# Ownership Structure and Economic Growth

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# Ownership Structure $\Longrightarrow$ Economic Growth?

- Onwership structure is concentrated
  - BlackRock, Vanguard, State Street, and Fidelity control 30% of votes of S&P 500 firms
  - Top 4 chaebols account for 55% of stock market capitalization in Korea

Share

- Firms maximize shareholder values $\Longrightarrow$
  Partially internalize externalities for commonly owned firm
- Ownership structure (common ownership, cross ownership, M&A, FDI, ...) $\Longrightarrow$
  Economic growth?
  - Business stealing effect
  - Technology spillover effect

# Quantitative Schumpeterian Growth Model with Ownership Structure

- Existing Schumpeterian growth models:
  - Monopolistic competition (no strategic interaction)
  - Very few firms in Markov perfect equilibrium
- This paper: Many oligopolists + Ownership structure
- Identify three inter-firm networks for publicly listed patenting firms in the US ($\simeq$ 1000 firms)
  - Ownership structure
  - Product market rivalry
  - Technology spillover
- Common ownership in the US:
  - Internalization of business stealing $\Longrightarrow g \downarrow\downarrow$
  - Internalization of technology spillover $\Longrightarrow g \uparrow$

# Literature

- Competition & Innovation:
  d'Aspremont and Jacquemin (1988); Kamien et al. (1992); Aghion et al. (2001, 2005); Acemoglu and Akcigit (2012); Aghion et al. (2013); Bloom et al. (2013); Lopez and Vives (2019); Peters (2020); Akcigit and Ates (2021, 2023); Liu et al. (2022); Cavenaile et al. (2023); Anton et al. (2023, 2024); Kini et al. (2024); Hopenhayn and Okumura (2024)
  Quantitative Schumpeterian growth model with ownership structure
- Hedonic Demand / Empirical IO:
  Lancaster (1966); Rosen (1974); Berry et al. (1995); Nevo (2001); Pellegrino (2024); Ederer and Pellegrino (2024)
  Dynamic general equilibrium / R&D
- Oligopoly / Common Ownership / Market Power:
  Rubinstein and Yaari (1983); Rotemberg (1984); Neary (2003); Atkeson and Burstein (2008); Gutierrez and Philippon (2017); He and Huang (2017); Azar et al. (2018, 2022); Autor et al. (2020); Baqaee and Farhi (2020); De Loecker et al. (2020); Azar and Vives (2021); Edmond et al. (2023)

# Model

- Firm $i \in \{1, \ldots, n\}$
- Final good linear quadratic aggregator (Pellegrino, 2024; Ederer and Pellegrino, 2024):

$$Y_t = \boldsymbol{q}_t^T \boldsymbol{b}_t - \frac{1}{2} \boldsymbol{q}_t^T \boldsymbol{\Sigma} \boldsymbol{q}_t$$

- Linear inverse demand:

$$\boldsymbol{p}_t = \boldsymbol{b}_t - \boldsymbol{\Sigma} \boldsymbol{q}_t$$

- CRS intermediate good production technology:

$$q_{i,t} = a_{i,t} l_{i,t}$$

- Each firm has knowledge capital (state variable): $z_{i,t}$
- Each firm allocates knowledge capital to improve labor productivity and product quality:

$$\zeta a_{i,t} + b_{i,t} = z_{i,t}$$

# Law of Motion of Knowledge Capital

$$dz_t = \left( \underbrace{\Omega z_t}_{\text{tech spillover}} + \underbrace{\mu x_t}_{\text{R\&D}} \right) dt + \underbrace{\gamma z_t \circ dW_t}_{\text{shocks}}$$

- $\Omega = [\omega_{ij}]$: technology spillover matrix
- $x_{i,t} = \sqrt{d_{i,t}}$
  - $d_{i,t}$: R&D input in terms of final good
  - Innovation elasticity is 0.5
- $\mu$, $\gamma$: positive scalars

# Market Clearing and Preference

- Inelastic labor supply:

$$L = \sum_i l_{i,t}$$

- Final good market clearing:

$$C_t + \underbrace{\sum_i d_{i,t}}_{\text{R\&D input}} = Y_t$$

- Risk neutral representative household:

$$\max \; \boldsymbol{E}_t \left[ \int_t^{\infty} \exp\left(-\rho s\right) C_s ds \right]$$

# Common Ownership Weights

- $\boldsymbol{K} = [\kappa_{ij}]$: common ownership weights that firm $i$ places on the value of firm $j$ $\quad (\kappa_{ii} = 1)$
- More overlapping ownership b/w firm $i$ and $j \implies$ Higher $\kappa_{ij}$ Proportional Influece
- $\boldsymbol{K} = \boldsymbol{I}$: dispersed ownership (each firm maximizes its own value)
- $\boldsymbol{K} = \mathbf{1}_{n \times n}$: monopoly (maximizes total producer surplus)

# Cournot-Nash Equilibrium

- Firm $i$'s gross profit before subtracting dynamic R&D cost: Diagram

$$\pi_{i,t} = p_{i,t} q_{i,t} - w_t l_{i,t} = \left( b_{i,t} - \sum_j \sigma_{ij} q_{j,t} - \frac{w_t}{a_{i,t}} \right) q_{i,t} \quad \text{where} \quad \zeta a_{i,t} + b_{i,t} = z_{i,t}$$

- Given $w_t$, $z_{i,t}$, and $\{q_{j,t}\}_{j \neq i}$, firm $i$ chooses $a_{i,t}$, $b_{i,t}$, and $q_{i,t}$ to maximize $\sum_j \kappa_{ij} \pi_{j,t}$
- Quantity is a linear function of knowledge capital:

$$\boldsymbol{q}(\boldsymbol{z}_t) = \left\{ \underbrace{2 \frac{\zeta}{L} \mathbf{1}_{n \times n}}_{\text{labor cost}} + \underbrace{\boldsymbol{\Sigma}}_{\text{substitutability}} + \underbrace{\boldsymbol{K} \circ \boldsymbol{\Sigma}}_{\text{ownership} \times \text{substitutability}} \right\}^{-1} \boldsymbol{z}_t$$

- Ownership-weighted gross profits are expressed in quadratic form: $\sum_j \kappa_{ij} \pi_{j,t} = \boldsymbol{z}_t^T \boldsymbol{Q}^i \boldsymbol{z}_t$ Q

# Linear-Quadratic Differential Game

- Given other firms' R&D $\{x_{j,t}\}_{j\neq i,t\geq 0}$, firm $i$ chooses R&D $\{x_{i,t}\}_{t\geq 0}$ to maximize

$$\max_{\{x_{i,t}\}_{t\geq 0}} \quad V^i(\boldsymbol{z}_0) \equiv \boldsymbol{E}_0\left[\int_0^\infty \exp(-\rho t)\left\{\sum_j \kappa_{ij}\left(\pi_{j,t} - x_{j,t}^2\right)\right\} dt\right]$$

subject to $d\boldsymbol{z}_t = \left(\boldsymbol{\Omega}\boldsymbol{z}_t + \mu \boldsymbol{x}_t\right) dt + \gamma \boldsymbol{z}_t \circ d\boldsymbol{W}_t$

- Firm $i$'s HJB equation:

$$\rho V^i(\boldsymbol{z}) = \max_{x_i}\left\{\boldsymbol{z}^T \boldsymbol{Q}^i \boldsymbol{z} - \sum_j \kappa_{ij} x_j^2 + V_{\boldsymbol{z}}^i(\boldsymbol{z})\left[\boldsymbol{\Omega}\boldsymbol{z} + \mu \boldsymbol{x}\right] + \frac{\gamma^2}{2}\boldsymbol{z}^T V_{\boldsymbol{z}\boldsymbol{z}}^i(\boldsymbol{z})\,\boldsymbol{z}\right\}$$

# HJB Equations $\Longrightarrow$ Riccati Equations

- Guess and verify $V^i(z) = z^T X^i z$ (for any $z$)
- $X^i$ is the solution of stacked algebraic Riccati equations Riccati
- All public patenting firms in the US in our dataset ≃1000 firms $\Longrightarrow$ $1000^3 = 1$ billion undetermined coefficients (20 seconds on my laptop)

| Oligopolistic Schumpeterian | Computation time | # of firms | Productivity space |
|---|---|---|---|
| Cavenaile et al. (2023) | $O(2^n)$ | 4 | 6 grid |
| Our model | $O(n^4)$ | ≈1000 | Continuous |

# Balance Growth Path

- R&D strategy: $x_{i,t} = \left(\mu \boldsymbol{X}_i^i\right)^T z_t$ where $\boldsymbol{X}_i^i$ is the $i$ th column of $\boldsymbol{X}^i$
- The law of motion is rewritten as $dz_t = \boldsymbol{\Phi} z_t dt + \gamma z_t \circ d\boldsymbol{W}_t$ where

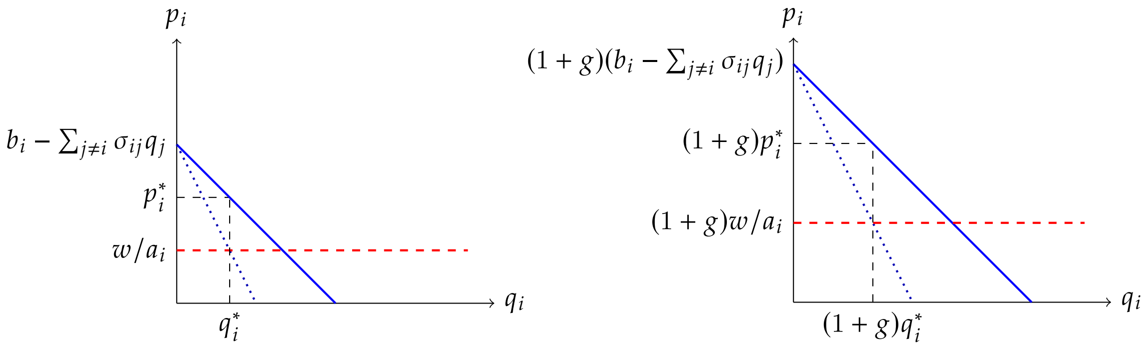
$$\boldsymbol{\Phi} \equiv \underbrace{\boldsymbol{\Omega}}_{\text{Tech Spillover}} + \underbrace{\mu^2 \left[\boldsymbol{X}_1^1 \cdots \boldsymbol{X}_n^n\right]^T}_{\text{R\&D}}$$

## Theorem

*Consider the deterministic economy* $(\gamma = 0)$. *If* $\boldsymbol{\Phi}$ *is irreducible, then:*
*(i) There exists largest positive eigenvalue of* $\boldsymbol{\Phi}$, $g$, *and associated positive eigenvector,* $z^*$.
*(ii) There exists a globally stable BGP such that the knowledge capital growth rate of all firms is* $g$, *and the knowledge capital distribution is a scalar multiple of* $z^*$.

- Proof: Perron–Frobenius Theorem
- "$\boldsymbol{\Phi}$ is irreducible" $\Longleftrightarrow$ "All firms are directly or indirectly connected technologically"

# Partial Equilibrium Diagram and (Deterministic) BGP




- $a_i$, $b_i$, $q_i (= a_i l_i)$, $p_i$, and $w/a_i$ grow at the same rate of $g$
- (i) (consumer surplus / producer surplus) and (ii) (cost / revenue) stay the same

Back

# Expected Growth Rate and Utility

- Apply Ito's lemma:

Decomposition

$$\begin{aligned} \log Y_t &= \log\left(\boldsymbol{z}_t^T \boldsymbol{Q} \boldsymbol{z}_t\right) \\ d\boldsymbol{z}_t &= \boldsymbol{\Phi} \boldsymbol{z}_t dt + \gamma \boldsymbol{z}_t \circ d\boldsymbol{W}_t \end{aligned} \implies \boldsymbol{E}_t\left[ g_t \middle| \boldsymbol{z}_t \right]$$

- Expected utility is expressed in quadratic form:

X

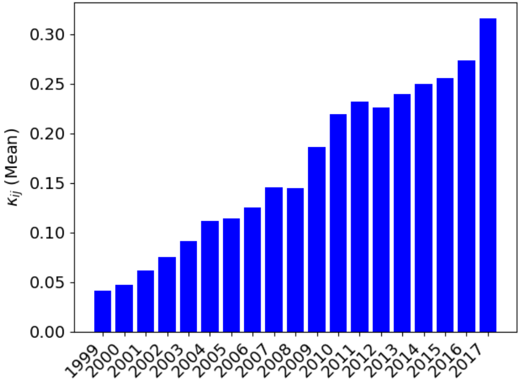
$$\boldsymbol{E}_t\left[ \int_t^\infty \exp\left(-\rho s\right) C_s ds \middle| \boldsymbol{z}_t \right] = \boldsymbol{z}_t^T X \boldsymbol{z}_t$$

- Solve the equilibrium once $\implies$ Can compute expected growth and utility for any $z_t$

# Common Ownership $K$

- Backus et al. (2021) construct a dataset on investors' holdings based on Form 13F
- Baseline: Rotemberg (1984) proportional influence

Proportional Influence



# Product Market Rivalry $\Sigma$

- Hoberg and Phillips (2016) estimates product proximity using business descriptions in 10-K
- Pellegrino (2024) estimates $\alpha$ to align with the cross-price elasticity of demand micro estimates

$$\underbrace{\sigma_{ij}}_{\text{substitutability}} = \alpha \times \text{product proximity b/w } i \text{ and } j \quad (i \neq j)$$

# Technological Proximity $\widetilde{\Omega}$

- Technological profile of firm $i$
  - The vector of the share of patents held by firm $i$ in each technology class
  - Baseline: group-level patent classifications ($\approx 4000$)
- Jaffe (1986) technological proximity measure $\tilde{\omega}_{ij}$:
  - Cosine similarity of the technological profiles b/w firm $i$ and $j$

# Distribution of Knowledge Capital $z_t$

| Variables | Identification |
|---|---|
| $\pi_{i,t}$ | Gross profit (before R&D cost) = Revenue − Cost of goods sold |
| $\boldsymbol{q}_t$ | $\pi_{i,t} = \sum_j \kappa_{ij}\, \sigma_{ij}\, q_{i,t}\, q_{j,t}$ |
| $\zeta/L$ | Matches sample firms' cost share (average markup) |
| $\boldsymbol{z}_t$ | $\boldsymbol{z}_t = \left\{ 2\frac{\zeta}{L}\boldsymbol{J} + \boldsymbol{\Sigma} + \boldsymbol{K} \circ \boldsymbol{\Sigma} \right\} \boldsymbol{q}_t$ |

# Technology Spillover $\mathbf{\Omega} = \beta\times$Technological Proximity $\widetilde{\mathbf{\Omega}}$ First Stage

$$z_{i,t+1} - z_{i,t} = \beta \sum_{j\neq i} \tilde{\omega}_{ij,t} z_{j,t} + \text{Year FE}_t + \epsilon_{i,t}$$

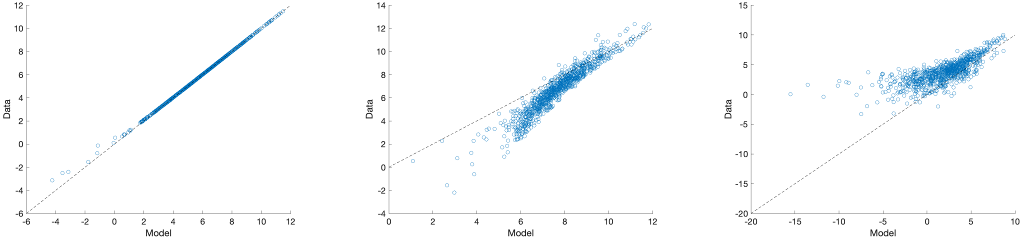
| | (1) | (2) | (3) |
|---|---|---|---|
| | $z_{i,t+1} - z_{i,t}$ | $z_{i,t+1} - z_{i,t}$ | $z_{i,t+1} - z_{i,t}$ |
| $\sum_{j\neq i} \tilde{\omega}_{ij,t} z_{j,t}$ | 0.000191*** | 0.000152*** | 0.000140*** |
| | (0.000035) | (0.000035) | (0.000039) |
| $\sqrt{\text{R\&D Expenditure}}$ | | 0.037** | |
| | | (0.021) | |
| Year Fixed Effects | ✓ | ✓ | ✓ |
| IV | | | ✓ |
| IV 1st Stage F-statistics | | | 4176 |
| No. observations | 16,324 | 15,173 | 14,181 |

SEs clustered by years and 4-digit naics industries are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

- IV: Firm-specific tax price of R&D from federal and state-specific rules (Bloom et al., 2013)

# Fit b/w Model and Data

- Comparison of firm-level model-generated values ($x$-axis) with observed data ($y$-axis)




(a) Log of Profit (Targeted) (b) Log of Sales (c) Log of R&D Expenditure

# Counterfactual Ownership Structures

| Ownership Structure | Description |
|---|---|
| Baseline | Observed ownership structure in 2017 |
| Dispersed | $\boldsymbol{K}^{D} = \boldsymbol{I}$ |
| Mean=1999 | $\kappa^{M1999}_{ij,2017} =$ const $\times\, \kappa_{ij,2017}$ and $\boldsymbol{E}\left[\kappa^{M1999}_{ij,2017}\right] = \boldsymbol{E}\left[\kappa_{ij,1999}\right]$ for $j \neq i$ |
| Uniform | $\kappa^{U}_{ij,2017} = \boldsymbol{E}\left[\kappa_{ij,2017}\right]$ for $j \neq i$ |
| Monopoly | $\boldsymbol{K}^{M} = \boldsymbol{1}$ |

# Total Output

| Total Output in 2017 (Social Optimum: 100) | Ownership (Baseline: 2017) | | | | |
|---|---|---|---|---|---|
| | Dispersed | Mean=1999 | Uniform | Baseline | Monopoly |
| Baseline | 91.30 | 91.02 | 90.78 | 89.08 | 89.17 |
| Only Business Steal $\boldsymbol{\Omega} = [0]$ | 91.30 | 91.02 | 90.78 | 89.08 | 89.17 |
| Only Tech Spill $\boldsymbol{\Sigma} = \boldsymbol{I}$, $\zeta/L = 0$ | 75.00 | 75.00 | 75.00 | 75.00 | 75.00 |

- Inelastic labor supply $\Longrightarrow$ Changes arise from product misallocation
- Common ownership exacerbates product misallocation

# Total R&D Expenditure

| Total R&D in 2017 (Social Optimum: 100) | Ownership (Baseline: 2017) | | | | |
|---|---|---|---|---|---|
| | Dispersed | Mean=1999 | Uniform | Baseline | Monopoly |
| Baseline | 27.08 | 26.83 | 26.44 | 23.21 | 18.48 |
| Only Business Steal $\boldsymbol{\Omega} = [0]$ | 29.08 | 28.72 | 27.95 | 24.23 | 18.85 |
| Only Tech Spill $\boldsymbol{\Sigma} = \boldsymbol{I}, \zeta/L = 0$ | 18.27 | 18.34 | 18.75 | 18.86 | 19.84 |

- Internalization of business stealing > Internalization of technology spillover
- Network heterogeneity is important

# Expected Growth Rate

| Expected Economic Growth Rate in 2017 (%) | Ownership (Baseline: 2017) | | | | |
|---|---|---|---|---|---|
| | Dispersed | Mean=1999 | Uniform | Baseline | Monopoly |
| Baseline | 1.796 | 1.793 | 1.791 | 1.753 | 1.713 |
| Only Business Steal $\mathbf{\Omega} = [0]$ | 1.097 | 1.094 | 1.093 | 1.062 | 1.020 |
| Only Tech Spill $\mathbf{\Sigma} = \boldsymbol{I},\ \zeta/L = 0$ | 2.051 | 2.054 | 2.068 | 2.072 | 2.107 |

- In baseline, the expected growth rate is
  - 0.043 pp (2.4%) lower compared to dispersed ownership, and
  - 0.040 pp (2.2%) lower compared to common ownership level in 1999.

# Expected Social Welfare

| Expected Social Welfare (Social Optimum: 100) | Ownership (Baseline: 2017) | | | | |
|---|---|---|---|---|---|
| | Dispersed | Mean=1999 | Uniform | Baseline | Monopoly |
| Baseline | 87.72 | 87.42 | 87.16 | 85.25 | 85.18 |
| Only Business Steal $\boldsymbol{\Omega} = [0]$ | 88.83 | 88.53 | 88.30 | 86.44 | 86.41 |
| Only Tech Spill $\boldsymbol{\Sigma} = \boldsymbol{I}, \zeta/L = 0$ | 68.81 | 68.82 | 68.88 | 68.89 | 69.02 |

- In the baseline, the consumption-equivalent welfare loss is
  - 2.8% compared to dispersed ownership, and
  - 2.5% compared to the common ownership level in 1999.

# Firm Value Share

| Firm Value Share in 2017 (%) | Ownership (Baseline: 2017) | | | | |
|---|---|---|---|---|---|
| | Dispersed | Mean=1999 | Uniform | Baseline | Monopoly |
| Baseline | 28.74 | 29.63 | 33.43 | 33.34 | 40.92 |
| Only Business Steal $\boldsymbol{\Omega} = [0]$ | 27.91 | 28.80 | 32.60 | 33.51 | 40.14 |
| Only Tech Spill $\boldsymbol{\Sigma} = \boldsymbol{I}$, $\zeta/L = 0$ | 64.82 | 64.81 | 64.76 | 64.74 | 64.63 |

- In baseline, firm value share is
  - 5.6% higher compared to dispersed ownership, and
  - 4.7% higher compared to common ownership level in 1999.

# Conclusion

- Quantitative Schumpeterian growth model with ownership structure
  - Utilize micro data and computational capability
- Common ownership in the US:
  1. Internalization of business stealing effect $\Longrightarrow g \downarrow\downarrow$
  2. Internalization of technology spillover effect $\Longrightarrow g \uparrow$
- Potential applications:
  - Chaebols in Korea
  - Zaibatsu (pre-WWII) and cross-shareholding (late 20th century) in Japan
  - FDI / multinational companies and international technology diffusion

# Share of Top 5 Shareholders in Largest Market Cap Firms

Back

| Microsoft | |
|---|---|
| Vanguard | 9.20% |
| Blackrock | 7.75% |
| Steven Ballmer | 4.48% |
| State Street | 3.97% |
| Fidelity | 2.66% |

| Nvidia | |
|---|---|
| Vanguard | 8.93% |
| BlackRock | 7.74% |
| Fidelity | 4.12% |
| State Street | 3.97% |
| Jensen Huang | 3.80% |

| Apple | |
|---|---|
| Vanguard | 9.29% |
| Blackrock | 7.48% |
| State Street | 3.96% |
| Fidelity | 2.27% |
| Geode Capital | 2.26% |

| Google | |
|---|---|
| Vanguard | 7.36% |
| Blackrock | 6.47% |
| State Street | 3.39% |
| Fidelity | 3.01% |
| Sergey Brin | 2.99% |

| Amazon | |
|---|---|
| Jeffrey Bezos | 8.58% |
| Vanguard | 7.77% |
| Blackrock | 6.50% |
| State Street | 3.44% |
| Fidelity | 3.10% |

| Meta | |
|---|---|
| Vanguard | 7.55% |
| Blackrock | 6.50% |
| Fidelity | 5.38% |
| Accel IX LP | 3.88% |
| State Street | 3.40% |

# Equity Investments by Big tech in AI Startups Back

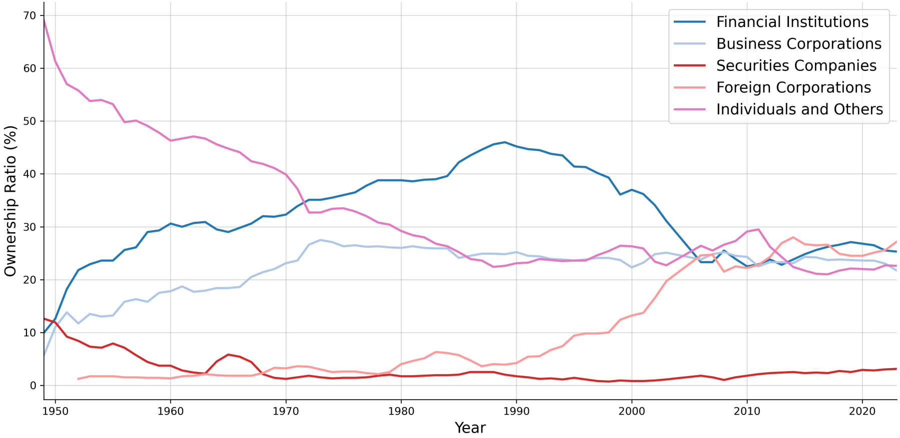
| Shareholding percentage | Microsoft | Google | Amazon |
|---|---|---|---|
| OpenAI (ChatGPT) | 49% | — | — |
| Anthropic (Claude) | — | 14% | 23% |

# Technology & Product Proximity: Example

| Tesla vs. Ford | |
|---|---|
| Technology Proximity | 0.11 |
| Product Proximity | 0.15 |

| Apple vs. Intel | |
|---|---|
| Technology Proximity | 0.57 |
| Product Proximity | 0.00 |

# Ownership Ratio by Holder Types in Japan



# Simple Model

- Static partial equilibrium model of oligopolistic competition in production and R&D
  - d'Aspremont and Jacquemin (1988); Kamien et al. (1992); Leahy and Neary (1997); Lopez and Vives (2019); Anton et al. (2024)
- Firm $i \in \{1, \ldots, n\}$ chooses quantity $q_i$ and R&D effort $x_i$
- Linear inverse demand: $\boldsymbol{p}(\boldsymbol{q}) = \boldsymbol{b} - \boldsymbol{\Sigma q} \quad (\sigma_{ii} = 1)$
- CRS production technology with marginal cost: $\boldsymbol{m}(\boldsymbol{x}) = \overline{\boldsymbol{m}} - \boldsymbol{\Omega x}$
- Quadratic cost of R&D: $c(x_i) = \frac{1}{2}x_i^2$

# Cournot & R&D Game

- Firm $i$'s profit:

$$\begin{aligned}\pi_i(\boldsymbol{q},\boldsymbol{x}) &= [p_i(\boldsymbol{q}) - m_i(\boldsymbol{x})]q_i - c(x_i)\\ &= \left[b_i - \sum_{j=1}^{n} \sigma_{ij} q_j - \overline{m}_i + \sum_{j=1}^{n} \omega_{ij} x_j\right] q_i - \frac{1}{2} x_i^2\end{aligned}$$

- Given $\{q_j, x_j\}_{j \neq i}$, firm $i$ chooses $q_i$ and $x_i$ to maximize $\sum_j \kappa_{ij} \pi_j(\boldsymbol{q},\boldsymbol{x})$

# Impact of Common Ownership on R&D

- Comparative statics where $\{q_k, x_k\}_{k \neq i}$ are held constant:

$$\frac{\partial x_i}{\partial \kappa_{ij}} = \frac{q_j}{2 - \omega_{ii}^2}(2\omega_{ij} - \omega_{ii}\sigma_{ij}) \qquad \forall\, j \neq i$$

  - SOC: $2 > \omega_{ii}^2$

- Internalize business stealing effect: $\partial^2 x_i / \partial \kappa_{ij} \partial \sigma_{ij} < 0$
- Internalize technology spillover effect: $\partial^2 x_i / \partial \kappa_{ij} \partial \omega_{ij} > 0$

# Rotemberg (1984) Proportional Influence

- $o \in \{1, 2, ..., n_o\}$: owners
- $s_{io}$: the proportion of shares in firm $i$ owned by owner $o$ where $\sum_o s_{io} = 1$
- $\widehat{V}_i$: value of firm $i$
- $\widetilde{V}_o \equiv \sum_i s_{io} \widehat{V}_i$: value of owner $o$
- Firms' objective:

$$\sum_o s_{io} \widetilde{V}_o \propto \sum_j \kappa_{ij} \widehat{V}_j$$

where

$$\kappa_{ij} \equiv \frac{\mathbf{s}_i^T \mathbf{s}_j}{\mathbf{s}_i^T \mathbf{s}_i} = \cos(\mathbf{s}_i, \mathbf{s}_j) \sqrt{\frac{IHHI_j}{IHHI_i}} \quad \text{where} \quad \mathbf{s}_i \equiv [s_{i1}, ..., s_{io}, ..., s_{in_o}]^T$$

Back

# Total Surplus

- Total surplus for product $i$:

$$ts_i(\boldsymbol{q},\boldsymbol{x}) = \pi_i(\boldsymbol{q},\boldsymbol{x}) + cs_i(\boldsymbol{q}) = q_i\left[b_i - \frac{1}{2}\sum_{j=1}^{n}\sigma_{ij}q_j - \overline{m}_i + \sum_{j=1}^{n}\omega_{ij}x_j\right] - \frac{1}{2}x_i^2$$

# R&D Externalities

1. Business stealing effect
   - Innovators steel the business (profits) of other firms
2. Technology spillover effect
   - Innovation improves the productivity of other firms
3. Appropriability effect (market power)
   - Innovators cannot appropriate the entire consumer surplus

# R&D Allocation and Externalities

- Firms maximize common owner weighted profits:

$$x^* = (K \circ \Omega)[\Sigma + K \circ \Sigma - \Omega(K \circ \Omega)]^{-1}(b - \overline{m})$$

- Firms maximize common owner weighted total surplus (★):

$$x^*_{TS} = (K \circ \Omega)\left[\frac{1}{2}(\Sigma + K \circ \Sigma) - \Omega(K \circ \Omega)\right]^{-1}(b - \overline{m})$$

- $K = [1]$ in (★) $\Longrightarrow$ Social Optimum
- Externalities: (i) Appropriability, (ii) Business stealing, (iii) Technology spillover

# Generalized Hedonic-Linear Demand (Pellegrino, 2024)

- $i \in \{1, 2, ..., n\}$: firms / products
- 1 unit of product $i$ provides
  - 1 unit of idiosyncratic characteristic $k \in \{1, 2, ..., n\}$
  - $\psi_{k,i}$ unit of shared characteristic $k \in \{n+1, n+2, ..., n+n_k\}$ where $\sum_k \psi_{k,i}^2 = 1$
- Aggregate each characteristic:

$$y_{k,t} = \begin{cases} q_{k,t} & k = 1, 2, ..., n \\ \sum_i \psi_{k,i} q_{i,t} & k = n+1, n+2, ..., n+n_k \end{cases}$$

- Linear quadratic aggregator over characteristics:

$$Y_t = (1-\alpha) \sum_{k=1}^{n} \left( \underbrace{\hat{b}_{k,t} y_{k,t} - \frac{1}{2} y_{k,t}^2}_{\text{idiosyncratic characteristic}} \right) + \alpha \sum_{k=n+1}^{n+n_k} \left( \underbrace{\hat{b}_{k,t} y_{k,t} - \frac{1}{2} y_{k,t}^2}_{\text{shared characteristic}} \right)$$

# Preview of Identification Strategy

| Networks | Measurement |
|---|---|
| Common ownership $K$ | Institutional investor holdings (Backus et al., 2021) |
| Product market rivalry $\Sigma$ | Product proximity (Hoberg and Phillips, 2016):<br>Text analysis of business description |
| Technology spillover $\Omega$ | Technology proximity (Jaffe, 1986; Bloom et al., 2013):<br>Patent classification |

# Generalized Hedonic-Linear Demand (Pellegrino, 2024)

- Quality:

$$b_i = (1-\alpha)\,\hat{b}_i + \alpha \sum_{k=n+1}^{n+n_k} \psi_k \hat{b}_k$$

- Inverse demand:

$$\frac{\boldsymbol{p}}{P} = \boldsymbol{b} - \boldsymbol{\Sigma q}$$

- Inverse cross price elasticity of demand:

$$\frac{\partial \log p_i}{\partial \log q_j} = -\frac{q_j}{p_i} \cdot \sigma_{ij}$$

- Cross price elasticity of demand:

$$\frac{\partial \log q_i}{\partial \log p_j} = -\frac{p_j}{q_i} (\boldsymbol{\Sigma}^{-1})_{ij}$$

# Static Profits

- Gross profit: $\pi_{i,t} = \sum_j \kappa_{ij}\sigma_{ij}q_{i,t}q_{j,t}$
- Firms choose labor productivity and product quality: $\zeta a_{i,t} = \sqrt{\zeta w_t}$, $b_{i,t} = z_{i,t} - \sqrt{\zeta w_t}$
- Labor market clearing: $L = \sum_i \frac{q_{i,t}}{a_{i,t}} \Longrightarrow \sqrt{\zeta w_t} = \frac{\zeta}{L}\sum_i q_{i,t}$
- $\boldsymbol{q}_t = \boldsymbol{N}\boldsymbol{z}_t$ where $N \equiv \left\{2\frac{\zeta}{L}\boldsymbol{J} + \boldsymbol{\Sigma} + \boldsymbol{K}\circ\boldsymbol{\Sigma}\right\}^{-1}$
- $\boldsymbol{N}_i$: the $i$ th row of $\boldsymbol{N}$
- Ownership weighted profit:

$$\sum_j \kappa_{ij}\frac{\pi_{j,t}}{P_t} = \sum_j \kappa_{ij}\sum_h \kappa_{jh}\sigma_{jh}q_{j,t}q_{h,t} = \boldsymbol{z}_t^T\boldsymbol{Q}^i\boldsymbol{z}_t$$

where

$$\boldsymbol{Q}^i = \frac{1}{2}\sum_j \kappa_{ij}\sum_h \kappa_{jh}\sigma_{jh}\left(N_j^T N_h + N_h^T N_j\right)$$

Back

# Riccati Equations

- $V^i(z) = z^T X^i z$ where $X^i$ is the solution of the stacked Riccati equation

$$0 = Q^i - \mu^2 \sum_j \kappa_{ij} X_j^j \left(X_j^j\right)^T + \left(\Phi - \frac{1}{2}\left(\rho - \gamma^2\right) I\right)^T X^i + X^i \left(\Phi - \frac{1}{2}\left(\rho - \gamma^2\right) I\right)$$

  - $X_i^i \equiv$ the $i$ th column of $X^i$
  - $\Phi \equiv \Omega + \mu^2 \begin{bmatrix} X_1^1 & \cdots & X_n^n \end{bmatrix}^T$

- Algorithm: Given $\begin{bmatrix} X_\tau^1 & \cdots & X_\tau^n \end{bmatrix}$, update $\begin{bmatrix} X_{\tau-\Delta}^1 & \cdots & X_{\tau-\Delta}^n \end{bmatrix}$ by

$$-\frac{X_\tau^i - X_{\tau-\Delta}^i}{\Delta} = Q^i - \mu^2 \sum_j \kappa_{ij} X_{j,\tau}^j \left(X_{j,\tau}^j\right)^T + \left(\Phi_\tau - \frac{1}{2}\left(\rho - \gamma^2\right) I\right)^T X_\tau^i + X_\tau^i \left(\Phi_\tau - \frac{1}{2}\left(\rho - \gamma^2\right) I\right)$$

Back

# Summary of Equilibrium

| Description | Expression |
|---|---|
| Production strategy | $\boldsymbol{q}_t = N\boldsymbol{z}_t$ |
| R&D strategy | $\boldsymbol{x}_t = \mu\tilde{X}\boldsymbol{z}_t$ |
| Law of motion | $d\boldsymbol{z}_t = \left(\Omega\boldsymbol{z}_t + \mu\boldsymbol{x}_t\right) dt + \gamma\boldsymbol{z}_t dW_t$ |
| Profit of final producers | $\Pi_t^F/P_t = \boldsymbol{q}_t^T \left(\frac{1}{2}\Sigma\right) \boldsymbol{q}_t$ |
| Total operating profit of firms | $\Pi_t/P_t = \boldsymbol{q}_t^T \left(\frac{1}{2}\Sigma \circ \left(K + K^T\right)\right) \boldsymbol{q}_t$ |
| Labor income | $w_t L/P_t = \boldsymbol{q}_t^T \left(\frac{\zeta}{L}J\right) \boldsymbol{q}_t$ |
| Output | $Y_t = \boldsymbol{q}_t^T \left(\frac{\zeta}{L}J + \frac{1}{2}\Sigma + \frac{1}{2}\Sigma \circ \left(K + K^T\right)\right) \boldsymbol{q}_t$ |
| Consumption | $C_t = Y_t - \boldsymbol{x}_t^T \boldsymbol{x}_t$ |

Back

# Intuition of Why the Model Has the BGP

- On the BGP, $\boldsymbol{a}_t$, $\boldsymbol{b}_t$, $\boldsymbol{z}_t$, and $\boldsymbol{q}_t$ grow at the same rate

| | |
|---|---|
| Technological Choice: | $\zeta a_{i,t} + b_{i,t} = z_{i,t}$ |
| Linear Production Technology: | $q_{i,t} = a_{i,t} l_{i,t}$ |
| Inelastic Labor Supply: | $L = \sum_i l_{i,t}$ |

- Linear and quadratic term in $\boldsymbol{q}_t$ of output grow at the same rate: Equilibrium Summary

$$Y_t = \boldsymbol{q}_t^T \boldsymbol{b}_t - \frac{1}{2} \boldsymbol{q}_t^T \boldsymbol{\Sigma} \boldsymbol{q}_t$$

# Output and Expected Utility

- Output: $Y_t = \boldsymbol{q}_t^T Q \boldsymbol{q}_t$ where

$$Q = \frac{\zeta}{L} J + \frac{1}{2}\Sigma + \frac{1}{2}\Sigma \circ \left(K + K^T\right)$$

- Expected utility:

$$V\left(\boldsymbol{z}_t\right) \equiv \boldsymbol{E}_t \left[ \int_t^{\infty} \exp\left(-\rho s\right) C_s ds \middle| \boldsymbol{z}_t \right] = \boldsymbol{z}_t^T X \boldsymbol{z}_t$$

where $X$ is the solution of the Lyapunov equation (obtained from households' HJB equation):

$$0 = Q - \mu^2 \tilde{X}^T \tilde{X} + X \left( \Phi - \frac{1}{2}\left(\rho - \gamma^2\right) I \right) + \left( \Phi - \frac{1}{2}\left(\rho - \gamma^2\right) I \right)^T X$$

Back

# Social Optimum

- Static optimal allocation: $\boldsymbol{q}_t^* = N^* \boldsymbol{z}_t$ where $N^* \equiv \left\{2\frac{\zeta}{L}J + \Sigma\right\}^{-1}$
- Optimal output: $Y_t^* = \boldsymbol{z}_t^T Q^* \boldsymbol{z}_t$ where $Q^* = \frac{1}{2}N^*$
- Optimal expected utility:

$$V^*\left(\boldsymbol{z}_t\right) \equiv \boldsymbol{E}_t\left[\int_t^\infty \exp\left(-\rho s\right) C_s ds \middle| \boldsymbol{z}_t\right] = \boldsymbol{z}_t^T X^* \boldsymbol{z}_t,$$

where $X^*$ is the solution of the Riccati equation (obtained from planner's HJB equation):

$$0 = Q^* - \mu^2 \left(X^*\right)^2 + X^* \left(\Phi^* - \frac{1}{2}\left(\rho - \gamma^2\right) I\right) + \left(\Phi^* - \frac{1}{2}\left(\rho - \gamma^2\right) I\right) X^*$$

- Optimal R&D: $\boldsymbol{x}_t^* = \mu X^* \boldsymbol{z}_t$
- Optimal technology transition matrix: $\Phi^* = \Omega + \mu^2 X^*$

Back

# Stochastic Process of Output

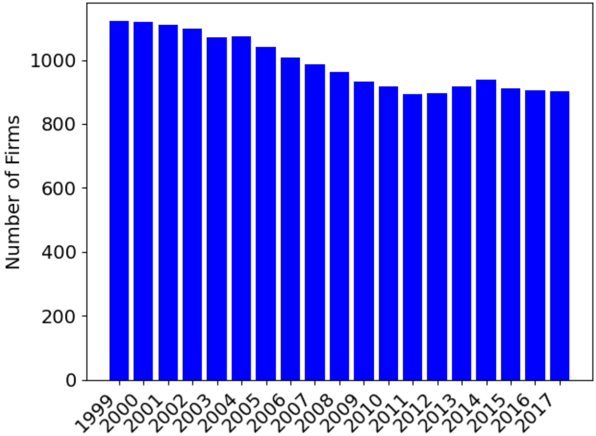
- Applying Itô's lemma,

$$d\log Y_t = \left[\frac{z_t^T\left(Q\Phi + \Phi^T Q\right)z_t}{Y_t} + \gamma^2\left\{\frac{\sum_i z_{i,t}^2 Q_{ii}}{Y_t} - \frac{2z_t^T Q\,\mathrm{diag}\left(z_t^2\right)Qz_t}{Y_t^2}\right\}\right]dt + \frac{2\gamma z_t^T Q\,\mathrm{diag}\left(z_t\right)}{Y_t}dW_t$$

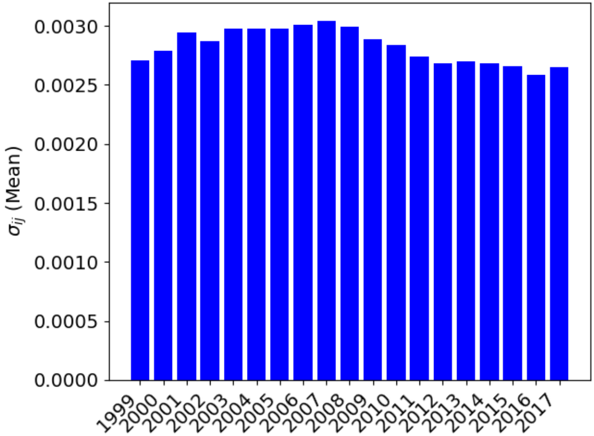
where $Y_t = z_t^T Q z_t$ and $\Phi = \Omega + \mu^2\widetilde{X}$

| | |
|---|---|
| Tech Spillover | $\frac{z_t^T\left(Q\Omega + \Omega Q\right)z_t}{Y_t}$ |
| R&D Contribution | $\frac{\mu^2 z_t^T\left(Q\widetilde{X} + \widetilde{X}^T Q\right)z_t}{Y_t}$ |
| Itô Correction | $\gamma^2\left\{\frac{\sum_i z_{i,t}^2 Q_{ii}}{Y_t} - \frac{2z_t^T Q\,\mathrm{diag}\left(z_t^2\right)Qz_t}{Y_t^2}\right\}$ |
| Total | $E\left[d\log Y_t\right]$ |

# Number of Sample Firms

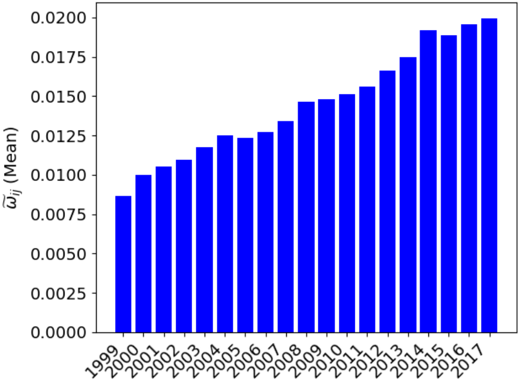


# Trend of Product Substitutability



# Technological Proximity

- Merge USPTO data with Compustat firms using DISCERN 2 dataset (Arora et al., 2024)
- Jaffe measure, Group-level patent classification, Stack for 5 years

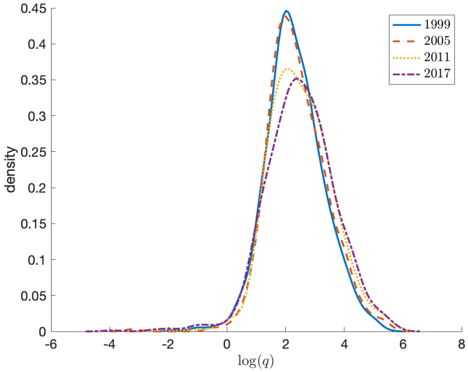


# Identification: Summary

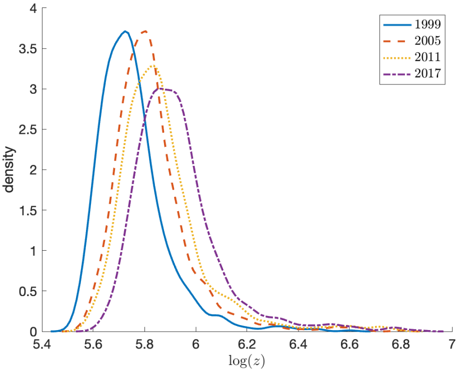
- Publicly available data + Compustat

| Notation | Description | Value | Source |
|---|---|---|---|
| $\boldsymbol{\Sigma}$ | Product proximity | | Form 10-K, Hoberg and Phillips (2016) |
| $\widetilde{\boldsymbol{\Omega}}$ | Technological proximity | | USPTO, Patent classification |
| $\boldsymbol{K}$ | Common ownership weights | | Form 13-F, Backus et al. (2021) |
| $\alpha$ | Product proximity $\longrightarrow$ Substitutability | 0.12 | Pellegrino (2024) |
| $\beta$ | Technological proximity $\longrightarrow$ Spillover | 0.00014 | Estimate the law of motion |
| $\gamma$ | St.d. of idiosyncratic shocks | 0.027 | Estimate the law of motion |
| $\zeta/L$ | Labor augmentation efficiency | 0.0063 | Compustat, Cost of goods sold |
| $\rho$ | Discount rate | 0.10 | $>$ risk free rates, $<$ private R&D returns |
| $\mu$ | R&D efficiency | 0.05 | 1.7% economic growth rate |

# Distributions of Estimated Knowledge Capital and Quantity




(a) Log of Quantity




(b) Log of Knowledge Capital

# Microeconometric Estimates vs. GHL (Pellegrino, 2024) (1/2)

| Market | Firm $i$ | Firm $j$ | Micro Estimate | GHL |
|---|---|---|---|---|
| Auto | Ford | Ford | -4.320 | -5.197 |
| Auto | Ford | General Motors | 0.034 | 0.056 |
| Auto | Ford | Toyota | 0.007 | 0.017 |
| Auto | General Motors | Ford | 0.065 | 0.052 |
| Auto | General Motors | General Motors | -6.433 | -4.685 |
| Auto | General Motors | Toyota | 0.008 | 0.005 |
| Auto | Toyota | Ford | 0.018 | 0.025 |
| Auto | Toyota | General Motors | 0.008 | 0.008 |
| Auto | Toyota | Toyota | -3.085 | -4.851 |

Back

# Microeconometric Estimates vs. GHL (Pellegrino, 2024) (2/2)

| Market | Firm $i$ | Firm $j$ | Micro Estimate | GHL |
|---|---|---|---|---|
| Cereals | Kellogg's | Kellogg's | -3.231 | -1.770 |
| Cereals | Kellogg's | Quaker Oats | 0.033 | 0.023 |
| Cereals | Quaker Oats | Kellogg's | 0.046 | 0.031 |
| Cereals | Quaker Oats | Quaker Oats | -3.031 | -1.941 |
| Computers | Apple | Apple | -11.979 | -8.945 |
| Computers | Apple | Dell | 0.018 | 0.025 |
| Computers | Dell | Apple | 0.027 | 0.047 |
| Computers | Dell | Dell | -5.570 | -5.110 |

Back

# First Stage

Back

| | (1) |
|---|---|
| Dependent Variable: | $z_{i,t}$ |
| User cost of R&D | $-39.495^{***}$ |
| | $(4.7044)$ |
| Year Fixed Effects | ✓ |
| No. observations | 12,947 |

SEs clustered by years and 4-digit naics industries are reported in parentheses.

- IV: User cost of R&D, driven by state-level tax variations (Wilson, 2009; Bloom et al., 2013)

# When Common Ownership Affects only R&D Decisions

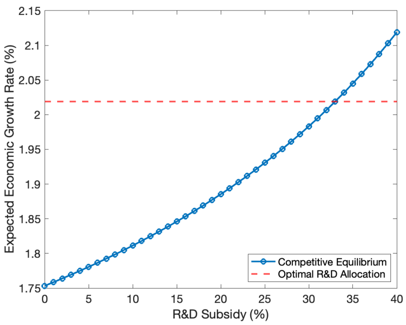
- Common ownership only influences R&D decisions (cf. d'Aspremont and Jacquemin (1988))

| | Ownership Structure | | |
|---|---|---|---|
| | Dispersed | Common R&D | Baseline |
| Output (Social Optimum: 100) | 91.30 | 91.30 | 89.08 |
| R&D Expenditure (Social Optimum: 100) | 26.17 | 19.76 | 22.36 |
| Expected Growth Rate (%) | 1.796 | 1.726 | 1.753 |
| Expected Social Welfare (Social Optimum: 100) | 87.72 | 87.49 | 85.25 |
| Firm Value Share (%) | 28.74 | 29.04 | 34.34 |

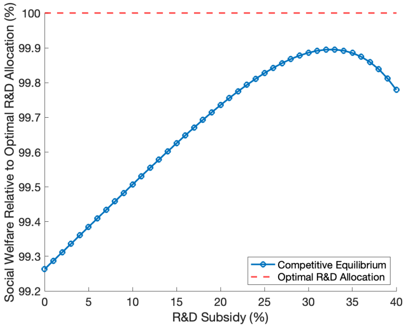
- Lowest R&D expenditure and expected growth rate
- Intermediate social welfare and firm value share

# Optimal Uniform R&D Subsidy

Social Optimum




(a) Expected Growth



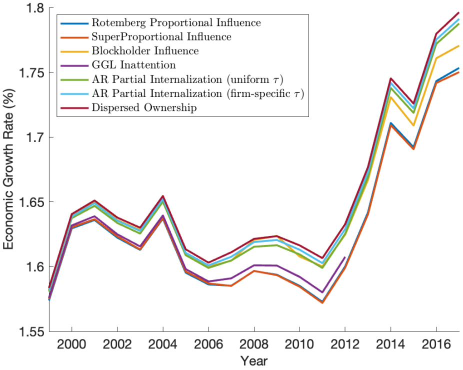

(b) Expected Social Welfare

- Optimal rate is $s$ =33%, which increases $g$ by 0.25 pp (14%)

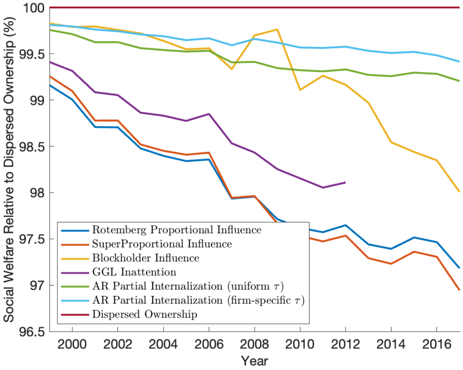
# Alternative Corporate Governance Models: Ederer and Pellegrino (2024)

1. Super-proportional influence: $\tilde{\kappa}_{ij} = \frac{\sum_{z=1}^{Z} s_{iz}\gamma_{iz}s_{jz}}{\sum_{z=1}^{Z} s_{iz}\gamma_{iz}s_{iz}}$ where $\gamma_{iz} = \sqrt{s_{iz}}$
2. Blockholder influence: $\tilde{\kappa}_{ij} = \frac{\sum_{z=1}^{Z} s_{iz}b_{iz}s_{jz}}{\sum_{z=1}^{Z} s_{iz}s_{jz}} \quad (i \neq j)$, where $b_{iz} = 1$ if $s_{iz} > 5\%$
3. Rational investor inattention
   - Gilje et al. (2020) (GGL) estimate the probability that an investor votes against Institutional Shareholders Service recommendations
   - Utilize the estimate to capture the investor's level of attention
4. Governance frictions and entrenchment
   - Azar and Ribeiro (2021) (AR) estimate an objective function where the manager of firm $i$ discounts other firms' profit by $\tau_i$

# Alternative Corporate Governance Models




(a) Expected Growth




(b) Expected Social Welfare

**Acemoglu, Daron, and Ufuk Akcigit.** 2012. “Intellectual Property Rights Policy, Competition and Innovation.” *Journal of the European Economic Association* 10 (1): 1–42.

**Aghion, P, N Bloom, R Blundell, R Griffith, and P Howitt.** 2005. “Competition and Innovation: An Inverted-U Relationship.” *The Quarterly Journal of Economics* 120 (2): 701–728.

**Aghion, Philippe, Christopher Harris, Peter Howitt, and John Vickers.** 2001. “Competition, Imitation and Growth with Step-by-Step Innovation.” *The Review of Economic Studies* 68 (3): 467–492.

**Aghion, Philippe, John Van Reenen, and Luigi Zingales.** 2013. “Innovation and Institutional Ownership.” *American Economic Review* 103 (1): 277–304.

**Akcigit, Ufuk, and Sina T Ates.** 2021. “Ten Facts On Declining Business Dynamism and Lessons From Endogenous Growth Theory.” *American Economic Journal: Macroeconomics* 13 (1): 257–298.

**Akcigit, Ufuk, and Sina T Ates.** 2023. “What Happened to US Business Dynamism?” *The Journal of Political Economy* 131 (8): 2059–2124.

**Anton, Miguel, Florian Ederer, Mireia Gine, and Martin Schmalz.** 2023. “Common Ownership, Competition, and Top Management Incentives.” *The journal of political economy* 131 (5): 1294–1355.

**Anton, Miguel, Florian Ederer, Mireia Gine, and Martin Schmalz.** 2024. “Innovation: The Bright Side of Common Ownership?” *Management science*.

**Arora, Ashish, Sharon Belenzon, Larisa Cioaca, Lia Sheer, Hyun Moh (john) Shin, and Dror Shvadron.** 2024. “DISCERN 2: Duke innovation & SCientific Enterprises Research Network.”

**Atkeson, Andrew, and Ariel Burstein.** 2008. “Pricing-to-Market, Trade Costs, and International Relative Prices.” *The American Economic Review* 98 (5): 1998–2031.

**Autor, David, David Dorn, Lawrence F Katz, Christina Patterson, and John Van Reenen.** 2020. “The Fall of The Labor Share and The Rise of Superstar Firms.” *The Quarterly Journal of Economics* 135 (2): 645–709.

**Azar, Jose, Martin C Schmalz, and Isabel Tecu.** 2018. “Anticompetitive Effects of Common Ownership.” *The Journal of Finance* 73 (4): 1513–1565.

**Azar, Jose, and Xavier Vives.** 2021. “General Equilibrium Oligopoly and Ownership Structure.” *Econometrica* 89 (3): 999–1048.

**Azar, José, Sahil Raina, and Martin Schmalz.** 2022. “Ultimate ownership and bank competition.” *Financial management* 51 (1): 227–269.

**Azar, José, and Ricardo Ribeiro.** 2021. “Estimating oligopoly with shareholder voting models.” *SSRN Electronic Journal*.

**Backus, Matthew, Christopher Conlon, and Michael Sinkinson.** 2021. "Common Ownership in America: 1980-2017." *American Economic Journal. Microeconomics* 13 (3): 273–308.

**Baqaee, David Rezza, and Emmanuel Farhi.** 2020. "Productivity and Misallocation in General Equilibrium." *The Quarterly Journal of Economics* 135 (1): 105–163.

**Berry, Steven, James Levinsohn, and Ariel Pakes.** 1995. "Automobile Prices in Market Equilibrium." *Econometrica* 63 (4): 841.

**Bloom, Nicholas, Mark Schankerman, and John VAN Reenen.** 2013. "Identifying Technology Spillovers and Product Market Rivalry." *Econometrica* 81 (4): 1347–1393.

**Cavenaile, Laurent, Murat Alp Celik, and Xu Tian.** 2023. "Are Markups Too High? Competition, Strategic Innovation, and Industry Dynamics."

**d'Aspremont, Claude, and A Jacquemin.** 1988. "Cooperative and noncooperative R&D in duopoly with spillovers." *The American Economic Review* 78 (5): 1133–1137.

**De Loecker, Jan, Jan Eeckhout, and Gabriel Unger.** 2020. "The Rise of Market Power and The Macroeconomic Implications." *The Quarterly Journal of Economics* 135 (2): 561–644.

**Ederer, Florian, and Bruno Pellegrino.** 2024. "A Tale of Two Networks: Common Ownership and Product Market Rivalry."

**Edmond, Chris, Virgiliu Midrigan, and Daniel Yi Xu.** 2023. "How Costly Are Markups?" *The Journal of Political Economy* 000–000.

**Gilje, Erik P, Todd A Gormley, and Doron Levit.** 2020. "Who's paying attention? Measuring common ownership and its impact on managerial incentives." *Journal of financial economics* 137 (1): 152–178.

**Gutierrez, German, and Thomas Philippon.** 2017. "An Empirical Investigation." *Brookings Papers on Economic Activity* 89–169.

**He, Jie (jack), and Jiekun Huang.** 2017. "Product Market Competition in a World of Cross-Ownership: Evidence from Institutional Blockholdings." *The Review of Financial Studies* 30 (8): 2674–2718.

**Hoberg, Gerard, and Gordon Phillips.** 2016. "Text-Based Network Industries and Endogenous Product Differentiation." *The Journal of Political Economy* 124 (5): 1423–1465.

**Hopenhayn, Hugo, and Koki Okumura.** 2024. "Dynamic Oligopoly and Innovation: A Quantitative Analysis of Technology Spillovers and Product Market Competition."

**Jaffe, Adam B.** 1986. "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits, and Market Value." *The American economic review* 76 (5): 984–1001.

**Kamien, Morton I, Eitan Muller, and Israel Zang.** 1992. "Research Joint Ventures and R&D Cartels." *The American Economic Review* 82 (5): 1293–1306.

**Kini, Omesh, Sangho Lee, and Mo Shen.** 2024. "Common Institutional Ownership and Product Market Threats." *Management Science* 70 (5): 2705–2731.

**Lancaster, Kelvin J.** 1966. “A New Approach to Consumer Theory.” *The Journal of Political Economy* 74 (2): 132–157.

**Leahy, Dermot, and J Peter Neary.** 1997. “Public Policy Towards R&D in Oligopolistic Industries.” *American Economic Review* 87 (4): 642–662.

**Liu, Ernest, Atif Mian, and Amir Sufi.** 2022. “Low Interest Rates, Market Power, and Productivity Growth.” *Econometrica* 90 (1): 193–221.

**Lopez, Angel L, and Xavier Vives.** 2019. “Overlapping Ownership, R&D Spillovers, and Antitrust Policy.” *The Journal of Political Economy* 127 (5): 2394–2437.

**Neary, J Peter.** 2003. “Globalization and market structure.” *Journal of the European Economic Association* 1 (2-3): 245–271.

**Nevo, Aviv.** 2001. “Measuring Market Power in the Ready-to-Eat Cereal Industry.” *Econometrica* 69 (2): 307–342.

**Pellegrino, Bruno.** 2024. “Product Differentiation and Oligopoly: A Network Approach.” *The American Economic Review*.

**Peters, Michael.** 2020. “Heterogeneous Markups, Growth, and Endogenous Misallocation.” *Econometrica* 88 (5): 2037–2073.

**Rosen, Sherwin.** 1974. “Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition.” *The Journal of Political Economy* 82 (1): 34–55.

**Rotemberg, Julio.** 1984. "Financial transaction costs and industrial performance."

**Rubinstein, Ariel, and Menahem E Yaari.** 1983. "The Competitive Stock Market as Cartel Maker: Some Examples." *STICERD - Theoretical Economics Paper Series*.

**Wilson, Daniel J.** 2009. "Beggar thy neighbor? The in-state, out-of-state, and aggregate effects of R&D tax credits." *The Review of Economics and Statistics* 91 (2): 431–436.