The Dynamic Consequences of Monopoly Power

Mohamad Adhami, Jean-Felix Brouillette and Emma Rockall

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Motivation

Welfare consequences of product market power?

The *static* perspective (Edmond, Midrigan and Xu, 2022):

- Markup level: constrains output
- Markup dispersion: misallocation

We extend the analysis to a *dynamic* setting:

- Endogenous growth from innovation by profit-maximizing firms
- How do the welfare costs of markups change in this setting?
- Equilibrium vs. constrained-optimal allocation

Theoretical setting

To characterize consequences of markups, must take a stance on:

- Origin of product market power
- Nature of innovation

We adopt the particular view that:

- Market power from monopolistic competition among differentiated firms
- Innovation as costly reduction of firms' marginal cost of production
- VES demand and heterogeneity in productivity imply markup dispersion

Theoretical setting

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Alternatives left for future work:

- Oligopolistic competition
- Product quality improvements

Outline

1. Partial equilibrium intuition
2. General equilibrium model
3. Quantification
4. Counterfactuals

Partial equilibrium intuition

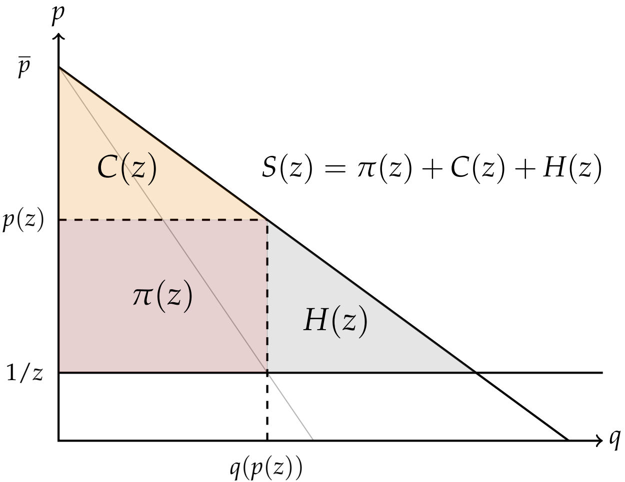
Let p denote a commodity's price and $q(p)$ be demand at this price

A monopolist produces at marginal cost $1/z > 0$ and the demand function satisfies:

$$\frac{\partial q(p)}{\partial p} < 0, \quad q(1/z) > 0 \quad \text{and} \quad \vartheta(p) \equiv -\frac{\partial \ln(q(p))}{\partial \ln(p)} > 1$$

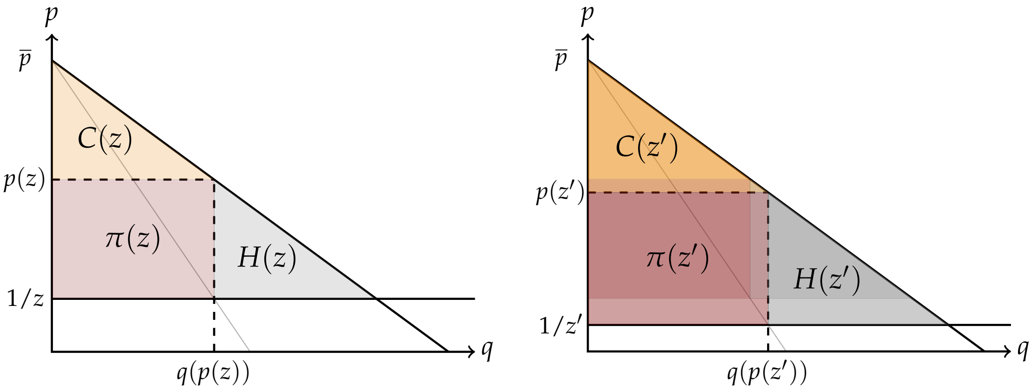
- The profit-maximizing price $p(z)$ is such that $q(p(z)) > 0$

Static cost of monopoly power



Details

What about dynamics?



Introducing dynamics

Achieve $g\%$ improvement in z at cost $i(g)$ for i strictly increasing-convex

To 1st-order approx., the producer and planner dynamic problems are:

$$\max_g \{\underbrace{\pi(z) + \pi'(z)gz}_{\approx \pi((1+g)z)} - i(g)\} \quad \text{and} \quad \max_g \{\underbrace{S(z) + S'(z)gz}_{\approx S((1+g)z)} - i(g)\}$$

First-order conditions of each problem:

$$\pi'(z) = i'(g)/z \quad \text{and} \quad S'(z) = i'(g)/z$$

Private and social incentives won't coincide if $\pi'(z) \neq S'(z)$

Too little innovation?

Proposition 1

The ratio $R(z)$ of marginal producer surplus to marginal social surplus from an infinitesimal reduction in marginal cost is characterized by:

$$R(z) \equiv \frac{\pi'(z)}{S'(z)} = \frac{q(p(z))}{q(1/z)} < 1.$$

All else equal, for any downward-sloping demand function with a price elasticity above unity, social incentives for productivity improvements will exceed private incentives.

Misallocation of innovation?

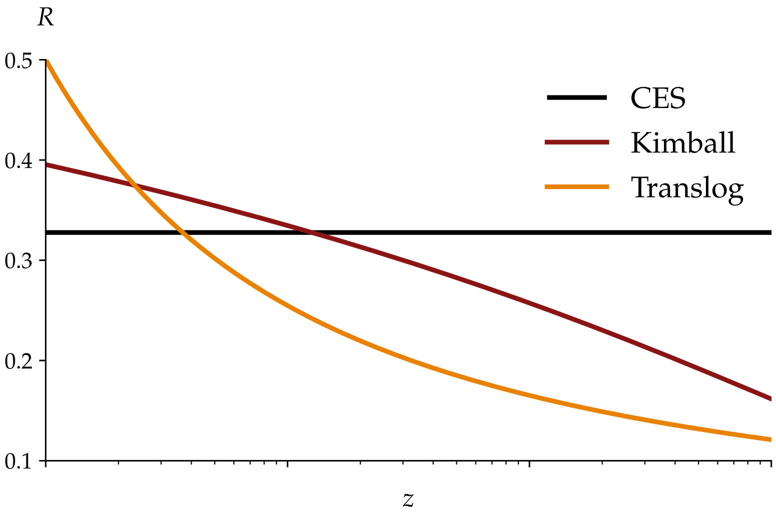
Proposition 2

The elasticity of the ratio $R(z)$ with respect to productivity is characterized by:

$$\frac{\partial \ln(R(z))}{\partial \ln(z)} = \frac{\vartheta(p(z))[\vartheta(p(z)) - 1]}{\vartheta(p(z)) + \varepsilon(p(z)) - 1} - \vartheta(1/z)$$

where $\varepsilon(p) \equiv \partial \ln(\vartheta(p))/\partial \ln(p)$ denotes the "super-elasticity" of demand.

Illustrative examples



Going from partial to general equilibrium

Partial equilibrium takeaways:

- Too little innovation
- Misallocation of innovation

Why a general equilibrium model?

- Quantitative counterfactuals
- Too much innovation from business stealing externality

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Theoretical ingredients

Endogenous growth from Markovian productivity improvements

- Ericson and Pakes (1995), Atkeson and Burstein (2010), Stokey (2014), Benhabib, Perla and Tonetti (2021), Lashkari (2023)

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Heterogeneous markups from VES demand and productivity dispersion

- Kimball (1995), Klenow and Willis (2016), Edmond, Midrigan and Xu (2022)

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- Kimball (1995), Klenow and Willis (2016), Edmond, Midrigan and Xu (2022)

Selection from endogenous entry and exit

- Hopenhayn (1992), Luttmer (2007), Arkolakis (2016), Lashkari (2023)

Population and preferences

Population of measure N_t growing at rate n:

$$\dot{N}_t = nN_t$$

Infinitely lived representative household with separable preferences:

$$U_0 = \int_0^\infty e^{-(\rho-n)t}[\ln(c_t) - v(h_t)]\mathrm{d}t \quad \text{where} \quad c_t \equiv C_t/N_t, \quad h_t \equiv H_t/N_t$$

Production technology

Final good Y_t is a Kimball (1995) aggregate of differentiated varieties:

$$M_t^{-1} \int_{j \in \mathcal{J}_t} \Upsilon(q_{jt}) \mathrm{d}j = 1 \quad \text{where} \quad q_{jt} \equiv \frac{y_{jt}}{Y_t / M_t} \quad \text{and} \quad M_t \equiv |\mathcal{J}_t|$$

Each variety produced by a single firm using labor l_{jt} with productivity z_{jt}:

$$y_{jt} = \exp(z_{jt}) l_{jt}$$

Must pay per-period fixed cost of $c_F > 0$ units of labor to remain active

Innovation technology

Productivity follows a controlled Itô diffusion process:

$$\mathrm{d}z_t = \gamma_t \mathrm{d}t + \sigma \mathrm{d}B_t$$

Labor requirement to achieve drift γ at detrended productivity $\hat{z}$ is $i(\gamma, \hat{z})$:

- $\hat{z}_t \equiv z_t - g_t t$
- $i : \mathbb{R}_0^+ \times \mathbb{R} \to \mathbb{R}_0^+$
- i is strictly increasing-convex in γ
- $i(0, \hat{z}) = 0$ and $\lim_{\gamma \to \infty} i(\gamma, \hat{z}) = \infty$

Entry and exit

- Potential entrants allocate $c_E > 0$ units of labor to achieve unit flow of entry
- Start producing with productivity draw from CDF $F_t^E(z)$
- $F_t^E(z)$ defined over productivity support of incumbents: $[\underline{z}_t, \infty)$
- Endogenous exit from unpaid fixed costs

Resource constraints

Final good is used for consumption:

$$C_t = Y_t$$

Labor can be allocated to production, innovation, entry or fixed costs:

$$L_t + I_t + c_E E_t + c_F M_t = H_t$$

Aggregate production and innovation labor:

$$L_t \equiv M_t \int_{\underline{z}_t}^{\infty} l_t(z) \mathrm{d}F_t(z) \quad \text{and} \quad I_t \equiv M_t \int_{\underline{z}_t}^{\infty} i(\gamma_t(z), \hat{z}) \mathrm{d}F_t(z)$$

Distribution

Economic environment

$\dot{N}_t = nN_t$	Population
$U_0 = \int_0^\infty e^{-(\rho-n)t}[u(c_t) + v(h_t)]\mathrm{d}t$	Preferences
$\int_{\underline{z}_t}^\infty \Upsilon(q_t(z))\mathrm{d}F_t(z) = 1, \quad q_t(z) \equiv y_t(z)M_t/Y_t$	Final good production
$y_t(z) = \exp(z)l_t(z)$	Variety production
$\mathrm{d}z_t = \gamma_t \mathrm{d}t + \sigma \mathrm{d}B_t$	Innovation
$C_t = Y_t$	Final good resources
$L_t + I_t + c_E E_t + c_F M_t = H_t$	Labor resources
$\dot{M}_t = (e_t - \delta_t)M_t$	Varieties
$\dot{F}_t(z) = -\gamma_t(z)F_t'(z) + \sigma^2 F_t''(z)/2 + e_t[F_t^E(z) - F_t(z)] - \delta_t[1 - F_t(z)]$	Distribution

Market structure

- Perfectly competitive **final good** (numéraire) market
- Perfectly competitive **labor** market
- Perfectly competitive **asset** market
- *Monopolistically* competitive **variety** markets

All prices taken as given besides firms choosing their variety's price

Decision problems

1. Household's problem Details
   - Choose $\{c_t, h_t\}_t$ to maximize lifetime utility
2. Final sector's problem Details
   - Choose $q_t(z)$ to maximize profits each period
3. Firm's static problem Details
   - Choose $p_t(z)$ to maximize profits each period
4. Firm's dynamic problem Details
   - Choose $\{\gamma_t(z), \underline{z}_t\}_t$ to maximize expected PDV of profits
5. Entrant's problem Details
   - Choose E_t to maximize expected PDV of profits

Optimality conditions

$v'(h_t)/u'(c_t) = w_t$ Intratemporal Euler equation

$\dot{c}_t/c_t = r_t - \rho$ Intertemporal Euler equation

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$p_t(z) = \mu(q_t(z))w_t \exp(-z)$	Monopoly pricing

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$V'_t(z) = w_t \times \partial i(\gamma, \hat{z})/\partial\gamma$	Optimal innovation
$V_t(\underline{z}_t) = V'_t(\underline{z}_t) = 0$	Value matching and smooth pasting

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$V_t(\underline{z}_t) = V_t'(\underline{z}_t) = 0$	Value matching and smooth pasting
$(\int_{\underline{z}_t}^{\infty} V_t(z)\mathrm{d}F_t^E(z) - w_t c_E)E_t = 0$	Free-entry condition

Equilibrium allocation

Given initial conditions $\{N_0, M_0, F_0(z)\}$:

- $\{c_t, h_t\}_{t=0}^{\infty}$ solve the household's problem
- $\{q_t(z)\}_{t=0}^{\infty}$ solve the final sector's problem
- $\{p_t(z)\}_{t=0}^{\infty}$ solve the firms' static problem
- $\{\gamma_t(z), \underline{z}_t\}_{t=0}^{\infty}$ solve the firms' dynamic problem
- $\{E_t\}_{t=0}^{\infty}$ satisfies the free-entry condition
- $\{Y_t\}_{t=0}^{\infty}$ satisfies the Kimball (1995) aggregator
- $\{w_t\}_{t=0}^{\infty}$ clears the labor market
- $\{r_t\}_{t=0}^{\infty}$ clears the asset market
- Population, measure of varieties and distribution of firms evolve as described

Balanced growth path

Restrict attention to BGP equilibrium allocations:

- $\{c_t, w_t, Y_t/N_t, \underline{z}_t\}$ grow at *endogenous* constant rate g
- $\{N_t, L_t, I_t, E_t, M_t\}$ grow at exogenous constant rate n
- $\{h_t, r_t, q_t(z), p_t(z), D_t, \gamma_t(z)\}$ are stationary
- Distribution $\mathcal{F}_t(\hat{z})$ of detrended productivity is stationary

Economic growth

Contributions to growth from: Details

- Incumbent firms' productivity growth $(+)$
- Incumbent firms' productivity volatility $(\pm)$
- Selection from entry $(\pm)$
- Selection from exit $(+)$

No growth from expanding varieties

Characterization

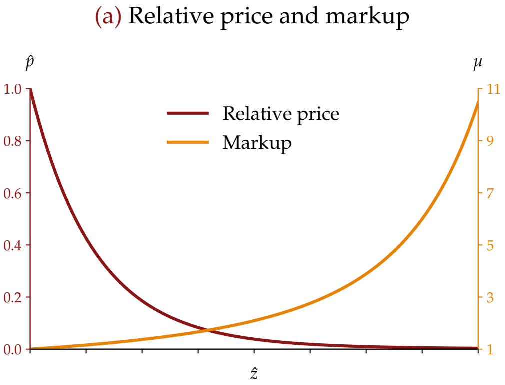
$$v(h) = \beta \times \frac{h^{1+\eta}}{1+\eta}$$ MaCurdy (1981)

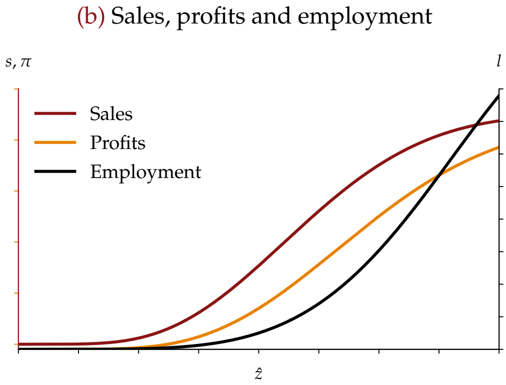
$$\Upsilon(q) = 1 + (\theta - 1)\exp\left(\frac{1}{\epsilon}\right)\epsilon^{\theta/\epsilon - 1}\left[\Gamma\left(\frac{\theta}{\epsilon}, \frac{1}{\epsilon}\right) - \Gamma\left(\frac{\theta}{\epsilon}, \frac{q^{\epsilon/\theta}}{\epsilon}\right)\right]$$ Klenow and Willis (2016)

$$i(\gamma, \hat{z}) = \exp(\psi + \phi\hat{z}) \times \frac{\gamma^{1+\lambda}}{1+\lambda}$$ Assumption

$$\mathcal{F}^E(\hat{z}) = \mathcal{F}(\hat{z})^\zeta$$ Benhabib, Perla and Tonetti (2021)

Firm-level static outcomes





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Policy interventions

Size-dependent transfers to firms:

$$\pi_t^*(z) = \pi_t(z) + T_t(q) \quad \text{where} \quad T_t(q) = [\varrho_0 \Upsilon(q) + \varrho_1 \Upsilon'(q) q] D_t Y_t / M_t$$

Optimal subsidy: $(\varrho_0, \varrho_1) = (1, -1)$

- Eliminate markup level and dispersion

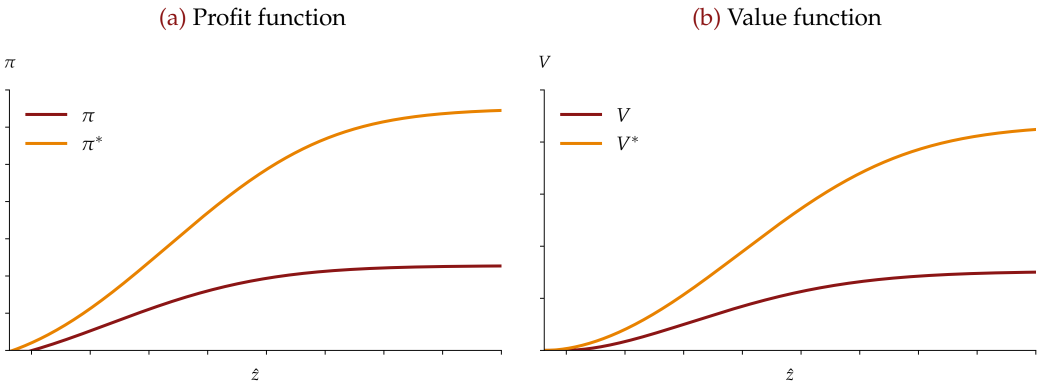
Uniform subsidy: $(\varrho_0, \varrho_1) = (0, x/(1-x))$

- Reduce markup level by x% but leave dispersion unchanged

Size-dependent subsidy: $(\varrho_0, \varrho_1) = (1/(1+x), -1)$

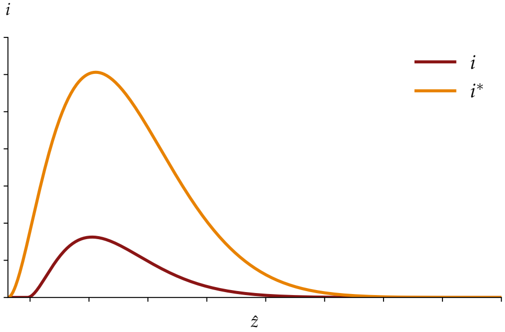
- Eliminate markup dispersion but leave level to $1 + x$

Profit and value function

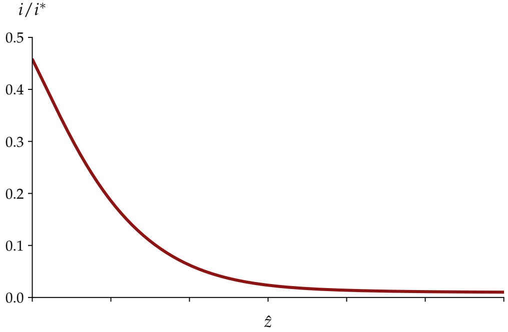


Innovation incentives response

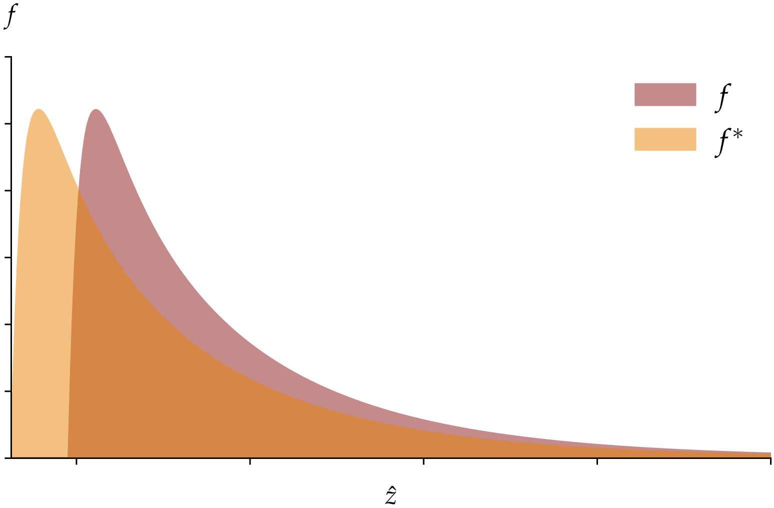
(a) Innovation labor



(b) Ratio



Distributional response



Next steps

1. Solution and estimation strategy
    - Spectral collocation + quadrature
    - Mathematical program with equilibrium constraints + TikTak multi-start
2. Estimation with firm-level administrative data from France
    - Data on revenues and quantities for manufacturing firms
3. Transition dynamics with physical capital
4. Alternative policy interventions?

Defining the surpluses

$$\pi(z) = p(z)q(p(z))/\vartheta(p(z))$$ Producer surplus

$$C(z) = \int_{p(z)}^{\overline{p}} q(p)\mathrm{d}p$$ Consumer surplus

$$H(z) = \int_{1/z}^{p(z)} [q(p) - q(p(z))]\mathrm{d}p$$ Harberger triangle

$$S(z) = \pi(z) + C(z) + H(z)$$ Social surplus

Back

Distribution

Cumulative density $M_t(z)$ of firms with productivity z:

$$M_t(z) = F_t(z)M_t \quad \text{where} \quad M_t = \int_{\underline{z}_t}^{\infty} \mathrm{d}M_t(z)$$

Law of motion given by Kolmogorov forward equation for all $z > \underline{z}_t$:

$$\dot{M}_t(z) = -\gamma_t(z)M_t'(z) + \sigma^2[M_t''(z) - M_t''(\underline{z}_t)]/2 + E_t F_t^E(z)$$

Standard boundary conditions:

$$M_t'(\underline{z}_t) = \lim_{z\to\infty} M_t'(z) = \lim_{z\to\infty} M_t''(z) = 0$$

Back

Distribution

Boundary conditions imply law of motion for measure of varieties:

$$\dot{M}_t = (e_t - \delta_t)M_t \quad \text{where} \quad e_t \equiv E_t/M_t \quad \text{where} \quad \delta_t \equiv \sigma^2 F_t''(\underline{z}_t)/2$$

Which in turn implies law of motion for $F_t(z)$ for all $z > \underline{z}_t$:

$$\dot{F}_t(z) = -\gamma_t(z)F_t'(z) + \sigma^2 F_t''(z)/2 + e_t[F_t^E(z) - F_t(z)] - \delta_t[1 - F_t(z)]$$

Back

Household's problem

Choose consumption and labor supply to maximize lifetime utility:

$$\max_{\{c_t,h_t\}_{t=0}^{\infty}} \int_0^{\infty} e^{-(\rho-n)t}[\ln(c_t) - v(h_t)]\mathrm{d}t \quad \text{s.t.} \quad \dot{a}_t = (r_t - n)a_t + w_t h_t - c_t$$

Value of corporate assets per capita denoted by $a_t \equiv A_t / N_t$:

$$A_t = M_t \int_{\underline{z}_t}^{\infty} V_t(z)\mathrm{d}F_t(z) \quad \text{where} \quad \lim_{t\to\infty} e^{-\int_0^t r_{t'}\mathrm{d}t'} A_t = 0$$

Delivers standard intratemporal and intertemporal Euler equations:

$$\frac{v'(h_t)}{u'(c_t)} = w_t \quad \text{and} \quad \frac{\dot{c}_t}{c_t} = r_t - \rho$$

Back

Final sector's problem

Choose demand for each variety to maximize profits:

$$\max_{\{q_t(z)\}_{z=\underline{z}_t}^{\infty}} \left\{ P_t - \int_{\underline{z}_t}^{\infty} p_t(z) q_t(z) \mathrm{d}F_t(z) \right\} Y_t \quad \text{s.t.} \quad \int_{\underline{z}_t}^{\infty} \Upsilon(q_t(z)) \mathrm{d}F_t(z) = 1$$

Delivers inverse demand functions:

$$p_t(z) = \Upsilon'(q_t(z)) P_t D_t$$

Price and demand indices defined as:

$$P_t \equiv \int_{\underline{z}_t}^{\infty} p_t(z) q_t(z) \mathrm{d}F_t(z) = 1 \quad \text{and} \quad D_t \equiv \left(\int_{\underline{z}_t}^{\infty} \Upsilon'(q_t(z)) q_t(z) \mathrm{d}F_t(z) \right)^{-1}$$

Back

Firm's static problem

Choose variety's price to maximize profits:

$$\pi_t(z) = \max_{p_t(z)} \{[p_t(z) - w_t \exp(-z)]\, q_t(z)\} Y_t / M_t - w_t c_F \quad \text{s.t.} \quad p_t(z) = \Upsilon'(q_t(z)) D_t$$

Set price to a markup above marginal cost:

$$p_t(z) = \frac{\mu(q_t(z)) w_t}{\exp(z)} \quad \text{where} \quad \mu(q) \equiv \frac{\vartheta(q)}{\vartheta(q) - 1}$$

Express firm profits as implicit function of productivity:

$$\pi_t(z) = \frac{p_t(z) q_t(z) Y_t}{\vartheta(q_t(z)) M_t} - w_t c_F$$

Back

Firm's dynamic problem

Control productivity drift and choose optimal exit time to maximize PDV of profits:

$$V_t(z) = \max_{\tau, \{\gamma_s\}_{s=t}^{\infty}} \mathbb{E}_t \left\{ \int_t^{t+\tau} e^{-\int_t^s r_{t'} \mathrm{d}t'} [\pi_s(z_s) - w_t i(\gamma_s, \hat{z}_s)] \mathrm{d}s \middle| z_t = z \right\}$$

$$\text{s.t.} \quad \mathrm{d}z_t = \gamma_t \mathrm{d}_t + \sigma \mathrm{d}B_t$$

Value function satisfies HJB equation in continuation region:

$$r_t V_t(z) = \pi_t(z) + \max_{\gamma} \{\gamma V_t'(z) - w_t i(\gamma, \hat{z})\} + \sigma^2 V_t''(z)/2 + \dot{V}_t(z)$$

As well as first-order, value matching and smooth pasting conditions:

$$V_t'(z) = w_t \times \frac{\partial i(\gamma, \hat{z})}{\partial \gamma} \quad \text{and} \quad V_t(\underline{z}_t) = V_t'(\underline{z}_t) = 0$$

Back

Entrant's problem

Engage in perfect competition on labor market:

$$V_t^E = \max_{E_t} \left\{ E_t \int_{\underline{z}_t}^{\infty} V_t(z) \mathrm{d}F_t^E(z) - w_t c_E E_t \right\}$$

Delivers free-entry condition (in complementary-slackness form):

$$\left(\int_{\underline{z}_t}^{\infty} V_t(z) \mathrm{d}F_t^E(z) - w_t c_E \right) E_t = 0$$

Back

Economic growth

Defining $\hat{Z} \equiv \left(\int_{\underline{\hat{z}}}^{\infty} q(\hat{p}(\hat{z}))\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})\right)^{-1}$ and $\hat{Z}^E \equiv \left(\int_{\underline{\hat{z}}}^{\infty} q(\hat{p}(\hat{z}))\exp(-\hat{z})\mathrm{d}\mathcal{F}^E(\hat{z})\right)^{-1}$:

$$g = \frac{\int_{\underline{\hat{z}}}^{\infty}[q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) - q(\hat{p}(\hat{z}))]\exp(-\hat{z})\gamma(\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}{\int_{\underline{\hat{z}}}^{\infty}[q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) - q(\hat{p}(\hat{z}))]\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}$$
$$+ \frac{\sigma^2 \int_{\underline{\hat{z}}}^{\infty}[q''(\hat{p}(\hat{z}))\hat{p}'(\hat{z})^2 + q'(\hat{p}(\hat{z}))\hat{p}''(\hat{z}) - 2q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) + q(\hat{p}(\hat{z}))]\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}{2\int_{\underline{\hat{z}}}^{\infty}[q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) - q(\hat{p}(\hat{z}))]\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}$$
$$+ \frac{e(\hat{Z}/\hat{Z}^E - 1)}{\hat{Z}\int_{\underline{\hat{z}}}^{\infty}[q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) - q(\hat{p}(\hat{z}))]\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}$$
$$- \frac{\delta[\hat{Z}q(p(\underline{\hat{z}}))\exp(-\underline{\hat{z}}) - 1]}{\hat{Z}\int_{\underline{\hat{z}}}^{\infty}[q'(\hat{p}(\hat{z}))\hat{p}'(\hat{z}) - q(\hat{p}(\hat{z}))]\exp(-\hat{z})\mathrm{d}\mathcal{F}(\hat{z})}$$

Back

Firm-level static outcomes

Firm's relative price (W denotes Lambert W-function), relative demand and profits:

$$\hat{p}(\hat{z}) = \frac{(\theta/\epsilon)\exp(-\hat{z})w_0/\overline{p}_0}{W[(\theta/\epsilon)\exp(\theta/\epsilon - \hat{z})w_0/\overline{p}_0]}$$

$$q(\hat{p}) = \begin{cases} [-\epsilon \ln(\hat{p})]^{\theta/\epsilon} & \text{if } \hat{p} < 1 \\ 0 & \text{if } \hat{p} \geq 1 \end{cases}$$

$$\pi_t(\hat{z}) = \frac{\hat{p}(\hat{z})q(\hat{p}(\hat{z}))^{1+\epsilon/\theta}\overline{p}_t Y_t}{\theta M_t} - w_t c_F$$

Back