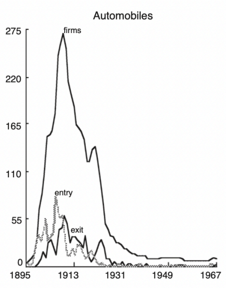
The Life-cycle of Concentrated Industries

Martin Beraja (Berkeley) Francisco Buera (WashU)

Motivation

- Firms in cutting-edge industries often engage in **dynamic competition *for the market***
- Many such industries have had a **life-cycle**: Entry → Shakeout → Concentration



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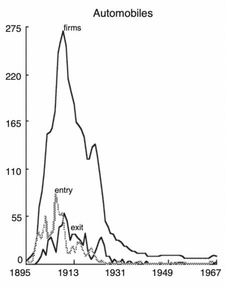

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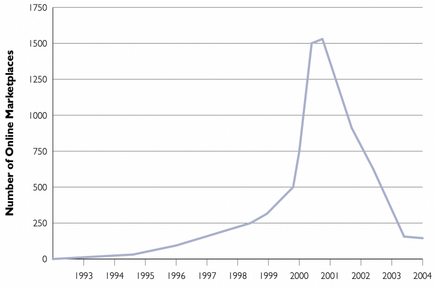

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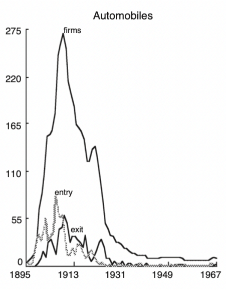

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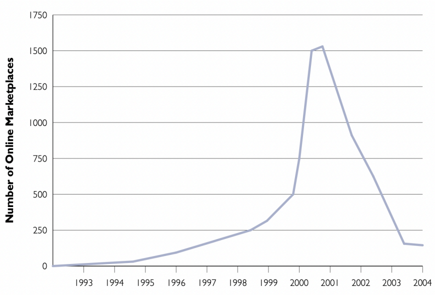

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- Also, OS or search engine industries. Windows or Google far ahead in a decade...

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- Fast **concentration** of digital industries — and rise of **superstar firms** — has rekindled a **debate** about appropriate **policy interventions to promote competition**

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- Are policies geared towards industries where competition is primarily static also appropriate for innovative industries, where firms compete *for the market*?
- How should policies to promote competition over the life-cycle **differ**?
  - Common belief in policy circles: for **digital / AI industries**, gov'ts should intervene **preemptively** and early on in the life-cycle, before concentration becomes **"irreversible"**

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2. **Application:** Digital and AI industries in the US (dataset from VentureScanner)

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Assumption 1: Flow profit function is:

(i) decreasing in $\underline{N}$ and $\bar{N}$,

(ii) increasing in z,

(iii) converges to fixed cost $-f$ as $z \rightarrow 0$ and $\bar{N} \rightarrow \infty$, and

(iv) such that at least one firm enters $\pi\left(1, 0; \underline{z}\right) + \lambda\pi\left(0, 1; \bar{z}\right)/r > 0$.

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Special case:

- Cost function: $\Gamma(q; z) = \frac{1}{z} q + f$
- Inverse demand function:

$$p_i = \frac{\sigma - 1}{\sigma} \left[\sum_{j=1}^{\underline{N}_t + \bar{N}_t} (q_j)^{\frac{\epsilon - 1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon - 1} \frac{\sigma - 1}{\sigma} - 1} (q_i)^{-\frac{1}{\epsilon}}$$

- Cournot competition in q

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Households

$$V\left(\underline{N}_t, \bar{N}_t\right) = \mathbb{E}_t\left[\int_t^{\infty} e^{-r(s-t)} U\left(\underline{N}_s, \bar{N}_s\right) ds\right]$$

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Special case:

$U = Q_t + X_t$, with quantity Q_t and outside good X_t,

and $Q_t = \left[\sum_{i=1}^{\underline{N}_t+\bar{N}_t} \left(q_{it}\right)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}\frac{\sigma-1}{\sigma}}$

Solve backward (recursively) for value functions and exit/entry policies

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- A **long-run** concentrated industry **equilibrium** $(0, \bar{N}^{LF}_{\infty})$ is given by $\bar{N}^{LF}_{\infty}$:
  1. Large firms don't **exit** in the long-run $\iff J\left(0, \bar{N}^{LF}_{\infty}; \bar{z}\right) = \frac{\pi\left(0, \bar{N}^{LF}_{\infty}; \bar{z}\right)}{r} \geq 0,$
  2. Small firms don't **enter** in the long-run $\iff J\left(1, \bar{N}^{LF}_{\infty}; \underline{z}\right) = \frac{\pi\left(1, \bar{N}^{LF}_{\infty}; \underline{z}\right) + \lambda \times J\left(0, \bar{N}^{LF}_{\infty} + 1; \bar{z}\right)}{r + \lambda} < 0,$
  3. Small firms **enter** before $\iff J\left(1, \bar{N}^{LF}_{\infty} - 1; \underline{z}\right) = \frac{\pi\left(1, \bar{N}^{LF}_{\infty} - 1; \underline{z}\right) + \lambda \times J\left(0, \bar{N}^{LF}_{\infty}; \bar{z}\right)}{r + \lambda} \geq 0.$

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Lemma 1. The equilibrium number of large firms $\bar{N}_\infty^{LF}$ in a concentrated industry state $(0, \bar{N}_\infty^{LF})$ is uniquely determined by (1)-(3).

Intuition: profit functions decreasing in $\bar{N}$, and hence so is value function $J\left(1, \bar{N}; \underline{z}\right)$

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&+ \lambda \times \left(\underline{N}-1\right) \times \left(J\left(\underline{N}-1,\bar{N}+1;\underline{z}\right) - J\left(\underline{N},\bar{N};\underline{z}\right)\right) \\
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Equilibrium industry life-cycle: Dynamics

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Let $\underline{N}^{\text{LF}}\left(\bar{N}\right)$ be the max # of small firms that industry with $\bar{N}$ large firms can sustain

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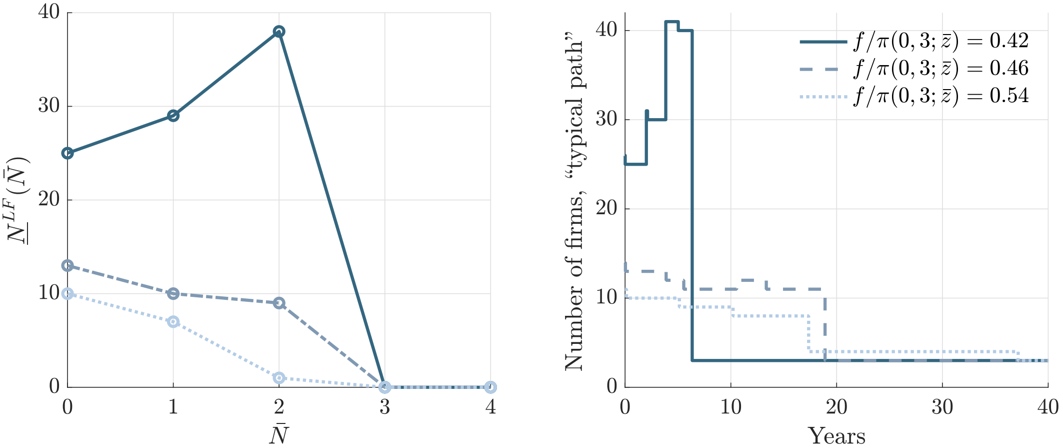
Entry, Shakeout, and Concentration: A Numerical Illustration



- In a competitive industry, the life-cycle is monotonic. **Why the non-monotonicity?**
  - Cost of delaying entry: more large firms present; e.g., $\pi(\underline{N}, 1; \underline{z}) - \pi(\underline{N}, 0; \underline{z}) < 0$
  - Benefit: Large gains right before the shakeout; e.g., $\pi(0, 3; \bar{z}) - \pi(\underline{N}, 3; \bar{z}) > 0$ ▸ Intuition

Equilibrium industry life-cycle: Scale differences between firms

- Relative scale $\longrightarrow$ **nature** of competition (static v. dynamic) and **optimal policy**
- **Scale** economies key driver of US concentration/markups (Autor et al, Philippon et al)
  - Particularly important in **digital/AI** industries (Goldfarb-Tucker)

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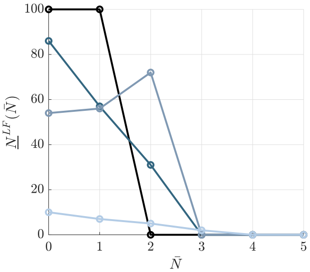

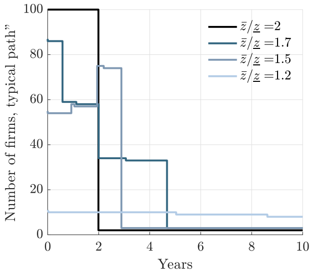

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- Such interventions would implement a **first best** but are **seldom used in practice**
- Governments **favor** policies that **promote competition** via **firm entry** or **antitrust**
  - These are the type of policies currently being discussed for digital/AI industries (Khan, 2016; Philippon, 2019; Tirole, 2023; Varian, 2018)

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- Implementation: time-varying subsidy to the fixed cost of small firms $s(\bar{N})$

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  - Capture policies that promote competition and firm entry in a **reduced form way**
    - Subsidies **early** in the life-cycle $\implies$ Act **before** industries become too concentrated

      Tax credits to startups / financing for small firms (Bloom et al., 2019; Itskhoki and Moll, 2019).
      Laxer regulations on data privacy in digital industries (Goldfarb and Tucker, 2012)

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  - Capture policies that promote competition and firm entry in a **reduced form way**
    - Subsidies **early** in the life-cycle $\implies$ Act **before** industries become too concentrated

      Tax credits to startups / financing for small firms (Bloom et al., 2019; Itskhoki and Moll, 2019). Laxer regulations on data privacy in digital industries (Goldfarb and Tucker, 2012)
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- <u>Goal</u>: analyze how nature of competition affects optimal policy over the life-cycle
  1. Are subsidies designed for promoting competition in static industries also appropriate for **innovative** industries where **dynamic competition for the market** is key?
  2. If not, how should subsidies over the life-cycle **differ**?

Scale Differences, Competition, and Optimal Policy

Theoretical results in **two limit** cases:

1. $\bar{z}/\underline{z} \to \infty$, with $\underline{z} \to 0$. Innovation leads to large scale diffs; competition <u>for</u> the market

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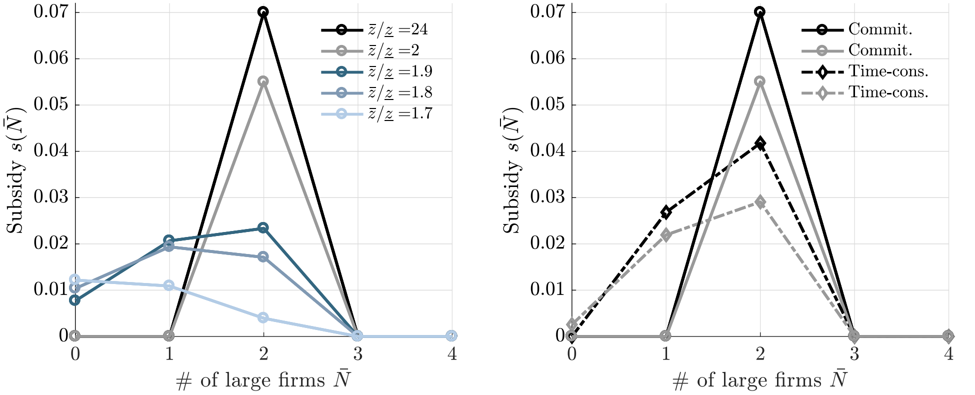
   - The government must subsidize firms in a nascent industry too
   - Subsidies are uniform over the life-cycle

Relative Scale and optimal policy



- Firm entry/exit mostly driven by **option value** of taking over the market
  $\Longrightarrow$ Governments can wait to intervene later in the life-cycle
- If the government cannot commit, the **time-consistent** policy must subsidize **earlier**

How do these results help inform competition policy debates?

Established belief in policy circles: innovative industries are "harder" to regulate

- For **digital / AI industries**, many argue that gov'ts should intervene **preemptively** and early on, before concentration becomes **irreversible**

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  - Instead, gov’t must subsidize early on when **static competition in the market** is important

Extensions

1. Collusion and antitrust

$$\pi\left(\underline{N},\bar{N};\bar{z}\right)=\frac{1}{\bar{N}}\pi^{\text{Cartel}}\left(\underline{N},\bar{N};\bar{z}\right)$$

2. Blocking competitors and antitrust

Large firms pay c to lower profits of small firms $\pi\left(\underline{N},\bar{N};\bar{z}\right)$

3. Endogenous Rate of Innovation λ at cost $c\left(\lambda\right)$ ▸ numerical example

$$J\left(\underline{N}^{LF}\left(\bar{N}+1\right),\bar{N}+1;\bar{z}\right)-J\left(\underline{N},\bar{N};\underline{z}\right)=c'\left(\lambda\left(\underline{N},\bar{N}\right)\right)$$

4. Innovation spillovers from large firms $\lambda(\bar{N})$

Application: Digital & AI Industries in the US

The **question** of how to regulate an industry **in practice** can be understood as:

Are firm choices mostly driven by dynamic competition for the market?
Or, is competition in the market important too?

- Model insight: Differences in **scale** as a key **moment** for diagnosing an industry

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- 17 categories of technologies/services: "AI," "Financial," "Real Estate," "Security," etc.
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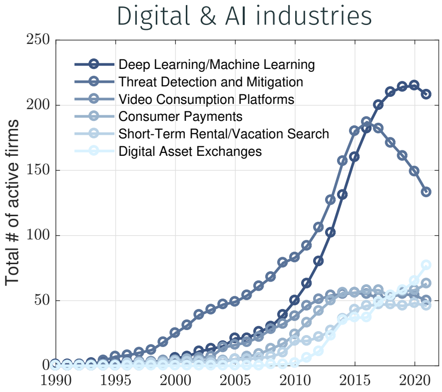
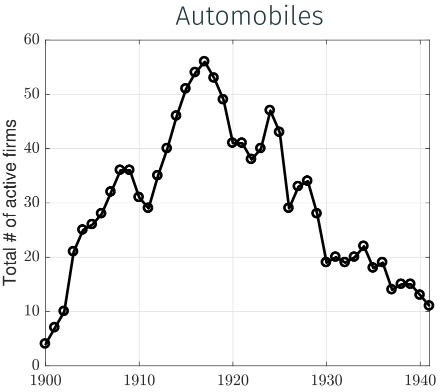
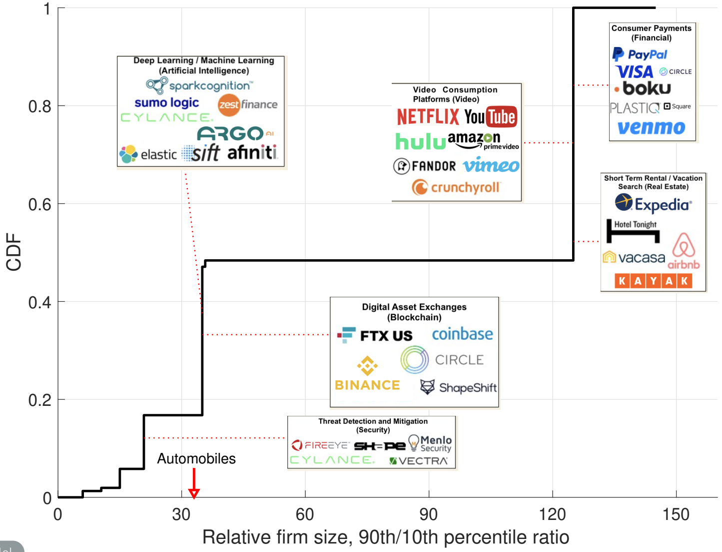
As a comparison, look at **Automobile** industry using *The 100 Year Almanac*


Digital & AI industries
Total # of active firms
Deep Learning/Machine Learning
Threat Detection and Mitigation
Video Consumption Platforms
Consumer Payments
Short-Term Rental/Vacation Search
Digital Asset Exchanges
0
50
100
150
200
250
1990
1995
2000
2005
2010
2015
2020


Automobiles
Total # of active firms
0
10
20
30
40
50
60
1900
1910
1920
1930
1940

Relative scale across industries



output-productivity model

Intuition for non-monotonic life-cycle

- In a **competitive** industry (Jovanovic-MacDonald), the life-cycle is **always monotonic**

  No firms exit when quantities are low (price is high). A mass of firms exit once they are high (price is low)

- In an **oligopolistic** industry (our model), the life-cycle may be **non-monotonic**
- Incentives to **delay entry**, from $\bar{N} = 1 \rightarrow 2$, given $\underline{N}$:

$$J(\underline{N}, 2; \underline{z}) - J(\underline{N}, 1; \underline{z}) = \overbrace{\pi(\underline{N}, 2; \underline{z}) - \pi(\underline{N}, 1; \underline{z}) + \frac{\lambda}{r + \lambda \underline{N}} \left[\pi(\underline{N}, 3; \bar{z}) - \pi(\underline{N}, 2; \bar{z})\right]}^{\text{cost of competing with an additional large firm } <0}$$

$$+ \underbrace{\frac{\lambda}{r + \lambda \underline{N}} \left[\pi(0, 3; \bar{z}) - \pi(\underline{N}, 3; \bar{z})\right]}_{\text{benefits of entering closer to the shakeout} >0} .$$

- "Business stealing" gains at shakeout occur closer to the time of entry

Jump back

Sources of Inefficiency

Constrained Planner's value of an additional firm (SB) v. **Equilibrium** value of staying (LF)

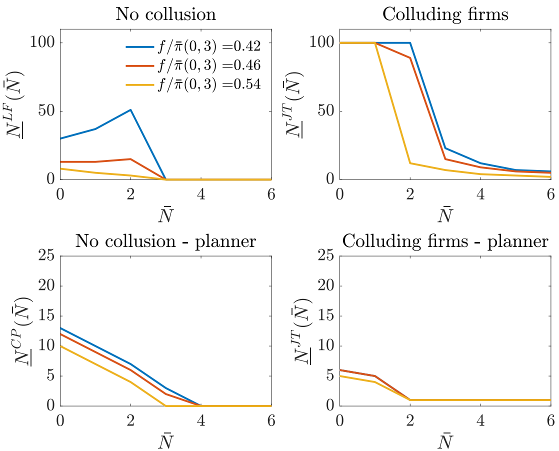
SB: $U\left(\underline{N}, \overline{N}\right) - U\left(\underline{N}-1, \overline{N}\right) \quad + \lambda\left(V\left(\underline{N}\left(\overline{N}+1\right), \overline{N}+1\right) - V\left(\underline{N}, \overline{N}\right)\right)$

LF: $\pi\left(\underline{N}, \overline{N}; \underline{z}\right) \quad + \lambda J\left(\underline{N}\left(\overline{N}+1\right), \overline{N}+1; \bar{z}\right) + \eta\left(\overline{N}\right)\left(\underline{N}-1\right) J\left(\underline{N}-1, \bar{N}; \underline{z}\right)$

1. Source of inefficiency I: Firms care about profits, not surplus $\Rightarrow \uparrow$ # firms
2. Source of inefficiency II: Firms do not internalize surplus destruction $\Rightarrow \downarrow$ # firms
3. Source of inefficiency III: War of attrition $\Rightarrow \downarrow$ # firms

▸ Jump back

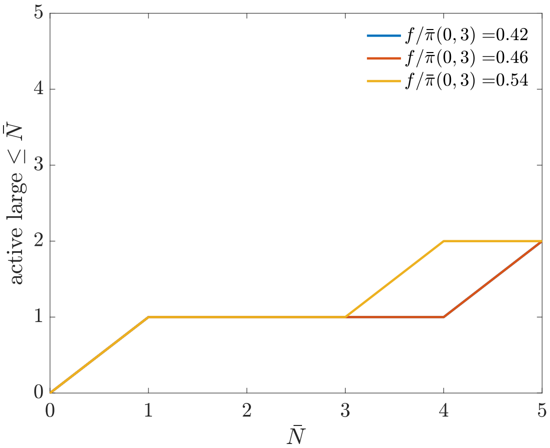
Collusion and Antitrust



- More incentives to entry, to participate in the cartel
- Planner wants to break the cartel, or less entry if it can't

▸ Jump back

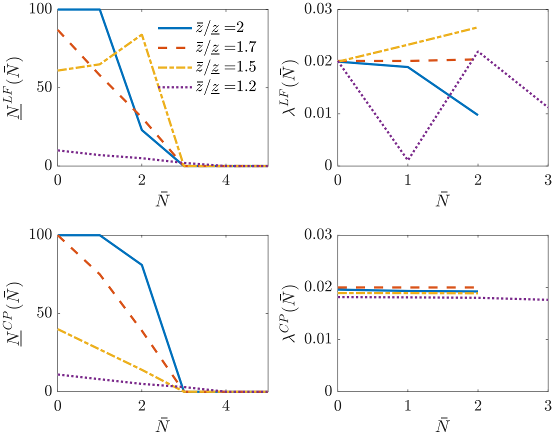
Collusion and Antitrust, innactive productive firms



- The cartel may not operate all firms/goods

Jump back

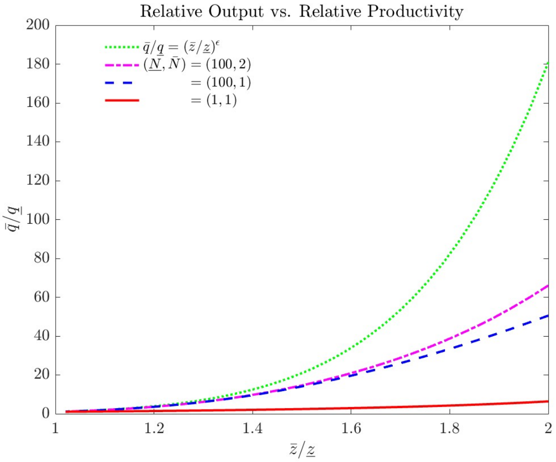
Intensive Margin of Innovation, λ endogenous



- $c(\lambda) = c_0\lambda^{1.1}$, c_0 calibrated so that $\lambda(\underline{N}(0), 0) = 0.02$
- Life cycle of entry and exit virtually unaffected

Jump back

Relative Output vs. Relative Productivity, $\epsilon = 7.5$



Jump back