Market Power when Ideas get Harder to Find: A Theory of Directed Innovation

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Ideas are getting harder to find (Bloom et al., 2020)

TABLE 7—SUMMARY OF THE EVIDENCE ON RESEARCH PRODUCTIVITY

Scope	Time period	Average annual growth rate (%)	Half-life (years)	Dynamic diminishing returns, β
Aggregate economy	1930–2015	–5.1	14	3.1
Moore's Law	1971–2014	–6.8	10	0.2
Semiconductor TFP growth	1975–2011	–5.6	12	0.4
Agriculture, US R&D	1970–2007	–3.7	19	2.2
Agriculture, global R&D	1980–2010	–5.5	13	3.3
Corn, version 1	1969–2009	–9.9	7	7.2
Corn, version 2	1969–2009	–6.2	11	4.5
Soybeans, version 1	1969–2009	–7.3	9	6.3
Soybeans, version 2	1969–2009	–4.4	16	3.8
Cotton, version 1	1969–2009	–3.4	21	2.5
Cotton, version 2	1969–2009	+1.3	–55	–0.9
Wheat, version 1	1969–2009	–6.1	11	6.8
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New molecular entities	1970–2015	–3.5	20	...
Cancer (all), publications	1975–2006	–0.6	116	...
Cancer (all), trials	1975–2006	–5.7	12	...
Breast cancer, publications	1975–2006	–6.1	11	...
Breast cancer, trials	1975–2006	–10.1	7	...
Heart disease, publications	1968–2011	–3.7	19	...
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Compustat, sales	3 decades	–11.1	6	1.1
Compustat, market cap	3 decades	–9.2	8	0.9
Compustat, employment	3 decades	–14.5	5	1.8
Compustat, sales/employment	3 decades	–4.5	15	1.1
Census of Manufacturing	1992–2012	–7.8	9	...

Source: Bloom et al. (2020)

Other Macro trends since 1980s:

- Rise of market power (De Loecker et al., 2020: ▸ US markups ↑)
- Declining business dynamism (▸ firm entry ↓, ▸ share of young firms ↓, ▸ firm size ↑)

This paper:

- Schumpeterian firm dynamics with search & directed innovation
- Prediction: in *ideas get harder to find* environment, market power should rise
- This and other predictions: all in line with data
- Key ingredient: **directed innovation**

Why innovation seems to be directed

Recent evidence: product market dominance deters firm entry

- Argente et al. (2021): patenting by leaders $\rightarrow$ less innovation by competitors/entrants
- Galasso and Schankerman (2015): invalidation of focal patent leads to more citations
  - effect starts after 2 years – consistent with more entry and cumulative innovation

$\Rightarrow$ Firm entry & innovation are **directed** rather than undirected

Model in a nutshell

Market-specific rate of creative destruction $= \Pr(\text{success}|\text{innovation}) \times \Pr(\text{innovation})$

1. With probability > 0, each innovation cannot build on leader's technology
   - Build on follower instead
   - The larger the leader-follower gap, the lower the likelihood of overtaking the leader
2. Search and Directed innovation
   - Choose sample size of market search, then target one and do R&D
   - Firms with high leader-follower gaps are targeted less than low-gap firms

Search and Directed innovation $\Rightarrow$ Selection on Market Power $\Rightarrow$ Macro Aggregates

Ideas get harder to find

Market-specific rate of creative destruction $= \Pr(\text{success}|\text{innovation}) \times \Pr(\text{innovation})$

1. With probability > 0, each innovation cannot build on leader's technology
   - Build on follower instead
   - The larger the leader-follower gap, the lower the likelihood of overtaking the leader
2. Search and Directed innovation
   - Choose **larger** sample size of market search, then target one and do R&D
   - Firms with high leader-follower gaps are targeted **even** less than low-gap firms

Search and Directed innovation $\Rightarrow$ Selection on Market Power $\Rightarrow$ Macro Aggregates

↑ ↑ **Rise of market power + Decline in business dynamism**

Related literature

Schumpeterian growth theory

- Aghion & Howitt (1992)
- Grossman & Helpman (1991)

Schumpeterian firm dynamics

- **Klette & Kortum (2004)**

Step-by-step innovation

- Aghion et al. (1997)

Endogenous markup distribution

- Peters (2020)

Market power, dynamism & growth: explanations

- Decline in knowledge diffusion: Akcigit & Ates (2021)
- Concentration and defensive R&D: Manera (2021)
- Role of IT: Aghion et al. (2021)
- Role of intangibles: De Ridder (2020)
- Declining interest rates: Liu et al. (2020)
- Declining population growth: Peters & Walsh (2021)

Decline in research productivity

- **Bloom et al. (2020)**

Rise of market power

- **De Loecker et al. (2020)**

Model

Model environment I

- Preferences:

$$U_0 = \int_0^\infty e^{-\rho t} \ln(C_t)\, dt$$

- All output is consumed:

$$C_t = Y_t$$

- Labor supplied inelastically to firms f and entrants e,

$$\int_f \Big(\underbrace{L_{P,f,t}}_{\text{production}} + \underbrace{L_{S,f,t}}_{\text{search}} + \underbrace{L_{R\&D,f,t}}_{\text{R\&D}} \Big) df + \underbrace{\mathcal{M}_{0,t} \times L_{e,t}}_{\text{entrant labor}} = L$$

Model environment II

- Final good and intermediate products $i \in [0,1]$:

$$Y_t = \exp\left(\int_0^1 \ln\left(\underbrace{y_{i,t}}_{\text{leader}} + \underbrace{y_{-i,t}}_{\text{follower}}\right) di\right) \quad \text{and} \quad \underbrace{y_{i,t}}_{\text{quantity}} = \underbrace{q_{i,t}}_{\text{technology}} \times \underbrace{l_{i,t}}_{\text{labor}}$$

- Bertrand competition $\Rightarrow$ markup $=$ gap,

$$\mu_{i,t} = \frac{q_{i,t}}{q_{-i,t}} \geq 1$$

- Only leaders produce and make profits:

$$\Pi_t(\mu_i) = \left(1 - \frac{1}{\mu_i}\right) Y_t$$

$\Rightarrow$ **gap** μ_i is **payoff-relevant** for market i

Timing

$$\underbrace{\text{Search } s \geq 1 \text{ markets; choose } i}_{\text{search stage}} \longrightarrow \underbrace{\text{Innovate in market } i}_{\text{innovation stage}} \longrightarrow \underbrace{\text{If new leader: produce}}_{\text{production}}$$

Two innovation-related decisions:

1. Sample size s: search intensity
2. Arrival rate of innovations

Timing

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Two innovation-related decisions:

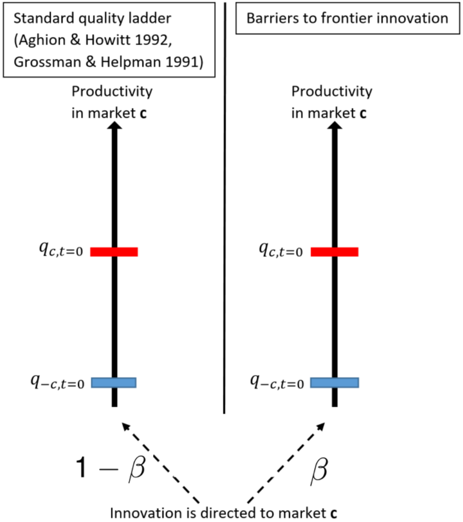
1. Sample size s: search intensity
2. Arrival rate of innovations

Innovation stage

Barriers to frontier innovation:

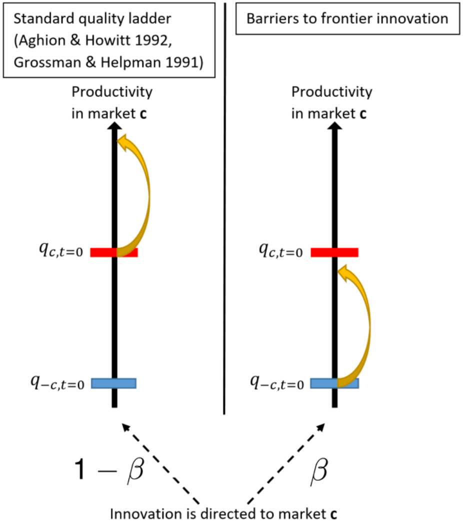
- With probability $\beta \in (0, 1)$, only build on follower's technology
- Microfoundations: strategic patents, trade secrets, slow technology diffusion

Innovation stage: high-gap market

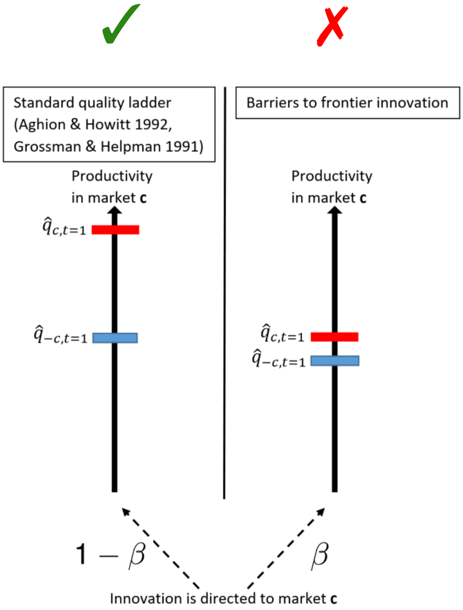


▸ low-gap market

Innovation stage: high-gap market



▸ low-gap market



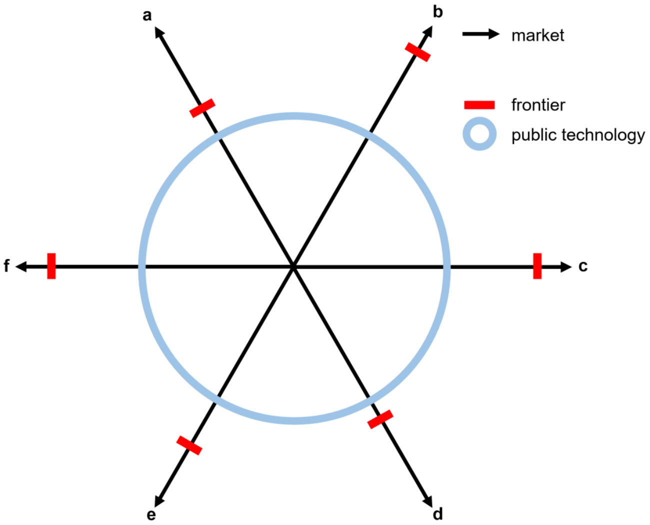
low-gap market

Timing

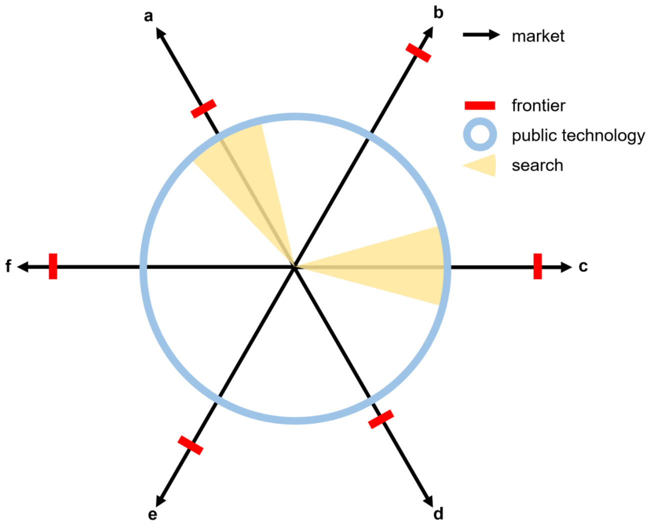
$\underbrace{\text{Search } s \geq 1 \text{ markets; choose } i}_{\text{search stage}} \longrightarrow \underbrace{\text{Innovate in market } i}_{\text{innovation stage}} \longrightarrow \underbrace{\text{If new leader: produce}}_{\text{production}}$

$\Rightarrow$ search markets to target a less dominant (low-gap) leader

Search stage



Search stage



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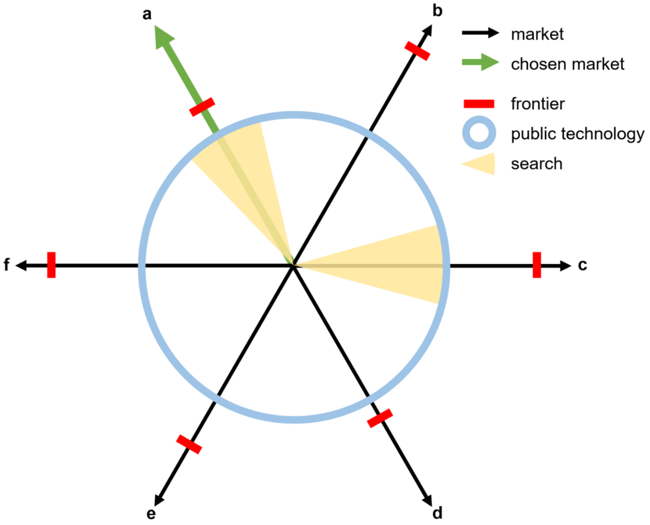

Full model: Firm dynamics à la Klette & Kortum (2004) [details]

- Innovation by entrants and incumbents
- Firm size distribution

Simplified model: Standard quality ladder à la Grossman & Helpman (1991)

- Innovation by entrants
- 1-product firms

Entry

- Free entry
- Labor to search s markets and generate 1 innovation:

$$L_e(s) = \underbrace{\frac{1}{\phi}\eta s^{\frac{1}{\eta}}}_{\text{search}} + \underbrace{\frac{1}{\theta}}_{\text{R\&D}}$$

η: search elasticity

ϕ: search productivity

θ: research productivity

free entry condition

Steady state

Assumption: Innovation steps drawn from $\sim \mathrm{Pareto}(\alpha)$

Proposition

Stationary distribution of leader-follower gaps μ is $\sim \mathrm{Pareto}(\frac{\alpha}{s^*})$,

graphical proof

$$cdf(\mu) = 1 - \mu^{-\frac{\alpha}{s^*}}$$

Proposition

Optimal search intensity is

$$s^* = \left(\frac{\phi/\theta}{4/\beta - 2 - \eta} \right)^{\eta}$$

$\Rightarrow$ Decline in research productivity ($\theta \downarrow$) incentivizes more search: $s^* \uparrow$

figure

Parametrization of pre-1980s (full model)

Assigned	Value	Description
ρ	0.01	Discount rate
β	0.5	Barriers to frontier innovation
η	0.5	Search elasticity
γ	0.5	Incumbent R&D elasticity
δ	0.7	Entry externality
L	1	Size of labor force (normalized)

Estimated	Value	Description	Key moment	Model	Data
$\tilde{\theta}$	0.63	**Incumbent R&D productivity**	TFP growth	0.0182	0.0182
θ	0.45	**Entrant R&D productivity**	Entrants' % TFP growth	0.25	0.25
α	13.2	Pareto shape of innovations	Firm entry rate	0.13	0.13
ϕ	25.2	Search productivity	Average markup	1.1	1.1

What caused the macro trends since the 1980s?

Find support for 2 explanations:

1. **Declining research prod.** ($\theta\downarrow$, $\tilde{\theta}\downarrow$) $\Rightarrow$ can explain sign + magnitude of effects
2. Barriers to frontier innovation ($\beta\uparrow$) $\Rightarrow$ can explain sign of effects, but not magnitude

Today vs. pre-1980s: Decline in research productivity

- Optimal to search more markets $\Rightarrow$ more selection, more **market power**
  1. Higher markups & dispersion, higher profit share ✓
- **R&D**? Higher profit share dominates lower research productivity
  2. Higher % of R&D workers ✓
- **Growth**? Decline in research productivity dominates increase of R&D workers
  3. Productivity growth slows down ✓
  4. Less firm entry ✓

growth equation

- **Firm size**? Entrants' innovation rate drops more than incumbents'
  5. Larger and older firms ✓

Implications of research productivity $\downarrow$ by 75%

	pre-1980 s.s.	2010 s.s.	Change: Model	Change: Data	Change: Sign	**Model/Data**
Targeted moments						
TFP growth	0.0182	0.0096	-47%	-72%	✓	**65%**
Entrants' % TFP growth	0.25	0.206	-18%	-	-	-
Firm entry rate	0.13	0.064	-51%	-39%	✓	**131%**
Average markup	1.1	1.15	$+4.5\%$	$+7\%$	✓	**64%**
Untargeted moments						
Average firm size	2.16	2.44	$+13\%$	$+15\%$	✓	**87%**
Profit share	0.041	0.084	$+105\%$	$+75\%$	✓	**140%**
R&D workers/labor force	0.076	0.086	$+13\%$	$+50\%$	✓	**26%**

Conclusions

- Directed innovation matters for the macroeconomy, market power and growth
- *Ideas got harder to find* (Bloom et al. 2020) is a unified explanation for macro trends

Thank you for your attention!

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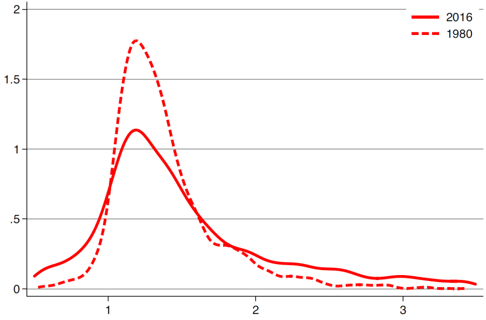
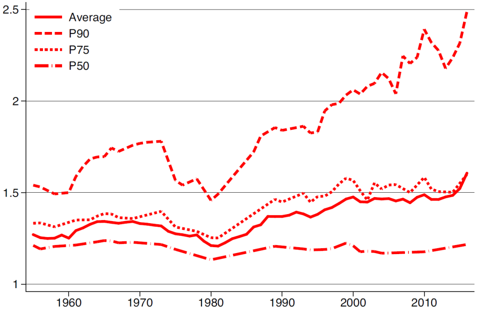
Appendix

Markups increased, especially at the top



(A) Kernel density (unweighted)

US markup distribution, Compustat data
Source: De Loecker et al. (2020)

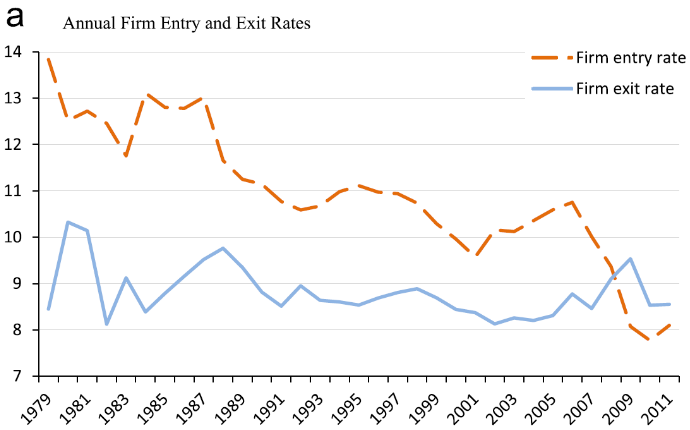


(B) Percentiles markup distribution (revenue weight)

US markup percentiles, Compustat data
Source: De Loecker et al. (2020)

return

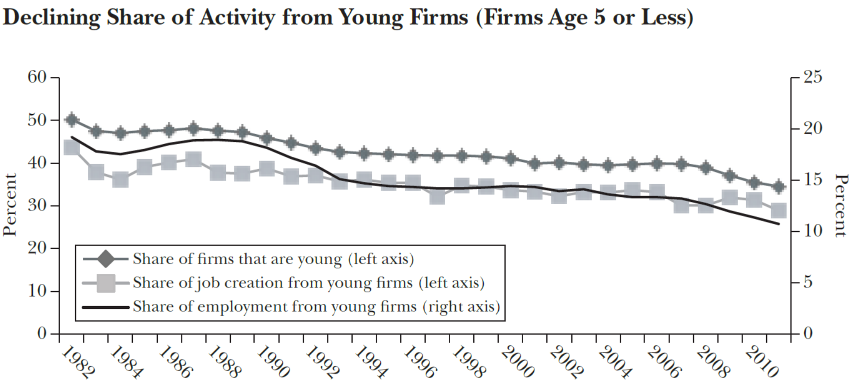
Firm entry rate ↓



Source: Decker et al. (2016) using BDS data

◂ return

Share of young firms ↓

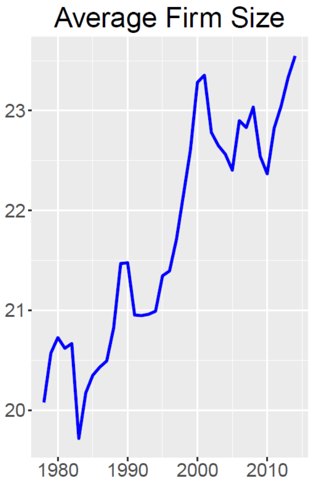


Source: Author calculations from the US Census Bureau's Business Dynamics Statistics.

Source: Decker et al. (2014)

return

Firm size ↑



Number of workers per firm. Source: Hopenhayn et al. (2018) using BDS data

return

Research productivity ↓

TABLE 7—SUMMARY OF THE EVIDENCE ON RESEARCH PRODUCTIVITY

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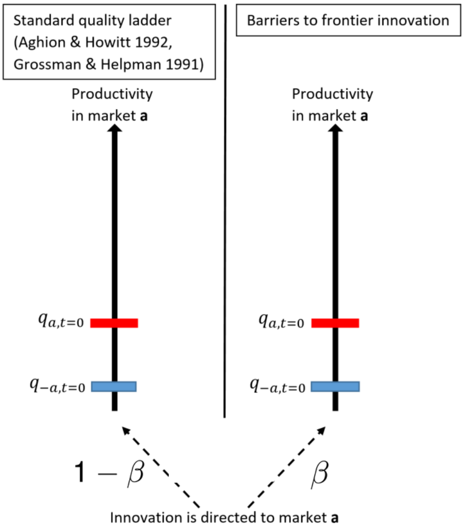
Source: Bloom et al. (2020)

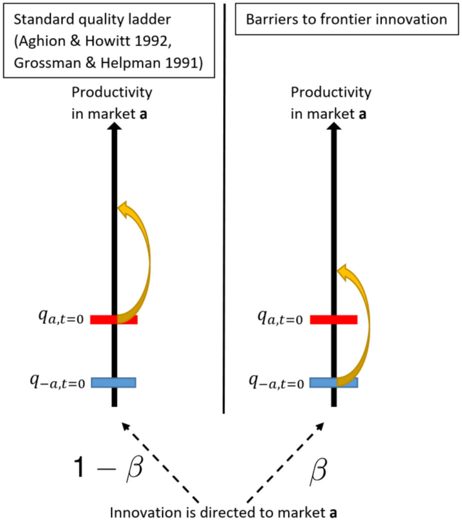
◂ return

Innovation stage: low-gap market

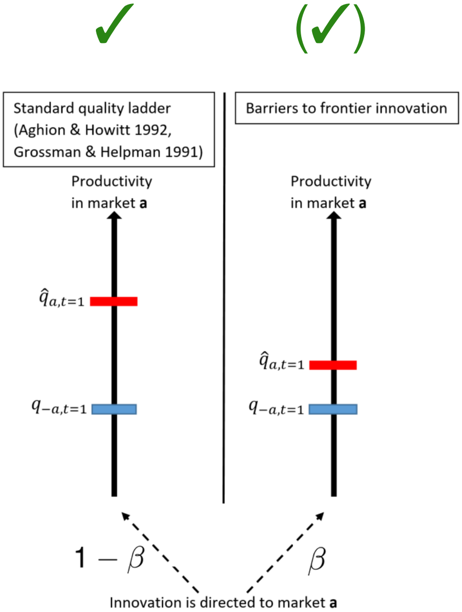


return

Innovation stage: low-gap market



return


✓
(✓)
Standard quality ladder (Aghion & Howitt 1992, Grossman & Helpman 1991)
Barriers to frontier innovation
Productivity in market a
Productivity in market a
$\hat{q}_{a,t=1}$
$q_{-a,t=1}$
$\hat{q}_{a,t=1}$
$q_{-a,t=1}$
$1-\beta$
β
Innovation is directed to market a

return

Firms

A firm j is the collection $\mathcal{I}(j)$ of markets (or product lines) in which j is the leader

- Payoff-relevant state variable: $\{\mu_i\}_{i \in \mathcal{I}(j)}$
- Firm size $n_j = |\mathcal{I}(j)|$

Firm dynamics

- Grow if innovate in a line operated by another firm
- Shrink if other firms/entrants innovate in a line $i \in \mathcal{I}(j)$
- Exit if last product is lost
- New firms enter with 1 product

return

Firm Problem I

To search a sample of s markets at rate x, need to employ

$$L_S(s, x) = x \frac{1}{\phi} \eta s^{\frac{1}{\eta}}$$

- $\eta \in (0, 1)$: search elasticity
- ϕ: search productivity

return

Firm Problem II

To innovate at rate x, a size-n firm needs to employ

$$L_{R\&D}(x|n) = \frac{1}{\tilde{\theta}}\gamma x^{\frac{1}{\gamma}} n^{\frac{\gamma-1}{\gamma}}$$

- $\gamma \in (0,1)$: innovation elasticity
- $\tilde{\theta}$: incumbent research productivity
- Can show: innovation intensity per product, $\tilde{x} \equiv x/n$, is the same for all firms

return

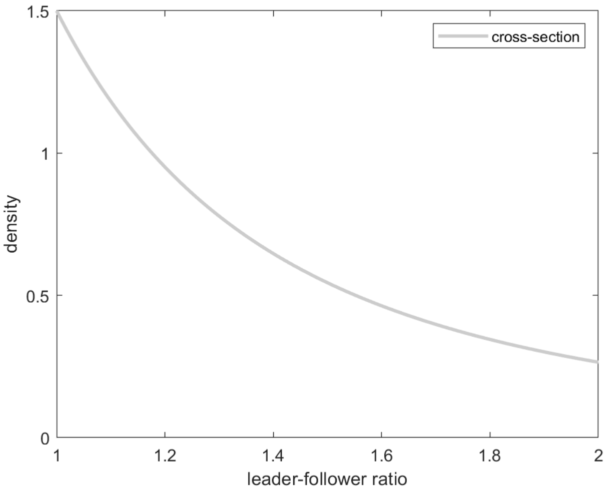
Free entry condition

Free entry condition determines mass of entrants $\mathcal{M}_0$:

$$0 = \max_{s} \left(\underbrace{1 - \beta + \beta \Pr\left(\text{innov} > \text{gap}(s)\right)}_{\Pr(\text{success}|\text{innov}),\ \uparrow \text{ in } s} \right) \times \underbrace{\mathbb{E}\left(V_{\text{new}}\right)}_{\downarrow \text{ in } \mathcal{M}_0} - \underbrace{L_e(s)}_{\uparrow \text{ in } s} \times wage$$

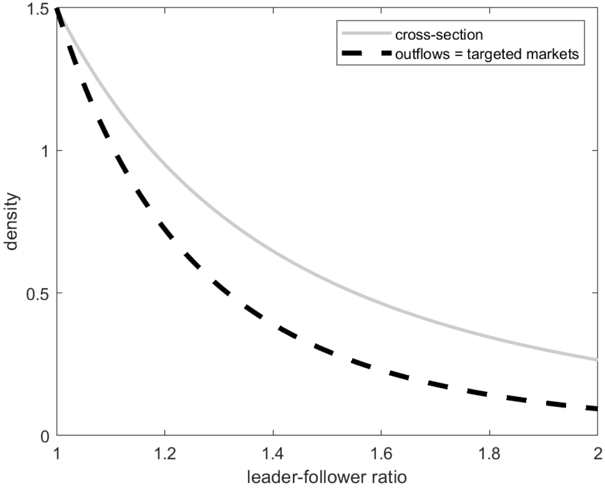
return to entry specification

Stationary Distribution?



◂ return

Stationary Distribution?



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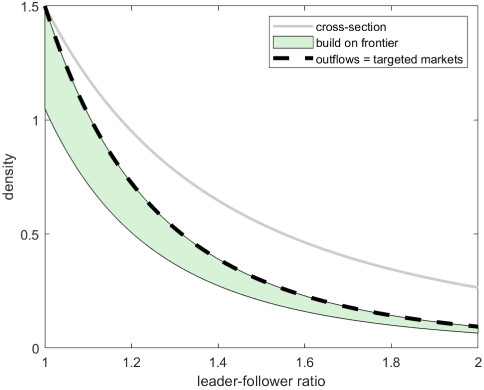
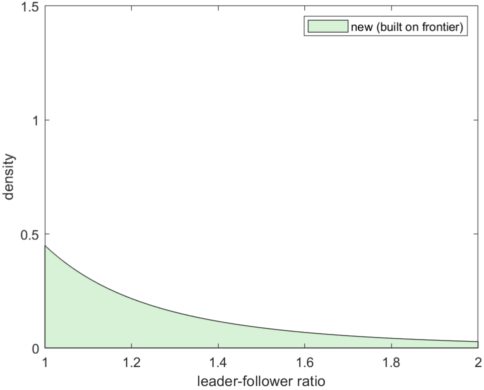


Outflows



Inflows

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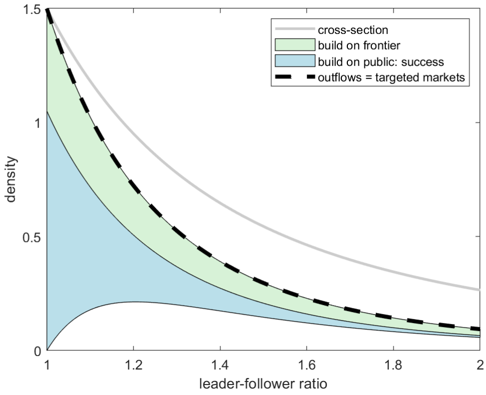

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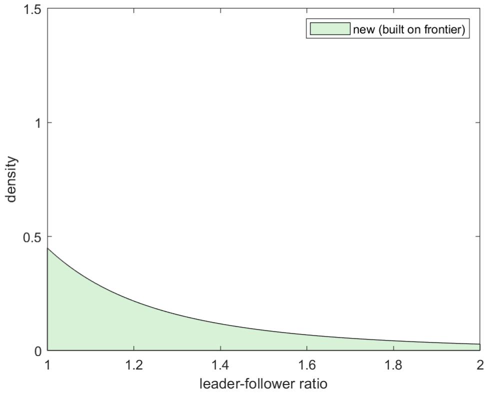
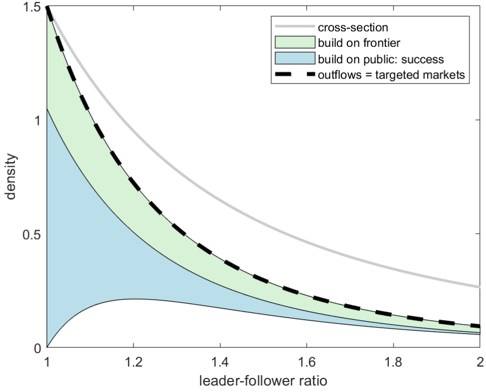
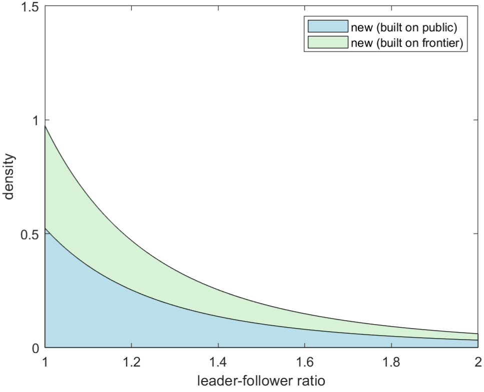


Inflows

Stationary Distribution?

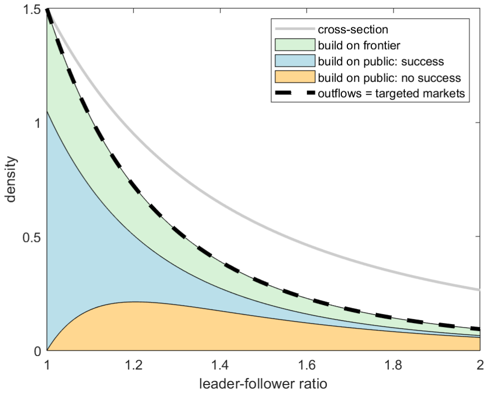


Outflows

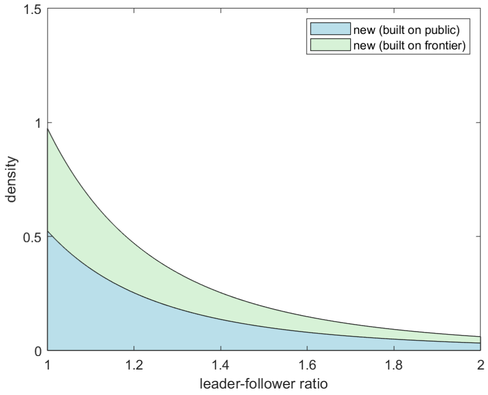


Inflows

Stationary Distribution?

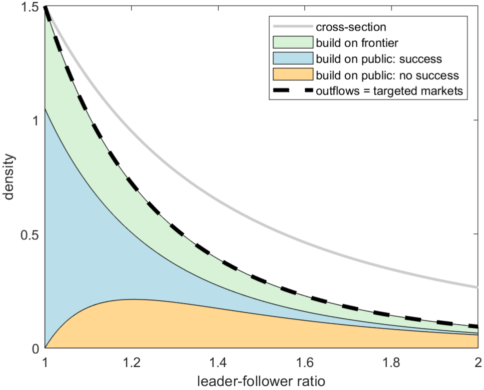


Outflows

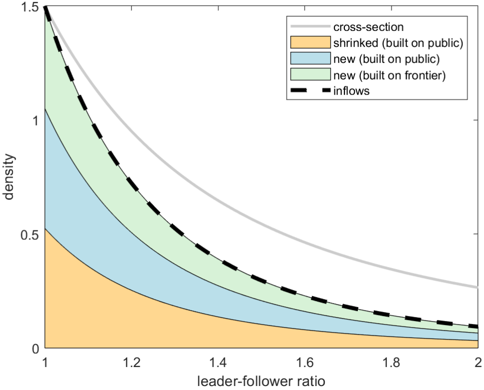


Inflows

Stationary Distribution?

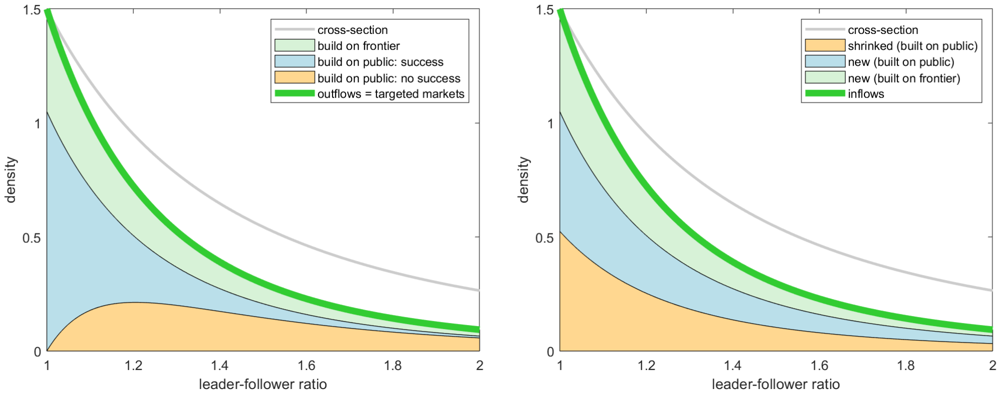


Outflows



Inflows

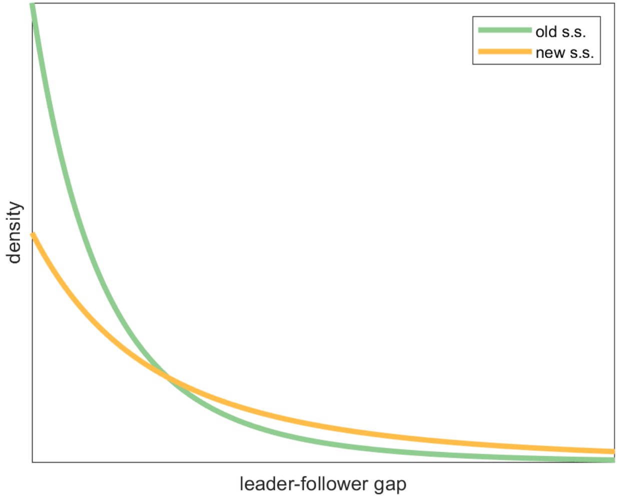
Stationary Distribution? Yes!



Outflows = Inflows

return

Effect of more search on gap distribution



return

Productivity growth: new vs. old steady state

$$g = \underbrace{(\tilde{x} + \mathcal{M}_0)}_{\textbf{declines}} \times \underbrace{\Pr(\text{success})}_{=(1-\frac{\beta}{2}),\ \text{constant}} \times \underbrace{\mathbb{E}(\ln(\text{StepSize}))}_{=\frac{1}{\alpha},\ \text{constant}}$$

(where $\mathcal{M}_0$ is the mass of entrants in the full model)

return

Product value function in steady state I

- Define $v_t(\mu) \equiv \frac{V_t(\mu)}{wage_t}$ as product value normalized by the wage
- $v_t(\mu) = v(\mu)$ constant in steady state
- It holds $\forall \mu \geq 1$:

$$\rho v(\mu) = \underbrace{\left(1 - \frac{1}{\mu}\right)\frac{Y}{wage} + \left(\frac{1}{\gamma} - 1\right)\frac{1}{\tilde{\theta}}\gamma(\tilde{x})^{\frac{1}{\gamma}}}_{\substack{\text{instantaneous payoff:} \\ \text{profits + option value of innovation}}}$$

$$- \underbrace{(\tilde{x} + \mathcal{M}_0)}_{\substack{\text{aggregate \#} \\ \text{of innovations}}} \underbrace{\frac{\alpha \mu^{-\alpha-1}}{\frac{\alpha}{s^*}\mu^{-\frac{\alpha}{s^*}-1}}}_{\substack{\text{gap-specific} \\ \text{correction of} \\ \text{hazard rate} \\ \text{(search effect)}}} \left(v(\mu) - \underbrace{\beta \Pr(\lambda \leq \mu)\,\mathbb{E}\left(v\left(\frac{\mu}{\lambda}\right)|\lambda \leq \mu\right)}_{\text{leader survives but gap shrinks}}\right),$$

Product value function in steady state II

Product value for $\mu = 1$ simplifies to

$$v(1) = \left(\frac{1}{\gamma} - 1\right)\frac{1}{\tilde{\theta}}\gamma(\tilde{x})^{\frac{1}{\gamma}} - \left(\tilde{x} + \mathcal{M}_0\right) s^* \, v(1)$$

- To solve for $v(\mu)$ for all $\mu > 1$, "unravel from below"

Solving for $\mathcal{M}_0$

Product value function $\forall \mu \geq 1$:

$$\rho v(\mu) = \underbrace{\left(1 - \frac{1}{\mu}\right)\frac{Y}{wage} + \left(\frac{1}{\gamma} - 1\right)\frac{1}{\tilde{\theta}}\gamma(\tilde{x})^{\frac{1}{\gamma}}}_{\text{instantaneous payoff}}$$

$$- \underbrace{(\tilde{x} + \mathcal{M}_0)}_{\substack{\text{aggregate \#} \\ \text{of innovations}}} \underbrace{\frac{\alpha\mu^{-\alpha-1}}{\frac{\alpha}{s^*}\mu^{-\frac{\alpha}{s^*}-1}}}_{\substack{\text{gap-specific} \\ \text{correction of} \\ \text{hazard rate}}} \left(v(\mu) - \underbrace{\beta \Pr(\lambda \leq \mu)\,\mathbb{E}\left(v\left(\frac{\mu}{\lambda}\right)|\lambda \leq \mu\right)}_{\text{leader survives but gap shrinks}}\right),$$

Free entry condition reads

$$\left(1 - \frac{\beta}{2}\right)\mathbb{E}(v_{\text{new}}) = \frac{1}{\phi}\eta s^{*\frac{1}{\eta}} + \frac{1}{\theta}(\mathcal{M}_0)^{\delta},$$

where we know the formula for s^* $\Rightarrow$ Easy to solve for $\mathcal{M}_0$ numerically