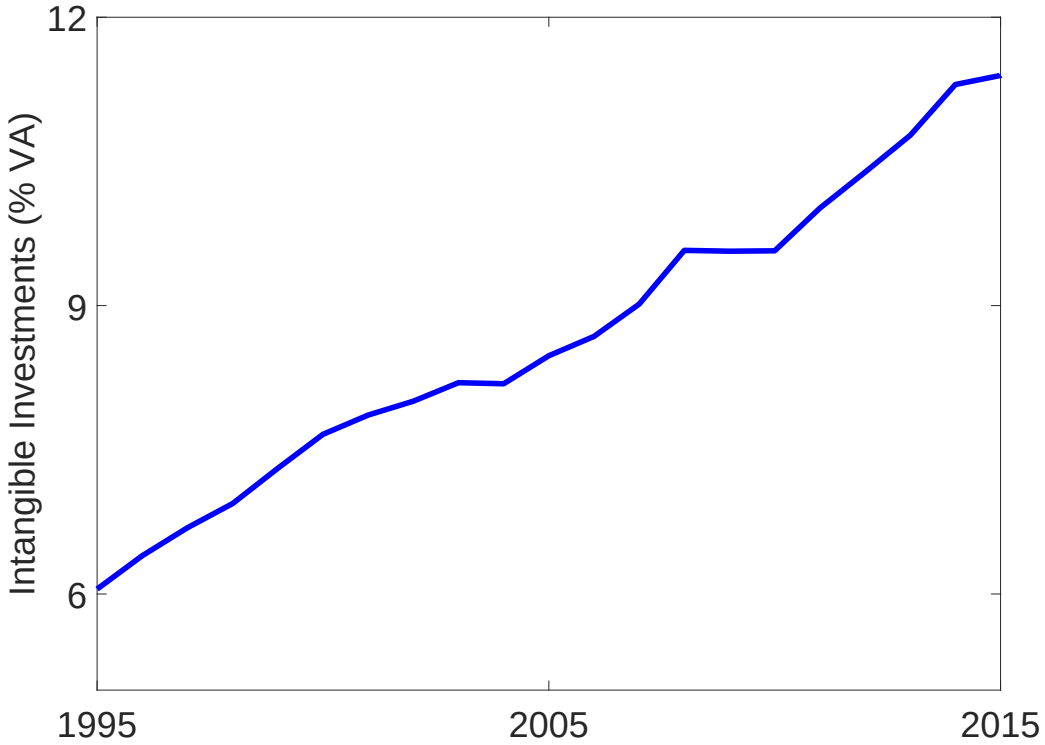
My explanation: intangible inputs



U.S. Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016) France

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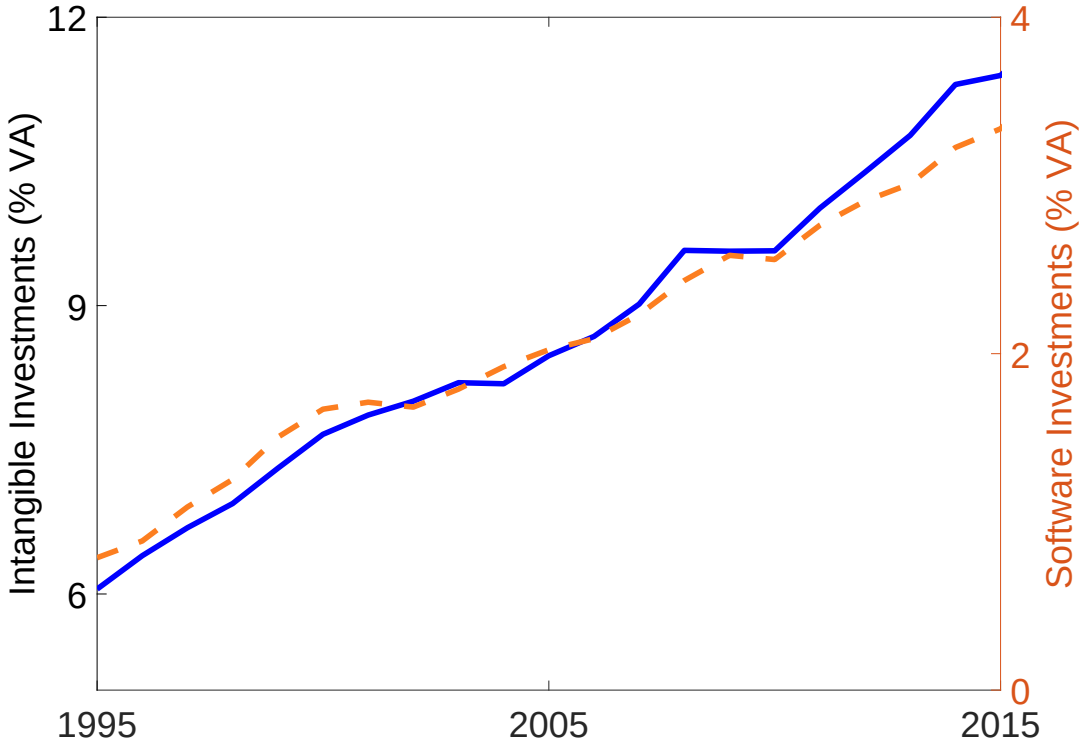

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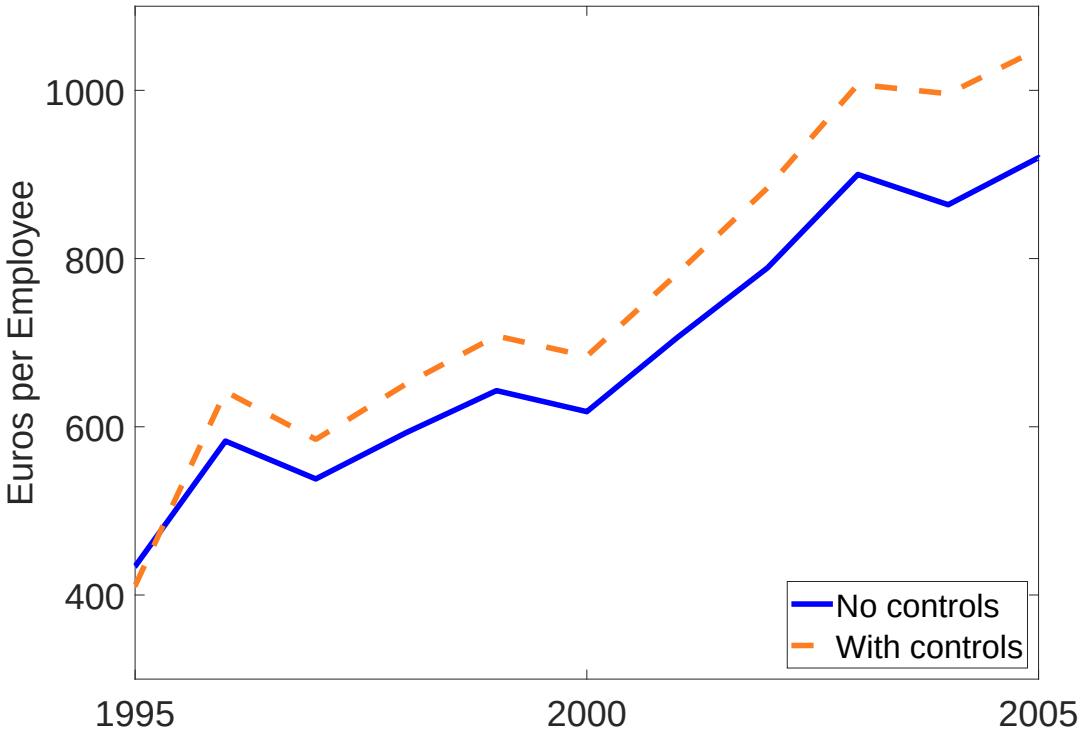
Intangible inequality



Standard Deviation of Software Investments per Employee

Controls: industry-trend, 5-digit f.e., and size. Source: EAE (14.000 French firms)

Macroeconomic model

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- Mechanism:
  - Paradox: small group of innovative high-intangible firms firms can reduce creative destruction and innovation after causing a boom
  - High-intangible firms with low marginal costs undercut innovative competitors on price and dominate sectors, which deters entry

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- Ratio of fixed to variable costs increases over time
- Ratio of fixed to variable costs increases when adopting technologies

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A new measure of fixed costs derived from operating profits and markups:

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Markup estimation procedure

Data

Balance sheet and income statement data from French Census and DGFiP

- Universe of firms from 1994-2016 from merging FARE and FICUS
- Production and employment data from tax and social security files
- Merge with representative surveys on software investments (*EAE*), IT-systems (*TIC*), research and development (*CIS*)

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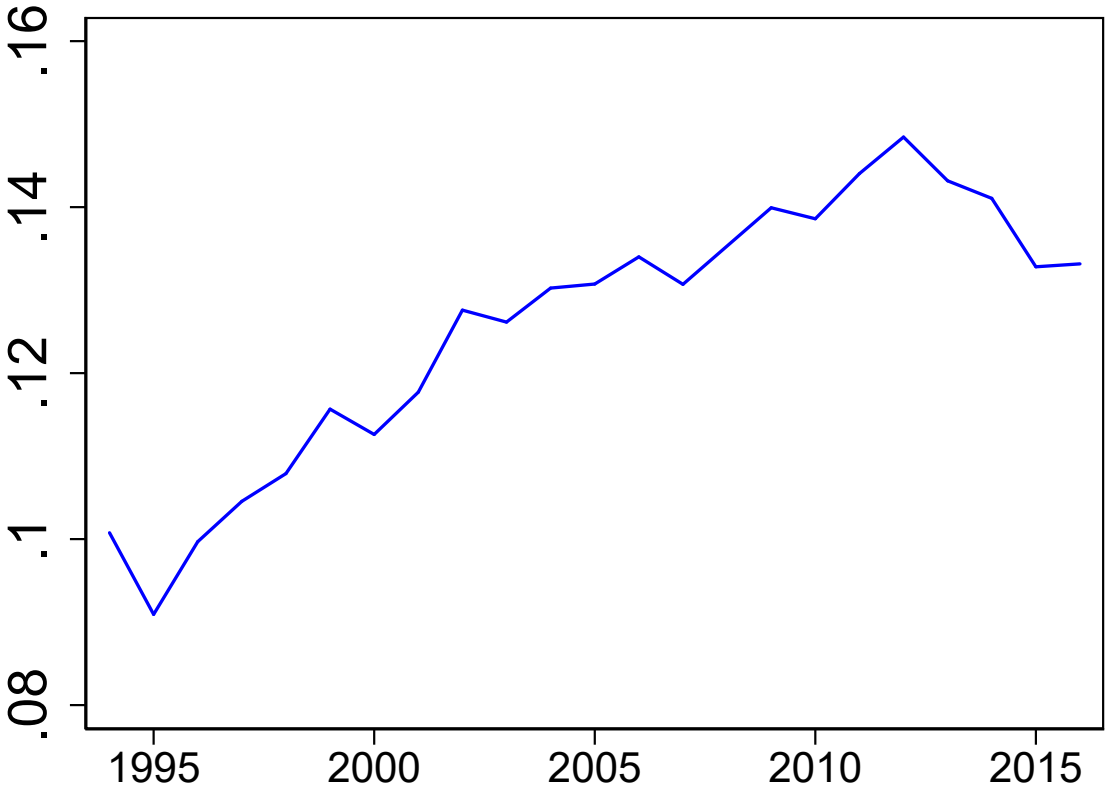
Treatment

- Drop financial, insurance and real estate (FIRE) firms
- Firms without employees, zero/negative sales, wage bill, capital
- Nominal variables are deflated with EU-KLEMS sector-level deflators

Result: 9.5 million firm-years across 572 NACE industries

Trend

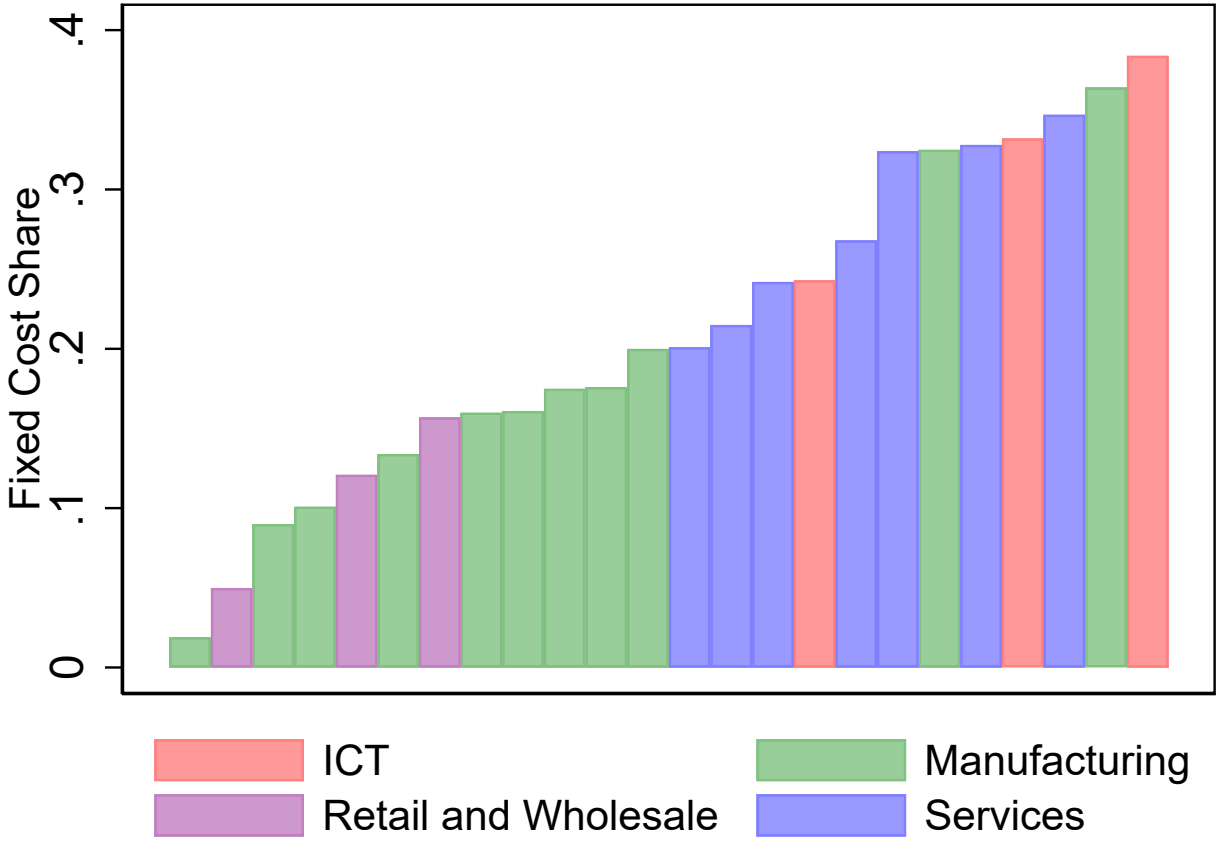


Fixed costs as a share of total cost (sales-weighted)

Source: Own calculations based on universe of French firms (FARE-FICUS)

▸ US Public Firms

Industries



Fixed costs as a share of total cost,
sales-weighted average within NACE sections and major 2-digit industries.

Source: Own calculations based on universe of French firms (FARE-FICUS)

Fixed costs and intangibles

$$\frac{\tilde{S}_{it}}{TC_{it}} = \beta \cdot Adoption_{it} + \gamma' X_{it} + \varepsilon_{it}$$

Fixed Cost Share	ERP	CRM	CAO	RFID
Adoption Dummy	0.015***	0.006***	0.020***	0.023***
	(0.002)	(0.002)	(0.006)	(0.006)
Year F.E.	✓	✓	✓	✓
Industry F.E.	✓	✓	✓	✓
Size Poly.	✓	✓	✓	✓
N	63,928	69,200	30,415	16,847
R^2	0.32	0.32	0.32	0.39

Data: FARE-FICUS merged with TIC 2006-2016, observations weighted with TIC sample weights. Firm-clustered standard errors in brackets. All dep. variables are binary.

▸ Communication Technologies ▸ Marketing and Social Media ▸ Panel: software investments

Innovation in the macroeconomic model

Standard models of economic growth:

- Firms expand the range of products they can produce through R&D

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This model: high-IT firms have lower marginal production costs

- Trade-off consumers: high-cost innovative good vs low cost incumbent
- Greater chance that innovator does not become market leader
- Discourages entry and innovative investments by low-IT firms

Growth and innovation

	Sales growth	R&D Intensity
Fixed Cost Share	0.105***	0.012**
	(0.001)	(0.005)
N	7,895,588	85,566
R^2	0.115	0.011
Year F.E.	✓	✓
Firm F.E.	✓	✓
Size Poly.	✓	✓

Data: FARE-FICUS income statement data, CIS innovation data.
Firm-clustered standard errors in brackets.

Full table

Structural estimation

- Assume all firms have equal intangible productivity ϕ
- Simulated method of moments: 32,000 firms for 50 years
- Match moments for 1979/1994 using a genetic algorithm

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		France		U.S.	
Parameter	**Moment**	**Data**	**Model**	**Data**	**Model**
$\bar{\lambda}$	Productivity growth	1.3%	1.3%	1.3%	1.3%
ϕ	Fixed costs (%)	9.5%	9.5%	12.0%	12.0%
σ	Gibrat's Law	-0.035	-0.035	-0.035	-0.035
η^e	Entry rate	10.0%	9.9%	13.8%	12.2%
η^x	R&D intensity	3.1%	2.6%	2.5%	2.5%

Experiment

Introduce group firms with higher intangible-efficiency:

- Match increase in fixed costs and decline in entry

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Introduce group firms with higher intangible-efficiency:

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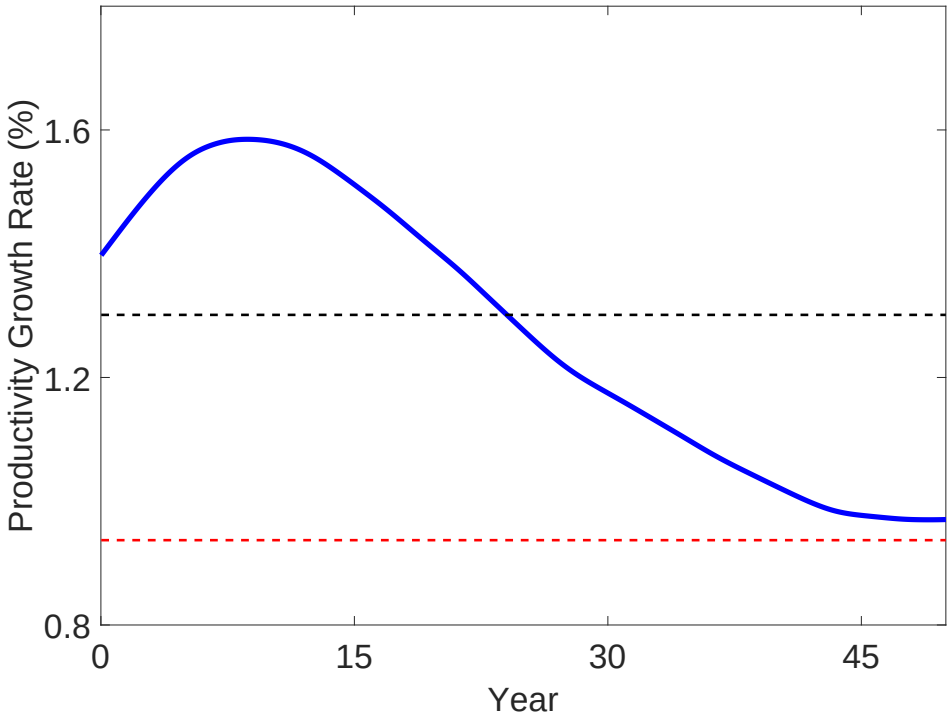
	France		U.S.	
Variable	**Δ model**	**Δ data**	**Δ model**	**Δ data**
Targeted				
Avg. fixed cost share	4.5 pp	4.5 pp	10.1 pp	10.6 pp
Entry rate	-3.6 pp	-3.6 pp	-5.6 pp	-5.8 pp
Untargeted				
Productivity growth	-0.2 pp	-1.3 pp	-0.4 pp	-0.9 pp
Reallocation rate	-24 %	-23 %	-38 %	-23 %
Avg. markup	10 pt	11 pt	17 pt	30 pt

Transition: productivity growth

- Transitory boom due to intangibles
- long-term decline due to concentration and entry



Black-dashed: original steady state. Red-dashed: new steady state. French calibration

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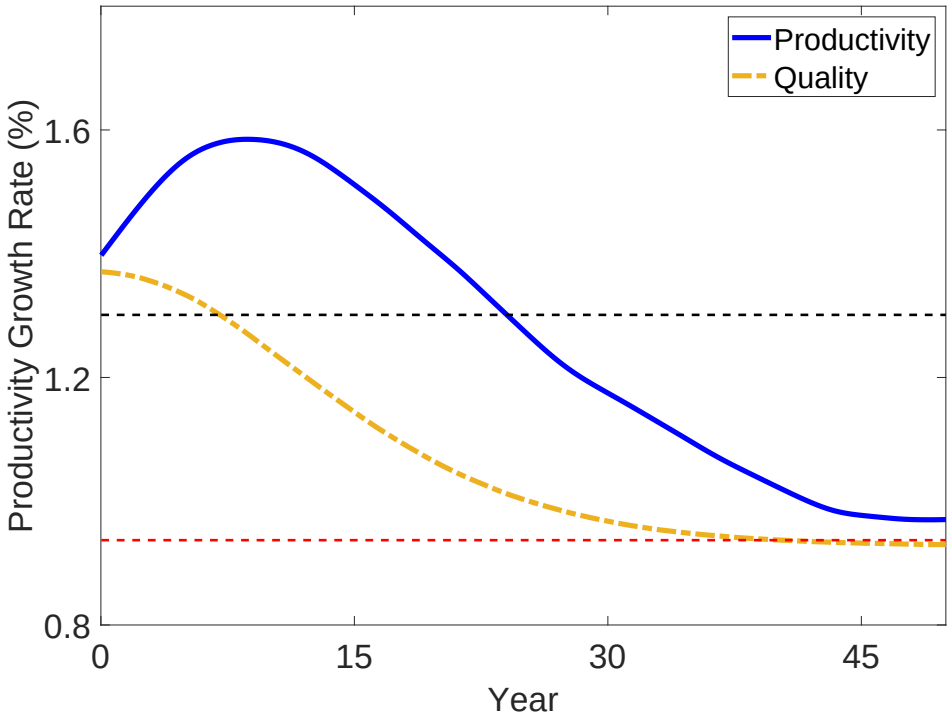

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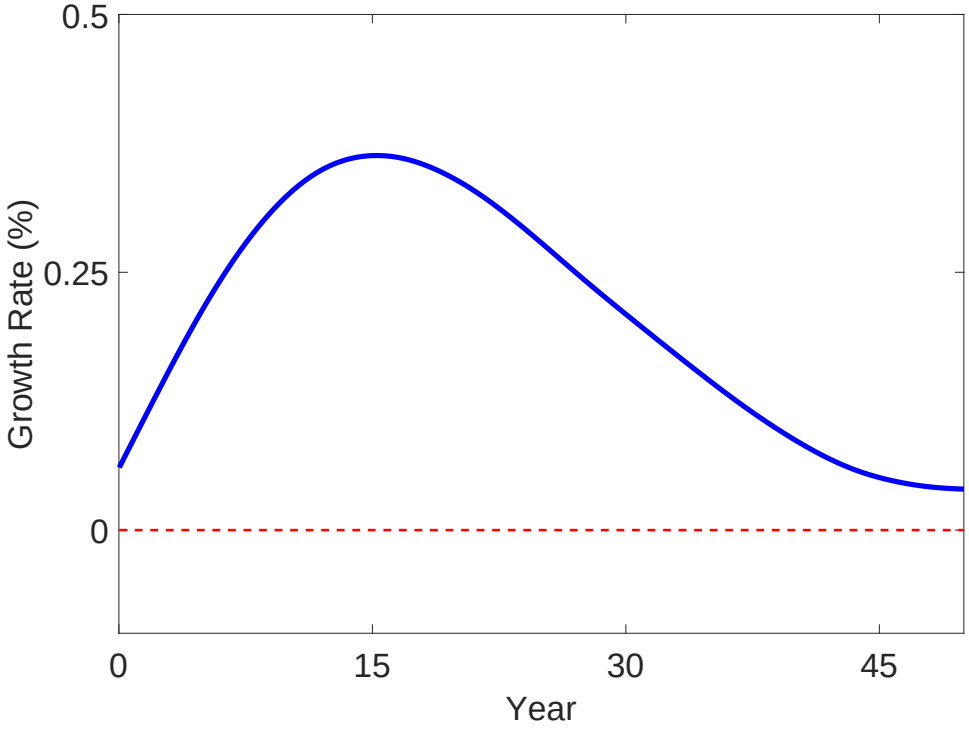
Transition: intangibles contribution

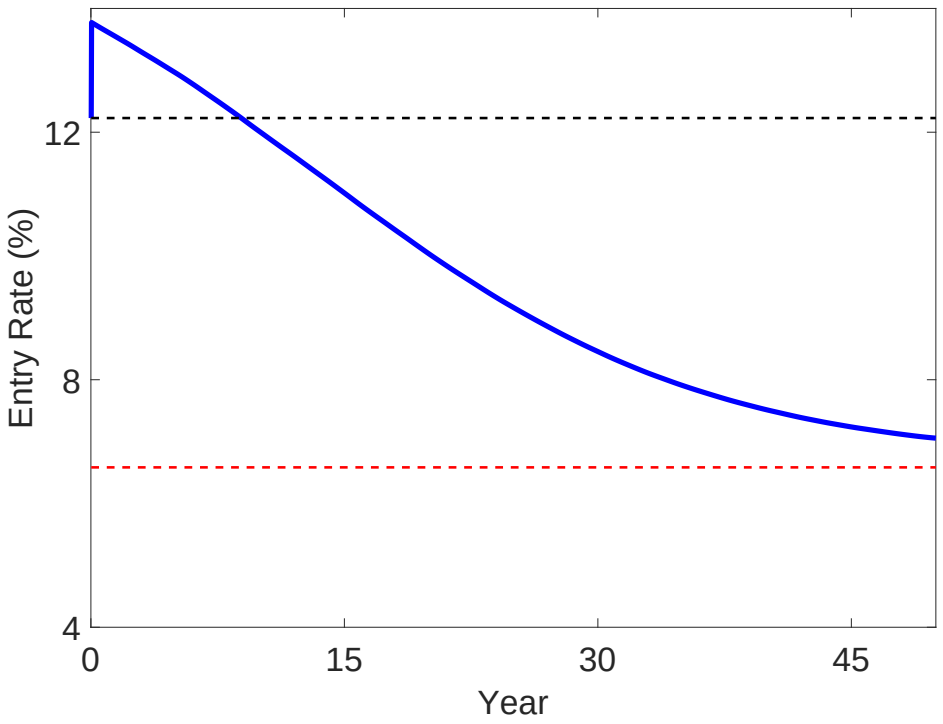
- Transitory effect intangibles wears off as firms fully adopt



Contribution of intangible adoption to growth. Red-dashed: steady state. French calibration

Transition: entry rate

- Entry declines as probability of successful innovation declines



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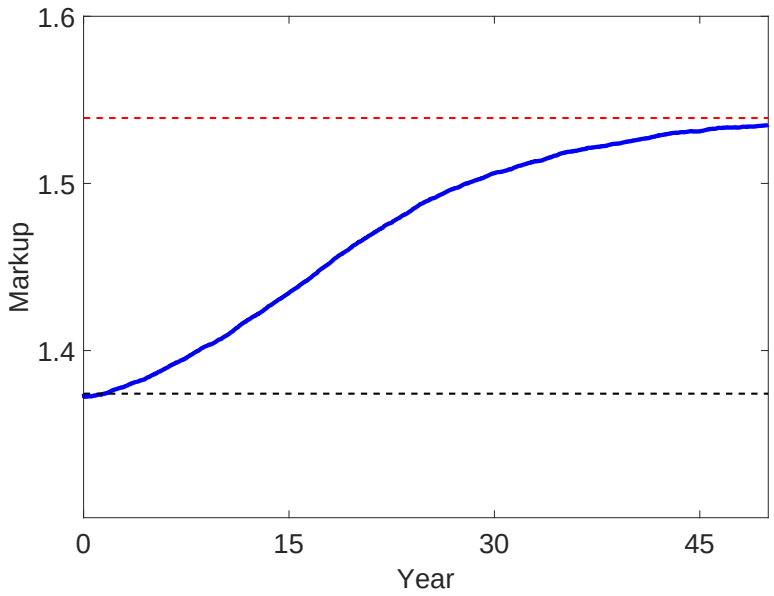
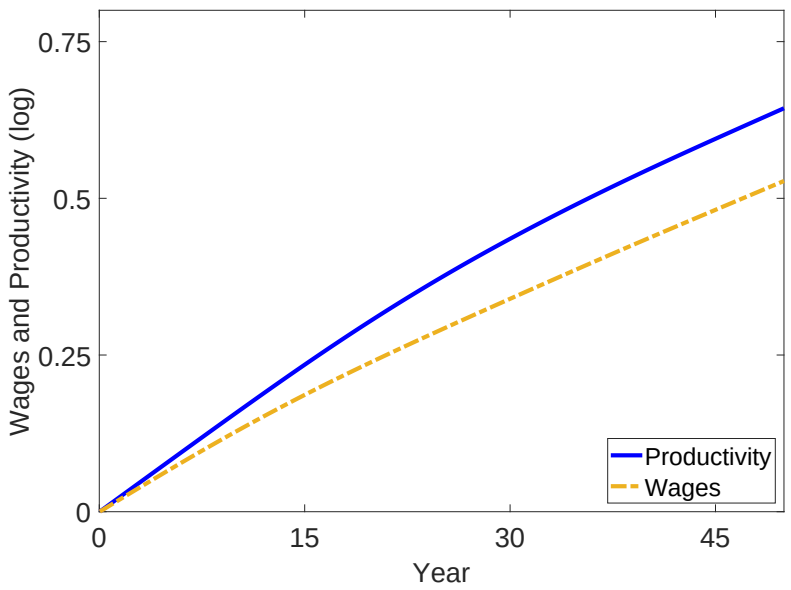
Transition: markups and wages

- Markups up: decoupling of wages and productivity



(a) Avg. Markup



(b) Wage Rate

Black-dashed: original steady state. Red-dashed: new steady state. French calibration

Conclusion

Three macroeconomic trends:

- Low productivity growth despite high R&D, fall in business dynamism, rise of market power/concentration

Propose unequal rise of intangibles as common explanation:

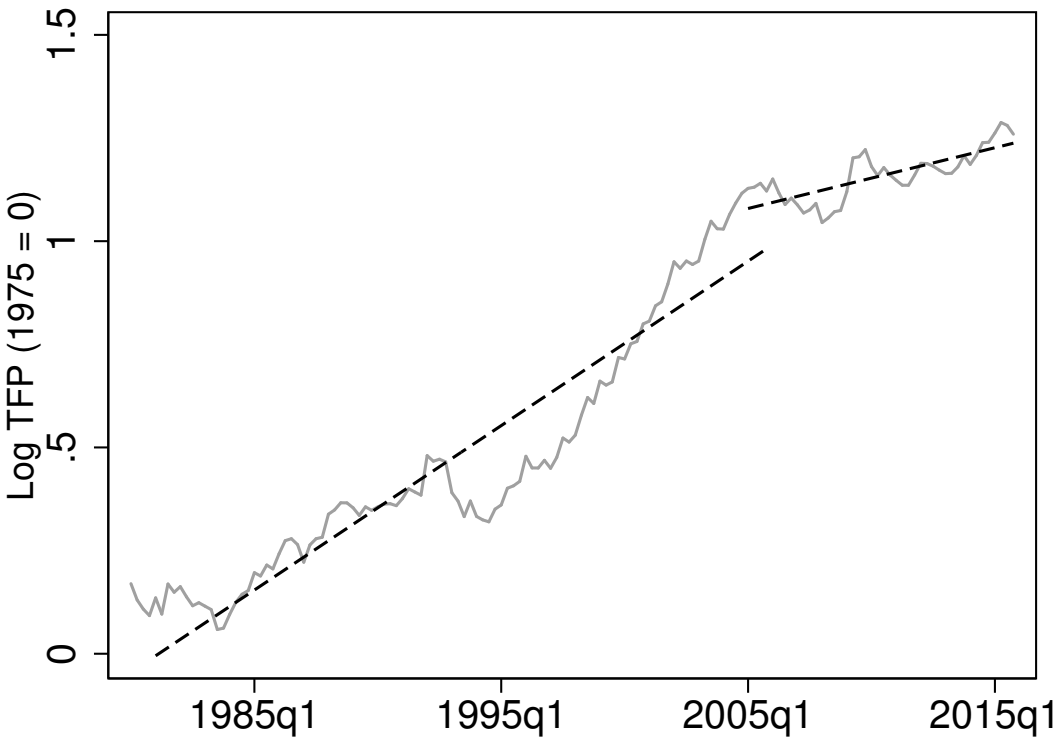
- Intangible inputs reduce marginal costs, raise fixed costs
- Firms with low adoption costs can reduce aggregate growth

Results:

- Endogenous growth model with intangibles, entry/exit dynamics, variable markups: explains significant part of slowdown

Appendix

Productivity growth

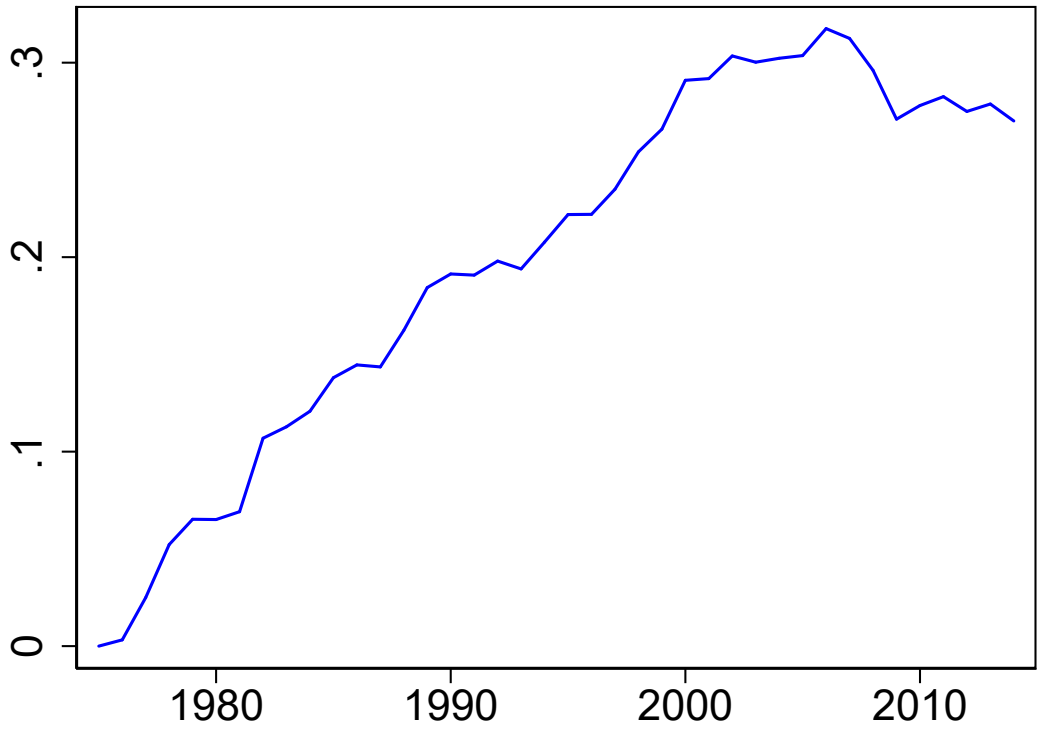


Total Factor Productivity between 1975 and 2016.

Data: Fernald/FRSF

Back - Intro

Productivity growth (France)



Total Factor Productivity between 1975 and 2016.

Data: Penn World Tables

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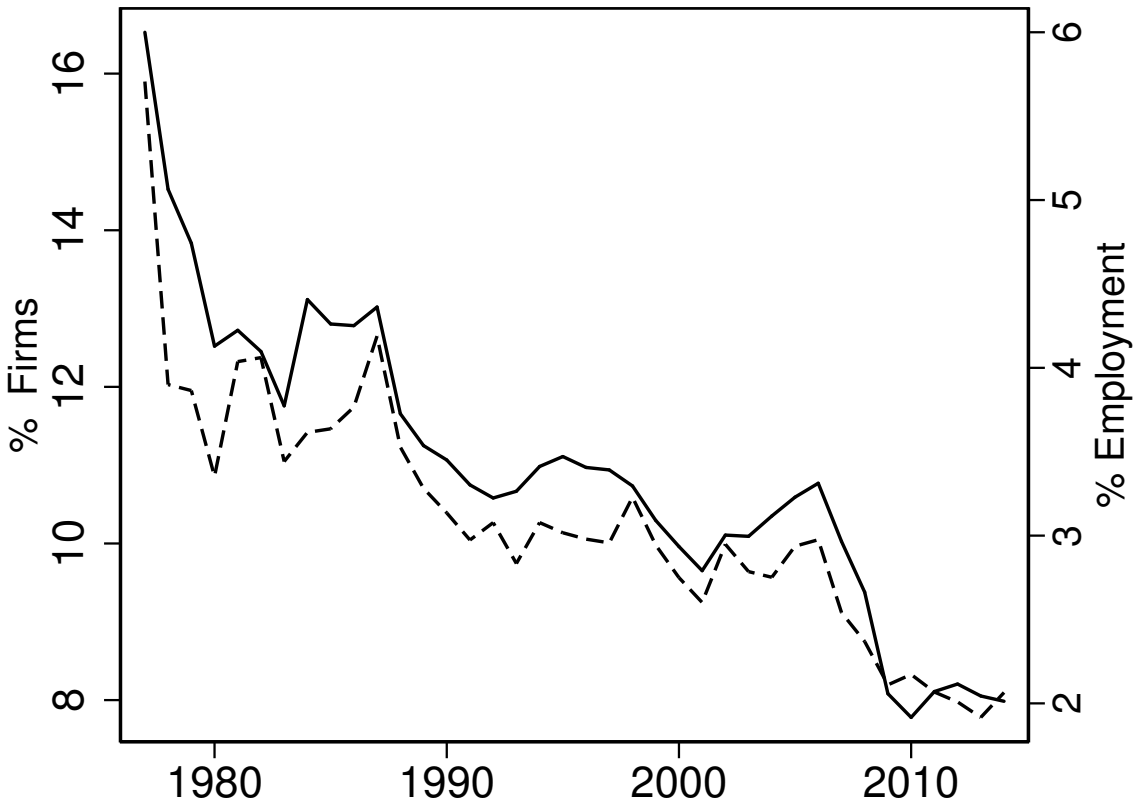
Business dynamism: entry



Start-ups as percentage of firms (solid) and employment (dash)

Data: Business Dynamics Statistics, U.S. Census

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French evidence

Business dynamism: entry rate (France)

Percentage of employment by new firms ($\leq$ 1yr) in private sector employment (HP).

Source: own calculations based for universe of French firms (FARE-FICUS)

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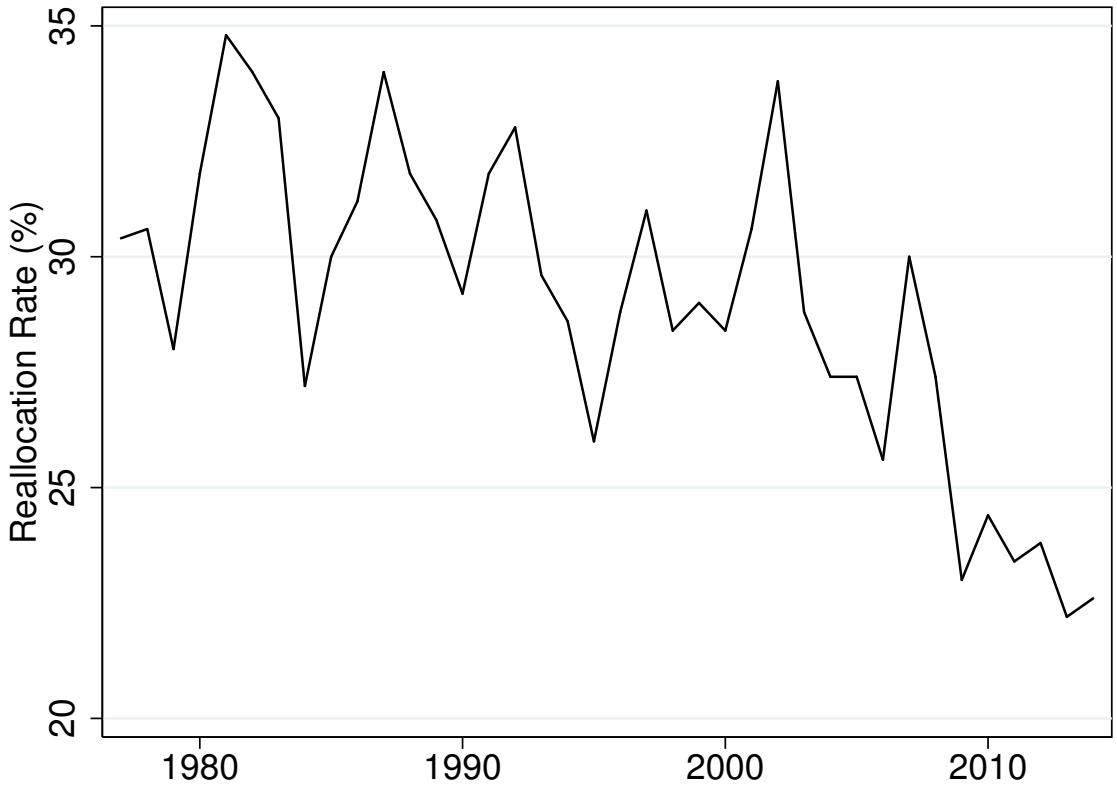
Back - Data

Business dynamism: reallocation rate



Sum of job destruction and creation rate (%)

Data: Business Dynamics Statistics, U.S. Census

French evidence
Back - Intro

Business dynamism: reallocation rate (France)

Sum of job creation and job destruction rates across companies (HP).

Source: own calculations based for universe of French firms (FARE-FICUS)

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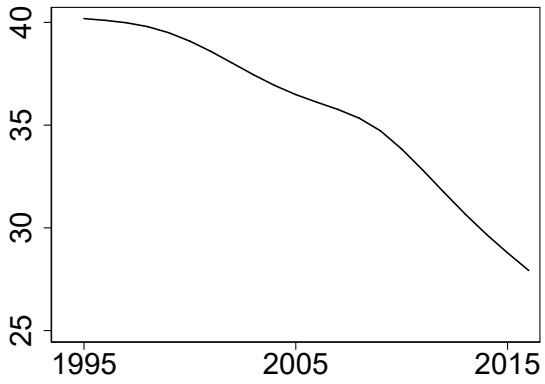
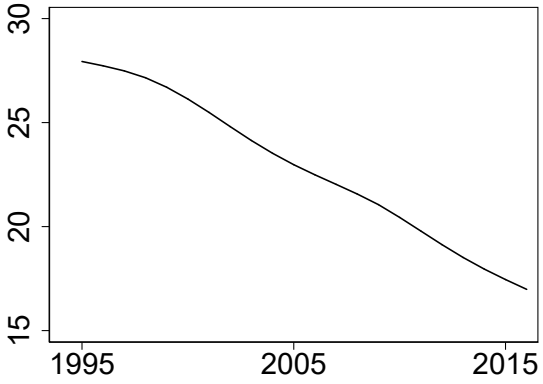
Back - Data

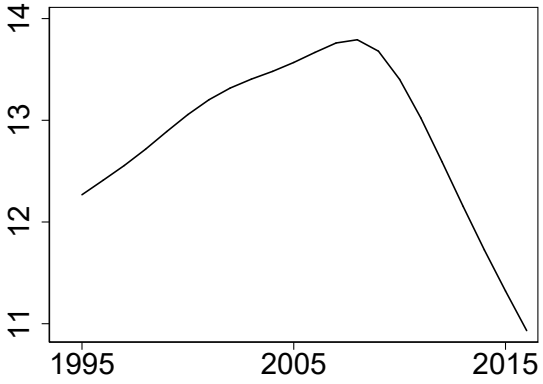
Business dynamism: skewness of growth (France)



(c) 90-10 Difference



(d) 90-50 Difference



(e) 50-10 Difference

Difference (perc. point) in growth between percentiles of the employment-growth distribution.

Source: own calculations based for universe of French firms (FARE-FICUS)

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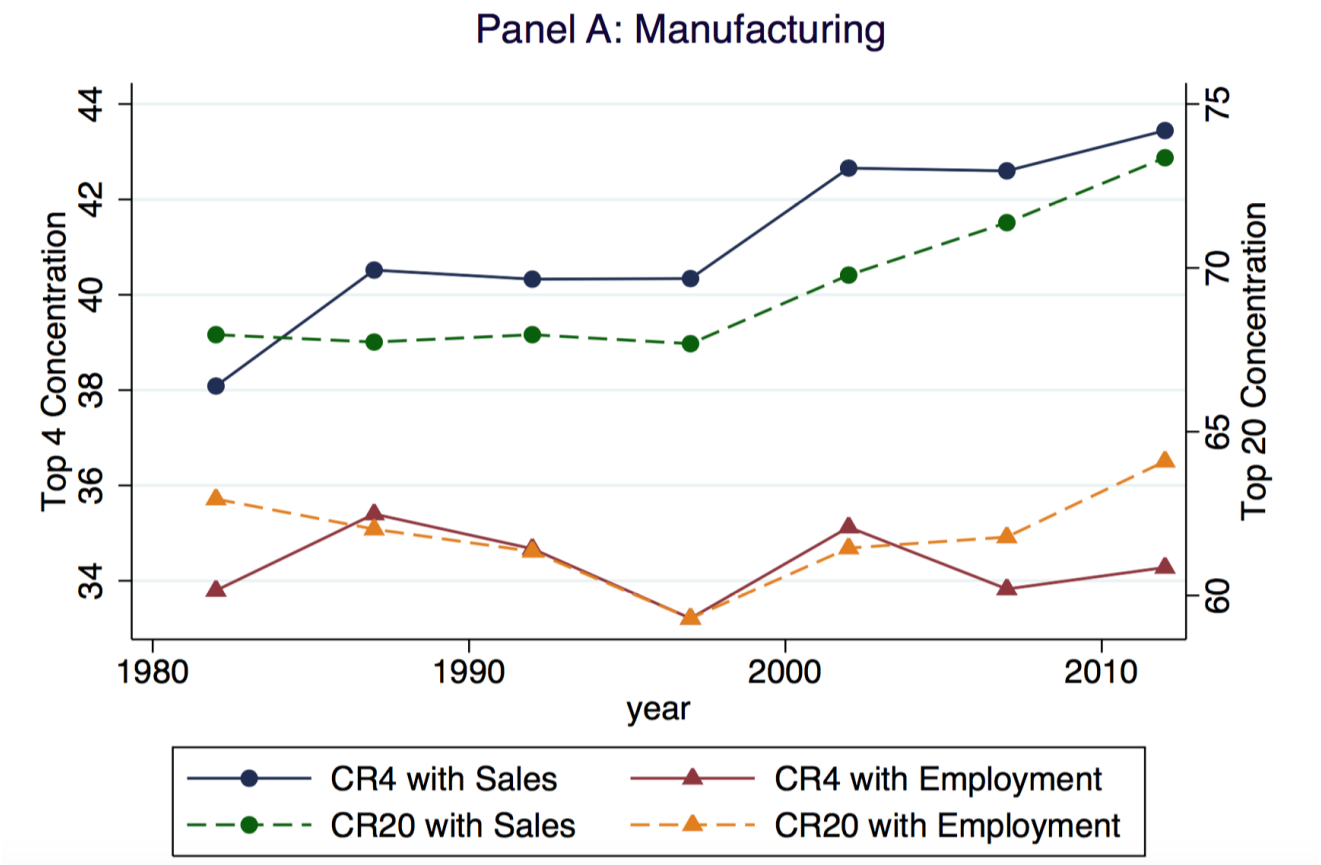
Firm concentration

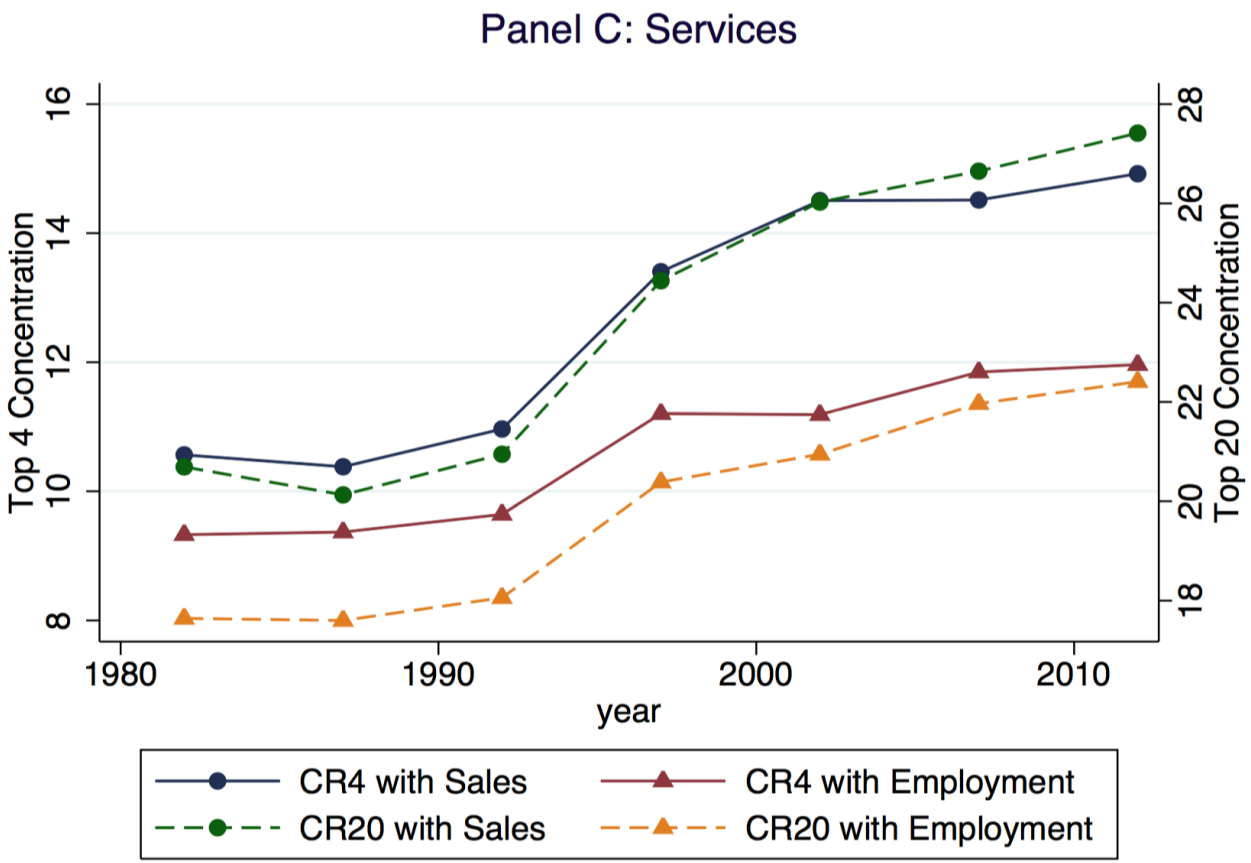


Fraction of sales and employment by top 4 or 20 firms by 4-digit industry.

Source: Autor et al (2017) based on U.S. Census Data

French evidence

Firm concentration



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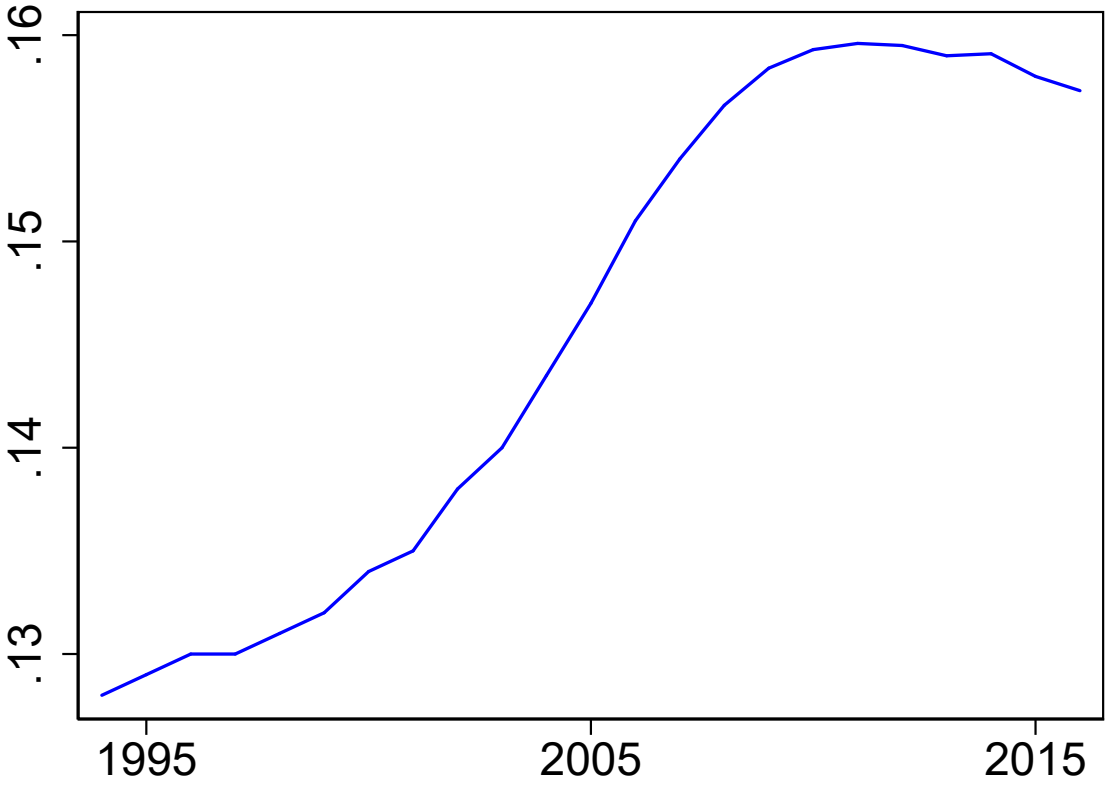
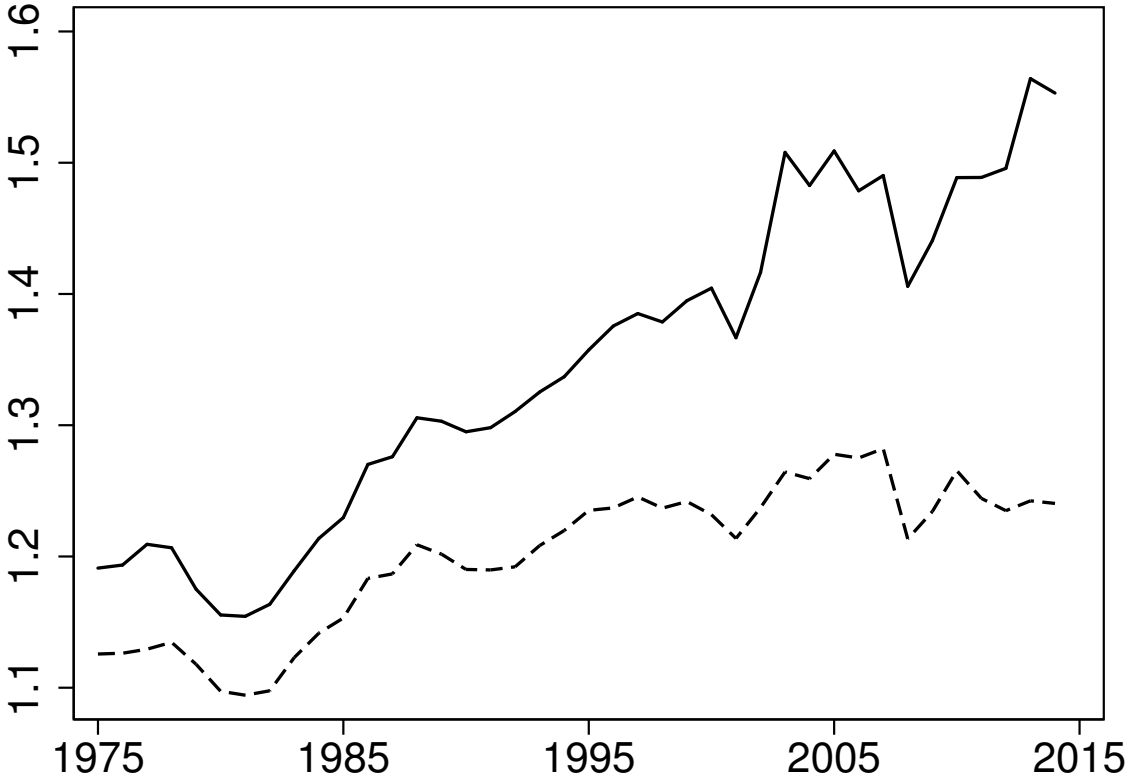


Average Herfindahl Index at 4-digit NACE level, weighted by value added (HP).

Source: own calculations based for universe of French firms (FARE-FICUS)

Back - Into
Back - Data

Markups

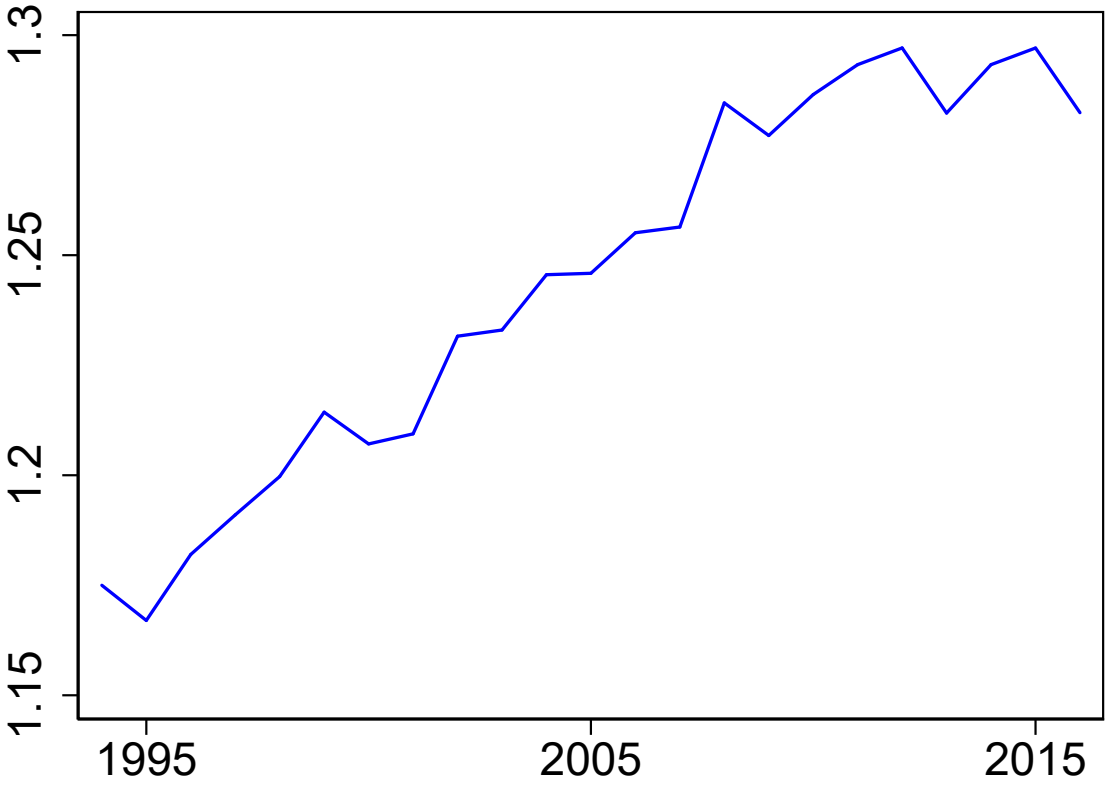


Average markup weighted by sales (solid) and costs (dashed)

Source: Own calculations based on Compustat Data

Back - Into

Markups (France)



Average markup weighted by sales (solid) and costs (dashed)

Source: Own calculations based on Compustat Data

Back - Into

Markups

Hall (1988): Markup μ of firm i in year t can be written as:

$$\mu_{it} = \theta_{it}^{m} \cdot \left(\frac{p_{it} \cdot y_{it}}{p_{it}^{m} \cdot m_{it}} \right)$$

- $p_{it} \cdot y_{it}$: Revenue (sales)
- $p_{it}^{m} \cdot m_{it}$: Expenditure on variable input m (materials)
- θ_{it}^{m}: Elasticity of output y_{it} with respect to input m
  - Estimation: iterative GMM as in De Loecker & Warzynski (2012)

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Markups Estimation

- Assume a translog production function:

$$\ln y_{it} = \ln a_{it} + \sum_{h \in \{k,l,m\}} \left(\beta^h \cdot \ln h_{it} + \beta^{hh} \cdot [\ln h_{it}]^2 \right)$$

  - a: productivity (hicks-neutral)
  - k: capital
  - l: labor input (wage bill)
  - m: intermediate inputs and materials

$$\mu_{it} = (\beta^m + 2 \cdot \beta^{mm} \cdot \ln m_{it}) \left(\frac{p_{it} y_{it}}{p^m m_{it}} \right)$$

- Productivity a might depend on factor usage (k,l,m), $\Rightarrow$ OLS invalid
  - Estimate β^h and β^{hh} per sector using iterative GMM procedure
  - De Loecker & Warzynski (2012) and De Loecker and Eeckhout (2017)

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Markup Estimation

Find sales of function of production factors including technology, to purge sales from unexpected demand shocks:

$$\ln\ y_{it} = \underbrace{\sum_{x=0}^{3}\sum_{y=0}^{3}\sum_{z=0}^{3}\gamma_{xyz}\ln\ k_{it}^{z}\ln\ l_{it}^{y}\ln\ m_{it}^{z} + \Psi_t}_{\phi_{it}} + \varepsilon_{it} \tag{1}$$

Causal production function's parameters follow from log TFP:

$$\ln\ a_{it} = \phi_{it} - \sum_{h\in\{k,l,m\}}\left(\beta^{h}\cdot\ln\ h_{it} + \beta^{hh}\cdot[\ln\ h_{it}]^{2}\right) \tag{2}$$

where log TFP follows AR(1) process:

$$\ln\ a_{it} = g(\ln\ a_{it-1}) + \xi_{it} \tag{3}$$

where ξ_{it} is estimated by an iterative GMM with moment condition:

$$\mathbb{E}\left(\xi_{it}\left[k_{it}\quad l_{it-1}\quad m_{it-1}\quad k_{it}^{2}\quad l_{it-1}^{2}\quad m_{it-1}^{2}\quad\right]'\right) = 0 \tag{4}$$

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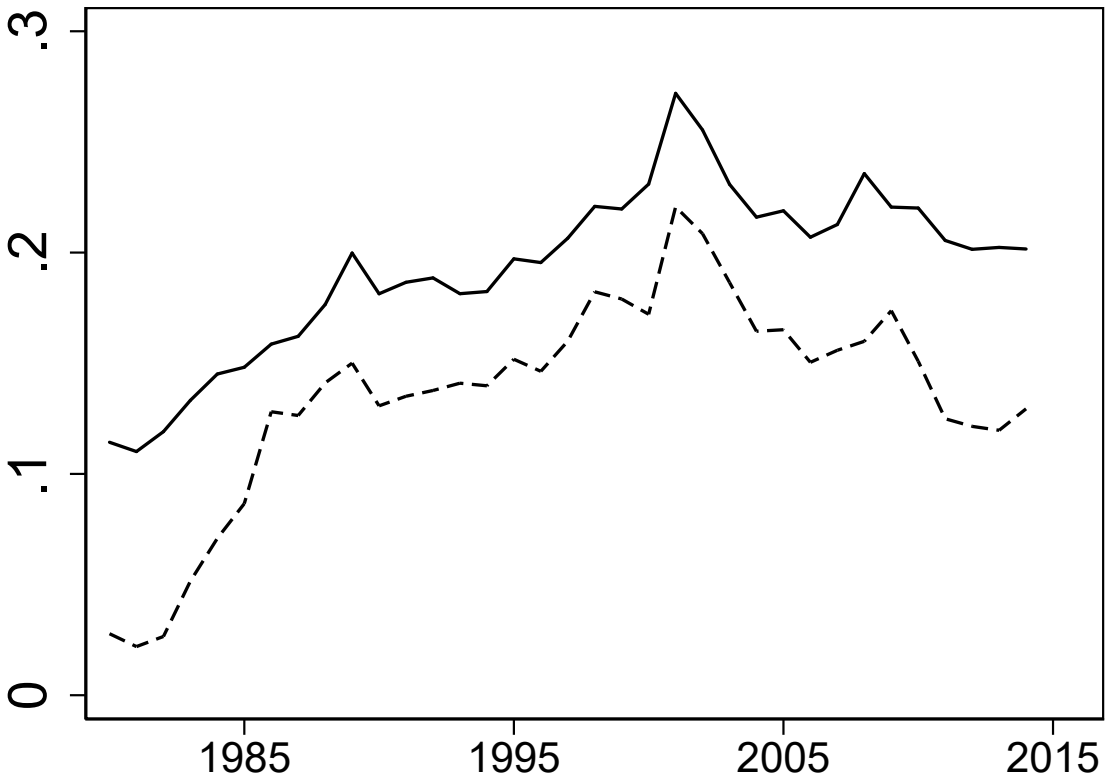
Fixed costs over time: US public firms



Fixed costs as a share of total cost (sales-weighted), derived from markups and profit rate. Solid line: average across 2-digit industries. Dashed line: average across Compustat firms.

Source: Own calculations based on Compustat data

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Literature

Rise of corporate profits:

- Labor and capital shares: Karabarbounis and Neiman (2013), Caballero et al. (2016), De Loecker and Eeckhout (2017), Eggertson et al. (2018), Gutierrez (2017), Kehrig and Vincent (2017)
- Concentration, Autor et al. (2017), Gutierrez and Philippon (2017, 2018)
- Misallocation: Peters (2016), Baqaee and Farhi (2017), Midrigran (2018)
- Intangibles: Crouzet and Eberly (2018), Criscuolo et al. (2018)

Fall of business dynamism:

- Decline in reallocation rates:
  - Davis et al (2006), Decker et al. (2014), Haltiwanger et al. (2014)
- Decline in entry rates:
  - Reedy and Strom (2012), Karahan et al. (2015), Decker et al. (2014), Pugsley and Sahin (2015), Alon et al. (2018)

Back

Fixed costs and communication technology

$$Communication_{it}^{x} = \beta^{x} \cdot \frac{F_{it}}{TC_{it}} + \gamma^{x\prime} X_{it} + \varepsilon_{it}^{x}$$

Technology:	Videoconferencing	Internal soc. med.	Remote access
Fixed Cost Share	0.144***	0.118***	0.020
	(0.012)	(0.016)	(0.040)
Year F.E.	✓	✓	✓
Industry F.E.	✓	✓	✓
Size Poly.	✓	✓	✓
N	45,572	8,990	60,327
R^2	0.243	0.056	0.262

Data: FARE-FICUS merged with TIC 2006-2016, observations weighted with TIC sample weights. Firm-clustered standard errors in brackets. All dep. variables are binary.

Back

Fixed costs and online sales and marketing

$$Adoption_{it}^{x} = \beta^{x} \cdot \frac{F_{it}}{TC_{it}} + \gamma^{x\prime} X_{it} + \varepsilon_{it}^{x}$$

	Social Media (binary)				
Technology:	Image	Reviews	Client contact	Website	Websales (%)
Fixed Cost Share	0.014	-0.018	-0.026	0.020	-0.002
	(0.033)	(0.042)	(0.041)	(0.016)	(0.005)
Year F.E.	✓	✓	✓	✓	✓
Industry F.E.	✓	✓	✓	✓	✓
Size Poly.	✓	✓	✓	✓	✓
N	8,990	8,990	8,990	76,377	76,377
R^2	0.040	0.138	0.059	0.136	0.138

Data: FARE-FICUS merged with TIC 2006-2016, observations weighted with TIC sample weights. Firm-clustered standard errors in brackets. Back

Literature

Market power and intangibles:

- Brynjolfsson et al. (2008), Bessen (2017) at US industry level:
  - IT-intensive industries have greatest level + increase concentration
  - IT-intensity (IV'ed) explains most of increase in concentration (Bessen)
  - also have largest increase profit margin, productivity (Bessen)
- Firm level:
  - Bijnens and Konings (2018): Belgium census data ⇒ larger decline in business dynamism in high ICT intensity industries (also within manufacturing, services).
  - OECD (2017), Calligaris et al. (2018): increase in markups larger in industries with high digital intensity
  - Crouzet and Eberly (2018), Bessen and Righi (2019): Firm-level relationship between intangibles, markups, productivity

Back

Aghion et al. 'A Theory of Rising Rents and Falling Growth'

Explains productivity slowdown through lack of R&D

- Summary:
  - Productive firms stop growing because of span of control
  - IT increases span of control
  - Lowers expected markup $\Rightarrow$ productive firms more likely to compete with productive firms $\Rightarrow$ less R&D

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- Main differences:
  - Have a 50% drop in R&D intensity
    - ★ This paper: R&D intensity increases (quantitatively matching the data)
  - No entry and exit
    - ★ This paper: Decline in entry (quantitatively matching the data)

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Recent related papers

Rise of concentration and fall in entry:

- Demographics: Hopenhayn, Neira and Singhania (2018)
- Scalable IT: Lashkari and Bauer (2018), Bessen and Righi (2019), Korinek and Ng (2019)
  $\Rightarrow$ Contribution: also explain productivity growth, markups

Two-firm models of growth, dynamism, concentration:

- Low interest rates: Liu, Mian and Sufi (2019)
  - Low interest rates increase firm patience
  - Leader and follower have greater incentive to invest, but incentive increases more for leader (because they are more likely to win)
  - Strategic interaction: follower invests less, so both end up investing less
- Knowledge diffusion: Akcigit and Ates (2019)
  - Decline in knowledge transfusion form leader to follower firms, potentially driven by change in patenting behavior

Back

What is ϕ?

Extensive literature shows heterogeneous effect of IT on productivity

- Brynjolfsson and Hitt (2000), Bresnahan et al. (2002), Crespi et al. (2007), Bartel et al (2007), Garicano and Heaton (2010)

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Recent evidence: efficient management practices are a key determinant:

- Bloom et al. (2012): *Americans do IT better*
  - European establishments have smaller productivity boost from IT expense
  - IT productivity increases when establishment becomes US-owned (!)

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- Schivardi and Schmitz (2019): *IT (..) and Southern Europe's Lost Decades*
  - Productivity effect of IT is entirely conditional on WMS management score - Existing differences across firms start to 'matter'

Back

Intangibles as productivity-enhancements

Example 1: Enterprise Resource Planning (ERP)

- Automate business processes like supply chain, inventory management
- Receive an order: software orders components, allocates production time, invoices customer
- Lower marginal costs, higher fixed costs

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Example 2: Software behind Tesla's autopilot

- Costly initial development, independent of sales
- Software can be installed in all cars that are sold
- Software a greater share of valued added? Variable costs relatively low

Back

Equilibrium

Definition:

- w, Y, π grow at constant rate g
- r, e, L^p, $s(\phi_i, \lambda_{ij})$, $x(n_i, \phi_i)$ $\mu(\phi_i, \lambda_{ij})$, $\tau(\phi_i)$, $M(\phi_i)$, and $K(\phi_i)$ are constant
- Firms obey static first order condition for pricing and intangibles, dynamic first order condition for innovation and entry, consumption grows along the Euler equation.
- The labor and goods markets clear:

$$1 = L^p + L^{rd} + L^s$$

$$Y = C$$

Back

Dynamic optimization

Incumbents choose rate of innovation x_i to maximize firm value:

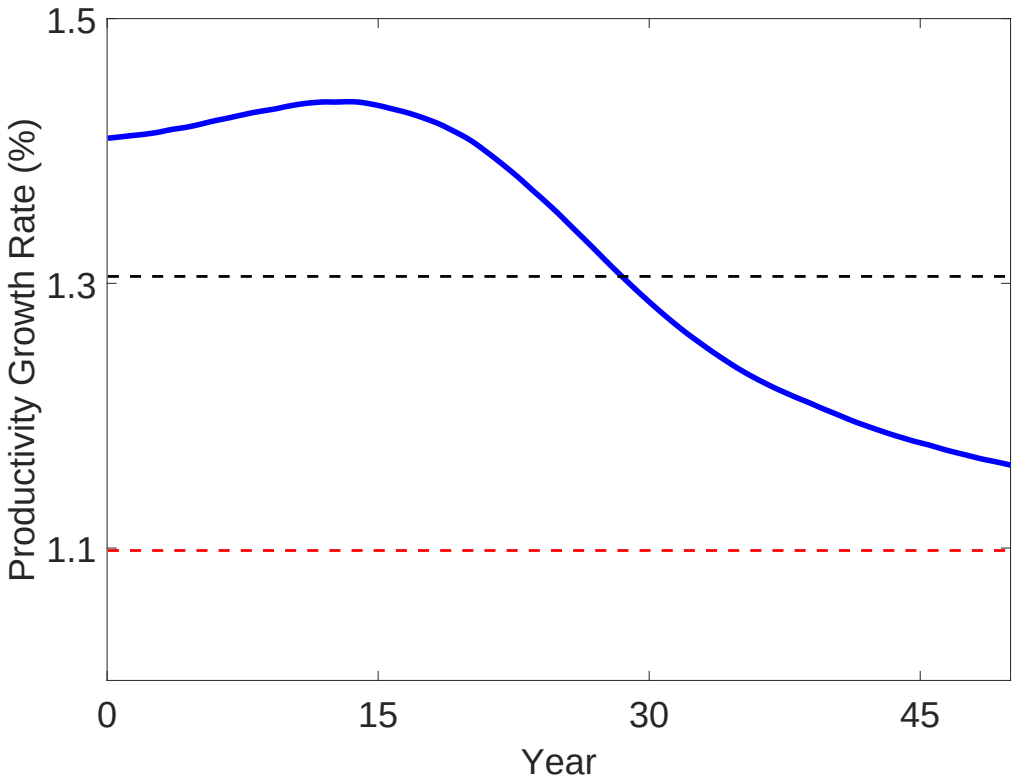
$$rV_t(\phi_i, \tilde{J}_i) - \dot{V}_t(\phi_i, \tilde{J}_i) =$$

$$\left\{ \begin{array}{c} \underbrace{\sum_{j \in \tilde{J}_i} \pi_t(\phi_i, \lambda_{ij})}_{\textbf{profits per product}} \\ \underbrace{+ \sum_{j \in \tilde{J}_i} \tau(\phi_i) \left[V_t(\phi_i, \tilde{J}_i \setminus \{\lambda_{ij}\}) - V_t(\phi_i, \tilde{J}_i) \right]}_{\textbf{loss from creative destruction}} \\ \underbrace{+ \max_{x_i \geq 0} \left\{ x_i \cdot \Pr\left(\lambda_{ij} \geq \frac{p^{choke}(\phi_i)}{p^{choke}(\phi_{-i})} - 1 \right) \cdot \mathbb{E}\left[V(\phi_i, \tilde{J}_i \cup_+ \lambda_{ij}) - V_t(\phi_i, \tilde{J}_i) \right] - w\eta_x(x_i)^{\psi_x} n^{-\sigma} \right\} - F_x(\phi_i, n_i)}_{\textbf{external innovation benefits and costs, and fixed shop costs}} \end{array} \right\}$$

- Following Akcigit and Kerr (2018), assume a value function linear in n by equating F_x to external R&D option value.

Back

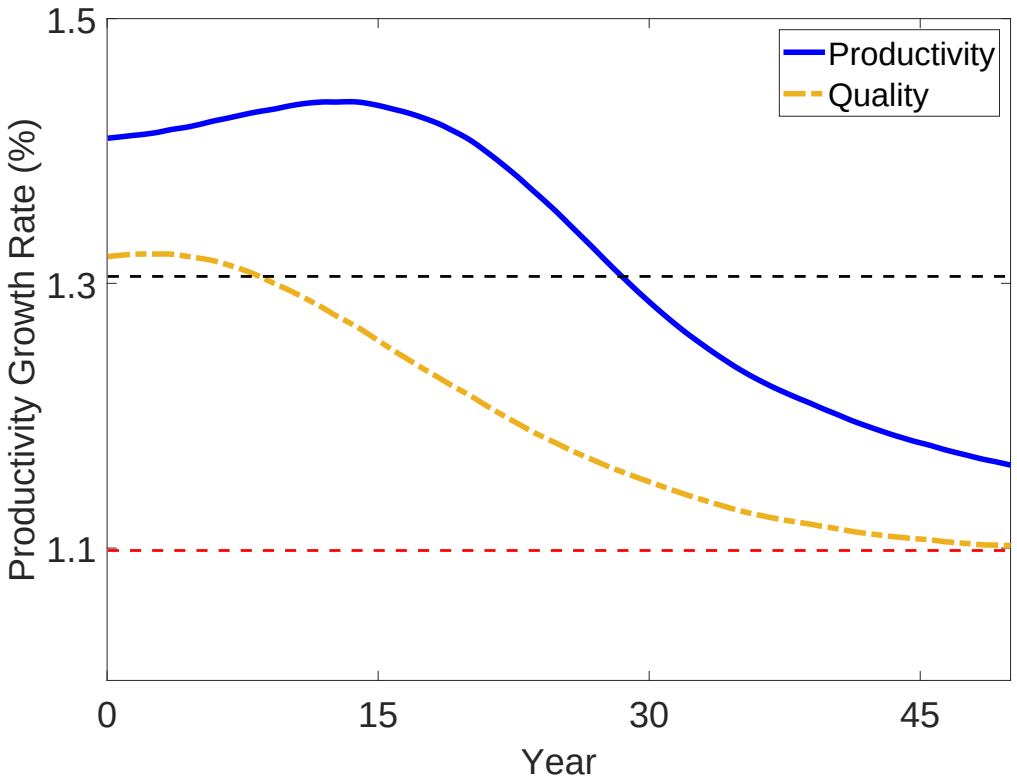
Transition: productivity growth



Black-dashed: original steady state. Red-dashed: new steady state.

U.S. calibration

Transition: productivity growth



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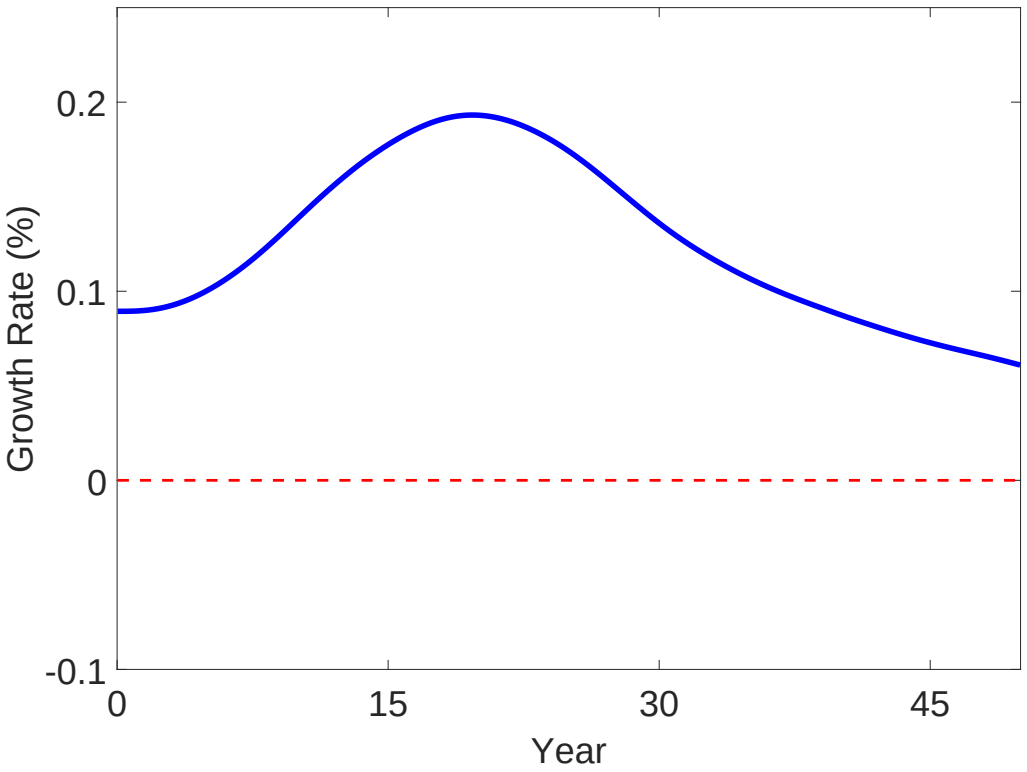
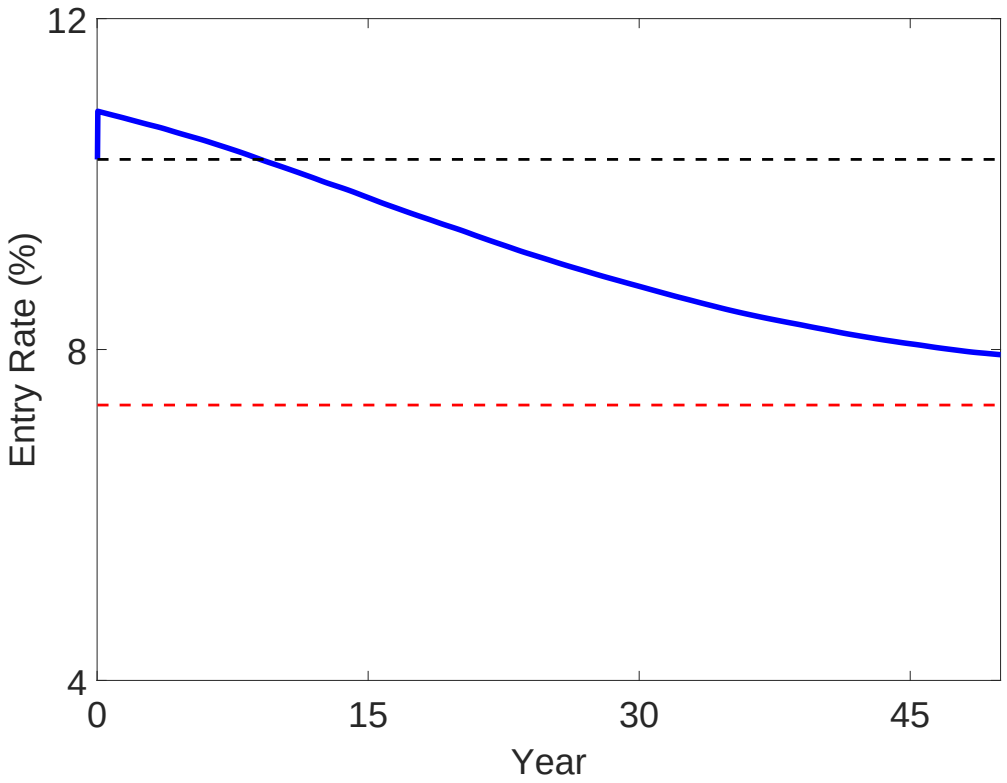


Contribution of intangible adoption to growth. Red-dashed: steady state.

U.S. calibration

Transition



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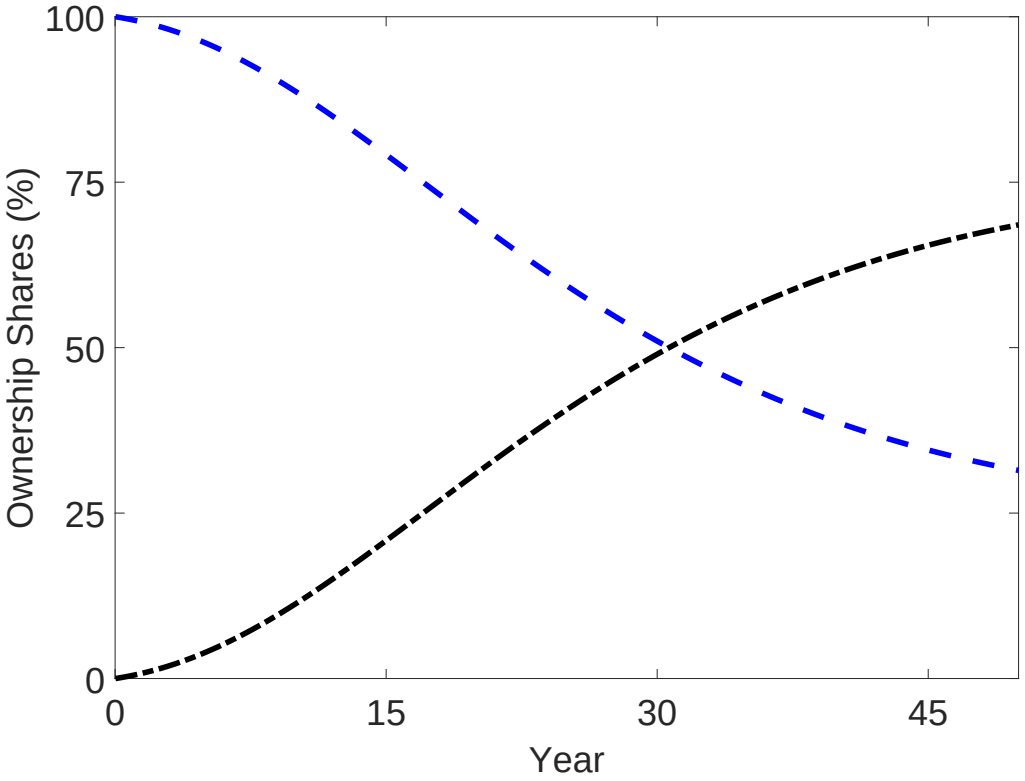
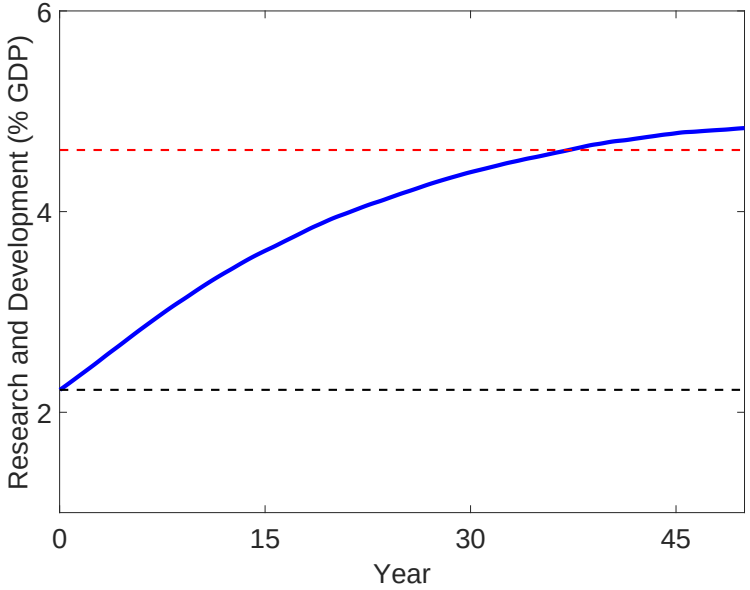


Black dash-dotted line: fraction produced by high-intangible firms.

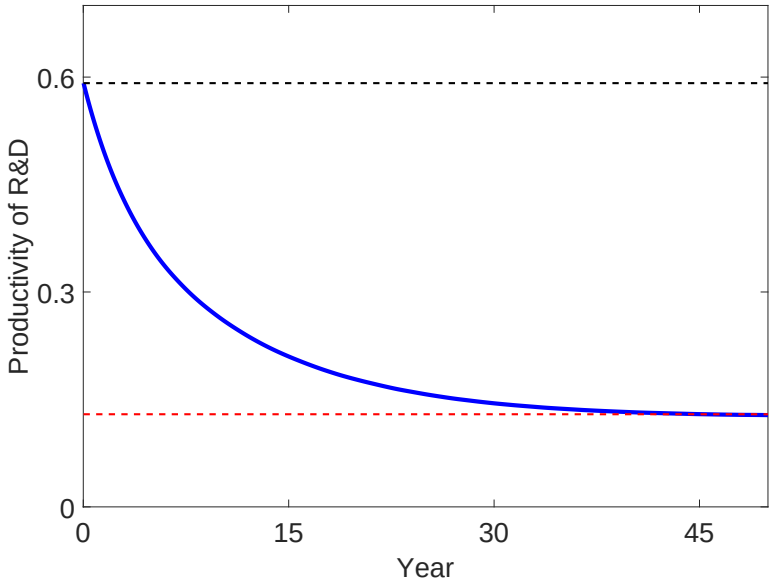
Blue-dashed line: fraction produced by other firms.

U.S. calibration

Transition



(a) Research Intensity

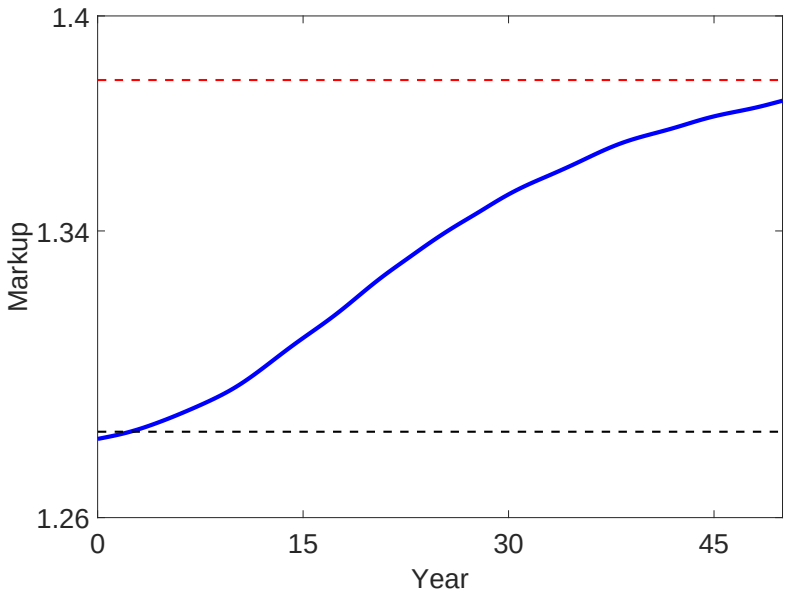


(b) Research Productivity

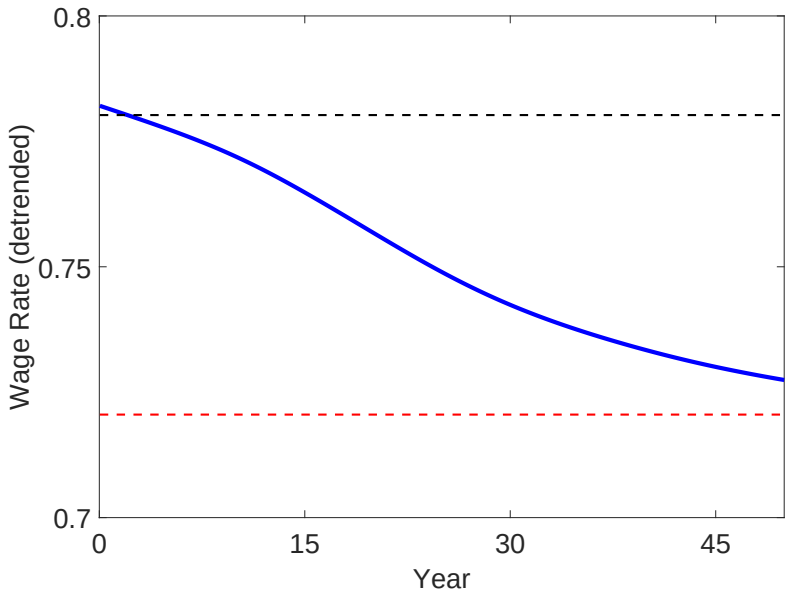
Black-dashed: original steady state. Red-dashed: new steady state.

▸ U.S. calibration

Transition



(a) Avg. Markup



(b) Wage Rate

Black-dashed: original steady state. Red-dashed: new steady state.

▸ U.S. calibration

Growth and innovation

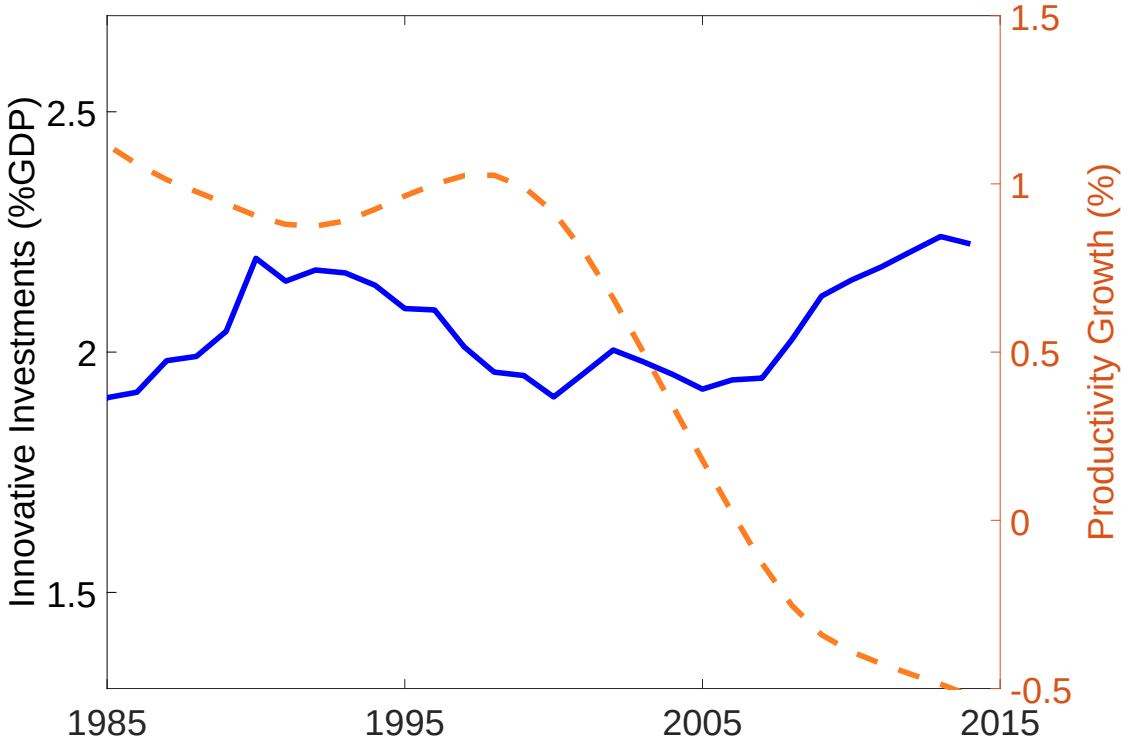
Sales growth				
Fixed Cost Share	0.129***	0.396***	0.445***	0.105***
	(0.001)	(0.001)	(0.005)	(0.005)
N	7,895,588	7,895,588	7,895,588	7,895,588
R^2	0.115	0.221	0.250	0.110
R&D Intensity				
Fixed Cost Share	0.014***	0.013***	0.022***	0.012**
	(0.001)	(0.001)	(0.005)	(0.005)
N	85,566	85,566	85,566	85,566
R^2	0.084	0.093	0.002	0.011
Year F.E.		✓	✓	✓
Industry F.E.	✓	✓		
Firm F.E.			✓	✓
Size Poly.	✓	✓	✓	✓

Data: FARE-FICUS income statement data, CIS innovation data.
Firm-clustered standard errors in brackets.

Back

Ideas are getting harder to find

- Low growth but high innovative investments: hard to rationalize

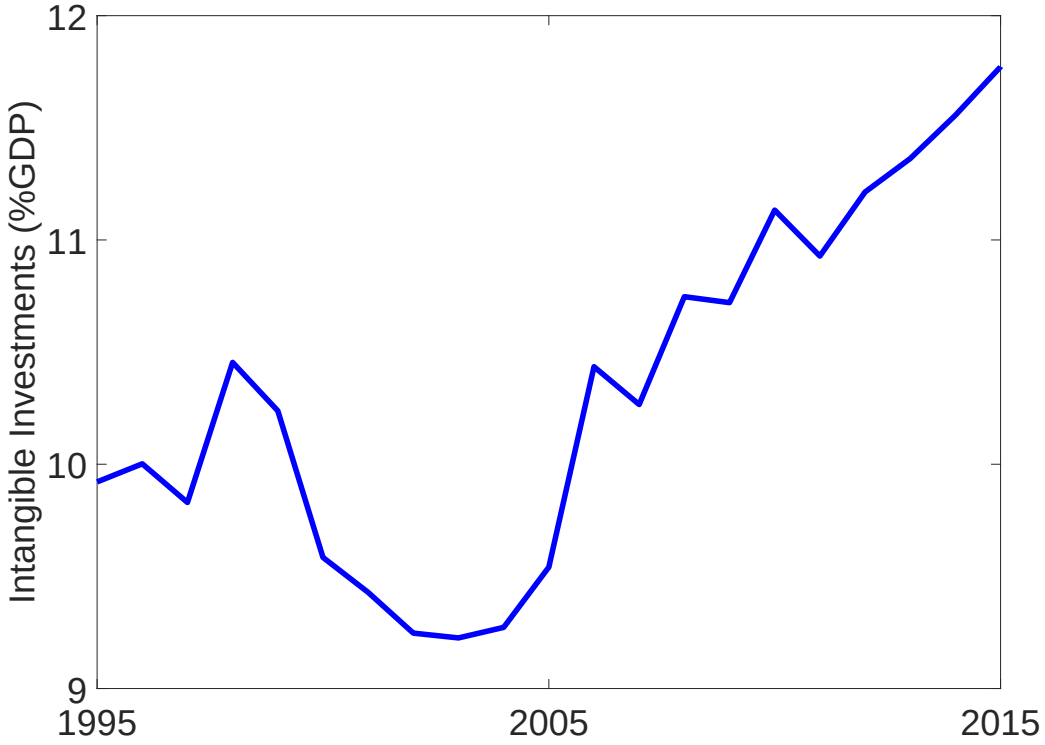


French. Investments in Intellectual Property excluding Software

Source: BEA Fixed Private Investments, Fernald (FRBSF) Back

Intangible inputs

- Intangible investments now exceed capital investments



French. Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016) Back

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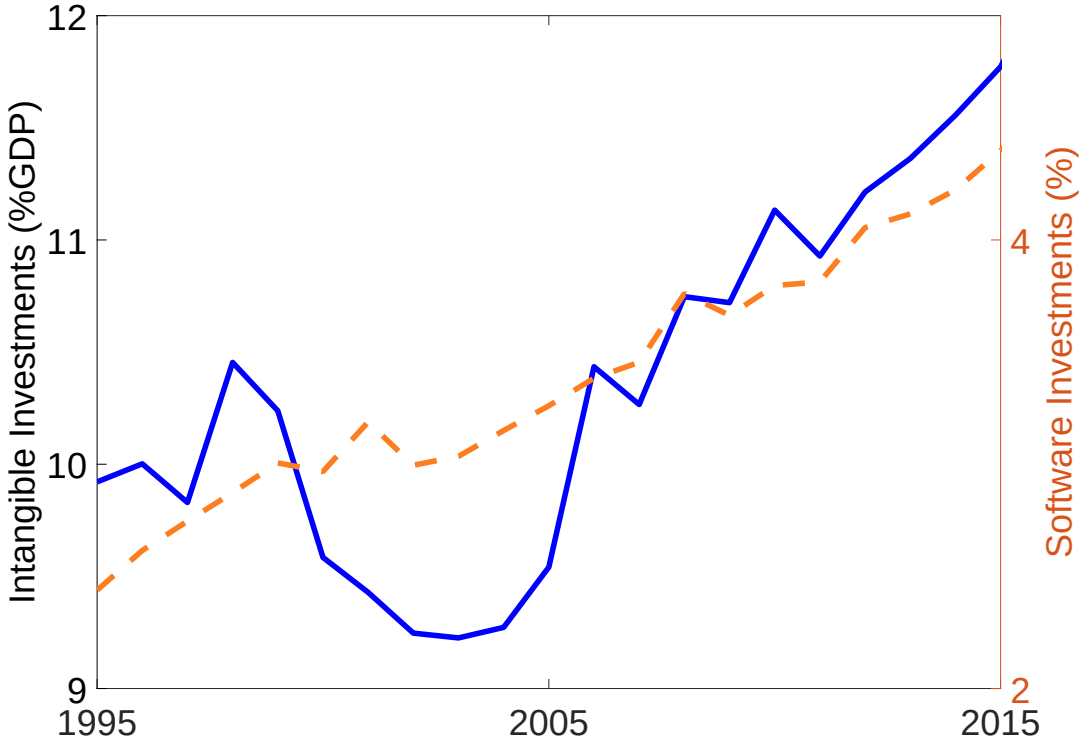

French Investments in Software and Economic Competencies

Source: Intan-Invest, Corrado et al. (2016) Back

Aggregate variables

Equilibrium wage w:

$$w = \underbrace{\exp\left(\int_0^1 \ln\left[\frac{q_{ij}}{1-s_{ij}}\right] dj\right)}_{\text{CES Productivity}} \cdot \underbrace{\exp\left(\int_0^1 \ln\left[\frac{1-s_{ij}}{1+\lambda_{ij}}\right] dj\right)}_{\text{Avg. Inverse Markup}}$$

Gross domestic product Y:

$$Y = \underbrace{L^p}_{\text{production labor}} \cdot \underbrace{\exp\left(\int_0^1 \ln\left[\frac{q_{ij}}{1-s_{ij}}\right] dj\right)}_{\text{CES productivity}} \cdot \underbrace{\frac{\exp \int_0^1 \ln \mu_{ij}^{-1} dj}{\int_0^1 \mu_{ij}^{-1} dj}}_{\text{efficiency wedge}}$$

Back

Static optimization

Setting: innovator i and incumbent $-i$ play two-stage simul. move game

Stage 1: firms choose marginal cost reduction s_{ij} and pay fixed costs

Stage 2: firms choose optimal price p^*_{ij}

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Solve for optimal static decisions through backward induction:

$$p^*_{ij} = \begin{cases} mc_{-ij} \cdot (1 + \lambda_{ij}) & \text{if } mc_{-ij} \cdot (1 + \lambda_{ij}) > mc_{ij} \\ mc_{ij} & \text{otherwise (no sales)} \end{cases}$$

$$p^*_{-ij} = \begin{cases} mc_{ij} \cdot (1 + \lambda_{ij})^{-1} & \text{if } mc_{-ij} \cdot (1 + \lambda_{ij}) < mc_{ij} \\ mc_{-ij} & \text{otherwise (no sales)} \end{cases}$$

Back

Static optimization

Best response by incumbent given optimal pricing is is:

$$1 - s_{ij}^* = \begin{cases} \left[(1+\lambda_{ij}) \cdot (1 - s_{-ij}^*) \cdot \psi \cdot \frac{w}{Y} \cdot (1-\phi_i)\right]^{\frac{1}{\psi+1}} & \text{if } (1 - s_{-ij}) \cdot (1+\lambda_{ij}) > 1 - s_{ij} \\ & \text{and } \pi(\phi_i, s_{ij}^*, s_{-ij}^*) \geq 0 \\ 0 & \text{otherwise (no sales)} \end{cases}$$

$$1 - s_{-ij}^* = \begin{cases} \left[(1+\lambda_{ij})^{-1} \cdot (1 - s_{ij}^*) \cdot \psi \cdot \frac{w}{Y} \cdot (1-\phi_i)\right]^{\frac{1}{\psi+1}} & \text{if } (1 - s_{-ij}) \cdot (1+\lambda_{ij}) < 1 - s_{ij} \\ & \text{and } \pi(\phi_{-i}, s_{-ij}^*, s_{ij}^*) \geq 0 \\ 0 & \text{otherwise (no sales)} \end{cases}$$

Nash equilibrium:

- Firm that charges marginal cost in stage 2 must have $s = 0$
- Firm with lowest quality-adjusted choke price always has $s > 0$ best response