Endogenous Technology Adoption in a Search Economy

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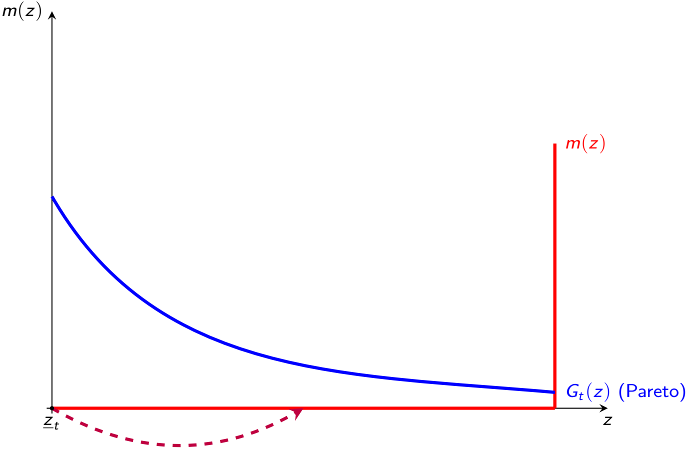
Workhorse Growth Models

Models based on creative destruction (Aghion and Howitt, 1992)

- The monopoly rents of an incumbent motivate potential entrants to pursue innovation

- Little incentive to narrow the gap with the leader through costly technology adoption

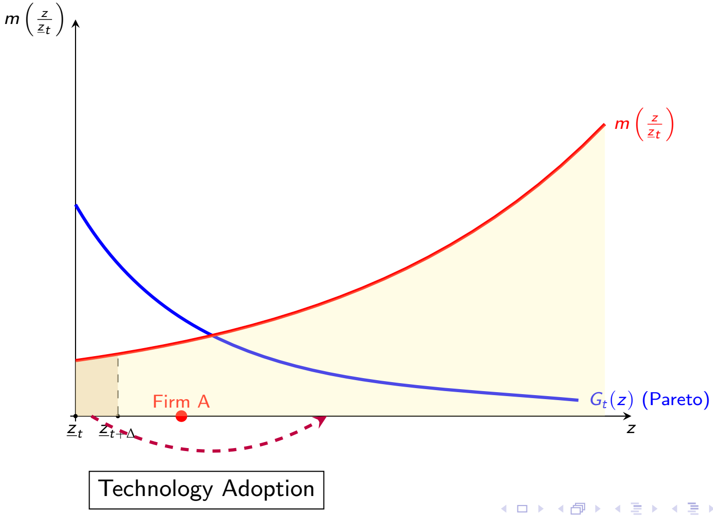


No Technology Adoption

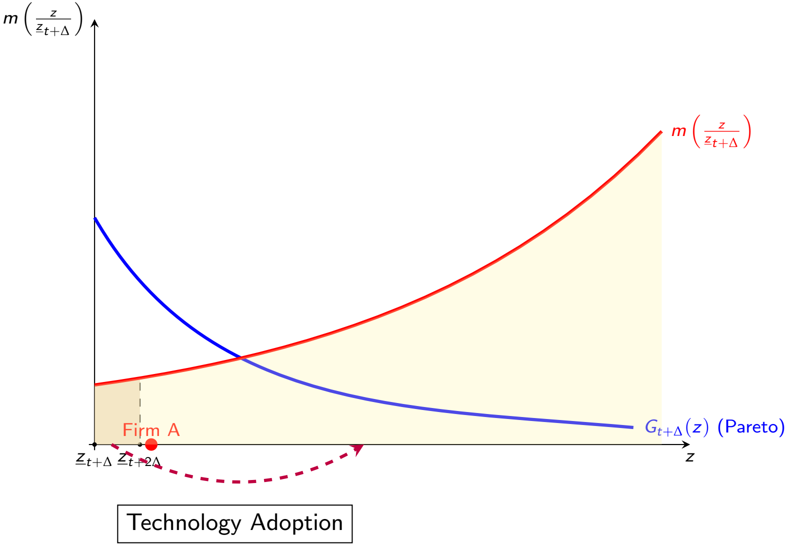
Frictional Search

Frictional search allows heterogeneous firms producing an identical variety to coexist in the market while charging different prices

- Now, technology laggards engage in costly adoption

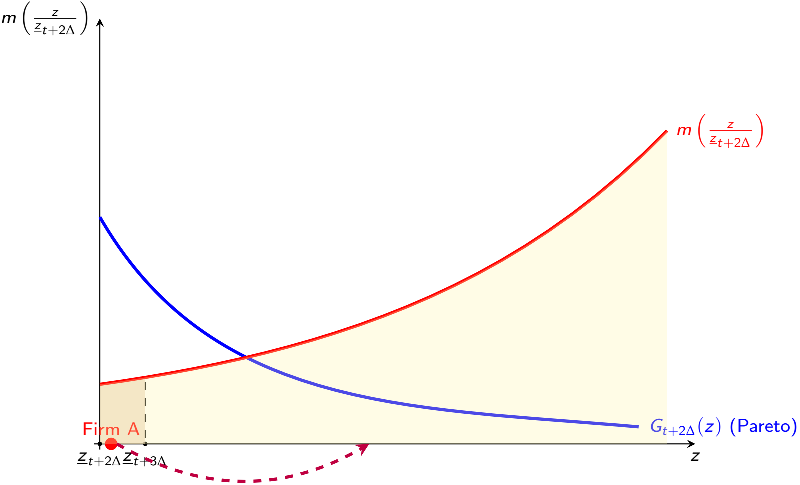


After Δ



- Firm A gets closer to the technology lower bound (markup↓)

After 2Δ



Firm A: Technology Adoption (Costly)

- Firm A finally hits the lower bound and engages in costly adoption (optimal stopping). The lower bound $\underline{z}_t$ grows at a constant rate g_z (along the balanced growth path).

What We Do

Characterize the balanced growth path for the economy with search frictions and technology adoption

- Multiple varieties, each produced by a continuum of firms with different productivities

- Static block (the endogenous markup distribution) + dynamic block (technology adoption decisions—production vs. paying a fixed cost for technology adoption)

- Surprising discontinuity: the degree of search frictions does not affect growth, provided that it is positive

  —As search becomes more efficient, the partial-equilibrium effect on markups (markup$\downarrow$) is exactly offset by the general-equilibrium effect on demand (demand$\uparrow$)

- Characterize three model extensions: endogenous firm entry, endogenous search effort, and creative destruction (breaking this partial- and general-equilibrium balance)

Quantitative analysis: structural changes in search efficiency (more efficient) and the right tail of the productivity distribution (thicker) over the past three decades have substantially raised welfare through technology adoption

- The U.S. productivity growth slowdown implies a sizable increase in adoption barriers

Literature

The Baseline Model

Environment

- A unit mass of homogeneous consumers (a unit labor supply)
- A unit continuum of varieties, each produced by a measure S of heterogeneous firms with different productivity (TFP)
- Both consumers and firms are subject to a Poisson search friction

Households preference:

$$U_t = \int_t^{\infty} e^{-\rho(s-t)} \ln C_s \, ds, \quad C_t = \left[\int_{\mathcal{S}_t} C_t(\omega)^{\frac{\sigma-1}{\sigma}} \, d\omega \right]^{\frac{\sigma}{\sigma-1}}$$

- $\mathcal{S}_t \subseteq [0,1]$ with measure $|\mathcal{S}_t| = \Omega_t$ is a random subset of accessible varieties to the representative consumer
- Face the usual budget constraint:

$$P_t C_t + A_t = w_t + \Pi_t + r_t A_t$$

Zero supply

- Normalize $P_t = 1$ (final good as numeraire)

Production Technology

Firms draw productivity from the Pareto distribution:

$$G_t(z) = 1 - \left(\frac{z}{\underline{z}_t}\right)^{-\theta}$$

Growth rate g_z (BGP)

- The shape parameter $\theta > 1$ with smaller θ indicating a heavier right tail
- Endogenous lower bound $\underline{z}_t > 0$ is determined by dynamic technology adoption decisions of firms, preserving the Pareto distribution with the shape parameter θ

Firms with z produce with labor and the CES aggregate of accessible intermediate varieties:

$$y_t(z) = z\left[\frac{Q_t(z)}{\alpha}\right]^{\alpha}\left[\frac{l_t(z)}{1-\alpha}\right]^{1-\alpha}, \quad Q_t(z) = \left[\int_{\mathcal{S}_t} q_t(\omega; z)^{\frac{\sigma-1}{\sigma}} \, \mathrm{d}\omega\right]^{\frac{\sigma}{\sigma-1}}$$

Accessible varieties

- The marginal cost $c_t(z) = \frac{w_t^{1-\alpha}}{z}$, whose time-invariant distribution is given by

$$H(c) = \left(\frac{c}{\bar{c}}\right)^{\theta}$$

Search and Matching

À la Menzio (2024a,b) and Miyauchi (2024), the Poisson arrival rate of a random encounter for any given variety:

$$M_t = \lambda S^{\gamma^s} B^{\gamma^b}$$

where λ denotes search efficiency and $B = S + 1$

Poisson arrival of suppliers

Probability that a given buyer encounters n random suppliers during unit time:

$$\frac{\exp\left(-\lambda S^{\gamma^s} B^{\gamma^b - 1}\right)\left(\lambda S^{\gamma^s} B^{\gamma^b - 1}\right)^n}{n!}$$

- The measure of accessible varieties (for consumers and firms)

$$\Omega_t = 1 - \exp\left(-\lambda S^{\gamma^s} B^{\gamma^b - 1}\right)$$

Probability that a given supplier with price p matches a buyer with n other encounters:

$$\left[1 - F_t(p)\right]^n$$

- $F_t(p)$: the price distribution

Firm's Problem

Firms with productivity z maximize profits, given by

$$\pi_t(p; z) = \bar{b}_t(p) \cdot \bar{q}_t(p) \cdot \left(p - \underbrace{\frac{w_t^{1-\alpha}}{z}}_{=c_t(z)} \right)$$

- $\bar{b}_t(p)$ is the expected number of buyers matched with the firm (within variety)
- $\bar{q}_t(p) = \bar{Q}_t p^{-\sigma}$ denotes demand per buyer, where $\bar{Q}_t$ is the expected real expenditure of a random buyer (across varieties)
- For analytical tractability, set $\sigma = 1$ (pricing features a Ricatti equation)

Write optimal $\tilde{p}_t(z)$ as $p_t(c)$

- $p_t(c)$ becomes time-invariant along the balanced growth path

Deriving $\bar{b}_t(p)$

Markup

Time-invariant

The markup charged by producers of varieties with unit cost c is given by:

$$m(c) \equiv \frac{p(c)}{c} = \frac{\left[\lambda S^{\gamma^s} B^{\gamma^b-1} H(c)\right]^{-\frac{1}{\theta}} \exp\left(-\lambda S^{\gamma^s} B^{\gamma^b-1} H(c)\right)}{\int_{\lambda S^{\gamma^s} B^{\gamma^b-1} H(c)}^{\infty} x^{-\frac{1}{\theta}} \exp(-x)\, \mathrm{d}x}$$

which decreases (increases) monotonically with unit cost c (produtivity z).

- $\Lambda(c) \equiv \lambda S^{\gamma^s} B^{\gamma^b-1} H(c)$ is the arrival rate of sellers with marginal costs below c
- The markup function is written as a gamma hazard rate

$$m(c) = m(\Lambda(c)) = \frac{\widetilde{\Gamma}'\left(\frac{\theta-1}{\theta}, \Lambda(c)\right)}{1-\widetilde{\Gamma}\left(\frac{\theta-1}{\theta}, \Lambda(c)\right)},$$

where

$$\widetilde{\Gamma}(a,x) = \frac{\int_0^x u^{a-1}\exp(-u)\,\mathrm{d}u}{\Gamma(a)}$$

- Note that $H(c) = \left(\frac{z_t}{z}\right)^{\theta}$, meaning $m\left(\frac{z_t}{z}\right)$

Interpretation

Firm Profit and Value

The markup $m(c_t(z))$ depends only on the inverse relative productivity $\hat{z} \equiv \frac{z_t}{z}$

- Profit $\pi_t(z) = D_t \cdot \hat{\pi}(\hat{z})$ is increasing (decreasing) in z ($\hat{z}$), where

Scale effect

$$D_t = \lambda^{\frac{\theta+1}{\theta}} S^{\frac{\theta+1}{\theta}\gamma^s - 1} B^{\frac{\theta+1}{\theta}\gamma^b - \frac{1}{\theta}} \overline{Q}_t$$

is the aggregate demand shifter

- Further detrend D_t by defining $D_t = \tilde{D} \cdot w_t$

Firm value function $V_{p,t}(z) = D_t \cdot v(\hat{z})$:

$$r_t V_{p,t}(z) = \pi_t(z) + \frac{\mathrm{d} V_{p,t}(z)}{\mathrm{d} t}$$

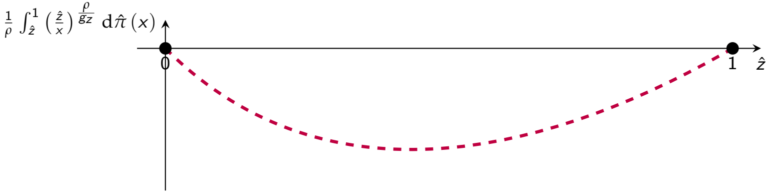
Firm Profit and Value

Detrended firm value function

Detrended value of current profits

$$v(\hat{z}) = \frac{1}{\rho}\hat{\pi}(\hat{z}) + \underbrace{\frac{1}{\rho}\int_{\hat{z}}^{1}\left(\frac{\hat{z}}{x}\right)^{\frac{\rho}{g_z}} \mathrm{d}\hat{\pi}(x)}_{\text{Catch-up (adoption)}}.$$

Detrended value of future profit losses



- This term approaches zero for $\hat{z} \to 0$ (most productive) or $\hat{z} \to 1$ (least productive)

Technology Adoption

Technology adoption requires paying a fixed cost of κ units of labor. The value is:

$$V_{a,t} = \int_{\underline{z}_t}^{\infty} V_{p,t}(z)\,\mathrm{d}G_t(z) - \kappa w_t$$

- Usual value matching condition:

$$V_{p,t}(\underline{z}_t) = V_{a,t}$$

- Smooth-pasting condition (Stokey, 2009):

$$\left.\frac{\partial V_{p,t}(z)}{\partial z}\right|_{z=\underline{z}_t} = \left.\frac{\partial V_{a,t}}{\partial z}\right|_{z=\underline{z}_t} = 0$$

Closing the Model

Aggregate real profit Π_t is given by:

$$\Pi_t = \left[\widetilde{D} S \int_0^1 \hat{\pi}(x)\, \mathrm{d}\hat{G}(x)\right] w_t,$$

where the detrended demand shifter $\widetilde{D}$ is:

Average production labor

$$\widetilde{D} = \left[\underbrace{(1-\alpha)\,\theta \int_0^1 \Gamma\left(\frac{\theta-1}{\theta}, \lambda S^{\gamma^s} B^{\gamma^b - 1} x^{\theta}\right) x^{\theta}\, \mathrm{d}x}_{\text{Labor misallocation}}\right]^{-1} \quad \frac{1 - S\kappa\theta g_z}{S}$$

Allocative efficiency (search friction)

- Even relatively unproductive firms retain positive labor demand, depressing $\tilde{D}$

Minimum Cost Distribution | Real Wage

Discontinuous Growth

Output, real wage, and consumption grow at g (BGP):

$$g = \frac{g_z}{1-\alpha} = \begin{cases} \dfrac{1-(1-\alpha)\,\rho S\kappa\theta}{(1-\alpha)\,[(1-\alpha)\,\theta+1]\,S\kappa\theta}, & \text{for } \lambda \in \mathbb{R}_{++}, \\ 0, & \text{for } \lambda = \infty. \end{cases}$$

- As long as $\lambda < \infty$, its magnitude does not affect the level of aggregate growth

Note that there are two effects when search becomes less frictional ($\lambda\uparrow$)

1. **Partial equilibrium effect**: the markup declines, reducing the incentive to adopt

$$\mathbb{E}v\,(x; g_z) - v\,(1; g_z) = \frac{1}{\rho+\theta g_z}\cancel{\int_0^1 \Gamma\left(\frac{\theta-1}{\theta}, \lambda S^{\gamma^s} B^{\gamma^b - 1} x^\theta\right) x^\theta \, \mathrm{d}x}$$

Detrended value
of adoption

2. **General equilibrium effect**: aggregate demand increases

$$\widetilde{D} = \left[(1-\alpha)\,\theta \cancel{\int_0^1 \Gamma\left(\frac{\theta-1}{\theta}, \lambda S^{\gamma^s} B^{\gamma^b - 1} x^\theta\right) x^\theta \, \mathrm{d}x}\right]^{-1} \frac{1 - S\kappa\theta g_z}{S}$$

The two effects exactly offset each other

Model Extensions

Breaking the Partial- and General-Equilibrium Balance

Entry cost

Extension 1: endogenous firm entry (Hopenhayn, 1992)

- Firm measure S is endogenously determined via the free-entry condition:

$$\underbrace{V_{e,t}}_{\text{Value of entry}} = \int_{\underline{z}_t}^{\infty} V_{p,t}(z)\,\mathrm{d}G_t(z) - \xi w_t = 0$$

- Other equilibrium conditions remain unchanged

$\propto \tilde{D}^{-1}$

- Less frictional search ($\lambda\uparrow$) reduces entry, i.e., $S\downarrow$, raising growth ($g\uparrow$) on the balanced growth path. S is determined by

$$\underbrace{\frac{1+\rho S\kappa}{(\xi-\kappa)\left[(1-\alpha)\theta+1\right]\rho S}}_{\downarrow \text{ in } S} = \frac{\int_0^1 \Gamma\left(\frac{\theta-1}{\theta}, \lambda S^{\gamma^s} B^{\gamma^b-1} x^{\theta}\right) x^{\theta}\,\mathrm{d}x}{\underbrace{\left(\lambda S^{\gamma^s} B^{\gamma^b-1}\right)^{-\frac{1}{\theta}} \exp\left(-\lambda S^{\gamma^s} B^{\gamma^b-1}\right) - \Gamma\left(\frac{\theta-1}{\theta}, \lambda S^{\gamma^s} B^{\gamma^b-1}\right)}_{=v(1)}}$$

Breaking the Partial- and General-Equilibrium Balance

Extension 2: endogeneous search effort (Arkolakis et al., 2025)

- A productivity-z firm chooses search effort $\lambda_t(z)$—the Poisson arrival rate of encounters between the firm and buyers is $\lambda_t(z)\, S^{\gamma^s} B^{\gamma^b}$. The firm chooses

$$\left(\tilde{p}_t\left(z;\overline{\lambda}_t\right), \underbrace{\lambda_t\left(z;\overline{\lambda}_t\right)}_{\uparrow \text{ in } z}\right) = \arg\max_{p,\lambda} \pi_t(\lambda, p, z) - \frac{\chi}{\varphi}\lambda^{\varphi} w_t$$

Search effort cost

- The arrival rate of total encounters remains Poisson, with

$$M_t = \overline{\lambda}_t S^{\gamma^s} B^{\gamma^b}, \quad \overline{\lambda}_t = \underbrace{S \int_{\underline{z}_t}^{\infty} \lambda_t(z)\, \mathrm{d}G_t(z)}_{\text{Aggregate search effort}} \tag{1}$$

- Two externalities (determine $\overline{\lambda}_t$ in a fixed-point problem):
  1. **Positive**: a higher $\lambda_t(z)$ mitigates labor misallocation and raises $\widetilde{D}\left(\overline{\lambda}\right)$,
  2. **Negative**: a higher $\lambda_t(z)$ depresses detrended profits $\hat{\pi}\left(\hat{z};\overline{\lambda}\right)$ for all $\hat{z}$.

- In our calibration, a lower χ (higher $\overline{\lambda}_t$) reduces search-labor misallocation, raising g

Derivation

Breaking the Partial- and General-Equilibrium Balance

Extension 3: creative destruction (Aghion and Howitt, 1992)

- Productivity follows a Pareto distribution truncated from both above and below:

$$\widetilde{G}_t(z) = \frac{1 - \left(\frac{z}{\underline{z}_t}\right)^{-\theta}}{1 - \left(\underbrace{\frac{\overline{z}_t}{\underline{z}_t}}_{\text{Constant } \iota^{-1} \text{ (BGP)}}\right)^{-\theta}},$$

- A firm's productivity leaps to a level marginally above the current technology frontier, with an exogenous Poisson arrival rate $\delta > 0$, pushing out $\overline{z}_t$

  —A shock to $\delta\uparrow$ increases the frontier growth rate, which in turn strengthens adoption incentives (Benhabib, Perla, and Tonetti, 2021)

- Bellman equation:

$$r_t \widetilde{V}_{p,t}(z) = \tilde{\pi}_t(z) + \delta \left[\underbrace{\widetilde{V}'_{p,t}(\overline{z}_t)\frac{\mathrm{d}\overline{z}_t}{\mathrm{d}t} + \widetilde{V}_{p,t}(\overline{z}_t)}_{\text{Jump to the frontier}} - \widetilde{V}_{p,t}(z) \right] - \varsigma \left(\frac{\underline{z}_t}{z}\right)^{\eta} w_t + \frac{\mathrm{d}\widetilde{V}_{p,t}(z)}{\mathrm{d}t}.$$

- In our calibration, a higher λ excessively reduces the detrended value of adoption (due to the upper bound), lowering g

Quantitative Analysis

Calibration and Estimation

Assumption (Structural Changes)

We treat the Poisson arrival rate of sellers $\frac{M}{B}$, the Pareto shape parameter θ, and technology adoption cost κ as having undergone structural changes over the past three decades

- Estimate $\frac{M}{B}$ and θ via GMM for 1989-1993 and 2019-2023 from the estimated markups for Compustat firms

  —Markup estimation from the production approach of De Loecker et al. (2020); with output elasticity estimation from Ackerberg et al. (2015) and De Ridder et al. (2025)

- Given a stable $g_z \simeq 0.8\%$[a], to what extent must the adoption cost parameter κ have changed?—according to the baseline + 3 different model extensions

[a] From U.S. utilization-adjusted TFP growth from Fernald (2015)

Need to estimate markups for firms producing an identical variety:

- Use time-varying product cosine similarity measures from the Embedding-Based Text Network Industry Classification (ETNIC) data of Hoberg and Phillips (2025)

Calibration and Estimation

For estimated markup $\hat{m}_{it}$:

$$\log \hat{m}_{it} = \beta_1^{\text{data}} + \sum_{n=2}^{4} \beta_{\Delta n}^{\text{data}} Q_{n,it} + \epsilon_{it}$$

and for model-implied markup m_{it}

$$\log m_{it} = \beta_1^{\text{model}} + \sum_{n=2}^{4} \beta_{\Delta n}^{\text{model}} Q_{n,it} + \epsilon_{it}$$

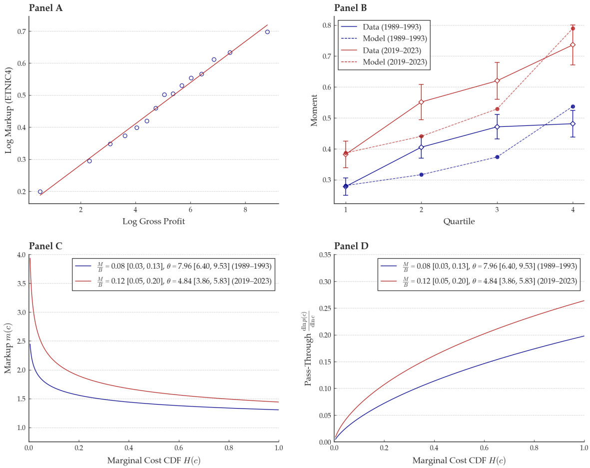
- $Q_{n,it}$: a dummy that equals 1 if the gross profit of firm i at time t falls into the nth quartile

The GMM estimator is given by:

$$\left(\widehat{\frac{M}{B}}, \hat{\theta}\right) = \underset{\left(\frac{M}{B}, \theta\right)}{\arg\min} \left(\boldsymbol{\beta}^{\text{data}} - \boldsymbol{\beta}^{\text{model}}\right)' \, \boldsymbol{W} \, \left(\boldsymbol{\beta}^{\text{data}} - \boldsymbol{\beta}^{\text{model}}\right) \tag{2}$$

Optimal weighting matrix

- The secular trend is more efficient search ($\frac{M}{B}\uparrow$) and a thicker right tail of the productivity distribution ($\theta\downarrow$)



Panel A shows a binned scatter plot of log markup against log gross profit, where markups are estimated using ETNIC data from Hoberg and Phillips (2025) and financial data from Compustat over the sample period from 1989 to 2023. Panel B compares the moments obtained by running the following regression in the data and the model:

$$\log \hat{m}_{it} = \beta_1 + \sum_{n=2}^{4} \beta_{\Delta n} \, Q_{n,it} + \epsilon_{it},$$

where the plotted moments correspond to β_1 and $\beta_1 + \beta_{\Delta n}$ for $n \in \{2, 3, 4\}$. Panels C and D illustrate the model-implied within-variety markup and pass-through, respectively, based on the estimated $\left(\widehat{\frac{M}{B}}, \hat{\theta}\right)$ for the two sub-periods.

Table: Parameterization

Description (Notation)	Method	Value
Poisson arrival rate of sellers ($\frac{M}{B}$)	GMM estimation (see text)	0.08 $[0.03, 0.13]$ for 1989–1993
		0.12 $[0.05, 0.20]$ for 2019–2023
Pareto shape of productivity distribution (θ)	GMM estimation (see text)	7.96 $[6.40, 9.53]$ for 1989–1993
		4.84 $[3.86, 5.83]$ for 2019–2023
Consumer discount rate (ρ)	External calibration from Akcigit and Kerr (2018)	0.02
Cost share of intermediate inputs (α)	External calibration from Edmond et al. (2023)	0.45
Poisson arrival rate of creative destruction (δ)	External calibration from Aghion et al. (2019)	0.01
Research cost elasticity (η)	External calibration from Acemoglu et al. (2018)	0.50
Total measure of firms per variety (S)	Internal calibration (see text)	0.01
Fixed cost of technology adoption (κ)	Internal calibration (see text)	Model-specific
Fixed cost of entry (ξ)	Internal calibration (see text)	2670.78
Search cost elasticity (φ)[1]	Internal calibration (see text)	2.32 for 1989–1993
		1.36 for 2019–2023
Research cost scale (ς)	Internal calibration (see text)	0.72
Elasticities in Poisson encounter rate (γ^s and γ^b)	No calibration required given $\frac{M}{B}$	–
Search cost scale (χ)	No calibration required given $\frac{M}{B}$	–
Initial productivity lower bound ($\underline{z}_0$)	Normalization	1

[1]For reference, in the Chilean economy in 2019, φ equals 4.5 (goods) and 2.8 (service) (Arkolakis et al., 2025).

Baseline Model

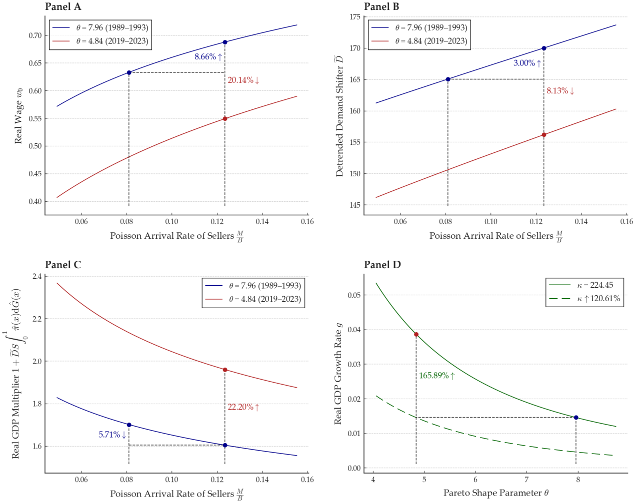


Figure: Baseline Model

Panel A illustrates the initial real wage w_0. Panel B shows the detrended demand shifter $\widetilde{D}$. Panel C presents the real GDP multiplier $1 + \widetilde{D}S \int_0^1 \hat{\pi}(x)\, d\hat{G}(x)$. Panel D visualizes the real GDP growth rate g.

Endogenous Entry

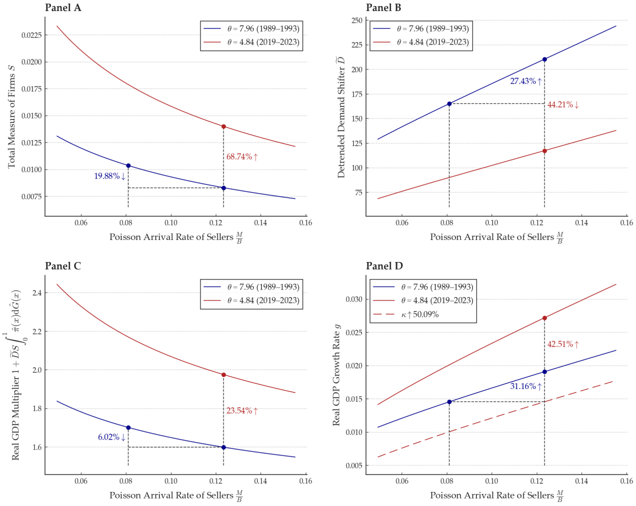


Figure: Endogenous Entry

Panel A illustrates the total measure of firms per variety, S. Panel B shows the detrended demand shifter $\widetilde{D}$. Panel C presents the real GDP multiplier $1 + \widetilde{D}S \int_0^1 \hat{\pi}(x)\, d\hat{G}(x)$. Panel D visualizes the real GDP growth rate g.

Endogenous Search Effort

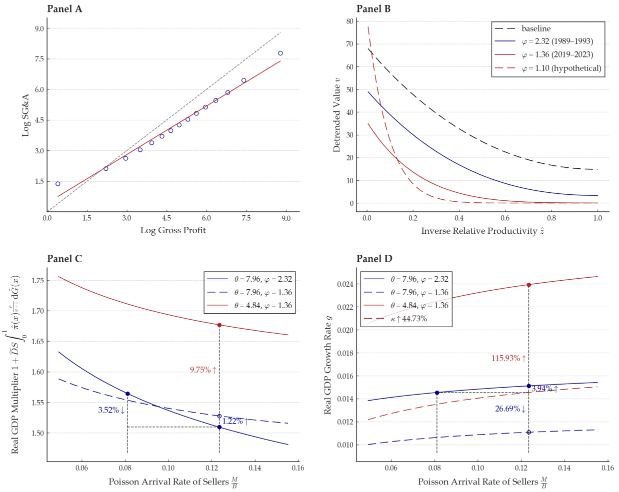


Figure: Endogenous Search Effort

Panel A shows a binned scatter plot of log selling, general, and administrative expenses (SG&A) against log gross profit using Compustat data from 1989 to 2023. Panel B illustrates the detrended value function $v\left(\hat{z};\overline{\lambda}\right)$ for different values of the search-cost elasticity parameter φ. Panel C presents the real GDP multiplier $1+\widetilde{D}S\int_0^1 \hat{\pi}\left(x\right)^{\frac{\varphi}{\varphi-1}} \mathrm{d}\hat{G}\left(x\right)$.

Creative Destruction

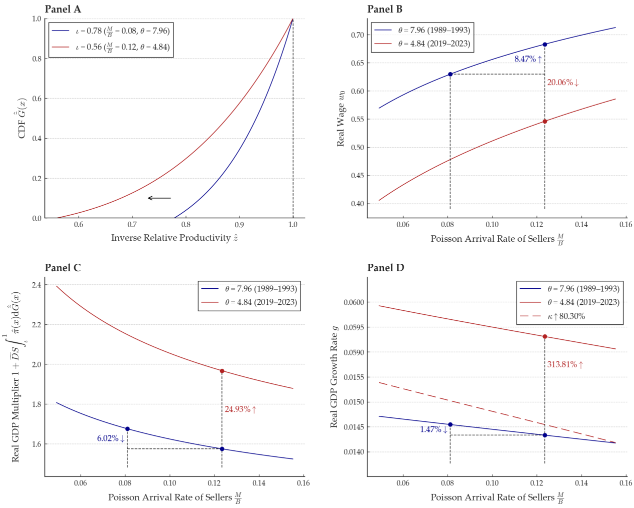


Figure: Creative Destruction

Panel A illustrates the inverse productivity dispersion ι for two sets of $\left(\widehat{\frac{M}{B}}, \hat{\theta}\right)$. Panel B shows the initial real wage w_0. Panel C presents the real GDP multiplier $1 + \widetilde{D}S \int_\iota^1 \hat{\pi}(x)\, \mathrm{d}\hat{\widetilde{G}}(x)$. Panel D visualizes the real GDP growth rate g.

Thank you very much!
(Appendix)

Literature

Frictional search to microfound imperfectly competitive market structures and characterize the static equilibrium price dispersion

- Stigler (1961), Varian (1980), Burdett and Judd (1983), Janssen and Moraga-González (2004), Ellison and Ellison (2009), Choi et al. (2018), Menzio (2024a,b)

Models of technology adoption and diffusion

- Agents are passively exposed to technological externalities (Kortum, 1997; Luttmer, 2007, 2011; Bloom et al., 2013; Buera and Oberfield, 2020)
- Active decisions of firms to adopt better technology at a cost: Lucas and Moll (2014), Perla and Tonetti (2014), Sampson (2016) and Perla et al. (2021)

Endogenous search efforts in product markets

- Allen (2014), Arkolakis et al. (2025)

Interaction between technology adoption and innovation

- Benhabib et al. (2021), Trouvain (2024)

Large incumbents using various tactics to stifle technology adoption by their smaller competitors (strategic patenting, litigation, and restrictions on labor mobility)

- Galasso and Schankerman (2015), Hall et al. (2021), Akcigit and Ates (2023), Akcigit and Goldschlag (2023), Argente et al. (2025), Fernández-Villaverde et al. (2025)

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The Expected Number of Matched Buyers

Total number of encounters
with buyers with n other encounters

The number of encounters between a supplier and buyers with n other encounters per unit time:

$$\frac{B\frac{\exp\left(-\lambda S^{\gamma^s}B^{\gamma^b-1}\right)\left(\lambda S^{\gamma^s}B^{\gamma^b-1}\right)^{n+1}}{(n+1)!}(n+1)}{S}=\lambda S^{\gamma^s-1}B^{\gamma^b}\frac{\exp\left(-\lambda S^{\gamma^s}B^{\gamma^b-1}\right)\left(\lambda S^{\gamma^s}B^{\gamma^b-1}\right)^{n}}{n!}$$

The expected number of buyers whom a given supplier with price p matches with:

$$\sum_{n=0}^{\infty}\lambda S^{\gamma^s-1}B^{\gamma^b}\frac{\exp\left(-\lambda S^{\gamma^s}B^{\gamma^b-1}\right)\left(\lambda S^{\gamma^s}B^{\gamma^b-1}\right)^{n}}{n!}\left(1-F_t\left(p\right)\right)^n$$
$$=\underbrace{\lambda S^{\gamma^s-1}B^{\gamma^b}\exp\left(-\lambda S^{\gamma^s}B^{\gamma^b-1}F_t\left(p\right)\right)}_{=\overline{b}_t(p)}$$

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Pass-Through Interpretation

Decreasing $m(c)$ implies incomplete pass-through from c to $p(c)$

$$\frac{\mathrm{d}\ln p(c)}{\mathrm{d}\ln c} = \theta\Lambda(c)\left[m(c) - 1\right] < 1$$

As $c\uparrow$, note that $m(c)\downarrow$ and $\Lambda(c)\uparrow$

- $m(c)\downarrow$ (weaker market power) $\Longrightarrow$ lower pass-through (Atkeson and Burstein, 2008)
- $\Lambda(c)\uparrow \Longrightarrow$ more likely that potential buyers encounter sellers with lower costs (greater competition)$\Longrightarrow$ focus on buyers who encounter sellers with higher marginal costs

Escape-competition
(raising pass-through)

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Minimum Cost Distribution

Probability that the minimum cost of a given variety among sellers encountered by a buyer with n encounters is no more than c:

$$1-[1-H(c)]^n = 1-\left[1-\left(\frac{c}{\overline{c}}\right)^{\theta}\right]^n$$

Probability that the minimum cost of any given variety among sellers encountered by any given buyer is no more than c:

$$\begin{aligned}\Omega H_{min,t}(c) &= \sum_{n=1}^{\infty} \frac{\exp\left(-\lambda S^{\gamma^s} B^{\gamma^b-1}\right)\left(\lambda S^{\gamma^s} B^{\gamma^b-1}\right)^n}{n!}\left\{1-\left[1-\left(\frac{c}{\overline{c}}\right)^{\theta}\right]^n\right\} \\ &= 1-\exp\left(-\lambda S^{\gamma^s} B^{\gamma^b-1}\overline{c}^{-\theta}c^{\theta}\right)\end{aligned}$$

leading to

$$H_{min}(c) = \frac{1-\exp\left(-\lambda S^{\gamma^s} B^{\gamma^b-1}\overline{c}^{-\theta}c^{\theta}\right)}{\Omega}.$$

- Right-truncated Weibull distribution with shape parameter θ, scale parameter $\lambda S^{\gamma^s} B^{\gamma^b-1}$ and truncation point $\overline{c}$

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Real Wage

Real wage w_t is given by:

$$w_t = \left[\exp\left[1 - \frac{\lambda S^{\gamma^s} B^{\gamma^b - 1} \exp\left(-\lambda S^{\gamma^s} B^{\gamma^b - 1} \right) - \mu\left(\lambda S^{\gamma^s} B^{\gamma^b - 1} \right)}{\Omega} \right] \left(\lambda S^{\gamma^s} B^{\gamma^b - 1} \right)^{\frac{1}{\theta}} \underline{z}_t \right]^{\frac{1}{1-\alpha}}$$

where the measure of accessible varieties $\Omega = 1 - \exp\left(-\lambda S^{\gamma^s} B^{\gamma^b - 1} \right)$ and

$$\mu\left(\lambda S^{\gamma^s} B^{\gamma^b - 1} \right) = \int_0^{\lambda S^{\gamma^s} B^{\gamma^b - 1}} \frac{\ln \Gamma\left(\frac{\theta - 1}{\theta}, x \right)}{\exp(x)} \, \mathrm{d}x$$

When search becomes more efficient (i.e., higher)

- Access to a wider range of varieties (i.e., higher Ω)
- More likely to encounter sellers with low marginal costs (i.e., higher $H_{min}(c)$)
- Sellers tend to charge lower prices due to intensified competition (i.e., lower $p(c)$)

—All forces raise real wage w_t

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Endogenous Search Effort

Additional convexity

Detrended firm value function

$$v\left(\hat{z};\overline{\lambda}\right)=\frac{\varphi-1}{\rho\varphi}\left[\hat{\pi}\left(\hat{z};\overline{\lambda}\right)^{\frac{\varphi}{\varphi-1}}+\int_{\hat{z}}^{1}\left(\frac{\hat{z}}{x}\right)^{\frac{\rho}{g_z}}\mathrm{d}\hat{\pi}\left(x;\overline{\lambda}\right)^{\frac{\varphi}{\varphi-1}}\right].$$

Output, real wage, and consumption grow at g (BGP):

$$g\left(\overline{\lambda}\right)=\frac{g_z\left(\overline{\lambda}\right)}{1-\alpha}=\frac{1-\left[\Xi\left(\overline{\lambda}\right)+(1-\alpha)\,\theta\right]\rho S\kappa}{(1-\alpha)\left[\Xi\left(\overline{\lambda}\right)+(1-\alpha)\,\theta+1\right]S\kappa\theta},$$

where

$$\Xi\left(\overline{\lambda}\right)=\frac{\frac{1}{\varphi}\int_0^1\hat{\pi}\left(x;\overline{\lambda}\right)^{\frac{\varphi}{\varphi-1}}\mathrm{d}\hat{G}\left(x\right)}{\int_0^1\hat{\pi}\left(x;\overline{\lambda}\right)^{\frac{1}{\varphi-1}}\Gamma\left(\frac{\theta-1}{\theta},\overline{\lambda}S\gamma^{s}B\gamma^{b-1}x^{\theta}\right)x^{\theta}\,\mathrm{d}x}.$$

- $\Xi\left(\overline{\lambda}\right)$: labor misallocation from low-productivity firms' labor for search activities

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