The Spatial Distribution of Markups

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Introduction

- How much does the *geographic segmentation* of the US economy matter for competition and market power?
- Trade in goods across the US exhibits substantial home bias in shipments [e.g., Wolf 2000, Hillberry and Hummels 2008, Martínez-San Román et al 2017]
- Most work on the macro consequences of market power treats the domestic economy as a *single, perfectly integrated national market*.
- **Does that matter?**

This Paper

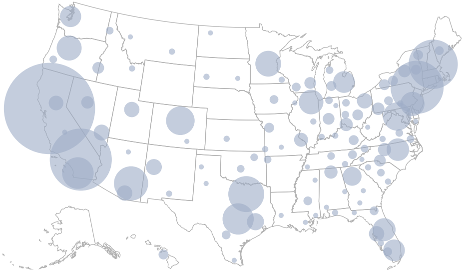
- Quantitative spatial general equilibrium model
  - heterogeneous multi-establishment firms, shipping across many locations
  - oligopolistic competition in each destination market
  - *endogenously variable markups*, firm-and-location-specific
- Calibrate model with US manufacturing data to match
  - *national sales concentration* in **363 6-digit NAICS industries**
  - *exact geographic footprint* of $\sim$**220,000 firms** across **170 Economic Areas**
  - *gravity effects* in Commodity Flows Survey, for each 3-digit NAICS industry

Geographic Footprint: Where Sectors Produce

Some goods are produced *everywhere*, others are *clustered*.

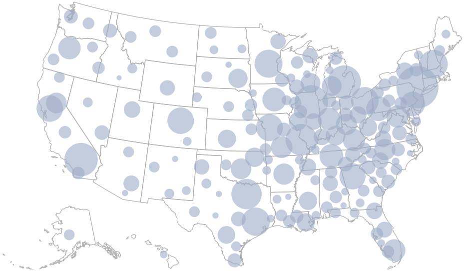
A. Semiconductors & Electronic Components

Sector-level: 1471 firms, 1843 establishments



B. Ready-Mix Concrete

Sector-level: 1915 firms, 2162 establishments



Geographic Footprint: Where Firms Produce

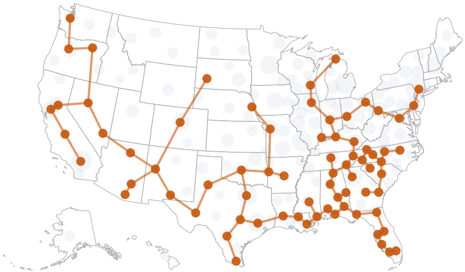
We place each firm's establishments *exactly* where they are in the data.

A. Semiconductors & Electronic Components

Example: one firm with 44 establishments

B. Ready-Mix Concrete

Example: one firm with 74 establishments



Key Findings

- **Spatial frictions substantially limit competition.**
  [equivalent to removing a randomly chosen $\sim$90% of firms]
  contrasts with BEJK 2003, Atkeson-Burstein 2008, EMX 2015, ACDR 2017: small pro-competitive effects when many firms
- **Welfare costs of markups are large and unevenly distributed.**
  [about $\sim$1% in large central markets, up to $\sim$20% in Honolulu]
- **Production concentration is a poor measure of market competition.**
  [production HHI $\sim$0 spatial correlation with sales HHI or markups]
- **Lower spatial frictions** creates *endogenous divergence* in concentration.
  [national sales concentration $\Uparrow$ but local sales concentration $\Downarrow$]

Model

Environment

- Finite J locations $j, k = 1, ..., J$ [*convention: j = source, k = destination*].
- Continuum $s \in [0, 1]$ sectors.
- Finite $N(s)$ firms per sector [*oligopolistic competition*]
  - firms can have multiple establishments
  - firm-location productivity $z_{ij}(s)$, no establishment $\Rightarrow$ set $z_{ij}(s) = 0$
- Sector-specific iceberg trade costs $\tau_{jk}(s) \geq 1$.
- Labor L_j at location j, supply E_j efficiency units [*immobile in benchmark*].

Final Good

- Based on Atkeson-Burstein (2008) nested-CES setup.
- At destination k, nontradeable consumption good CES *across sectors*

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

- And *within sector* another CES aggregate over finite $N(s)$ firms

$$C_k(s) = \left(\sum_{i=1}^{N(s)} C_{ik}(s)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \qquad \gamma > \theta$$

Firms Have Multiple Establishments

- Firm i sells at destination k sourcing from establishments at $j = 1, ..., J$.
- Another CES layer, *within-firm, across-establishments* [i.e., across locations]

$$C_{ik}(s) = \left(\sum_{j=1}^{J} c_{ijk}(s)^{\frac{\eta-1}{\eta}} \right)^{\frac{\eta}{\eta-1}}, \qquad \eta \geq \gamma$$

- Firm i uses labor to produce at establishments $j = 1, ..., J$

$$y_{ijk}(s) = z_{ij}(s)\, l_{ijk}(s)$$

- Resource constraints

$$y_{ijk}(s) = \tau_{jk}(s) c_{ijk}(s)$$

Profit Maximization: Within-Firm Allocation

- Consider least-cost way to supply destination k.
- **Result.** Firm i sets *destination-specific* markup $\mu_{ik}(s)$, regardless of sourcing

$$p_{ijk}(s) = \mu_{ik}(s)\, \frac{W_j}{z_{ij}(s)}$$

- No reason to distort allocations *within the firm*.
- Firm-level price index is markup over marginal cost of supplying destination k

$$P_{ik}(s) = \mu_{ik}(s) \times \underbrace{\left(\sum_{j=1}^{J} \left(\frac{\tau_{jk}(s) W_j}{z_{ij}(s)} \right)^{1-\eta} \right)^{\frac{1}{1-\eta}}}_{=:\mathrm{MC}_{ik}(s)}$$

Oligopolistic Competition

- **Key intuition:** *larger firms face less elastic demand, set larger markups*
  - market shares at destination k

$$\omega_{ik}(s) = \left(\frac{P_{ik}(s)}{P_k(s)}\right)^{1-\gamma}$$

  - demand elasticities, under Cournot competition

$$\varepsilon_{ik}(s) = \left(\omega_{ik}(s)\frac{1}{\theta} + (1-\omega_{ik}(s))\frac{1}{\gamma}\right)^{-1}$$

  - markups

$$\mu_{ik}(s) = \frac{\varepsilon_{ik}(s)}{\varepsilon_{ik}(s)-1}$$

- *Geography and trade costs limit market contestability.*

General Equilibrium

- Profits *paid out in proportion to labor income*

$$\Pi_j = \bar{\pi} \, W_j E_j L_j$$

for some constant $\bar{\pi} \geq 0$ to be determined in equilibrium.

- Labor market clearing in *each location j*

$$E_j L_j = \int_0^1 \sum_{k=1}^{J} \sum_{i=1}^{N(s)} l_{ijk}(s) \, ds$$

pins down local wages W_j.

Calibration

Parameterization

- *Locations*: 170 BEA **Economic Areas**, firm locations from **NETS**

1	Los Angeles-Riverside-Orange County	14.6%	of total employment
2	New York-No. New Jer.-Long Island	7.2%	
3	Chicago-Gary-Kenosha	6.9%	
	⋮		
170	Scottsbluff, NE-WY	0.0012%	

- *Sectors*: 363 **NAICS 6-digit manufacturing**, e.g., Ready-Mix Concrete (327320), Breakfast Cereal (311230), Semiconductors (334413).

- *Employment*: L_j from US Census **County Business Patterns** (CBP).

- *Efficiency units*: E_j so model wage bill $W_j E_j L_j$ matches **CBP** wage bill.

Firms and Establishments

- *Geographic footprint*: Let $\mathcal{J}_i(s) \subseteq \{1, ..., J\}$ denote the set of EAs where firm i has establishments — straight from **NETS** data. Let $n_i(s) = |\mathcal{J}_i(s)|$.
- *Establishment counts*: observed

$$G(n) := \text{Prob}[n_i(s) \leq n] = \textbf{Empirical CDF}$$

- *Correlated ranks*: more establishments $\Rightarrow$ higher productivity

$$H(z, n) := \mathcal{C}(F(z), G(n)) = \textbf{Gumbel Copula}(\rho)$$

- *Firm productivity*: backed out from **Pareto**(ξ), i.e., $F(z) = 1 - z^{-\xi}$

$$z_{ij}(s) = z_i(s) \cdot \mathbf{1}[j \in \mathcal{J}_i(s)]$$

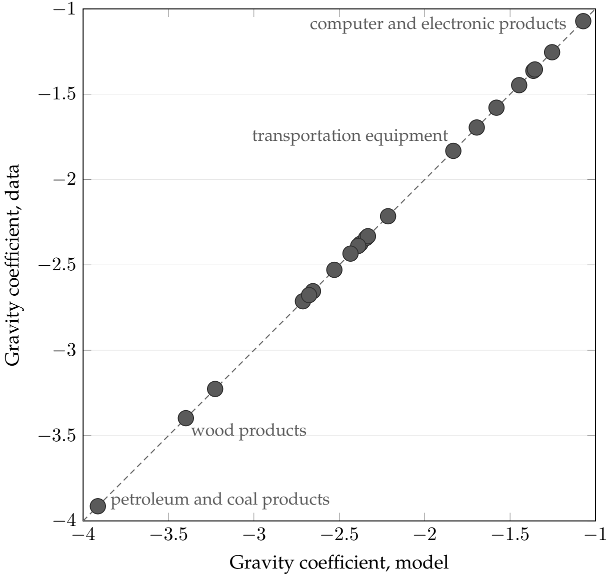
Parameter Values

Parameter		Value	Target
Assigned Values			
Elas. subs. across sectors	θ	1.25	Sector-level markups and concentration
Elas. subs. within sectors	$\gamma = \eta$	10	(Edmond, Midrigan and Xu, 2023)
Method of Moments			
Pareto tail firm $z_i(s)$	ξ	10.35	National concentration
Gumbel rank correlation	ρ	0.81	Employment share multi-estab firms
Trade cost wrt distance	$\delta(s)$		Gravity coeff. 3-digit NAICS

Model Fit

Moments [targeted]	Data	Model
National Concentration		
Top 4 sales share	0.42	0.44
HHI sales	0.10	0.10
Local Concentration		
HHI production	0.36	0.37
Top 4 sales share		0.58
HHI sales		0.15
Multi-Establishment Firms		
Fraction multi-establishment firms	0.03	0.03
Employment share of multi-establishment firms	0.54	0.53
Sales share of multi-establishment firms	0.62	0.55

Gravity Coefficients in Data and Model



Trade cost elasticities $\delta(s)$ chosen so the model reproduces CFS gravity coefficients $\beta(s)$ *exactly*.

Large negative $\beta(s)$ means *high gravity*, less tradeable.

Quantitative Results

Spatial distribution of concentration and markups

How anti-competitive are spatial frictions?

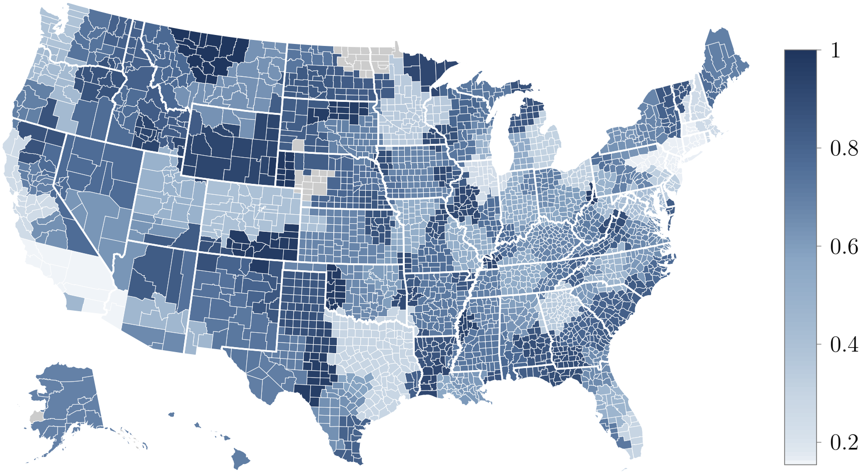
Welfare costs of markups

Misallocation decomposition

Trends in concentration

Local Production Concentration

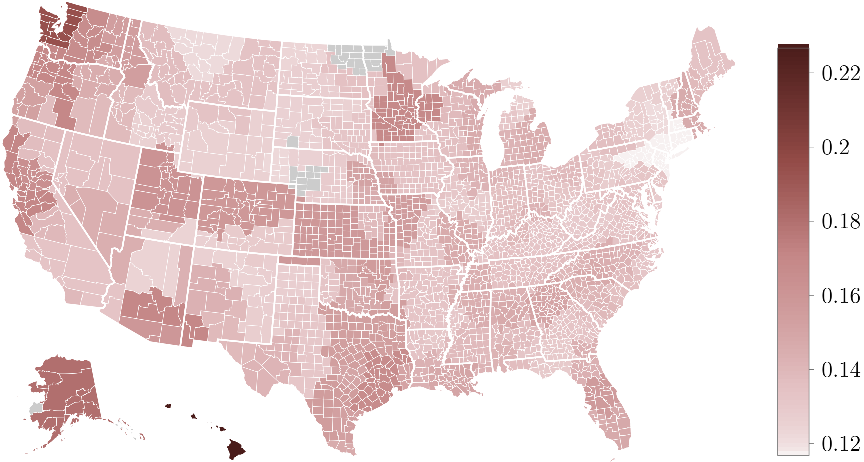
Local production HHIs are **extremely dispersed** [*range* 0.16 *to* 0.99]



Interpretation: HHI $= 1/5$ is like 5 equally-sized firms.

Local Sales Concentration

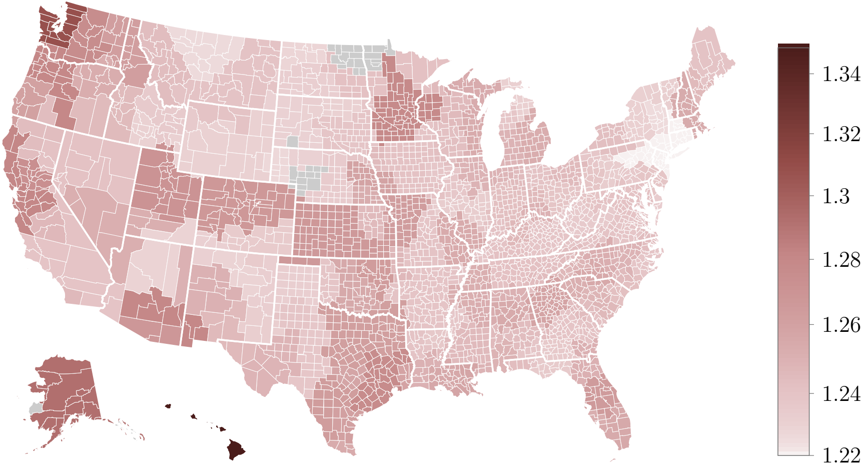
Local sales HHIs are **much more compressed** [*range* 0.12 *to* 0.22]



Average local sales HHI 0.15 vs. average national HHI 0.10.

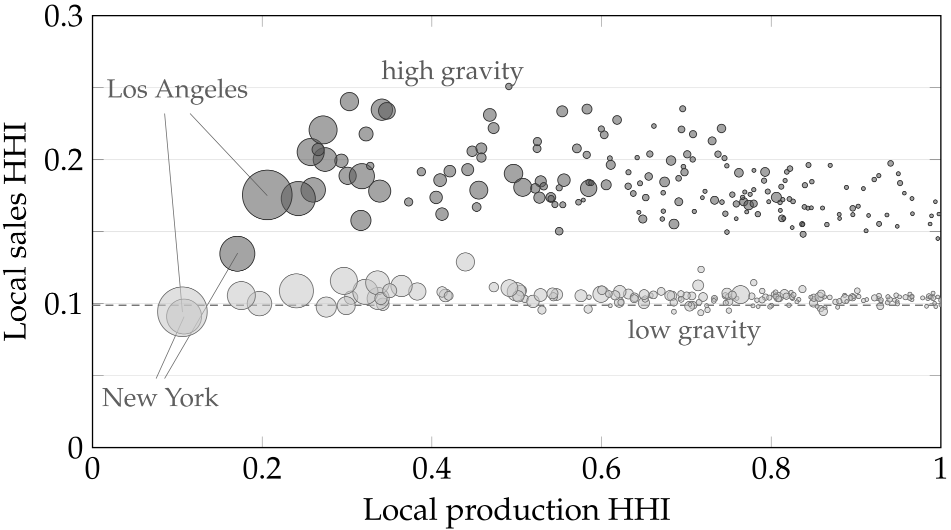
Spatial Distribution of Markups

Same map — average markups given by $\bar{\mu}_k = 1 \Big/ \left(\frac{\gamma - 1}{\gamma} - \left(\frac{1}{\theta} - \frac{1}{\gamma} \right) \overline{\mathrm{HHI}}_k \right)$



Average markup 1.26 — New York 1.22, Seattle 1.31, Honolulu 1.35.

Production vs Sales Concentration



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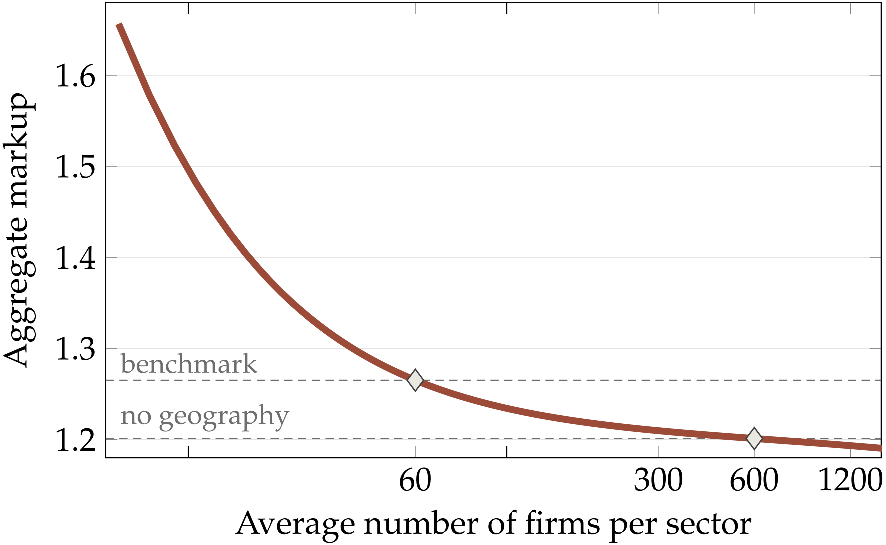
Removing All Geography / Spatial Frictions

	Benchmark	No Geography
Markups		
p01	1.13	1.13
p50	1.23	1.18
p99	1.62	1.50
Aggregate	**1.26**	**1.19**
Concentration		
National sales HHI	0.10	0.10
Local sales HHI	0.15	0.10
Local production HHI	0.37	0.10

Model with No Geography calibrated to same national concentration.

A Huge Reduction in Effective Competition

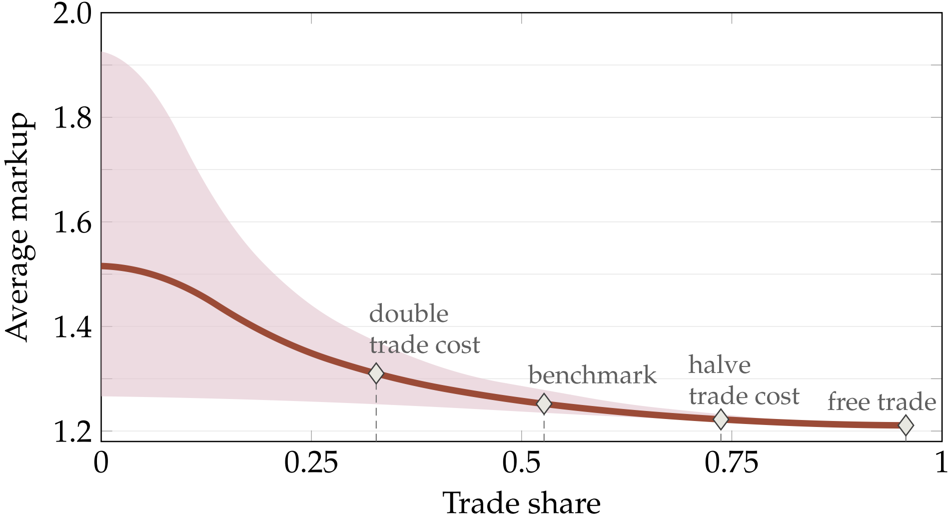


What Matters Is Effective Competition

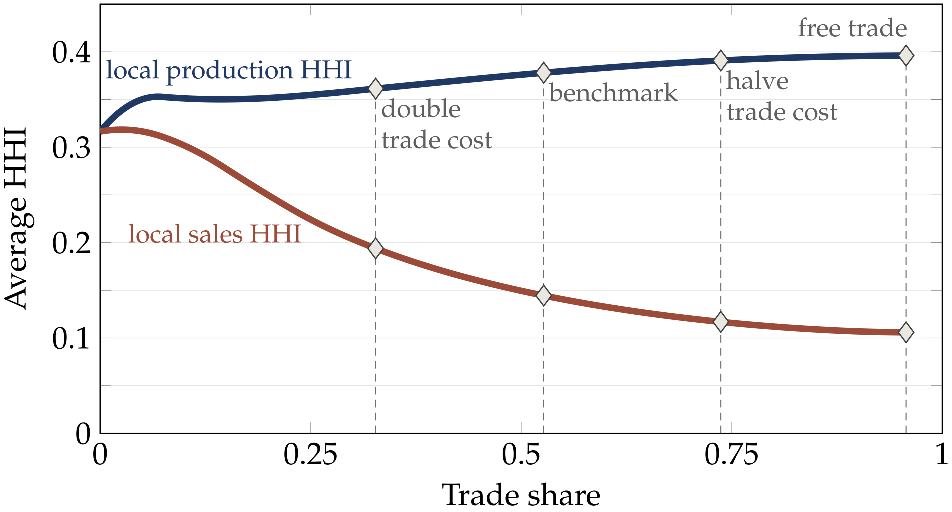
- To reproduce the anti-competitive effects of spatial frictions in an otherwise equivalent model without geography, we need to *shut down 90% of firms*.

- A macro model without geography is like assuming *the competitive conditions of New York and Los Angeles*, or better, prevail everywhere.

From Autarky to Free Trade: Markups



From Autarky to Free Trade: Concentration



Quantitative Results

Spatial distribution of concentration and markups

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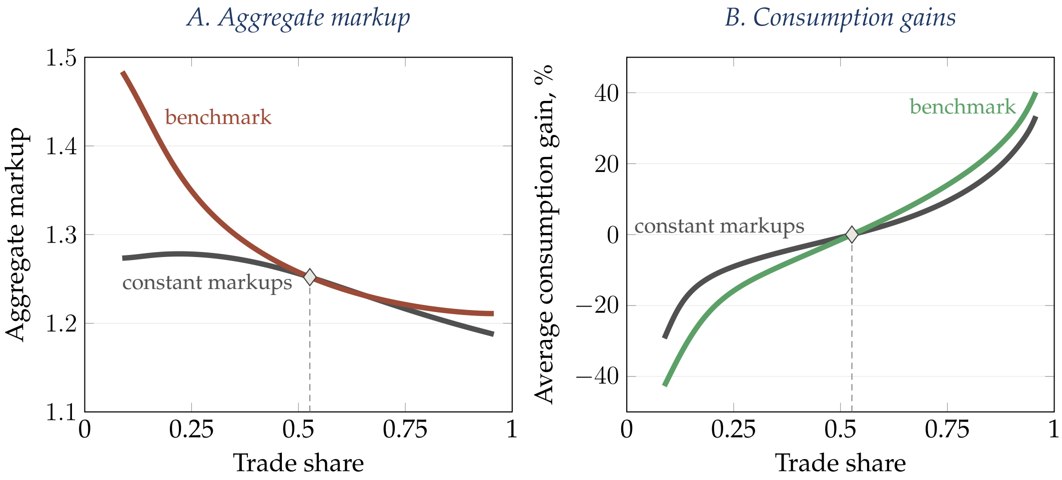
Welfare Costs of Markups

Consumption-equivalent gain from removing all markups:

	Benchmark	No Geography
Average gain, %	**5.8**	**3.7**
New York	0.9	
Los Angeles	3.6	
Minneapolis	9.1	
Phoenix	10.4	
Seattle	13.5	
Honolulu	21.5	

With geography, the costs are *much larger* on average and *extremely uneven*.

Why Endogenously Variable Markups Matter



Quantitative Results

Spatial distribution of concentration and markups

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Measuring Misallocation

- Aggregate productivity for destination k in sector s in benchmark economy

$$\bar{Z}_k(s) = \left(\sum_{j=1}^{J} \left(\frac{\bar{\mu}_{jk}(s)}{\bar{\mu}_k(s)} \right)^{-\gamma} \left(\frac{\bar{z}_{jk}(s)}{\tau_{jk}(s)} \right)^{\gamma-1} \left(\frac{W_j}{\bar{W}_k(s)} \right)^{-\gamma} \right)^{\frac{1}{\gamma-1}}$$

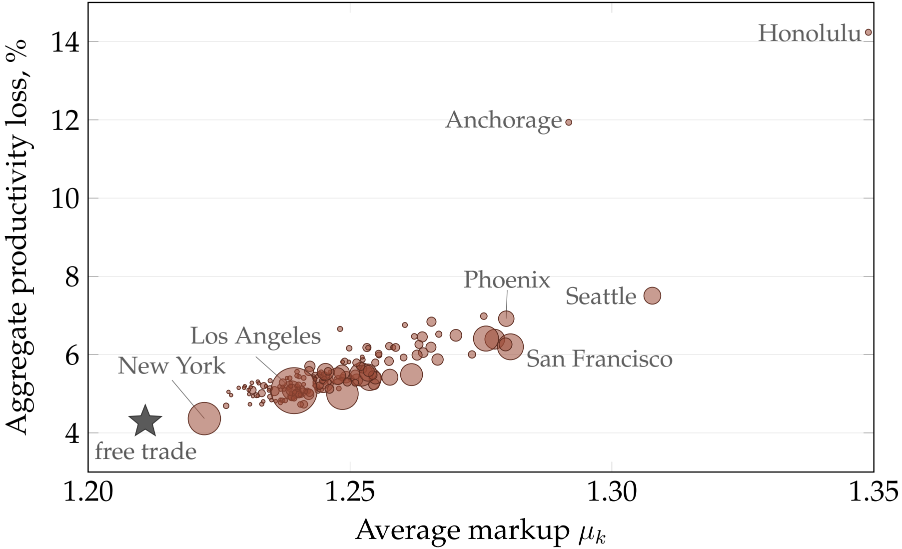
- Aggregating across sectors

$$\bar{Z}_k = \left(\int_0^1 \left(\frac{\bar{\mu}_k(s)}{\bar{\mu}_k} \right)^{-\theta} \bar{Z}_k(s)^{\theta-1} \left(\frac{\bar{W}_k(s)}{\bar{W}_k} \right)^{-\theta} ds \right)^{\frac{1}{\theta-1}}$$

- Efficient allocation $\bar{Z}_k^*$ sets *markup wedges to one*. Misallocation given by

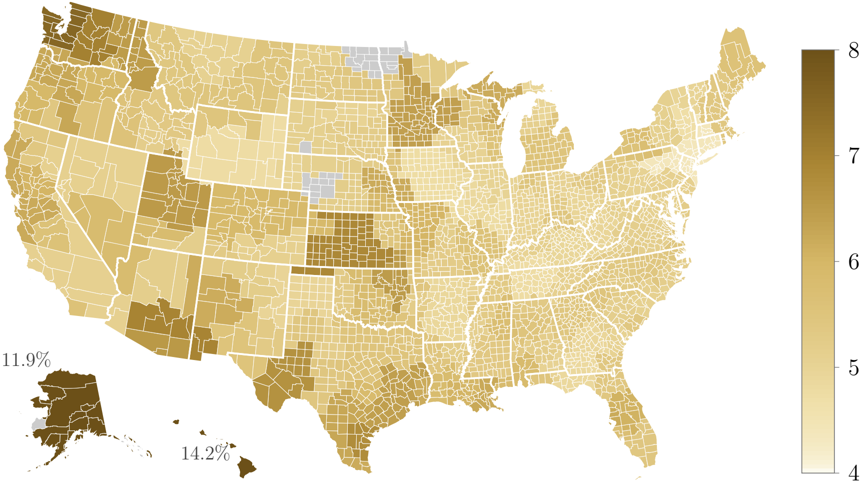
$$\hat{Z}_k := \frac{\bar{Z}_k}{\bar{Z}_k^*} \leq 1$$

Misallocation and Markups



Misallocation Losses

Misallocation losses $1 - \hat{Z}_k$, [*range* 4.4% *to* 14.2%]



Misallocation Decomposition

- Three dimensions of markup variation. Exact decomposition in levels

$$\hat{Z}_k = \underbrace{\hat{A}_k}_{\text{across firms}} \times \underbrace{\hat{B}_k}_{\text{across sources}} \times \underbrace{\hat{C}_k}_{\text{across sectors}}$$

  - *across firms*: within a source j, firms have different markups
  - *across sources*: at destination k, sources j have different markups
  - *across sectors*: at destination k, sectors s have different markups

- Report percentage losses from each kind of variation, approximately additive

Misallocation Decomposition Results

	Across firms	Across sources	Across sectors	Total
New York	3.1	0.8	0.5	**4.4**
Los Angeles	3.5	0.9	0.8	**5.1**
Minneapolis	3.5	2.0	1.0	**6.4**
Phoenix	3.5	2.3	1.3	**6.9**
Seattle	3.7	2.4	1.7	**7.5**
Anchorage	2.6	3.7	6.2	**11.9**
Honolulu	3.0	4.4	7.4	**14.2**
Average	3.0	1.9	0.7	**5.5**

Across-firms losses are *flat*, almost all geographic variation comes from markup dispersion across sources j and sectors s.

Quantitative Results

Spatial distribution of concentration and markups

Geography matters

Welfare costs of markups

Misallocation decomposition

Trends in concentration

Divergence or Convergence?

- Suppose we take as given that national sales concentration has been rising while local sales concentration has been falling.
- Should we think of this as *diverging trends* in concentration?
- Better understood as *convergence* towards a well-integrated national market.
- In the free trade limit, **the distinction between national and local concentration disappears**.

Changing National Integration

	$+20\%$	Benchmark	-20%	Free Trade
Decreasing Local Sales Concentration $\Downarrow$				
Top 4 share	0.61	0.58	0.56	**0.49**
HHI sales	0.16	0.15	0.13	**0.11**
Increasing National Sales Concentration $\Uparrow$				
Top 4 share	0.43	0.44	0.45	**0.49**
HHI sales	0.10	0.10	0.10	**0.11**
Increasing Local Production Concentration $\Uparrow$				
HHI production	0.36	0.37	0.38	0.40

Conclusions

- **Spatial frictions substantially limit competition.**
  [equivalent to removing a randomly chosen $\sim$90% of firms]
- **Welfare costs of markups are large and unevenly distributed.**
  [about $\sim$1% in large central markets, up to $\sim$20% in Honolulu]
- **Production concentration is a poor measure of market competition.**
  [production HHI $\sim$0 spatial correlation with sales HHI or markups]
- **Lower spatial frictions** creates *endogenous divergence* in concentration.
  [national sales concentration $\Uparrow$ but local sales concentration $\Downarrow$]

Appendix

Representative Consumer

- Aggregating budget constraints of L_k representative consumers in destination k

$$P_k C_k = W_k E_k L_k + \Pi_k$$

- Aggregate profits $\Pi = \sum_k \Pi_k$ *paid in proportion* $\bar{\pi}$ to labor income $W_k E_k L_k$

$$P_k C_k = (1 + \bar{\pi}) W_k E_k L_k$$

for some constant $\bar{\pi} > 0$ to be determined.

Demand

- Demand for output from location j to be sold at k by firm i in sector s

$$c_{ijk}(s) = \left(\frac{\tau_{jk}(s) p_{ijk}(s)}{P_{ik}(s)} \right)^{-\eta} \left(\frac{P_{ik}(s)}{P_k(s)} \right)^{-\gamma} \left(\frac{P_k(s)}{P_k} \right)^{-\theta} C_k$$

- Familiar aggregate and sector-level CES price indexes

$$P_k = \left(\int_0^1 P_k(s)^{1-\theta} \, ds \right)^{\frac{1}{1-\theta}}, \qquad P_k(s) = \left(\sum_{i=1}^{N(s)} P_{ik}(s)^{1-\gamma} \right)^{\frac{1}{1-\gamma}}$$

- Firm-level CES price index

$$P_{ik}(s) = \left(\sum_{j=1}^{J} (\tau_{jk}(s) p_{ijk}(s))^{1-\eta} \right)^{\frac{1}{1-\eta}}$$

Intermediate Producers

- Output sourced from j sold at k produced with

$$y_{ijk}(s) = z_{ij}(s)\, l_{ijk}(s)$$

- Marginal cost

$$\frac{W_j}{z_{ij}(s)}$$

- Profits from sales at destination k are then

$$\pi_{ik}(s) = \sum_{j=1}^{J} \left(p_{ijk}(s) - \frac{W_j}{z_{ij}(s)} \right) y_{ijk}(s)$$

- Given CRS, maximize profit for each destination k separately.

Oligopolistic Competition

- Can write the profits of firm i from each destination k

$$(P_{ik}(s) - \mathrm{MC}_{ik}(s))\, C_{ik}(s)$$

subject to the residual demand curve

$$C_{ik}(s) = \left(\frac{P_{ik}(s)}{P_k(s)}\right)^{-\gamma} \left(\frac{P_k(s)}{P_k}\right)^{-\theta} C_k$$

and price indexes.

Aggregation: Productivity Network

- Bilateral composite of goods shipped $j \to k$ within a sector

$$\bar{c}_{jk}(s) = \left(\sum_{i=1}^{N(s)} c_{ijk}(s)^{\frac{\gamma-1}{\gamma}} \right)^{\frac{\gamma}{\gamma-1}}, \qquad \bar{z}_{jk}(s) := \frac{\bar{y}_{jk}(s)}{\bar{l}_{jk}(s)}$$

- Endogenous *productivity network* $\bar{z}_{jk}(s)$, with $\bar{p}_{jk}(s) = \bar{\mu}_{jk}(s) W_j / \bar{z}_{jk}(s)$

$$\bar{z}_{jk}(s) = \left(\sum_{i=1}^{N(s)} \left(\frac{\mu_{ik}(s)}{\bar{\mu}_{jk}(s)} \right)^{-\gamma} z_{ij}(s)^{\gamma-1} \right)^{\frac{1}{\gamma-1}}$$

  - no markup dispersion $\Rightarrow$ standard CES index in $z_{ij}(s)$
  - dispersion reduces $\bar{z}_{jk}(s)$ below that benchmark
  - does *not* depend on $\tau_{jk}(s)$: within a sector, trade costs hit all firms equally

Closed form for $\eta = \gamma$. [Edmond, Midrigan and Xu 2015, 2023]

Solving the Model

- Markups $\mu_{ik}(s)$ implicitly solve

$$1 - \frac{1}{\mu_{ik}(s)} = \frac{1}{\gamma} + \left(\frac{1}{\theta} - \frac{1}{\gamma}\right) \frac{(\mu_{ik}(s)\mathrm{MC}_{ik}(s))^{1-\gamma}}{\sum_{\iota=1}^{N(s)}(\mu_{\iota k}(s)\mathrm{MC}_{\iota k}(s))^{1-\gamma}}$$

given the marginal costs

$$\mathrm{MC}_{ik}(s) = \left(\sum_{j=1}^{J}\left(\frac{\tau_{jk}(s)W_j}{z_{ij}(s)}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}}$$

- *Inner loop*: given W_j compute markups, allocations, and profits.
- *Outer loop*: given inner loop, find wages W_j that clear labor markets.

Trade Costs and Gravity

- Sector-specific log-linear relationship between trade costs and distance d_{jk}

$$\ln \tau_{jk}(s) = \delta(s) \ln d_{jk}$$

- Choose $\delta(s)$ so model reproduces coefficients $\beta(s)$ in *gravity regressions*

$$\ln(p_{jk}(s) y_{jk}(s)) = \gamma_j(s) + \gamma_k(s) + \beta(s) \ln d_{jk} + \epsilon_{jk}(s)$$

- **Gravity Regressions:**
  - EA-to-EA trade flows, 2017 Commodity Flows Survey
  - for each 3-digit NAICS

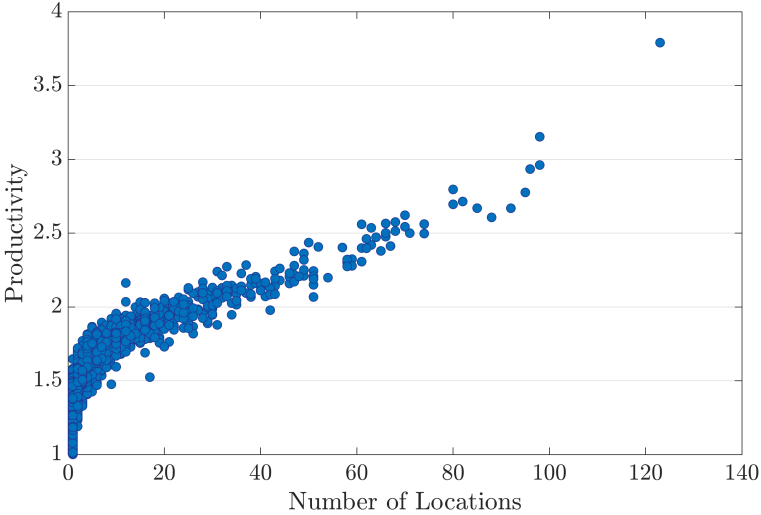
Calibration: Assigning Productivities

- Only $z_i(s)$ is unobserved — footprints $\mathcal{J}_i(s)$ and counts $n_i(s)$ come from **NETS**.

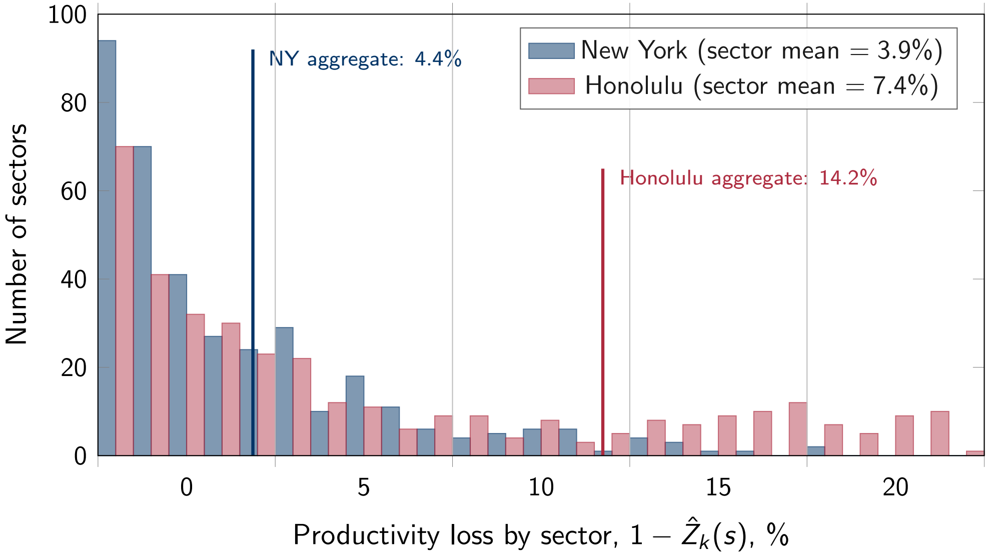
  1. Simulate a large pool of (z, n) pairs from the Gumbel copula $\mathcal{C}(F, G)$
  2. Condition on establishment count n
  3. Sample the *exact* number of real firms in that category
  4. Assign each to its *actual* locations $\mathcal{J}_i(s)$

- Preserves the empirical joint distribution of footprints and counts, while ξ and ρ match national concentration and the multi-establishment employment share.

Calibration: Productivity vs. Locations



New York vs. Honolulu



Labor Mobility: Setup

- Workers draw idiosyncratic amenities v_j, IID standard Fréchet

$$\text{Prob}[v_j \leq v] = \exp(-v^{-\sigma}), \qquad \sigma > 0$$

- Payoff from choosing location j, then choose $\max_j u_j(\boldsymbol{v})$

$$u_j(\boldsymbol{v}) = A_j\, v_j\, (1 + \bar{\pi}) \frac{W_j}{P_j} E_j$$

- Gives a labor supply curve with elasticity σ

$$L_k = \frac{\left(A_k E_k \frac{W_k}{P_k}\right)^{\sigma}}{\sum_j \left(A_j E_j \frac{W_j}{P_j}\right)^{\sigma}} \bar{L}$$

Profit income cancels — paid in proportion to labor income.

Labor Mobility: Consumption Gains

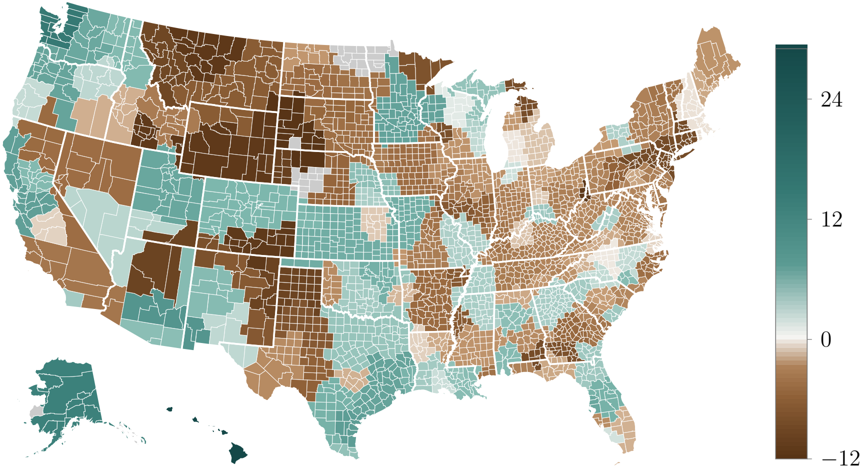
Gains from eliminating markups, %. $\sigma = 2$, amenities A_k match benchmark L_k.

	Immobile	Mobile	
Across locations	C_k/L_k	C_k/L_k	C_k
p10	3.6	3.7	−0.4
p25	3.9	4.1	0.9
p50	5.6	5.6	5.4
p75	6.9	6.9	9.3
p90	9.1	8.9	15.6
Average	**5.8**	**5.8**	6.0

Consumption *per worker* is **unchanged** — mobility does little to mitigate.

Labor Mobility: Where Workers Go

Same gain *per worker* decomposes into consumption *and* employment



p90: +15.6% C_k and +6–7% employment. p10: −0.4% C_k and −4% employment.