Part 4: Markups and Misallocation

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Misallocation and Aggregate Productivity
Central Bank of Chile

This lecture

1- Atkeson/Burstein (AER'08): variable markups in closed economy

- nested CES
- oligopolistic competition
- implications for markup dispersion and misallocation
- simple examples to build intuition

2- Edmond/Midrigan/Xu (AER'15): variable markups in open economy

- implications for gains from trade
- importance of head-to-head competition

3- Edmond/Midrigan/Xu (WP): alternative market structure

- monopolistic competition with kinked demand curves
- much more tractable dynamics

Atkeson/Burstein

- Key features
  - *nested CES*, finite number producers within a sector
  - *oligopolistic competition* within a sector
  - endogenous demand elasticities, decreasing in market share
- Market share reallocations change markup dispersion and aggregate TFP

Nested CES

- Output from a continuum of sectors

$$Y = \left(\int_0^1 y(s)^{\frac{\theta-1}{\theta}} \, ds \right)^{\frac{\theta}{\theta-1}}, \qquad \theta > 1$$

- Finite n competitors per sector

$$y(s) = \left(\sum_{i=1}^{n} y_i(s)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \qquad \gamma > \theta$$

Final good producers

- Choose intermediates $y_i(s)$ to max profits

$$PY - \int_0^1 \sum_{i=1}^{n} p_i(s) y_i(s)\, ds$$

- Implies demand curves facing intermediate producers

$$y_i(s) = \left(\frac{p_i(s)}{p(s)}\right)^{-\gamma} \left(\frac{p(s)}{P}\right)^{-\theta} Y$$

with price indexes

$$p(s) = \left(\sum_{i=1}^{n} p_i(s)^{1-\gamma}\right)^{\frac{1}{1-\gamma}}, \qquad P = \left(\int_0^1 p(s)^{1-\theta}\, ds\right)^{\frac{1}{1-\theta}}$$

Intermediate producers

- Finite n producers per sector

- Producer-level production function

$$y_i(s) = a_i(s) l_i(s)^{\alpha} k_i(s)^{1-\alpha}$$

- Productivity $a_i(s)$ is IID Pareto

$$\text{Prob}[a_i(s) \geq a] = a^{-\xi}$$

with shape parameter ξ (thick tails if ξ low)

- No *ex ante* sectoral heterogeneity,
but *ex post* sectoral heterogeneity because finite sample (n draws)

Pricing

- Price is markup over marginal cost

$$p_i(s) = \frac{\varepsilon_i(s)}{\varepsilon_i(s) - 1} \frac{c(w, r)}{a_i(s)}$$

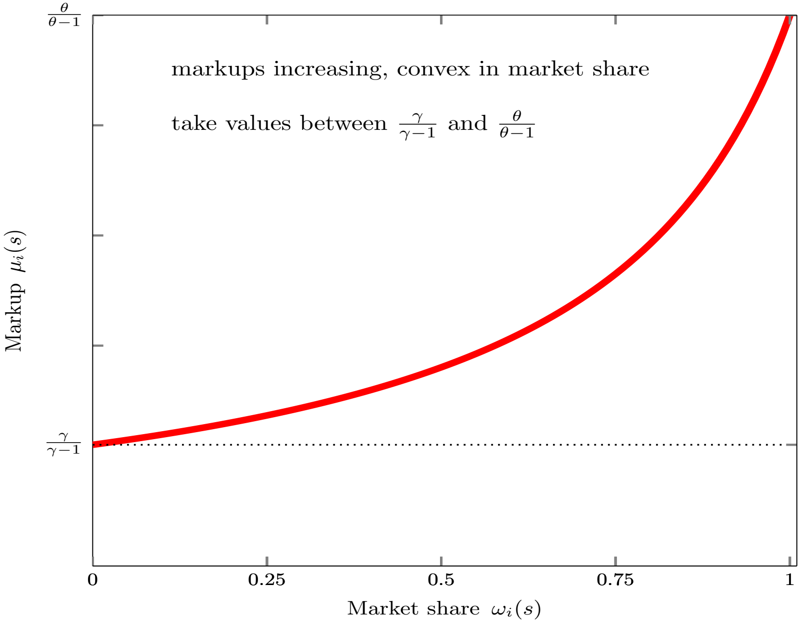
- Demand elasticity is decreasing in market share

$$\varepsilon_i(s) = \left(\omega_i(s) \frac{1}{\theta} + (1 - \omega_i(s)) \frac{1}{\gamma} \right)^{-1}, \qquad \text{(Cournot competition)}$$

- Hence markups increasing in market share

$$\omega_i(s) := \frac{p_i(s) y_i(s)}{\sum_{i=1}^{n} p_i(s) y_i(s)} = \left(\frac{p_i(s)}{p(s)} \right)^{1-\gamma}$$

Markups $\mu_i(s)$ and market shares $\omega_i(s)$



Fixed point problem (sketch)

- Let $\mathbf{a} := [a_i(s)]\,,\ \mathbf{p} := [p_i(s)]\,,\ \boldsymbol{\omega} := [\omega_i(s)]\,,\ \boldsymbol{\varepsilon} := [\varepsilon_i(s)]$

- Market shares

$$\boldsymbol{\omega} = f(\mathbf{p})$$

- Demand elasticity

$$\boldsymbol{\varepsilon} = g(\boldsymbol{\omega}) = g(f(\mathbf{p}))$$

- Prices

$$\mathbf{p} = h(\boldsymbol{\varepsilon}\,,\,\mathbf{a}) = h(g(f(\mathbf{p}))\,,\,\mathbf{a}) =: \phi(\mathbf{p}\,,\,\mathbf{a})$$

- Equilibrium prices $\mathbf{p}^*(\mathbf{a})$ solve this fixed point problem

- Recover equilibrium market shares, equilibrium markups

Aggregate TFP

- *First-best*

$$A = \left(\int_0^1 a(s)^{\theta-1} \, ds \right)^{\frac{1}{\theta-1}}$$

$$a(s) = \left(\sum_{i=1}^{n} a_i(s)^{\gamma-1} \right)^{\frac{1}{\gamma-1}}$$

Aggregate TFP

- *First-best*

$$A = \left(\int_0^1 a(s)^{\theta-1}\, ds \right)^{\frac{1}{\theta-1}}$$

$$a(s) = \left(\sum_{i=1}^{n} a_i(s)^{\gamma-1} \right)^{\frac{1}{\gamma-1}}$$

- *With variable markups*

$$A = \left(\int_0^1 \left(\frac{\mu(s)}{\mu} \right)^{-\theta} a(s)^{\theta-1}\, ds \right)^{\frac{1}{\theta-1}}$$

$$a(s) = \left(\sum_{i=1}^{n} \left(\frac{\mu_i(s)}{\mu(s)} \right)^{-\gamma} a_i(s)^{\gamma-1} \right)^{\frac{1}{\gamma-1}}$$

Markup dispersion

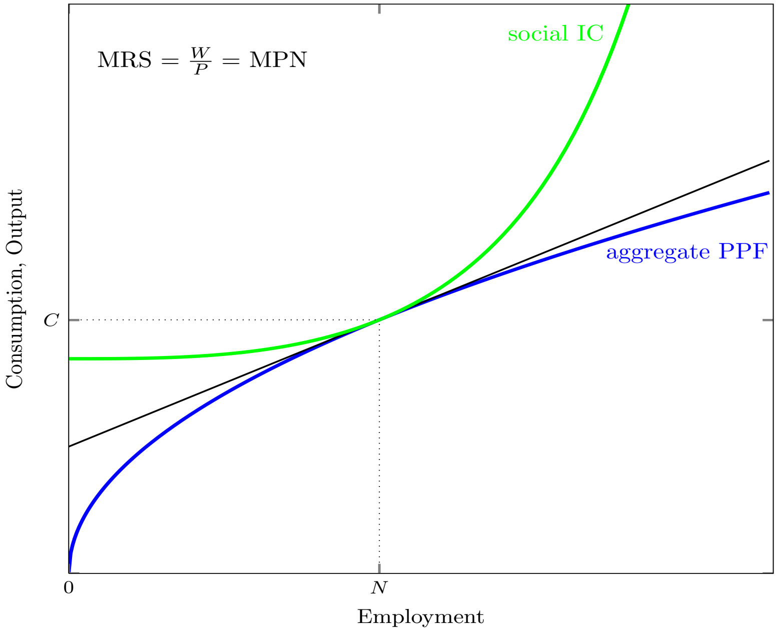
- Markup dispersion reduces aggregate TFP below first-best level

- With common markup, say μ, aggregate TFP is at first-best (relative prices still reflect relative marginal costs)

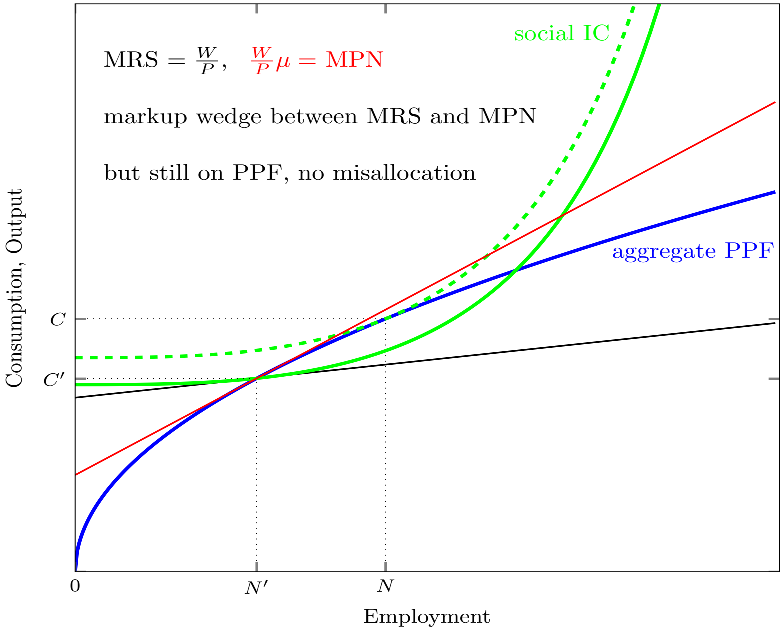
$$\frac{p_i(s)}{p_j(s)} = \frac{\mu \frac{c(w,r)}{a_i(s)}}{\mu \frac{c(w,r)}{a_j(s)}} = \frac{a_j(s)}{a_i(s)}$$

- So, in this case, no misallocation

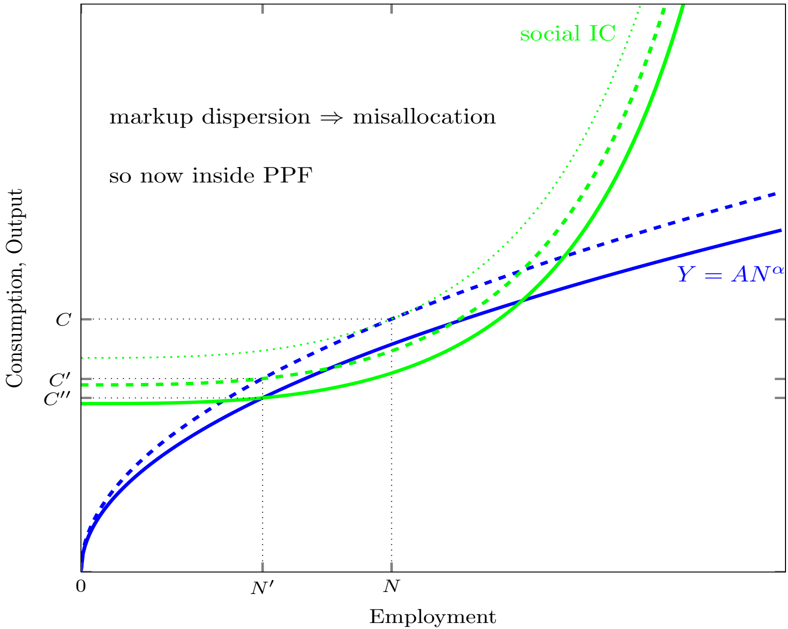
First-best levels



Aggregate markup μ



Markup dispersion $\mu_i(s)$



Homogeneous firms

- Suppose $n \geq 1$ producers per sector, identical productivity
- Identical market shares, $\omega_i(s) = 1/n$ each
- Identical markups

$$\mu_i(s) = \mu = \frac{n}{\left(\frac{\gamma-1}{\gamma}\right)n - \left(\frac{1}{\theta} - \frac{1}{\gamma}\right)}$$

  declining from $\frac{\theta}{\theta-1}$ at $n = 1$ to $\frac{\gamma}{\gamma-1}$ as $n \to \infty$

- Markup level distorts allocations, but TFP at first-best

Heterogeneous firms

- Suppose $n = 1$ producers per sector

  Monopoly markup $\frac{\theta}{\theta-1}$ (large) — but no misallocation

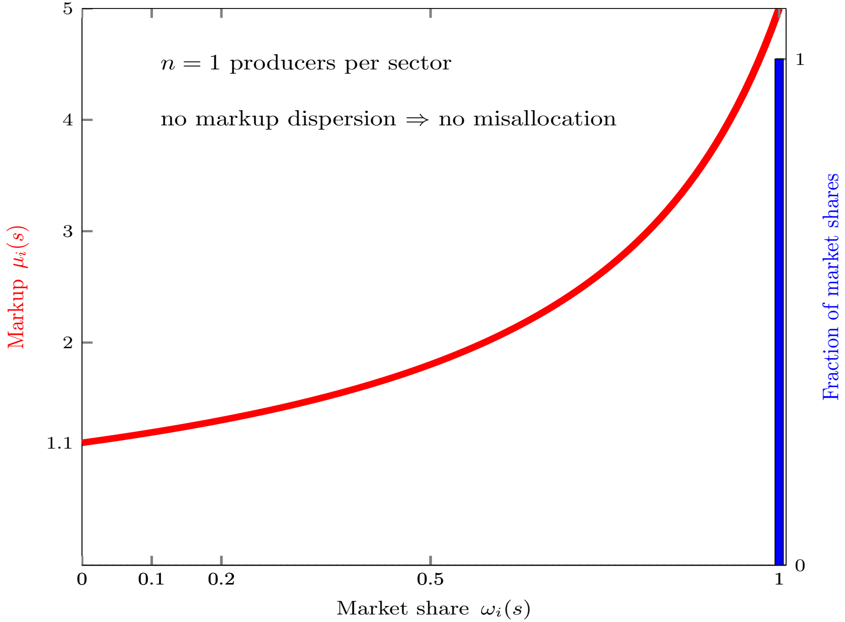
- Increase to $n = 2$ producers per sector

  Aggregate markup falls — but now markup dispersion

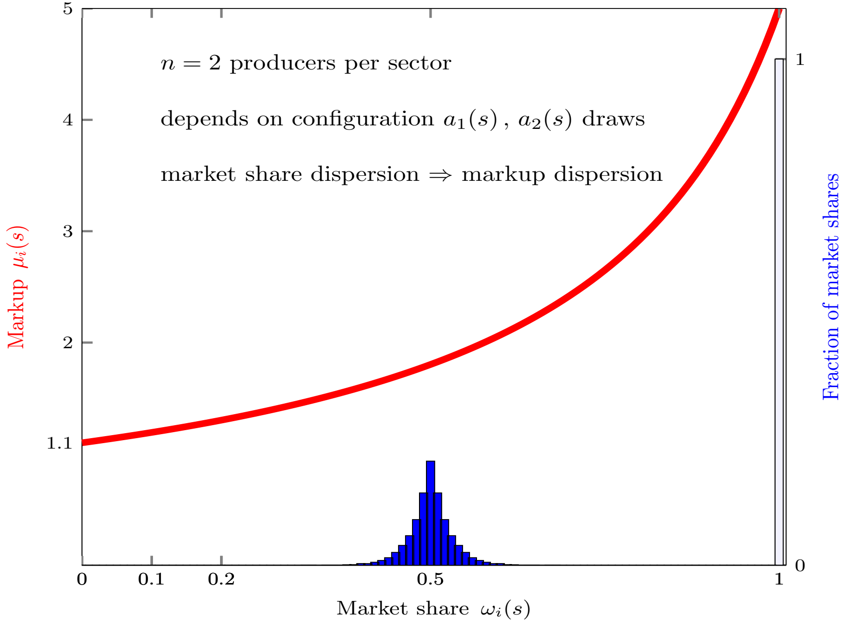
  Extent of markup dispersion depends on productivity dispersion

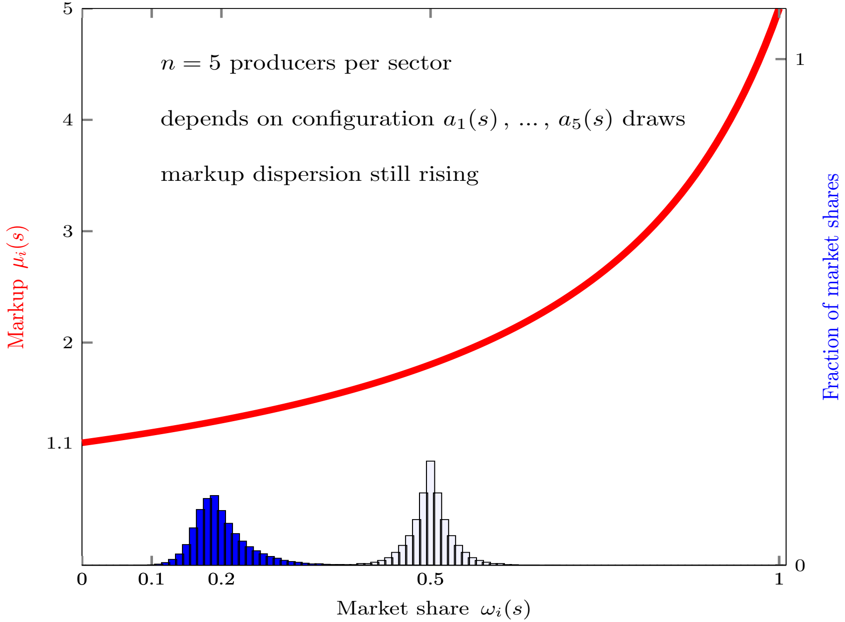
  Moreover, extent of fall in aggregate markup depends on markup dispersion (Jensen's ineq.)

Monopoly: high markup but no misallocation

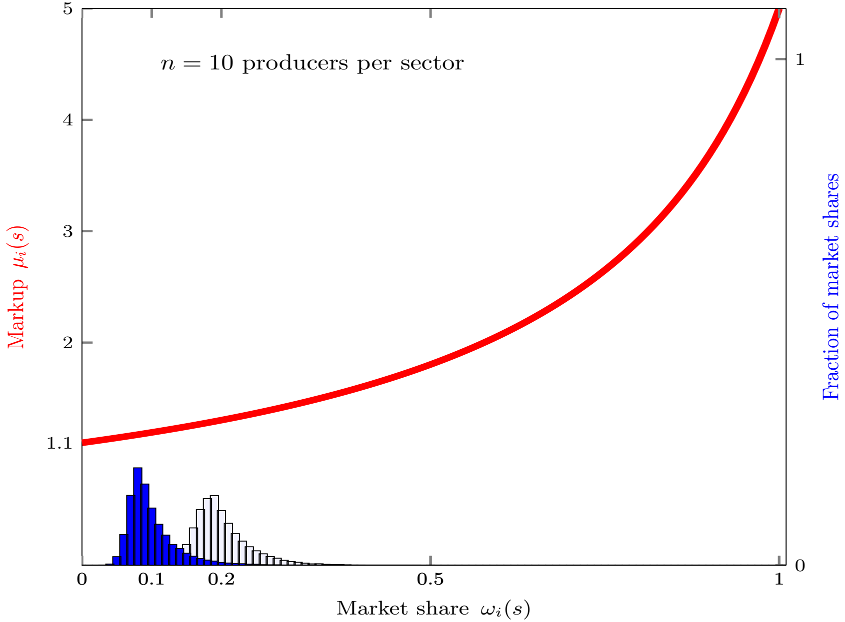


Duopoly: lower markups, but now misallocation

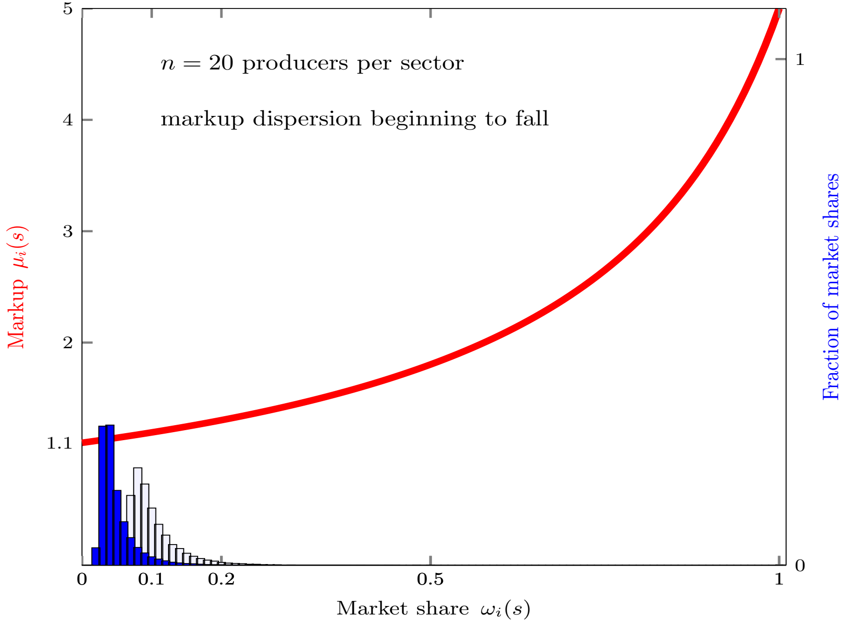




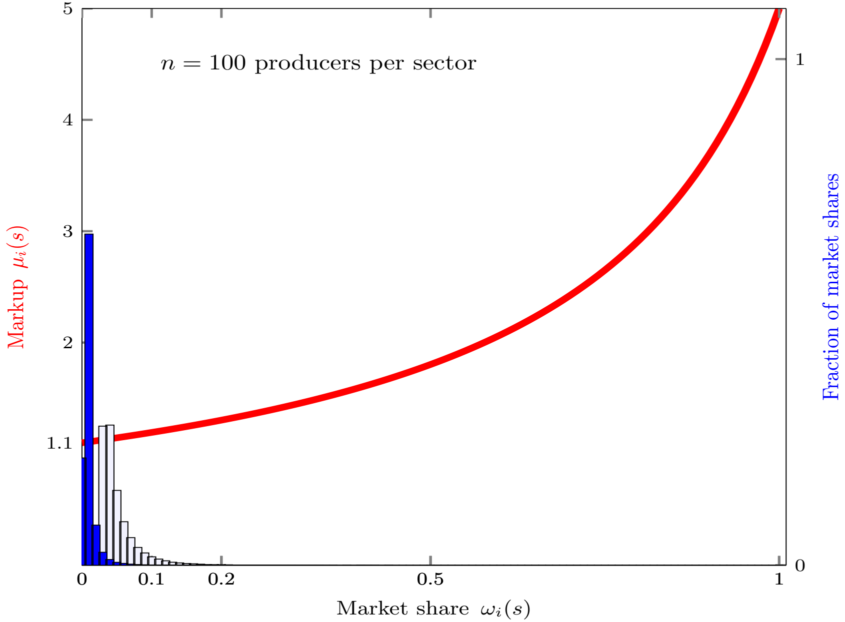
$n = 5$ producers per sector
depends on configuration $a_1(s)$, ..., $a_5(s)$ draws
markup dispersion still rising
Markup $\mu_i(s)$
Fraction of market shares
Market share $\omega_i(s)$
5
4
3
2
1.1
1
0
0
0.1
0.2
0.5
1



$n = 10$ producers per sector
Markup $\mu_i(s)$
Fraction of market shares
Market share $\omega_i(s)$
5
4
3
2
1.1
0
0.1
0.2
0.5
1
1
0

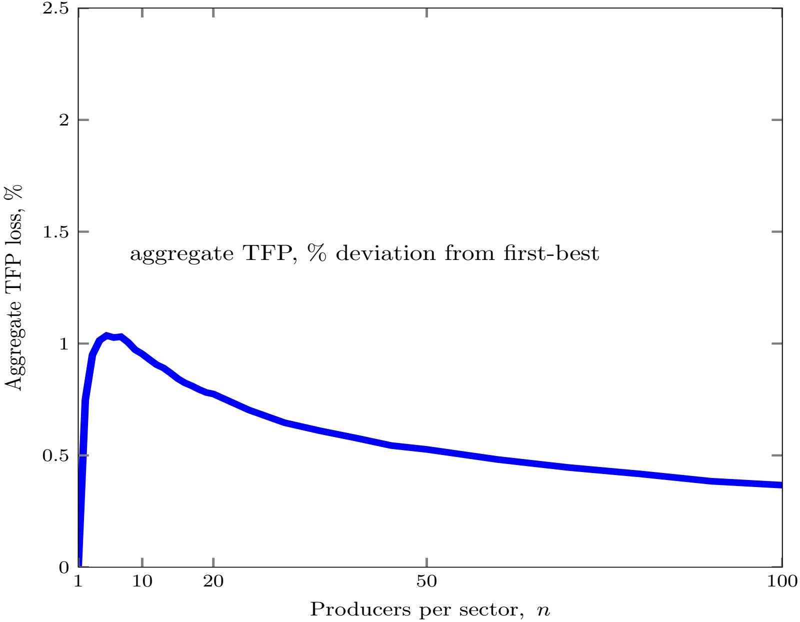


$n = 20$ producers per sector
markup dispersion beginning to fall
Markup $\mu_i(s)$
Fraction of market shares
Market share $\omega_i(s)$
5
4
3
2
1.1
1
0
0
0.1
0.2
0.5
1

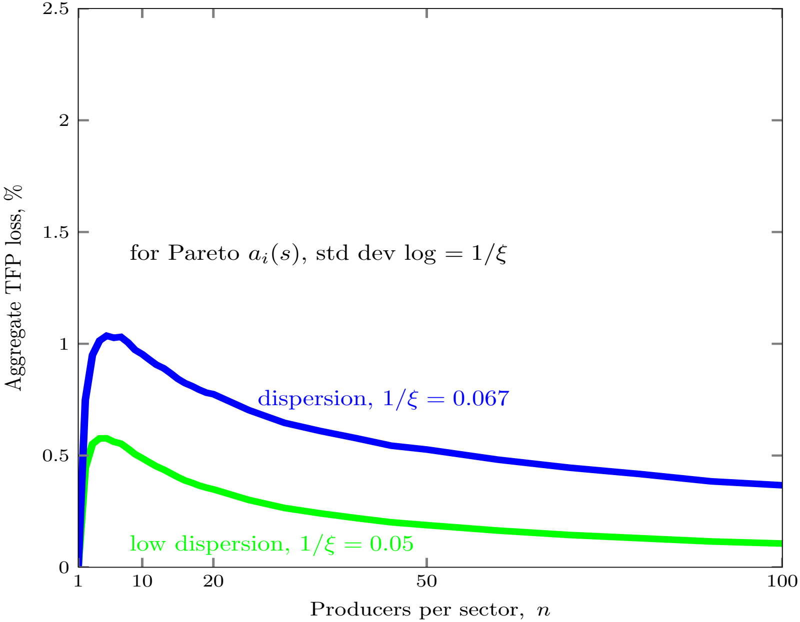


$n = 100$ producers per sector
Markup $\mu_i(s)$
Fraction of market shares
Market share $\omega_i(s)$
5
4
3
2
1.1
0
0.1
0.2
0.5
1
1
0

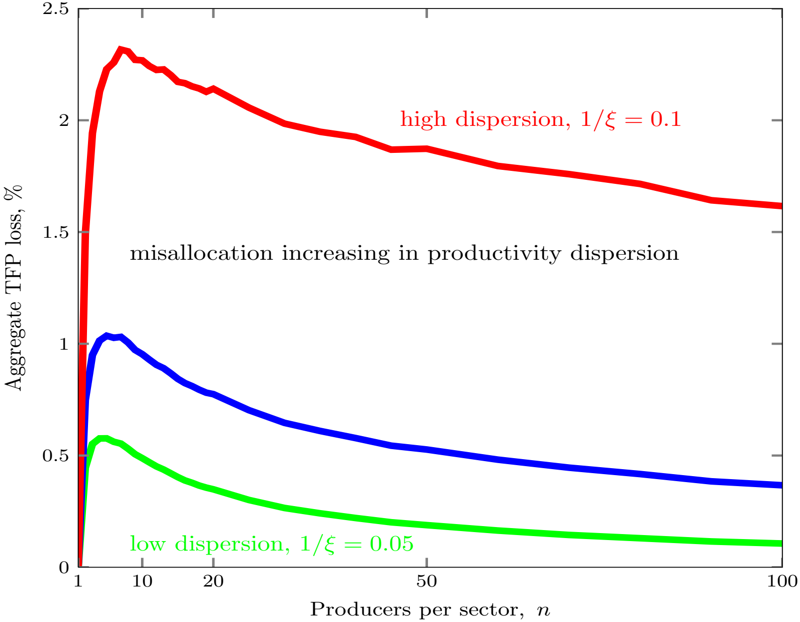
Misallocation and competition



Misallocation and productivity dispersion



Misallocation and productivity dispersion



Summary

- Misallocation
  - increasing in n for low n, then decreasing
  - level is higher the higher is productivity dispersion

    (high dispersion $\Rightarrow$ more chance of dominant producer)

- Aggregate markup
  - decreasing in n

Edmond/Midrigan/Xu

- Gains from international trade, 2-country model
- How much does trade increase competition, reduce misallocation?
- Parameterize to match within and across-sector concentration facts
- Applied to Taiwan, 7-digit manufacturing data
- Skip trade part today. Focus solely on micro-level facts

Empirical strategy: overview

- Two key ingredients

  (i) productivity distribution $a_i(s)$

  (ii) gap between θ and γ

- Our strategy

  (i) within-country distribution $a_i(s)$ to match concentration

  (ii) set $\gamma = 10$ (Atkeson-Burstein and many others)
  choose θ to match relationship between market shares and markups

Within-country productivity $a_i(s)$

- For producer i in sector s

$$a_i(s) = z(s)x_i(s)$$

with *sector productivity*

$$z(s) \sim \text{IID Pareto (shape } \xi_z\text{)}, \qquad s \in [0,1]$$

and *idiosyncratic productivity*

$$x_i(s) \sim \text{IID Pareto (shape } \xi_x\text{)}, \qquad i = 1, ..., n(s)$$

- Number of competitors per sector

$$n(s) \sim \text{IID Geometric } (\zeta), \qquad s \in [0,1]$$

Data

- Taiwan Annual Manufacturing Survey, 2000-2004
  - universe of establishments engaged in production
- Product-level information
  - 7-digit products (Taiwan classification, $\approx$ 5-digit SIC US)
  - sales by product by establishment
- Establishment-level information
  - employment, labor, materials, energy, total revenue

Concentration

Within-sector concentration among domestic producers.

	median	mean
# producers/sector	10	25
inv. Herfhindhal	3.9	7.3
share top producer	0.40	0.45
sales top to median	17	42

Concentration

Unconditional concentration. Size distribution of producers.

	sales	wages
fraction accounted by top 1%	0.41	0.24
fraction accounted by top 5%	0.65	0.47

Estimating θ: main idea

- Model predicts linear relation between inverse markup and market share in cross-section

$$\frac{1}{\mu_i} = \frac{\gamma - 1}{\gamma} - \left(\frac{1}{\theta} - \frac{1}{\gamma}\right)\omega_i$$

- Use DeLoecker-Warzynski (AER 2012) method to estimate μ_i

- Given γ, slope coefficient pins down θ

- In data, slope coefficient ≈ -0.68 so with $\gamma = 10$ need $\theta = 1.28$

Calibration results

	Data	Model
median inverse HH	3.9	3.8
median share top producer	0.40	0.41
median share	0.005	0.006
p75 share	0.02	0.03
p95 share	0.19	0.27
p99 share	0.59	0.59
inverse markup on market share	-0.68	-0.68

Parameters: $\gamma = 10, \theta = 1.28, \xi_x = 4.5, \xi_z = 0.6, \zeta = 0.04$

Markup distribution

	Data	Model
aggregate markup		1.31
mean markup	1.13	1.14
median markup	1.11	1.12
p75 markup	1.12	1.14
p90 markup	1.15	1.21
p95 markup	1.20	1.31
p99 markup	1.48	1.67
std dev log	0.06	0.08
log p95/p50	0.08	0.16
Misallocation, %		7.0

Markup distribution

	Data	Model	Autarky
aggregate markup		1.31	1.35
mean markup	1.13	1.14	1.15
median markup	1.11	1.12	1.12
p75 markup	1.12	1.14	1.14
p90 markup	1.15	1.21	1.23
p95 markup	1.20	1.31	1.35
p99 markup	1.48	1.67	1.76
std dev log	0.06	0.08	0.10
log p95/p50	0.08	0.16	0.19
Misallocation, %		7.0	9.0

Edmond Midrigan Xu 2015

- Alternative framework with monopolistic competition
- More suitable for introducing dynamics
- Role of markups in recent trends labor share, slowdown etc.
- Can add technology adoption etc., yet tractable framework
- AB setup: intractable due to finite number competitors in each industry

Consumer's Problem with non-CES preferences

- Consumers maximize

$$U(C, L)$$

- subject to:

$$1 = \int_{\Omega} \Upsilon\left(\frac{c(\omega)}{C}\right) d\omega$$

- and the budget constraint

$$\int_{\Omega} p(\omega)c(\omega)\, d\omega = WL + \Pi$$

$\boldsymbol{C}$: consumption; $\boldsymbol{L}$: labor;
$\boldsymbol{c(\omega)}$: consumption of ω; $\boldsymbol{p(\omega)}$: price of ω;
$\boldsymbol{W}$: wage; $\boldsymbol{\Pi}$: profits

Demand

- Lagrangean

$$\mathcal{L} = U(C,L) + \mu\left(WL + \Pi - \int_{\Omega} p(\omega)c(\omega)\,d\omega\right) + \lambda\left(\int_{\Omega} \Upsilon\left(\frac{c(\omega)}{C}\right)\,d\omega - 1\right)$$

- First Order Conditions

$$C: \qquad U_C = \lambda \int_{\Omega} \Upsilon'\left(\frac{c(\omega)}{C}\right)\frac{c(\omega)}{C^2}\,d\omega \tag{1}$$

$$L: \qquad -U_L = \mu W \tag{2}$$

$$c(\omega): \qquad \mu p(\omega) = \lambda \Upsilon'\left(\frac{c(\omega)}{C}\right)\frac{1}{C} \tag{3}$$

Demand (cont.)

- Eliminating λ between (1) and (3) gives

$$\mu p(\omega) = U_C \frac{\Upsilon'\left(\frac{c(\omega)}{C}\right)}{\int_\Omega \Upsilon'\left(\frac{c(\omega')}{C}\right)\frac{c(\omega')}{C}\,d\omega'}$$

- Multiplying both sides by $c(\omega)$ and integrating then gives

$$\mu \int_\Omega p(\omega)c(\omega)\,d\omega = U_C C \quad \text{or} \quad \mu P = U_C$$

where

$$PC = \int_\Omega p(\omega)c(\omega)\,d\omega$$

- Combining we have

$$\frac{p(\omega)}{P} = \frac{\Upsilon'\left(\frac{c(\omega)}{C}\right)}{\int_\Omega \Upsilon'\left(\frac{c(\omega')}{C}\right)\frac{c(\omega')}{C}\,d\omega'} \tag{4}$$

Demand (cont.)

- Define measure of competitiveness (high D more competition)

$$D = \int_\Omega \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{c(\omega)}{C} \, d\omega$$

- We can rewrite (4) as

$$\frac{p(\omega)}{P} D = \Upsilon' \left(\frac{c(\omega)}{C} \right)$$

- Define

$$\psi(x) := \Upsilon'^{-1}(x)$$

- So we get the residual demand curve

$$\frac{c(\omega)}{C} = \psi \left(\frac{p(\omega)}{P} D \right)$$

Demand (cont.)

- Klenow-Willis specification

$$\psi(x) = \left[1 - \varepsilon \log\left(\frac{\sigma}{\sigma - 1}x\right)\right]^{\sigma/\varepsilon}, \qquad \sigma > 1, \quad \varepsilon \geq 0$$

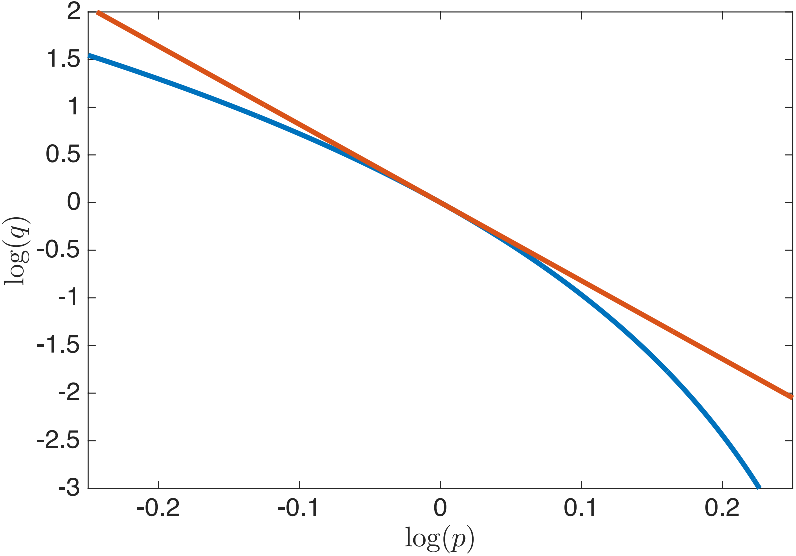
- Implying the demand elasticity

$$\theta(x) := -\frac{\psi'(x)x}{\psi(x)} = \frac{\sigma}{1 - \varepsilon \log\left(\frac{\sigma}{\sigma-1}x\right)}$$

- The implied markup is then

$$m(x) := \frac{\theta(x)}{\theta(x) - 1} = \frac{\frac{\sigma}{\sigma-1}}{1 + \frac{\varepsilon}{\sigma-1}\log\left(\frac{\sigma}{\sigma-1}x\right)} \tag{5}$$

Demand



Producer's Problem

Producers differ in productivity z, s.t. marginal cost is W/z

- Prices

$$p(z) = m(x(z))\frac{W}{z}$$

- Recall $x = (p/P)D$

$$x(z) = m(x(z))\frac{W}{z}\frac{D}{P}$$

- Supply Equation

$$x(z) = m(x(z))\frac{W}{z}\frac{D}{P}$$

$x(z; R)$: solution to fixed point problem; $R = \frac{D}{P}$

Boundary conditions

- $\overline{x}$ solves $\psi(\overline{x}) = 0$ (choke price)

$$\overline{x} = \frac{\sigma - 1}{\sigma} \exp\left(\frac{1}{\varepsilon}\right)$$

- $\underline{x}$ solves $\theta(\underline{x}) = 1$ (if $x < \underline{x}$ then $\theta(x) < 1$ so raising price increases profits)

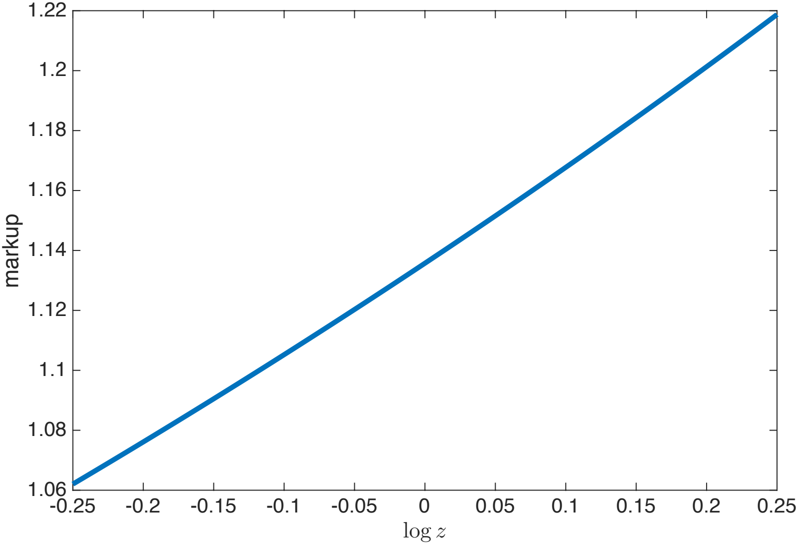
$$\underline{x} = \frac{\sigma - 1}{\sigma} \exp\left(-\frac{\sigma - 1}{\varepsilon}\right)$$

- Implied cutoffs for productivity

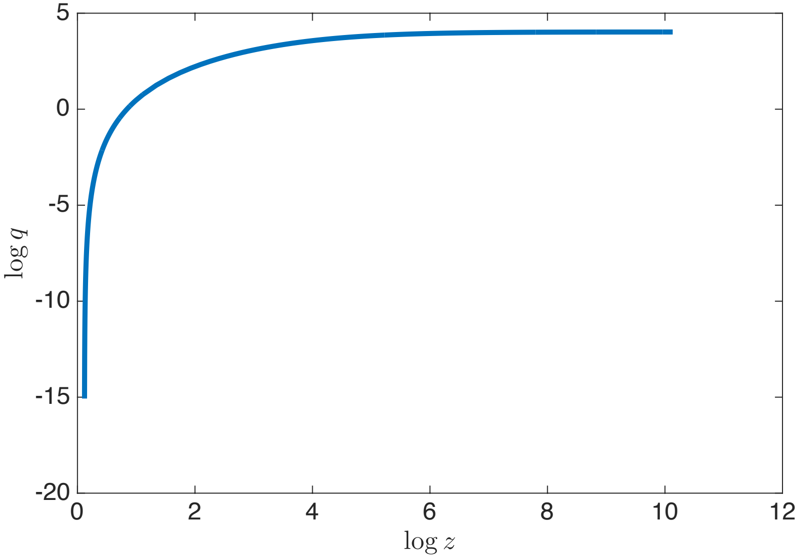
$$\overline{x} = x(\underline{z}; R) \quad \text{and} \quad \underline{x} = x(\overline{z}; R)$$

  - $z < \underline{z}$: shut down. $z > \underline{z}$: set same price / quantity

Optimal Markup



Optimal Quantity



Aggregation (R^*)

- Rewrite the Kimball aggregator

$$1 = \int_\Omega \Upsilon\left(\frac{c(\omega)}{C}\right)\, d\omega$$

as

$$1 = n \int \Upsilon\left(\psi\left(x(z;R)\right)\right)\, dH(z)$$

where n is the measure of producers

$$n := \int_\Omega d\omega$$

- Unique R^* solves this condition

$\boldsymbol{x(z;R)}$: solution to the producer's problem; $\boldsymbol{R}$: D/P

Aggregation (P^*, D^*)

- Expenditure shares add up to 1

$$1 = \int_{\Omega} \frac{p(\omega)c(\omega)}{PC}\, d\omega = n \int \frac{p(z)}{P} \frac{c(z)}{C}\, dH(z)$$

- So

$$P^* = n \int \frac{x(z; R^*)}{R^*} \psi(x(z; R^*))\, dH(z)$$

- Demand is then

$$D^* = R^* P^*$$

Aggregation (L, A)

- Labor market clearing

$$L = \int_{\Omega} l(\omega)\, d\omega = n \int \frac{y(z)}{z}\, dH(z)$$

- Using $A = Y/L$ we get aggregate productivity

$$A = \left(n \int z^{-1} \psi(x(z; R^*))\, dH(z) \right)^{-1}$$

Planner's Problem

Maximize C subject to

- Kimball aggregator

$$1 = \int_\Omega \Upsilon\left(\frac{c(\omega)}{C}\right) d\omega$$

- Resource Constraints

$$L = \int_\Omega l(\omega)\, d\omega, \qquad c(\omega) = z(\omega)l(\omega)$$

taking L and $z(\omega)$ as given.

Planner's Solution

- Lagrangean

$$\mathcal{L} = C + \lambda \left(\int_\Omega \Upsilon \left(\frac{c(\omega)}{C} \right) \, d\omega - 1 \right) + A \left(L - \int_\Omega \frac{c(\omega}{z(\omega)} \, d\omega \right)$$

- First Order Conditions

$$C : \qquad 1 = \lambda \int_\Omega \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{c(\omega)}{C^2} \, d\omega \tag{6}$$

$$c(\omega) : \qquad \lambda \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{1}{C} = A \frac{1}{z(\omega)} \tag{7}$$

Planner's Solution (cont.)

- Rewrite (6)

$$C = \lambda \int_{\Omega} \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{c(\omega)}{C} \, d\omega$$

- Rewrite (7)

$$\lambda \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{c(\omega)}{C} = A \frac{c(\omega)}{z(\omega)} \tag{8}$$

- Integrating (8) and combining the two

$$C = AL$$

Planner's Solution (cont.)

- Define D as earlier

$$D := \int_\Omega \Upsilon' \left(\frac{c(\omega)}{C} \right) \frac{c(\omega)}{C} \, d\omega, \quad \psi(x) := \Upsilon'^{-1}(x)$$

- So we get

$$C = \lambda D$$

- And

$$\frac{c(\omega)}{C} = \psi \left(\frac{AD}{z(\omega)} \right)$$

Planner's Solution (cont.)

- Plugging into Kimball aggregator we get

$$1 = n \int \Upsilon \left(\psi \left(\frac{AD}{z} \right) \right) dH(z)$$

- Plugging into resource constraint

$$A = \left(n \int z^{-1} \psi \left(\frac{AD}{z} \right) dH(z) \right)^{-1}$$

$\boldsymbol{H(z)}$: distribution of a mass n of producers

Optimal Quantity