Intangible capital, firm scope, and growth

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This paper: Model emphasizing 2, with an application to long-run growth

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Property rights determine degree of exclusivity — e.g. patents vs. trade secrets

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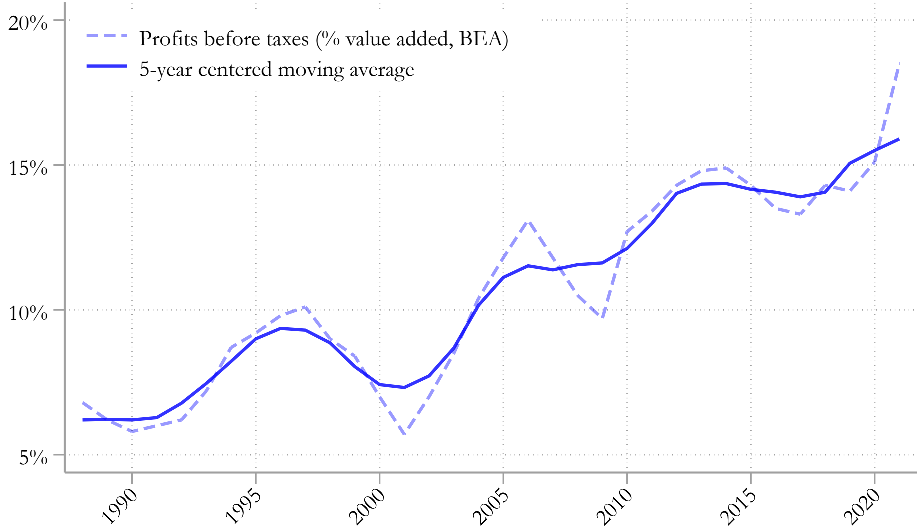
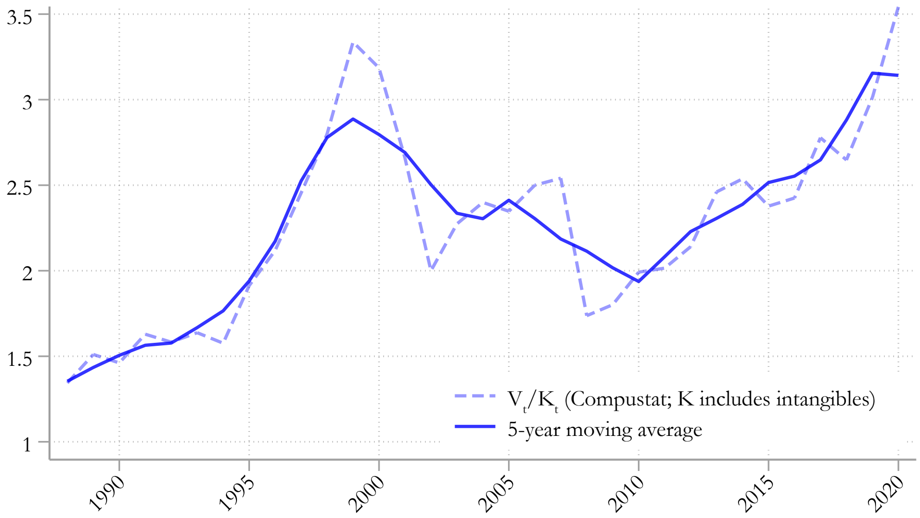
Why is this (hopefully) interesting?

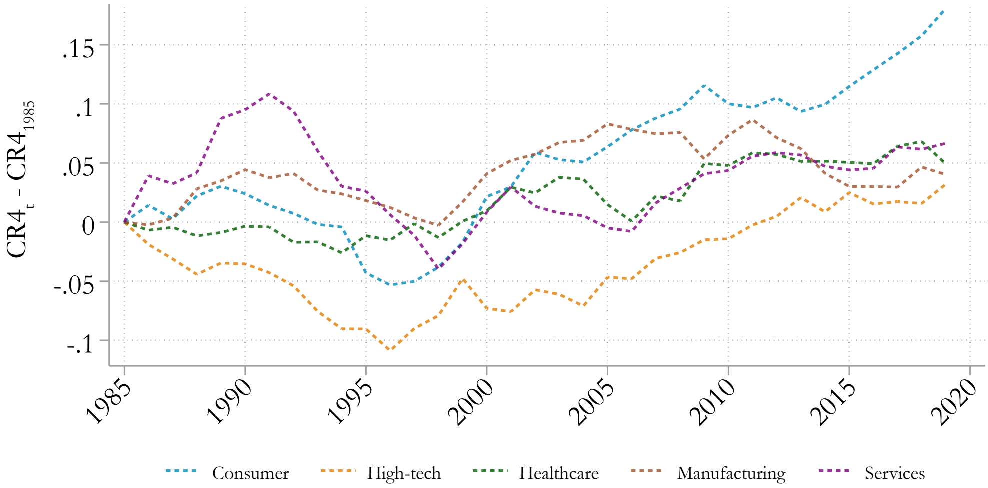
Corporate profits as a share of GDP have increased



Market valuations have increased

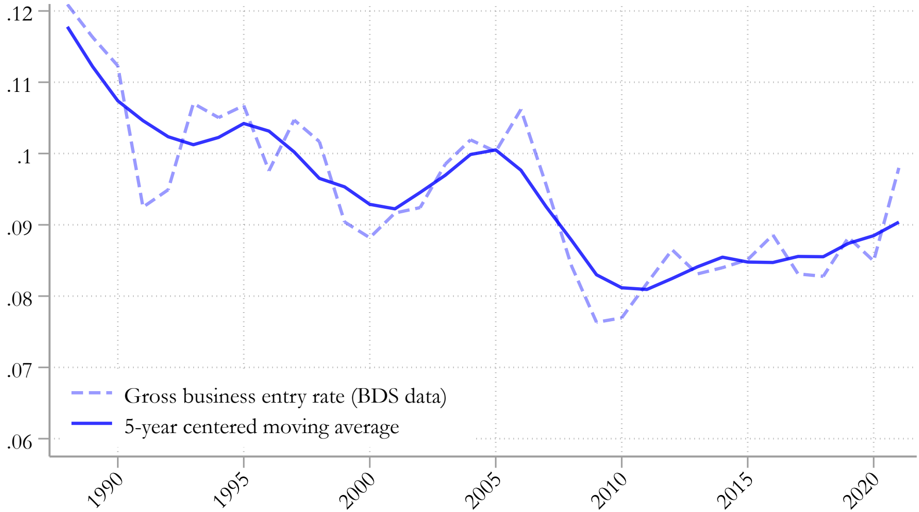


Concentration has increased



Compustat; NAICS-3D sectors weighted by sales.

Entry rates have fallen



Roadmap

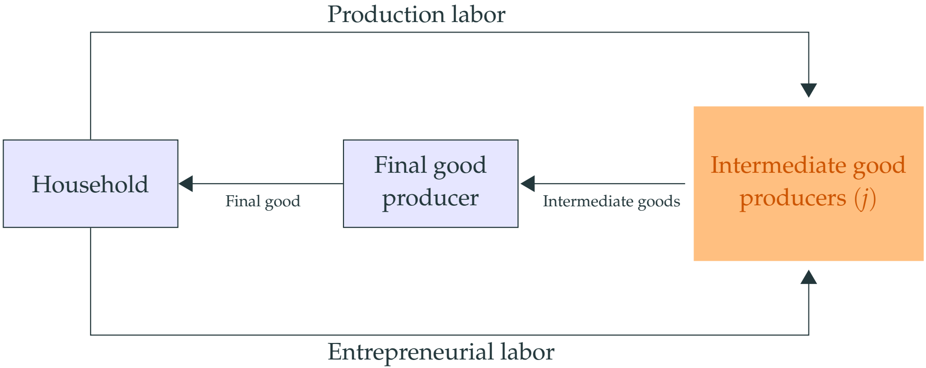
1. Model

2. Comparative statics

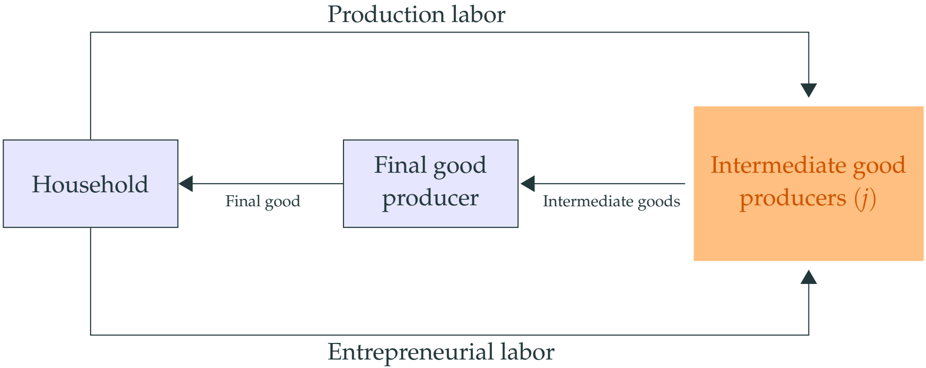
3. Data and transitional dynamics

1. Model

Structure


Production labor
Household
Final good
Final good producer
Intermediate goods
Intermediate good producers (j)
Entrepreneurial labor

Structure



Firm j produces measure x_j of intermediate varieties, indexed by m

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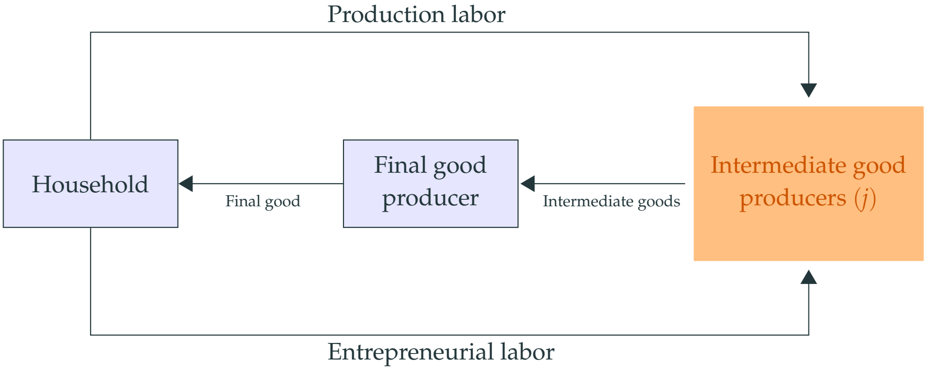

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$x_j \equiv$ **scope** of firm j

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Log utility

$$r_t = \frac{dC_t}{C_t} + \eta$$

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e.g. a patent for a touchscreen

using it for one product not reduce its availability for other products

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if $\rho > 0$, increasing returns to (x,n)

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What limits the scope of implementation?

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$$\overbrace{v_t^{(e)}(x,n)}^{\text{Entrepreneur surplus from entry}} = (1-\gamma_t(x,\lambda)) \times \overbrace{v_t(x,n)}^{\text{Enterprise value}}, \qquad \partial_x\gamma_t > 0, \quad \partial_{xx}\gamma_t \geq 0$$

Optimal scope $$x_t = \arg\max_x \overbrace{(1-\gamma_t(x,\lambda))}^{(-)\text{ exclusivity}} \underbrace{x^{1-\omega+\rho\omega}}_{(+)\text{ non-rivalry}}$$

The creation of new intangibles

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1 unit of entrepreneurial labor

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1 unit of entrepreneurial labor $\rightarrow$ intangible stock $n_t^{(e)}$

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For now, spillovers from incumbents $\rightarrow$ future entrants do not depend on ρ

Labor markets and equilibrium

Free-entry

$$L_{E,t} \geq 0 \quad \text{and} \quad v_t^{(e)} = W_t,$$

or

$$L_{E,t} = 0 \quad \text{and} \quad v_t^{(e)} \leq W_t.$$

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Balanced growth path

For any $\rho \in [0,1]$, if $\xi > 0$, there exists a unique equilibrium where $(x_t, L_{E,t})$ are constant and Y_t grows at rate $g > 0$.

2. Comparative statics

The effects of replicability

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$$\frac{dN_t^{(e)}}{N_t^{(e)}} = \xi L_E dt$$

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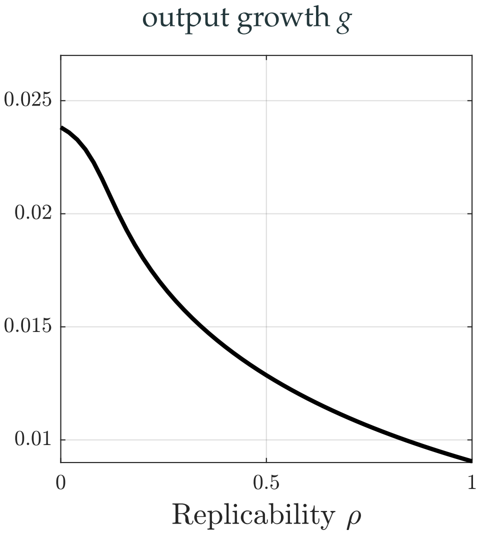

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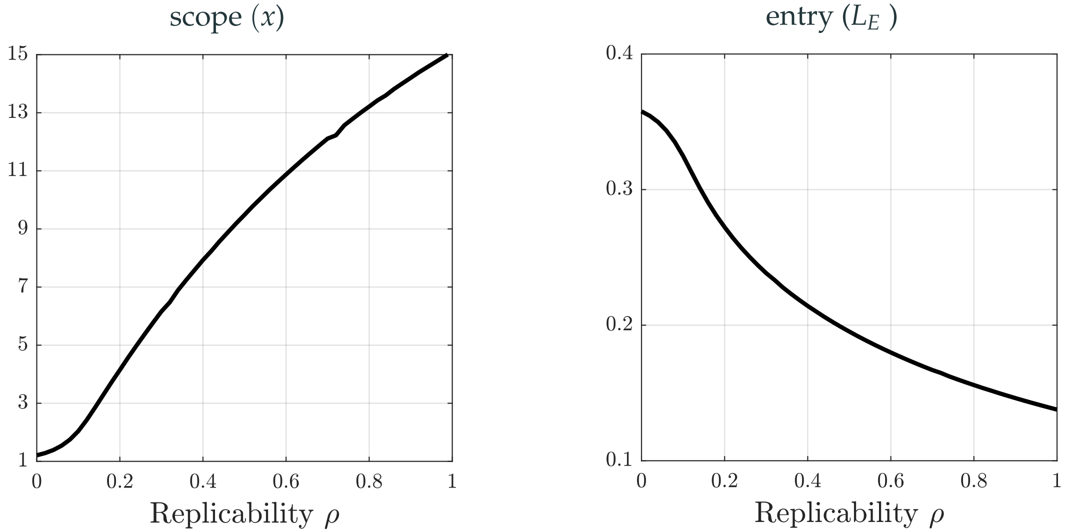

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higher wages + outsider rents discourage entrepreneurship

adding spillovers from incumbents $\rightarrow$ future entrants may help offset this

Adding Spillovers

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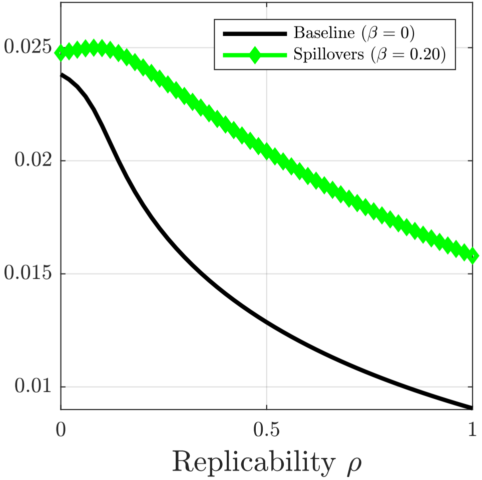
output growth g



Valuations and profits

Quantity, price, and user cost of capital

$$K_{N,t} = \int_0^{J_t} n_{j,t} dj \quad , \quad p_{K_N,t} = \frac{W_t}{n_t^{(e)}} \quad , \quad R_{N,t} dt = (r_t + \delta) dt - \frac{dp_{K_N,t}}{p_{K_N,t}}$$

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$$V_t = \underbrace{V_t^{(e)}}_{\text{entrepreneurs}} + \underbrace{\gamma V_t}_{\text{outsiders}}$$

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Aggregate Tobin's Q

$$Q_t = \frac{V_t}{p_{N,t} K_{N,t}} = \underbrace{\frac{1}{1-\gamma}}_{\text{non-exclusivity}} \overbrace{\frac{R_N - \eta}{\omega(R_N - \eta) + (1-\omega)\delta}}^{\text{market power}} > 1$$

Valuations and profits

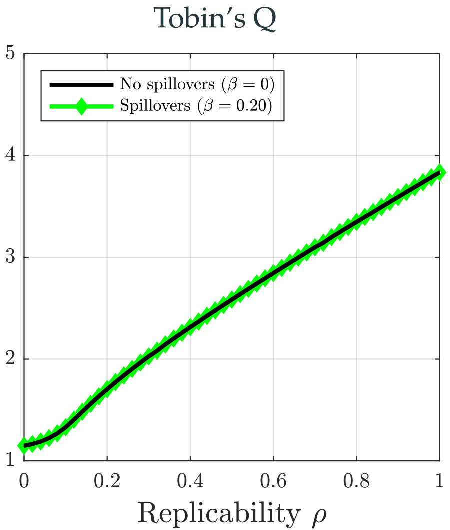
Distribution of capital income

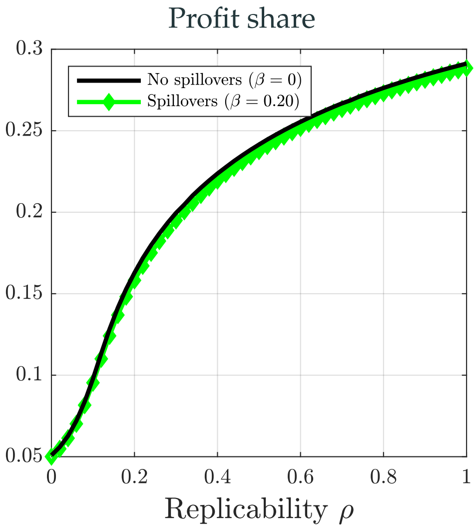
$$(1-\zeta\chi)Y_t \qquad \text{(Capital income)}$$

$$= \quad R_N\left(p_{N,t}K_{N,t}\right) \qquad \text{(Competitive capital cost)}$$

$$+ \quad (1-\zeta\chi)Y_t\left(\underbrace{\gamma}_{\text{outsiders}} + \overbrace{(1-\gamma)(1-\omega)\frac{R_N-(\eta+\delta)}{R_N-\delta}}^{\text{entrepreneurs}}\right) \qquad \text{(Profits)}$$

Valuations and profits





Concentration and measured productivity

Concentration (HHI)

$$H_t = \int_{j=0}^{J_t} \left(x_{\tau(j)}^{1-(1-\rho_{\tau(j)})\omega} \left(\frac{n_{\tau(j)}}{N_t} \right)^{\omega} \right)^2 dj$$

Measured Productivity (Solow Residual)

$$z = \overbrace{x^{(1-\zeta)\rho}}^{\text{Effect of replicability}} \underbrace{\left(x^{\frac{1-\omega}{\omega}} \frac{\xi x^{\beta} + \frac{\delta}{L_E}}{\left(\omega \xi x^{\beta} + \frac{\delta}{L_E} \right)^{\frac{1}{\omega}}} \right)^{1-\zeta}}_{\text{Effect of markups}}$$

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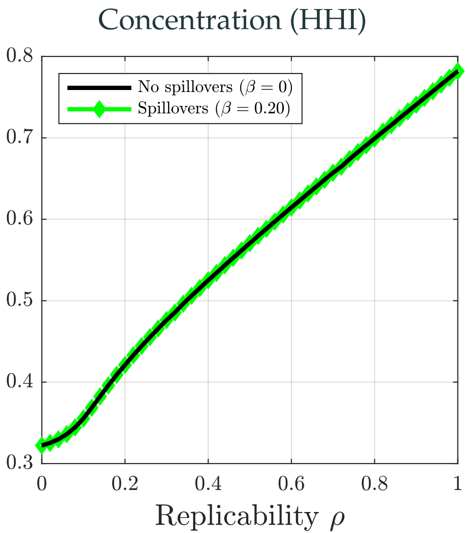

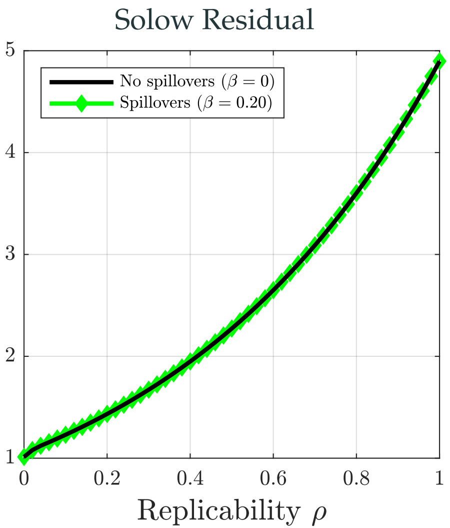

Data and transitional dynamics

Calibrated parameters (1988-1992)

Parameter	Description	Value	Source
η	Time discount rate	0.02	Annual calibration
ζ	Cobb-Douglas labor elasticity	0.70	Crouzet and Eberly (2023)
$1/\chi$	Markup	1.05	Crouzet and Eberly (2023)
δ	Obsolescence rate	0.11	Gross exit rate (BDS)
β	Spillovers	0	TBD
ρ	Non-rivalry		

Data on firm scope

Hoberg and Phillips (2024)

- US publicly traded firms, 1988-2021
  - *How many* product markets a firm operates in
  - Obtained from textual analysis of 10*K* statements, Part I, item 1 (business description)
- Advantages
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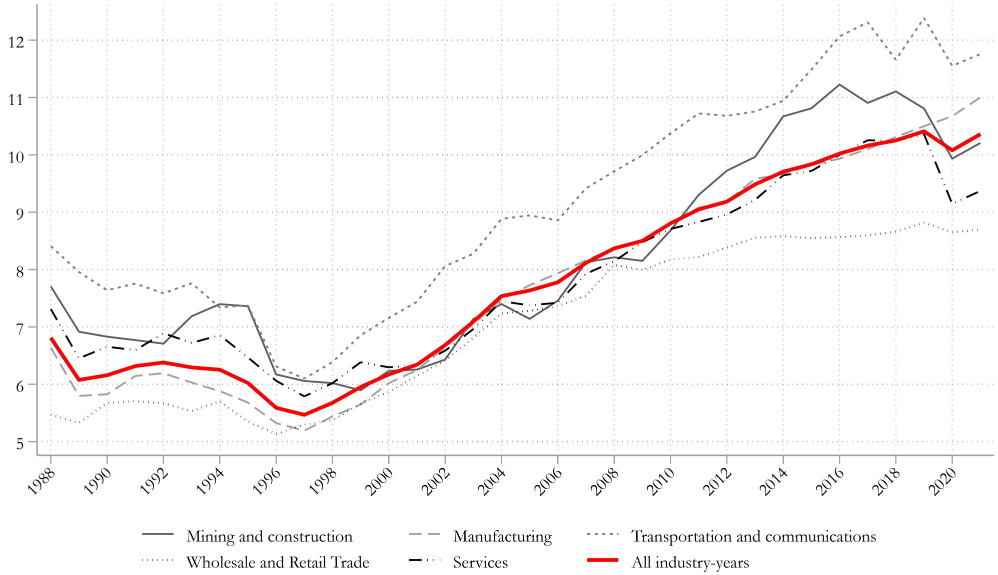
Firm scope over time



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Empirical target for scope: $x = 6.3$ (average, 1988-1992)

The covariance between scope and sales

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[Compustat sample and measure of n]

Model $\quad \text{Sales}_{j,t} \quad \propto \quad x_{j,t}^{1-\omega+\rho\omega} \, n_{j,t}^{\omega}$

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[Compustat sample and measure of n]

	1988-1992	1988-2021
	(1)	(1)
$\log(x_{j,t})$	0.30***	0.43***
	(6.8)	(10.3)
$\log(n_{j,t})$	0.66***	0.60***
	(21.9)	(24.9)
obs.	18700	140110
s.e. clustering	$t \times ind$	$t \times ind$
industry f.e.	✓	✓
year f.e.	✓	✓

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Calibrated value $\quad \rho = \frac{\beta_x - (1-\omega)}{\omega} = 0.18$

Data on ownership by founders and insiders

Firm sample: Firms with initial public offering (IPO), from Compustat/Execucomp

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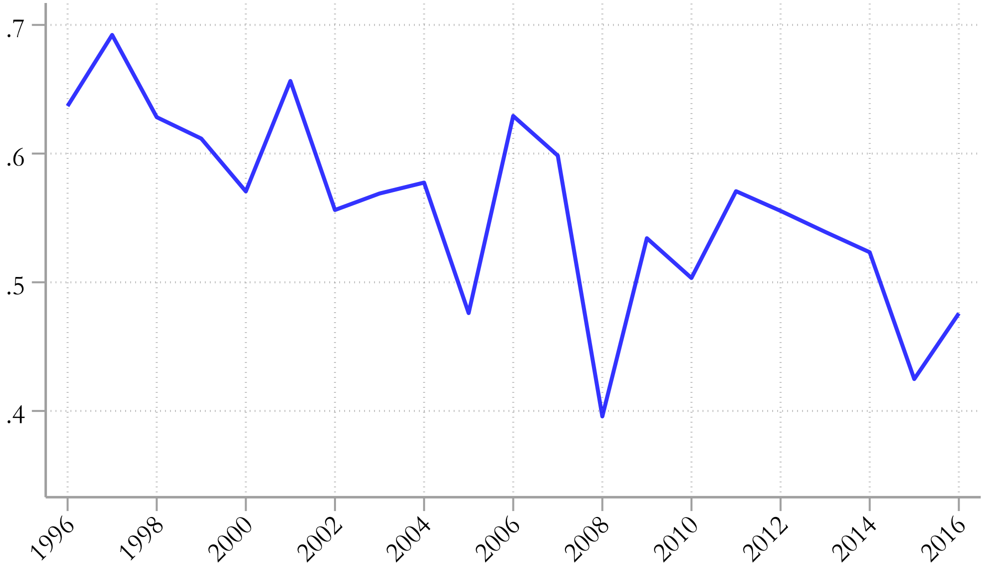
Ownership shares



Matched moments (1988-1992)

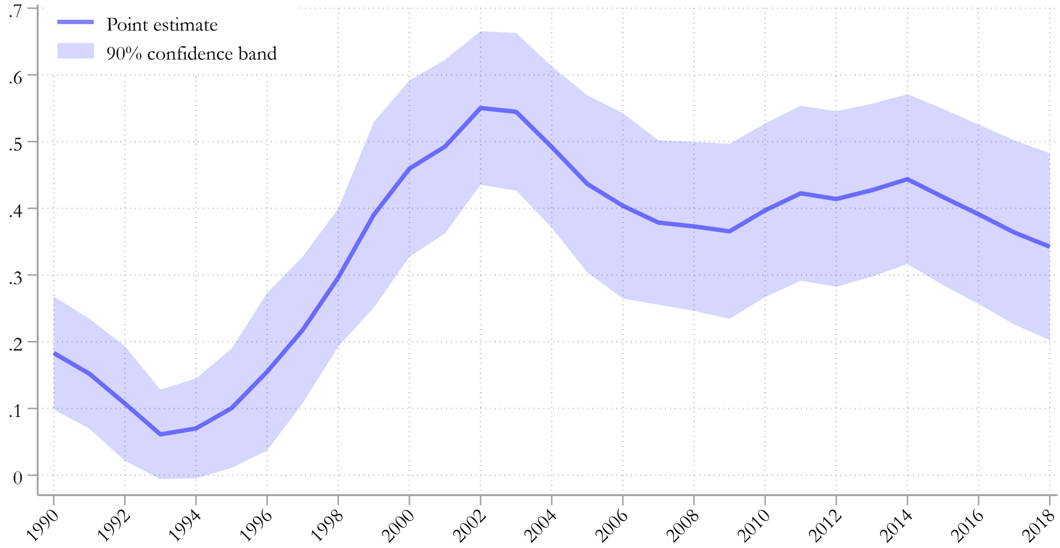
[Other data sources] [Other calibrations]

Par.	Description	Par. value	Targeted moment	Model counterpart	Data value	Model value
λ	Exclusivity	1.54	Outsider share	γ	0.36	0.34
α	Level of $\theta(x)$	2.64	Average scope	x	6.3	6.3
κ	Slope of $\theta(x)$	1.32	Tobin's Q	Q	1.5	1.6
ξ	Entr. productivity	0.39	Output growth	g	0.027	0.027

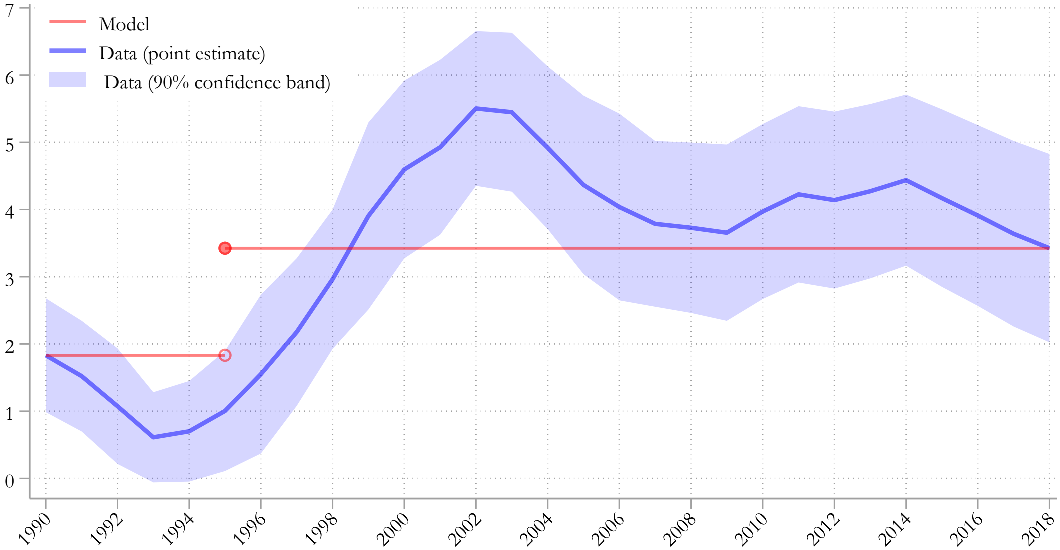
$$\text{In balanced growth,} \qquad \gamma(x;\lambda) \propto \frac{\bar{x}}{x}\theta(x)\mu(\lambda)$$

$$\text{\# outsiders needed to reach scope } x = \theta(x) = \max(\,0\,,\ \alpha(x-\bar{x})^{\kappa}\,)$$

Rolling window estimates of $\hat{\rho}$



The transition to a higher value of ρ

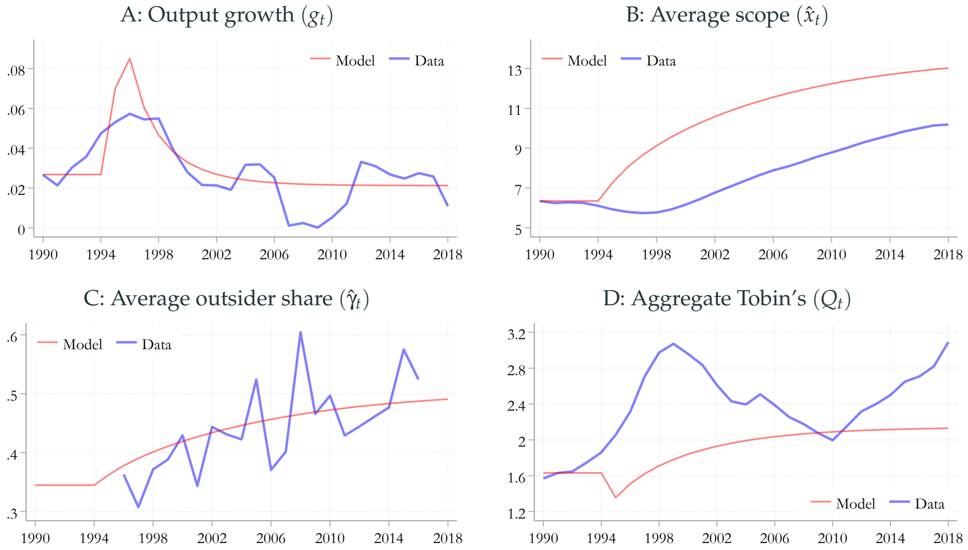


Balanced growth paths

[Other data sources] [Other calibrations]

	1988-1992 $\rho = \mathbf{0.18}$		2016-2020 $\rho = \mathbf{0.34}$	
Moment	Data	Model	Data	Model
Outsider share at IPO	0.36	0.34	0.52	0.51
Average scope	6.3	6.3	10.1	13.6
Tobin's Q	1.5	1.6	2.8	2.1
Output growth	0.027	0.027	0.011	0.021

Aggregate dynamics



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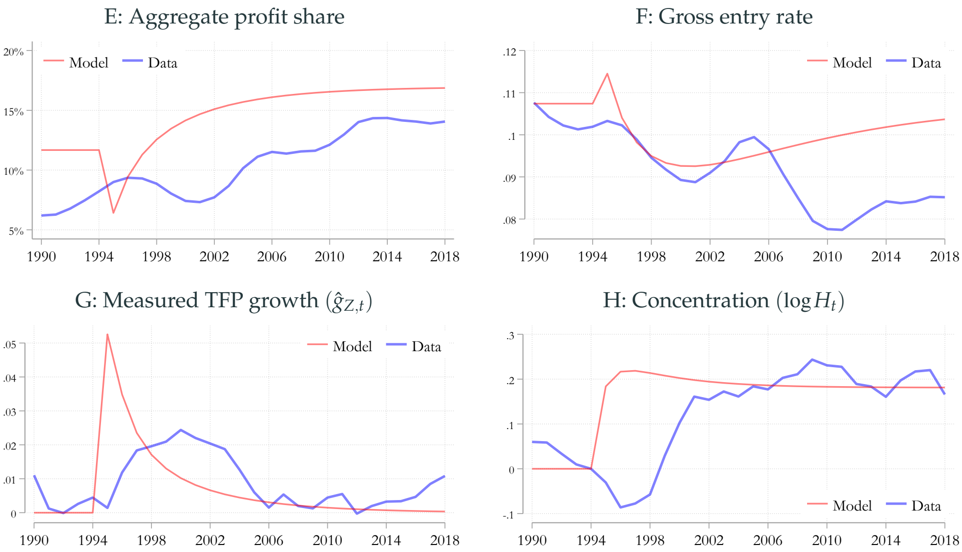

Conclusion

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Q : Intangibles are partly non-rival in use. How does that affect growth?

A : $\uparrow \rho \not\Rightarrow \uparrow g$

- Short run: $\uparrow g$
- Long-run: $\downarrow g$ and $\uparrow$ profits, valuations, concentration

Next :

- Implications for the measurement of capital
- Microfoundations

More

Non-exclusivity: microfoundations (1/3)

[Back]

For each m, entrepreneur "shares"/"stores" $n(m)$ with subset of employees ("outsiders")

$$\begin{aligned} \text{\# of outsiders per variety} &= \frac{\theta(x)}{x} \\ \text{Total \# of outsiders} &= \theta(x) \quad \equiv \quad \max\left(0\,,\ (x-\bar{x})^{\kappa}\right) \end{aligned}$$

With intensity λ, each outsider receives right to start their own firm

Intangible capital $n(m)$; scope $\bar{x} < x$; Cournot competition

$\lambda \leftrightarrow$ **non-exclusivity**

$\lambda = 0$: full exclusivity

$\lambda = +\infty$: no exclusivity

$\lambda \in (0, +\infty)$: patents, trademarks, non-compete clauses

Non-exclusivity: microfoundations (2/3)

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Result At entry, the expected value of the right to compete to each outsider is:

$$v_t^{(c)} = \bar{x}\left(\frac{\psi v_t^{(e)}}{x_t}\right)\mu_t(\lambda), \qquad \mu_t(\lambda) = \lambda \int_{s \geq t} e^{-\int_0^v (r_{t+u}+\lambda)du} \frac{A_{t+s}\nu_{t+s}}{A_t \nu_t} ds$$

where ν_t is the price-earnings ratio of the firm under monopoly, and ψ is a constant.

Intuition

$$\underbrace{\pi_t^{(c)}(m)}_{\text{Manager profits per variety}} = \underbrace{s^{(c)} \times \overbrace{\pi_t(m)}^{\text{Firm profits in monopoly}}}_{\text{Cournot profits}} \times \underbrace{(1-\varepsilon)}_{\text{Flow cost of competition}} \qquad [\psi = (1-\varepsilon)s^{(c)}] \qquad (0.1)$$

$\mu_t(\lambda)$: "competitive pressure" [$\mu_t(0) = 0$ — full exclusivity; $\mu_t(+\infty) = 1$ — no exclusivity]

Non-exclusivity: microfoundations (3/3)

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Entry deterrence To keep all employees from competing, entrepreneur must give them:

$$v_t^{(d)} = \int_0^{x_t} \frac{\theta(x_t)}{x_t} v_t^{(c)} dm = \theta(x_t)\, \bar{x} \left(\frac{\psi v_t^{(e)}}{x_t} \right) \mu_t(\lambda)$$

$$\implies \quad \gamma_t(x_t; \lambda) \quad = \quad \theta(x_t)\, \bar{x} \left(\frac{\psi}{x_t} \right) \mu_t(\lambda)$$

If ψ is sufficiently low ($\varepsilon \to 1, s^{(c)} \to 0$), deterrence is optimal to entrepreneur **ex-post**

$\leftrightarrow$ collusion is possible for each variety

Cournot competition: details

Equation (0.1) can be derived from solving the Cournot game between the incumbent firm and a potential competitor. The solution pins down uniquely $s^{(c)}$, the ratio of Cournot profits of the potential entrant to the monopoly profits of the incumbent.

The main result is that $s^{(c)}$ only depends on (ζ, χ), and the ratio ϕ of capital of the incumbent to the potential competitor.

The ratio of capital of the incumbent to the potential competitor is fixed. So, $s^{(c)}$ can be treated as a parameter.

Finally, let $s^{(inc,c)}$ denote the flow profits of the incumbent firm under Cournot competition, relative to their profits in monopoly. There can be cases where:

$$s^{(c)} + s^{(inc,c)} \geq 1,$$

i.e. Cournot competition generates more *total* profits than monopoly — even though it *always* generates less profits for the incumbent. In these cases deterrence might not be time-consistent for the incumbent.

In these cases, if the flow cost ε is large enough, it will remain profitable for the incumbent to deter entry.

Spillovers from incumbents to entrants

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Creation of new intangibles depends on scope of existing projects:

$$\frac{dN_t^{(e)}}{N_t^{(e)}} = \xi x_t^{\beta} L_{E,t} \, dt.$$

Interpretation:

New entrepreneurs receive ideas by observing existing firms.

Higher scope $x \to$ more new ideas generated.

Implications:

Depending on parameters, increasing ρ can lead to higher LR growth:

$\rho \uparrow \to x \uparrow \to$ higher growth.

Global solution

Define

$$\nu_t = \int_{s\geq} e^{-\int_0^v (r_{t+u}+\delta)du} \frac{A_{t+s}}{A_t} ds \qquad \text{[Price-earnings ratio for entrants]}$$

$$\mu_t = \lambda \int_{s\geq t} e^{-\int_0^v (r_{t+u}+\lambda)du} \frac{A_{t+s}\nu_{t+s}}{A_t \nu_t} ds \qquad \text{[Value of outsiders' option to compete]}$$

Then there exists sufficient states c_t such that:

$$\nu_t = \nu(c_t), \quad \mu_t = \mu(c_t), \quad L_{E,t} = L_E(c_t)$$

Given $L_E(.)$, $\nu(.)$, $\mu(.)$ solve a system of coupled ODEs

The relative size of new entrants c_t is a sufficient state:

$$c_t = \left(\frac{n_t^{(e)}}{N_t}\right)^{\omega}, \quad N_t = \left(\int_j n_{j,t}^{\omega} dj\right)^{\frac{1}{\omega}}.$$

Global solution

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Equilibrium equations:

$$\left(\eta + x(\mu(c_t))^{1-(1-\rho)\omega} L_E(c_t) c_t\right) \nu(c_t) = 1 + \left(\omega \xi L_E(c_t) + \delta - x(\mu(c_t))^{1-(1-\rho)\omega} L_E(c_t) c_t\right) c_t f'(c_t)$$

$$\left(\lambda - \delta + \frac{1}{\nu(c_t)}\right) \mu(c_t) = \lambda + \left(\omega \xi L_E(c_t) + \delta - x(\mu(c_t))^{1-(1-\rho)\omega} L_E(c_t) c_t\right) c_t \mu'(c_t)$$

$$0 = \min\left(L_E(c_t), 1 - \frac{1-\zeta\chi}{\zeta\chi} x(\mu(c_t))^{1-(1-\rho)\omega} (1 - \gamma(x(\mu(c_t)), \mu(c_t)))(1 - L_E(c_t)) c_t \nu(c_t)\right)$$

The functions $x(\mu)$ and $\gamma(x;\mu)$ are state-invariant and given by:

$$\gamma(x;\mu) = s_\pi \frac{\theta(x)}{x} \bar{x}\, \mu$$

$$x(\mu) = \arg\max_x\, (1 - \gamma(x;\mu)) x^{1-(1-\rho)\omega}$$

with s_π from the Cournot game.

This system can be solved using finite-difference methods.

Other data sources: Profit rates (BEA)

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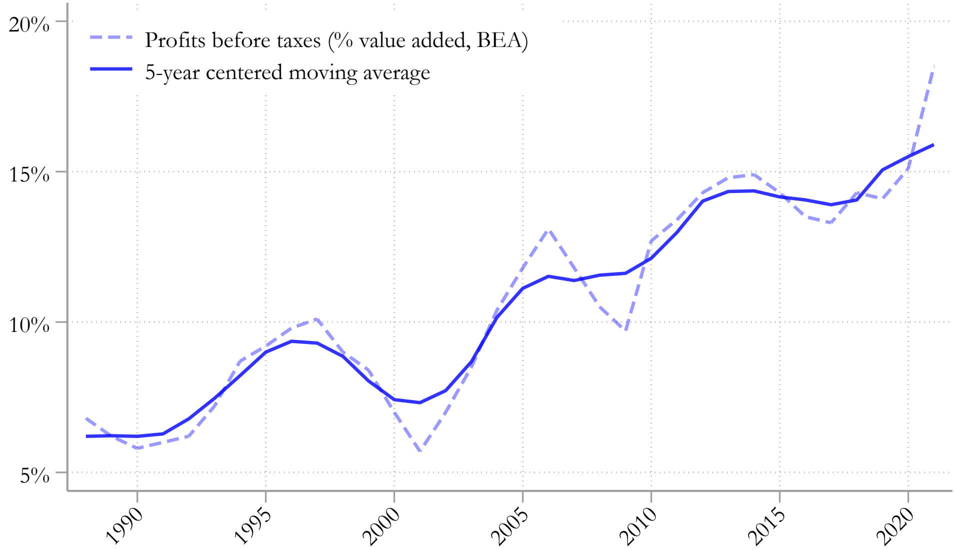

Other data sources: Tobin's Q (Compustat)

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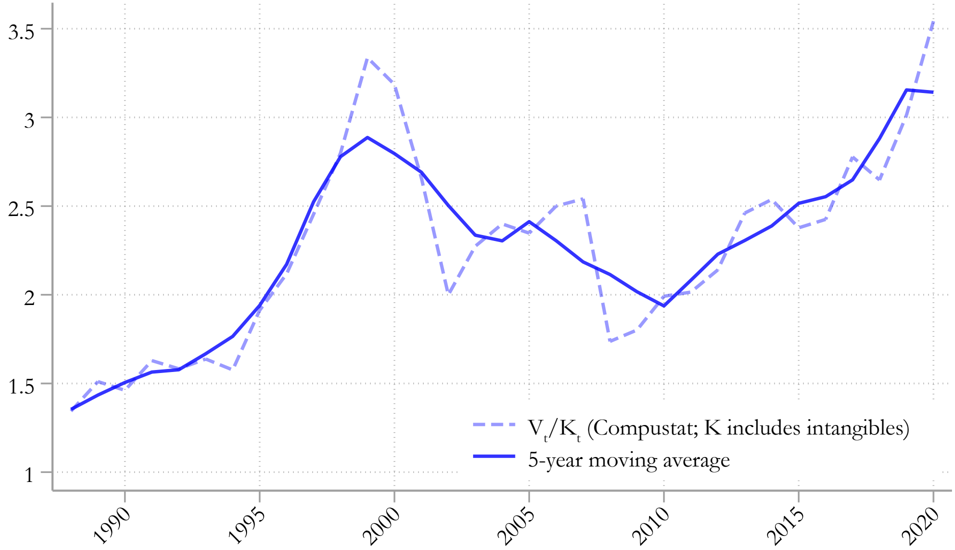

Other data sources: Gross entry rates (BDS)

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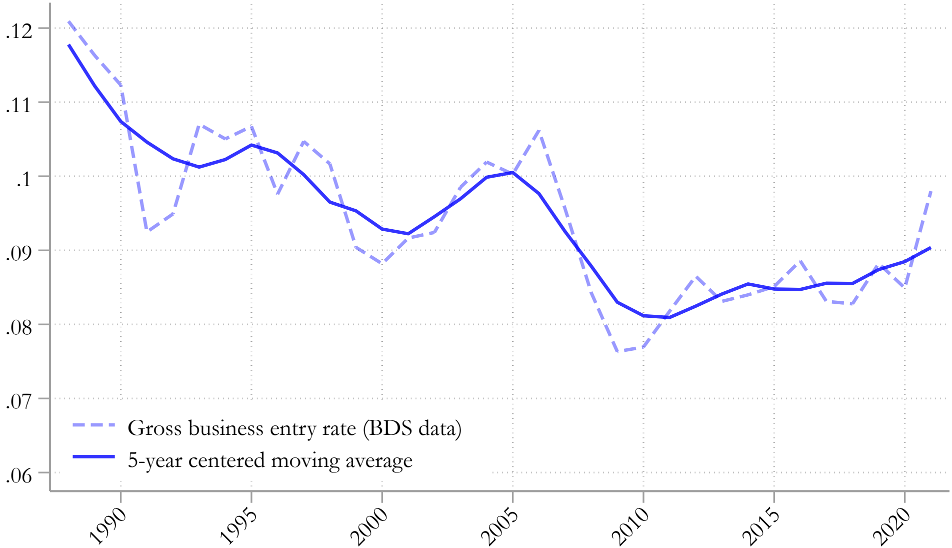

Other data sources: Growth rates (BEA)

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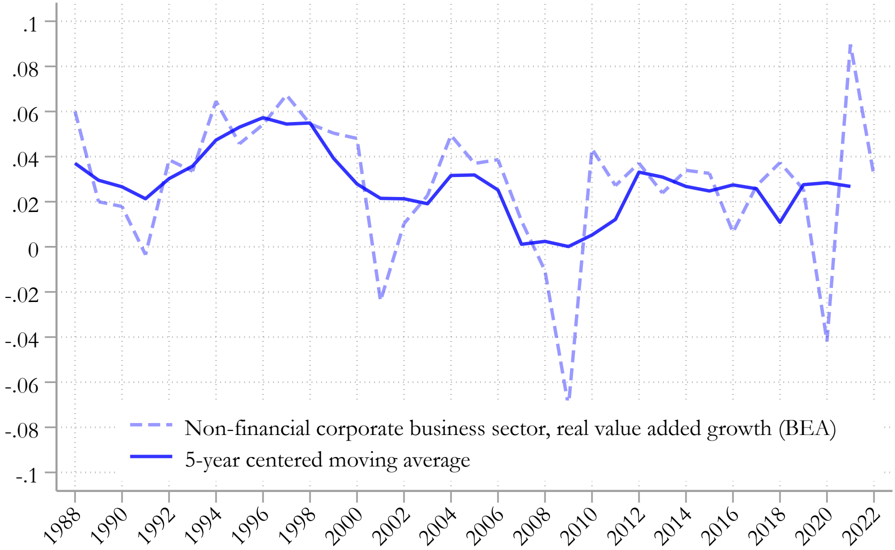

Other calibrations

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Consider the model with no delay ($\lambda = +\infty$), but calibrate ε, subject to: $\varepsilon \geq \underline{\varepsilon}(\zeta, \phi)$.

Par.	Description	Par. value	Targeted moment	Model counterpart	Data value	Model value
ε	Entry cost	0.89	Outsider share at IPO	γ	0.35	0.34
α	Level of $\theta(x)$	2.37	Average scope	x	6.3	6.3
κ	Slope of $\theta(x)$	1.34	Tobin's Q	Q	1.5	1.6
ξ	Entr. productivity	0.38	Output growth	g	0.027	0.027

$$\text{In balanced growth,} \qquad \gamma(x;\lambda) \propto \frac{\bar{x}}{x}\theta(x)\mu(\lambda)$$

$$\text{\# outsiders needed to reach scope } x = \theta(x) = \max(\,0\,,\ \alpha(x-\bar{x})^{\kappa}\,)$$

Other calibrations

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Consider the model with delay ($\lambda < +\infty$), but set $\varepsilon = 0$.

Par.	Description	Par. value	Targeted moment	Model counterpart	Data value	Model value
λ	Exclusivity	1.35	Outsider share at IPO	γ	0.35	0.34
α	Level of $\theta(x)$	0.27	Average scope	x	6.3	6.3
κ	Slope of $\theta(x)$	1.34	Tobin's Q	Q	1.5	1.6
ξ	Entr. productivity	0.38	Output growth	g	0.027	0.027

$$\text{In balanced growth,} \qquad \gamma(x;\lambda) \propto \frac{\bar{x}}{x}\theta(x)\mu(\lambda)$$

$$\#\text{ outsiders needed to reach scope } x = \theta(x) = \max(\,0\,,\ \alpha(x-\bar{x})^{\kappa}\,)$$

Other calibrations

[Back]

Consider the model with no delay ($\lambda = +\infty$), but calibrate ε, subject to: $\varepsilon \geq \underline{\varepsilon}(\zeta, \phi)$.

	1988-1992 $\rho = \mathbf{0.18}$		**2016-2020** $\rho = \mathbf{0.34}$	
Moment	Data	Model	Data	Model
Outsider share at IPO	0.35	0.32	0.50	0.53
Average scope	6.3	6.3	10.1	16.0
Tobin's Q	1.5	1.6	2.8	2.3
Output growth	0.027	0.027	0.011	0.021

Other calibrations

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Consider the model with no delay ($\lambda = +\infty$), but set $\varepsilon = 0$.

	1988-1992 $\rho = \mathbf{0.18}$		2016-2020 $\rho = \mathbf{0.34}$	
Moment	Data	Model	Data	Model
Outsider share at IPO	0.35	0.32	0.50	0.53
Average scope	6.3	6.3	10.1	15.4
Tobin's Q	1.5	1.6	2.8	2.3
Output growth	0.027	0.027	0.011	0.021