Strategic Innovation and Entry

Renjie Bao[1] Jan Eeckhout[2]

[1] Princeton
[2] UPF Barcelona

ESEM 2024

Rotterdam

August 29, 2024

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power $\Rightarrow$ inelastic demand $\Rightarrow$ incentivize entry

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power $\Rightarrow$ inelastic demand $\Rightarrow$ incentivize entry
  - Supply: high market power $\Rightarrow$ high incumbent productivity $\Rightarrow$ deter entry

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power $\Rightarrow$ inelastic demand $\Rightarrow$ incentivize entry
  - Supply: high market power $\Rightarrow$ high incumbent productivity $\Rightarrow$ deter entry
- Goal: quantify a macro model with demand heterogeneity and supply-side strategic innovation

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power ⇒ inelastic demand ⇒ incentivize entry
  - Supply: high market power ⇒ high incumbent productivity ⇒ deter entry
- Goal: quantify a macro model with demand heterogeneity and supply-side strategic innovation
  - Distinguish two types of innovation
    - **Quality ladder**: perfect spillover (e.g., idea of LLM)
    - **Productivity**: no spillover (e.g., train own LLM) and leader move first (e.g., OpenAI - ChatGPT)

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power ⇒ inelastic demand ⇒ incentivize entry
  - Supply: high market power ⇒ high incumbent productivity ⇒ deter entry
- Goal: quantify a macro model with demand heterogeneity and supply-side strategic innovation
  - Distinguish two types of innovation
    - **Quality ladder**: perfect spillover (e.g., idea of LLM)
    - **Productivity**: no spillover (e.g., train own LLM) and leader move first (e.g., OpenAI - ChatGPT)
  - Key mechanisms: leader innovates on productivity strategically
    - Intensive margin: escape competition (Aghion, Harris, Howitt, and Vickers, 2001)
    - Extensive margin: entry deterrence (*killer innovation*)

Motivation

- Stylized facts: the rise of market power and the decline of business dynamism
  - Demand: high market power ⇒ inelastic demand ⇒ incentivize entry
  - Supply: high market power ⇒ high incumbent productivity ⇒ deter entry
- Goal: quantify a macro model with demand heterogeneity and supply-side strategic innovation
  - Distinguish two types of innovation
    - **Quality ladder**: perfect spillover (e.g., idea of LLM)
    - **Productivity**: no spillover (e.g., train own LLM) and leader move first (e.g., OpenAI - ChatGPT)
  - Key mechanisms: leader innovates on productivity strategically
    - Intensive margin: escape competition (Aghion, Harris, Howitt, and Vickers, 2001)
    - Extensive margin: entry deterrence (*killer innovation*)
- Preview of results
  - Strategic innovation leads to an over-investment on productivity from the leaders
  - Ambiguous welfare effects with *higher growth* and *lower static efficiency* ⇒ quantify this trade-off
  - Policy: subsidize (or tax) leaders (or followers)?

Main Literature

- Schumpeterian growth model
  - Innovation with spillover: Grossman and Helpman (1991); Aghion and Howitt (1992); Klette and Kortum (2004); Lentz and Mortensen (2008); Acemoglu, Akcigit, Alp, Bloom, and Kerr (2018); Akcigit and Kerr (2018); Akcigit, Baslandze, and Lotti (2018), etc
  - Innovation with partial or no spillover: Aghion, Harris, Howitt, and Vickers (2001); Bloom, Schankerman, and Van Reenen (2013); Cavenaile, Celik, and Tian (2019); De Ridder (2019)

  We distinguish two types of innovation and study their different roles in growth and distribution

- Strategic innovation
  - Intensive margin: the escape-competition effect (Aghion, Harris, Howitt, and Vickers, 2001)
  - Extensive margin: start-up acquisition (Fons-Rosen, Roldan-Blanco, and Schmitz, 2021), distributional effects (Weiss, 2019), intangible (De Ridder, 2019), growth (Cavenaile, Celik, and Tian, 2019), interest rate (Liu, Mian, and Sufi, 2022)

  We study how strategic innovation interacts with both the demand (product differentiability) and the supply (market power, growth) side

Model

Environment

- Representative household

$$\max_{\{C_t, L_t\}_{t=0}^{\infty}} U_0 = \sum_{t=0}^{\infty} \beta^t \overline{q}_t \left(\frac{C_t}{\overline{q}_t} - \overline{\varphi}^{-\frac{1}{\varphi}} \frac{L_t^{1+\frac{1}{\varphi}}}{1+\frac{1}{\varphi}} \right), \quad \text{s.t.} \quad C_t \leq \Pi_t + W_t L_t, \ \forall t, \tag{1}$$

with nested-CES aggregation and $\theta < \min_j \{\eta_j\}$

$$C_t = \overline{q}_t \left[\int_0^1 (x_{jt} c_{jt})^{\frac{\theta-1}{\theta}} \, \mathrm{d}j \right]^{\frac{\theta}{\theta-1}} \quad \text{and} \quad c_{jt} = \left[\sum_{i=1}^{I_{jt}} (c_{ijt})^{\frac{\eta_j-1}{\eta_j}} \right]^{\frac{\eta_j}{\eta_j-1}}. \tag{2}$$

- Notation: industry quality q_{jt}, aggregate quality $\overline{q}_t = \int_0^1 q_{jt} dj$, relative quality $x_{jt} \equiv q_{jt}/\overline{q}_t$
- Distribution of η_j introduces variation in market power from the demand side

Environment

1. Innovation on quality ladder. Research firm $n \in \{1, ..., N_{jt}\}$ in each industry j solve

$$\max_{v_{njt} \geq 0} \pi^q_{njt}(v_{njt}, \mathbf{v}_{-njt}) = \underbrace{\frac{v_{njt}}{x_{j,t-1}v_0 + \sum_{n'} v_{n'jt}} \mathbb{E}_z \left[\pi^{a,*}_{\ell jt}(z)\right]}_{\text{expected return of winning quality ladder}} - \underbrace{W_t x^{\theta-1}_{j,t-1}\left(v_{njt} + \phi^q\right)}_{\text{quality innovation cost}} \quad (3)$$

- Quality dynamic: $q_{jt} = \lambda q_{j,t-1}$ with a quality ladder, which otherwise remains $q_{j,t-1}$
- Equilibrium number of research firms N^*_{jt} is determined by free entry

Environment

1. Innovation on quality ladder.
2. Innovation on productivity by leaders. The winner (if any) of quality innovation becomes the first mover in productivity innovation. The leader's problem writes

$$\pi^{a,*}_{\ell jt}(z_{\ell jt}) = \max_{a_{\ell jt}} \left\{ \pi_{\ell jt}\Big(a_{\ell jt}, \underbrace{a^*_{fjt}\left(a_{\ell jt}\right), I^*_{jt}\left(a_{\ell jt}\right)}_{\text{best response from followers}} \Big) - W_t l^a_{\ell jt}(a_{\ell jt}, z_{\ell jt}) \right\} \tag{4}$$

   – Productivity innovation labor

$$l^a_{\ell jt}(a_{\ell jt}, z_{\ell jt}) \equiv x^{\theta-1}_{jt} \frac{1}{z_{\ell jt}} \frac{a^{\gamma}_{\ell jt}}{\gamma}$$

Environment

1. Innovation on quality ladder.
2. Innovation on productivity by leaders.
3. Innovation on productivity by followers. Symmetric followers solve the fixed point problem

$$a^*_{fjt}(a_{\ell jt}, I_{jt}) = \arg\max_{a_{djt}} \left\{ \pi_{djt}\Big(\underbrace{a_{djt}, a^*_{fjt}}_{\text{NE}}, I^*_{jt}; \underbrace{a_{\ell jt}}_{\text{given}} \Big) - W_t l^a_{fjt}(a_{djt}) \right\}, \tag{5}$$

   – Productivity innovation labor

$$l^a_{fjt}(a_{fjt}) \equiv x^{\theta-1}_{jt} \frac{a^{\gamma}_{fjt}}{\gamma}$$

   – The equilibrium number of followers I^*_{jt} is determined by free entry

Environment

1. Innovation on quality ladder.
2. Innovation on productivity by leaders.
3. Innovation on productivity by followers.
4. Cournot competition on output market. Given $\{a^*_{\ell jt}, a^*_{fjt}, I^*_{jt}, q_{jt}\}$, firms compete with quantity

$$\pi_{ijt} = \max_{l^p_{ijt}} \left\{ p_{ijt}\left(y_{ijt}, y_{-ijt}\right) \underbrace{\left(a_{ijt} l^p_{ijt}\right)}_{\text{quantity } y_{ijt}} - W_t l^p_{ijt} \right\}, \ \forall i \in \{\ell, f, d\} \tag{6}$$

where the demand is given by household optimality

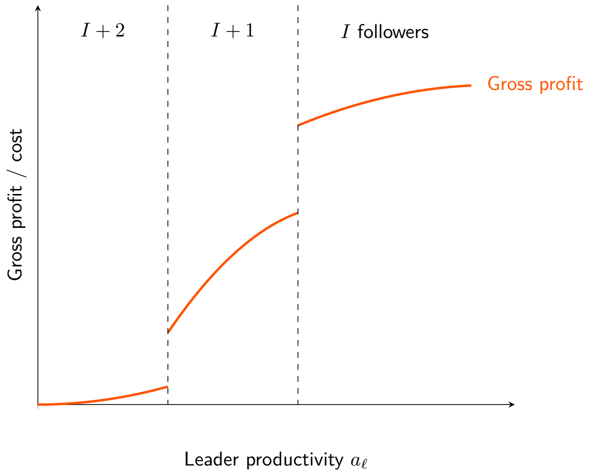
Environment

1. Innovation on quality ladder.
2. Innovation on productivity by leaders.
3. Innovation on productivity by followers.
4. Cournot competition on output market.

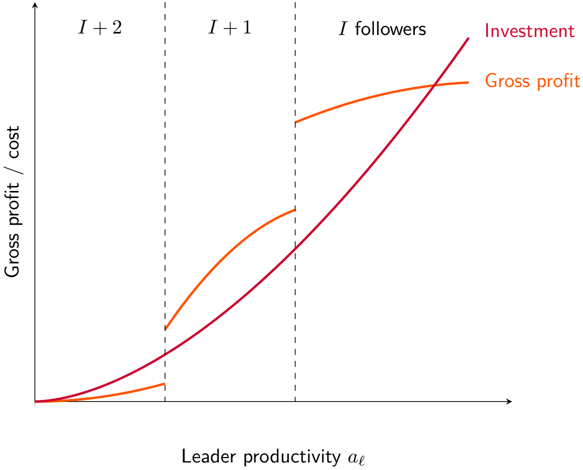
Definition (Balanced Growth Path) A Balanced Growth Path (BGP) is characterized by

- household optimality $\Rightarrow \{c_{\ell jt}, c_{fjt}, L_t\}$
- firm optimality $\Rightarrow \{v_{jt}, N_{jt}\}, \{a_{\ell jt}, a_{fjt}, I_{jt}\}, \{y_{\ell jt}, y_{fjt}\}$
- market clearing $\Rightarrow \{p_{\ell jt}, p_{fjt}\}, \{W_t\}$
- stationary distribution of (relative) quality $\Rightarrow \{x_{jt}\}$
- aggregates $\{\overline{q}_t,\ W_t,\ C_t,\ \Pi_t\}$ grow at the same rate g

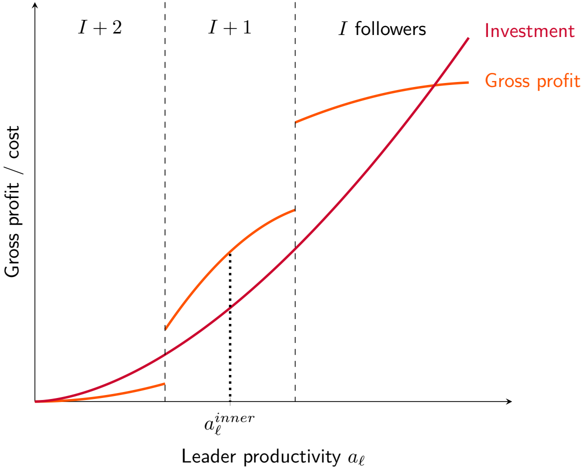
Killer Innovation



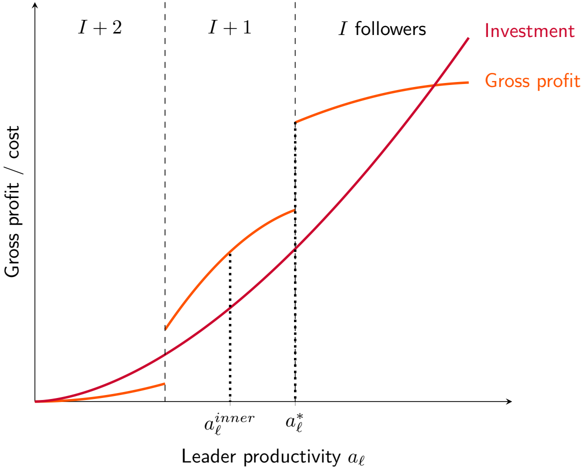
Killer Innovation



Killer Innovation



Killer Innovation



Quantification

Data and Distributional Assumptions

- Consider two periods: 1980-1999 and 2000-2019
- Data
  - US GDP growth: FRED
  - Growth by industry: BEA
  - Micro data on publicly traded firms from Compustat
- Distribution assumptions
  - Within-industry elasticity η: high value η_H with probability ρ and low value η_L with $1-\rho$
  - Leader type z_ℓ is Pareto with scale parameter 1 and shape parameter α_z

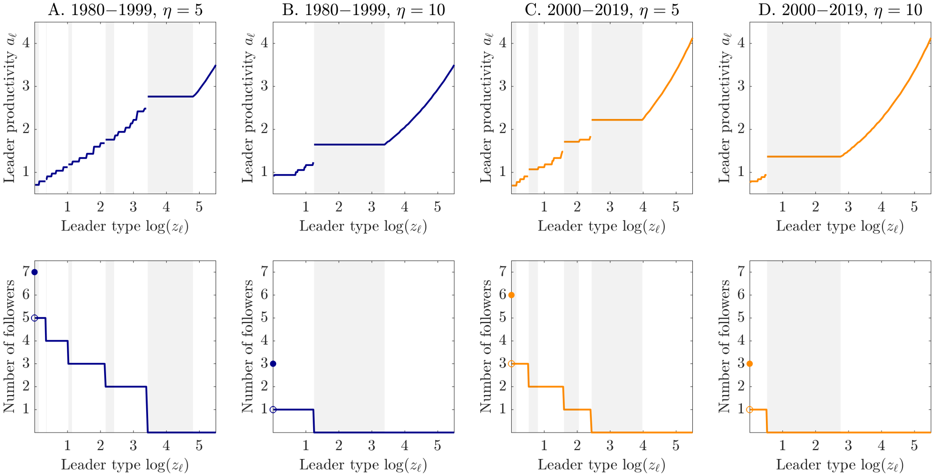
Calibration

	Meaning	Value	Source
θ	Cross-industry elasticity	1.20	De Loecker, Eeckhout, and Mongey (2021)
η_L	Within-industry elasticity (low)	5.00	Anderson and Van Wincoop (2004)
η_H	Within-industry elasticity (high)	10.00	Anderson and Van Wincoop (2004)
β	Discount factor	0.9284	Real interest rate by Cavenaile, Celik, and Tian (2019)
φ	Labor supply elasticity	0.25	Chetty, Guren, Manoli, and Weber (2011)
$\overline{\varphi}$	Labor supply intercept	1.19	Normalize $L = 1$ in 1980-1999
λ	Quality ladder (%)	6.63	Average growth rate of growing industries (BEA)

Estimation

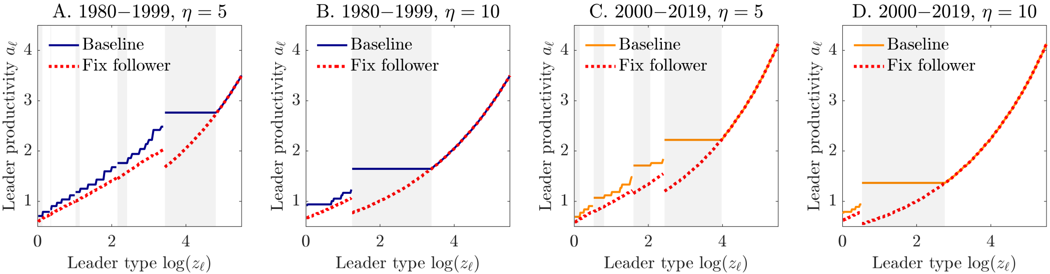
	Meaning	Moment	1980-1999			2000-2019		
			Value	Moment		Value	Moment	
				Data	Model		Data	Model
ϕ^q	Fixed cost of research	GDP growth rate (%)	0.18	3.16	3.18	0.011	1.94	2.02
v_0	DRS in research outcome	St.D. log lpr by industry	0.066	0.54	0.59	0.33	0.63	0.60
γ	Investment cost curvature	Diff. log lpr, p90 - p75	3.01	0.47	0.43	2.67	0.57	0.61
α_z	Shape for Pareto type z_ℓ	Markup p90	0.32	2.45	2.38	0.31	3.07	2.96
ρ	Fraction of high-η industry	Average markup, $<$ p75	0.42	1.35	1.40	0.83	1.44	1.44

Killer Innovation and Entry Deterrence



Counterfactuals

Eliminate Strategic Innovation: Fix Follower Reaction



- Over-investment on both extensive (shaded) and intensive (non-shaded) margin

Eliminate Strategic Innovation: Simultaneous Move

Period of time	Outcomes					
	Markup	# Follower	Growth (%)	Output*	Flow U*	Welfare*
Time period: 1980-1999						
Baseline	1.80	3.34	3.18	0.52	0.42	9.93
Simultaneous move	1.63	3.91	2.23	0.55	0.44	8.70
Time period: 2000-2019						
Baseline	1.96	2.42	2.02	0.41	0.33	6.30
Simultaneous move	1.81	2.54	1.74	0.45	0.36	6.47

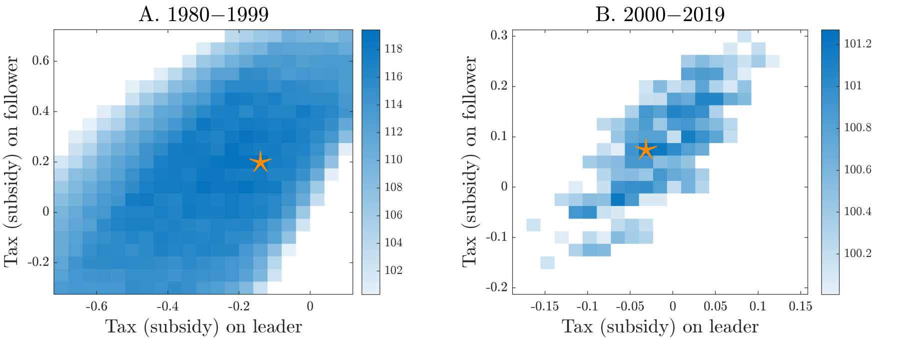
Eliminate Strategic Innovation: Simultaneous Move

Period of time	Outcomes					
	Markup	# Follower	Growth (%)	Output*	Flow U*	Welfare*
Time period: 1980-1999						
Baseline	1.80	3.34	3.18	0.52	0.42	9.93
Simultaneous move	1.63	3.91	2.23	0.55	0.44	8.70
Time period: 2000-2019						
Baseline	1.96	2.42	2.02	0.41	0.33	6.30
Simultaneous move	1.81	2.54	1.74	0.45	0.36	6.47

Eliminate Strategic Innovation: Simultaneous Move

Period of time	Outcomes					
	Markup	# Follower	Growth (%)	Output*	Flow U*	Welfare*
Time period: 1980-1999						
Baseline	1.80	3.34	3.18	0.52	0.42	9.93
Simultaneous move	1.63	3.91	2.23	0.55	0.44	8.70
Time period: 2000-2019						
Baseline	1.96	2.42	2.02	0.41	0.33	6.30
Simultaneous move	1.81	2.54	1.74	0.45	0.36	6.47

Counterfactual Policy: Profit Taxes and Subsidies



Conclusion

Conclusion

"Innovation distinguishes between a leader and a follower."

— Steve Jobs

Conclusion

"Innovation distinguishes between a leader and a follower."

— *Steve Jobs*

Our takeaways

- Strategic innovation leads to over-investment by leaders

Conclusion

"Innovation distinguishes between a leader and a follower."

— *Steve Jobs*

Our takeaways

- Strategic innovation leads to over-investment by leaders
- Ambiguous effects on welfare: dynamic growth gain vs. static efficiency loss

Conclusion

"Innovation distinguishes between a leader and a follower."

— *Steve Jobs*

Our takeaways

- Strategic innovation leads to over-investment by leaders
- Ambiguous effects on welfare: dynamic growth gain vs. static efficiency loss
- Ongoing trend: static efficiency loss gradually dominates dynamic benefits

Strategic Innovation and Entry

Renjie Bao[1] Jan Eeckhout[2]

[1] Princeton
[2] UPF Barcelona

ESEM 2024

Rotterdam

August 29, 2024