Market Size and Trade in Medical Services

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Economies of scale and trade in medical services

Perpetual policy discussion of geographic variation in medical services:

- Less populous places have worse health outcomes...
- ...but US doctors are disproportionately in big cities (50% more per capita)

Evaluating this situation hinges on returns to scale and tradability

- Increasing returns $\rightarrow$ productivity benefits from concentrating production
- Trade costs for services $\rightarrow$ proximity-concentration trade-off
- Heterogeneity in patients' travel costs $\rightarrow$ efficiency and equity considerations

How do local increasing returns and trade costs govern the geography of US healthcare production and consumption? (18% of US GDP)

This paper

Approach:

- Setting: Medicare (regulated provider payments)
- Model: Trade costs & scale economies $\rightarrow$ market-size effects
- Implementation: Logit demand $\rightarrow$ gravity equation $\rightarrow$ scale elasticity

Estimates:

- Domestic trade in medical services mimics trade in manufactures

  19% of production is exported; distance elasticity is about -1.7
- Market-size effect makes larger regions net exporters of medical services; stronger effect in less common services
- Geographic concentration $\rightarrow \uparrow$ service quality, $\uparrow$ specialization ($\alpha \approx 0.8$)

Counterfactual scenarios

Simple model generates rich depiction of proximity-concentration tradeoffs:

- Changes in output quality $\neq$ changes in patient market access: improving access need not mean subsidizing *output* in the region
- Production subsidies and travel subsidies can impose contrasting spillovers ("agglomeration shadows") on neighboring regions
- Production may be too dispersed: marginal return is higher in larger regions
- Production subsidies in smaller regions benefit lower-income patients more
- Lower-SES patients need larger travel subsidies to equalize access
- Size of the United States contributes to inequality in access

Contributions

Medical care: interregional trade & regional increasing returns

- Distribution of physicians/rural access Newhouse 1982a,b,c, 1990; Dranove, Shanley & Simon 1992; Buchmueller et al. 2006, Alexander & Richards, 2021; ...
- Studies mostly treat markets as local Dartmouth; Baumgardner 1988a,b; Bresnahan & Reiss 1991; Chandra & Staiger 2007; Finkelstein, Gentzkow & Williams 2016

Home-market effect for trade in services

- Market size and goods: Davis and Weinstein 2003; Hanson and Xiang 2004; Dingel 2017; Bartelme et al. 2019 Acemoglu and Linn 2004; Costinot et al. 2019
- Trade in services: Lipsey '09 Eaton & Kortum '19 Eilat & Einav '04, Muñoz '22

Central place theory and "spatial shopping" literature

- Central place theory: Christaller 1933; Hsu, Holmes and Morgan 2014; Schiff 2015
- Credit-card trade matrices: Agarwal et al. 2017; Dunn and Gholizadeh 2021

- Empirical setting and geographic patterns
- Theoretical framework
- Regional increasing returns in medical services
  - Estimating the scale elasticity
  - Strong home-market effect for aggregate medical services
- Mechanisms
  - How market-size effects vary with procedure characteristics
  - Sources of increasing returns: Division of labor and lumpy capital
  - Travel to access specialized services
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Medicare

- Medicare insures almost all Americans > 65 years old or disabled
  - 59 million beneficiaries and about 23% of healthcare expenditure (in 2017)
  - 39 million in Traditional Medicare (physicians & facilities bill Medicare)
- All willing providers covered; vast majority of doctors/hospitals
  - cf. private insurance: limited network, opaque pricing $\rightarrow$ patients have different choice sets
- Medicare regulates payment ("reimbursement") rates
  - Set based on estimates of average cost of care
  - Professional fee $\rightarrow$ physician (by procedure code)
  - Facility fee $\rightarrow$ hospital (by main diagnosis or major procedure)
  - Limited geographic variation (89 regions for professional fees)
  - We standardize both professional and facility fees at national average prices

Data

Medicare claims data for 2013-2017

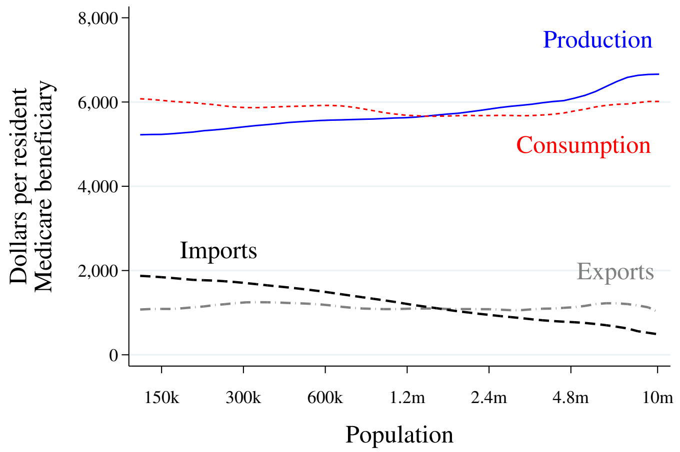
- Claims files report procedure, provider, date, payment
- We include all care provided by MD/DO outside Emergency Department
- 12,000+ 5-digit procedures in Healthcare Common Procedure Coding System
- 20% representative sample of patients contains ~210 million claim lines
- ZIP codes of patient and place of service

National Plan and Provider Enumeration System (NPPES)

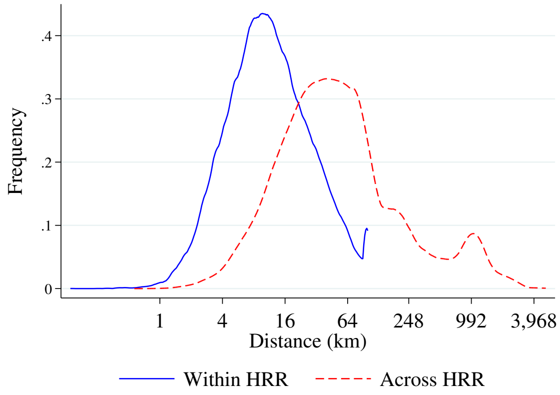
- Physician ID, name, specialization, and location

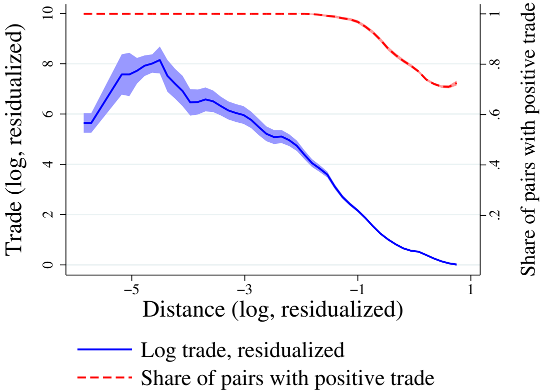
We aggregate ZIP codes to hospital referral regions (HRRs)

Production, consumption, trade, and market size



Trade declines with distance





Understanding these patterns

The geography of US medical services:

- Large markets are net exporters
- Traveling for care is costly

Are large markets net exporters because they have more patients?

- Are there regional increasing returns to scale in medicine?
- Are they so large that higher demand generates net exports?

How might policies change these geographic patterns?

- Where is the marginal return to subsidizing production highest?
- What happens if government subsidizes travel?

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Model of a market for a medical procedure (isoelastic case)

- Partial-equilibrium competitive model of one procedure with a fixed price
- N_j potential patients in region j. Patient k choosing care in region i gets

$$U_{ik} = \ln \delta_i + \ln \rho_{ij(k)} + \epsilon_{ik}$$

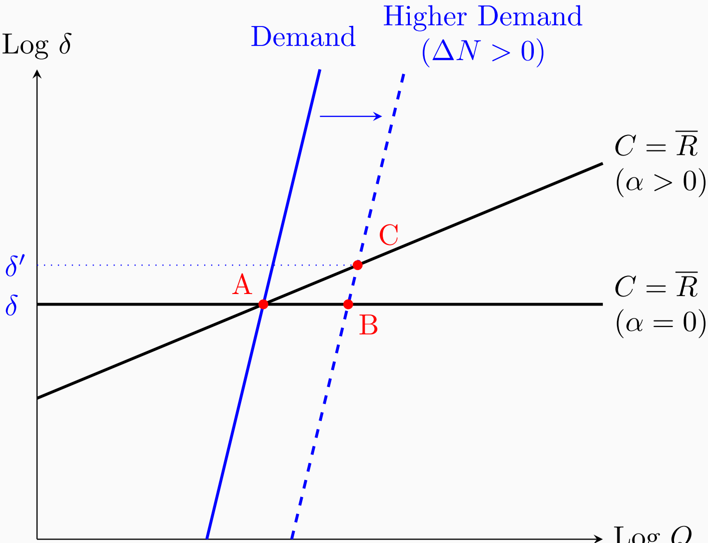
- Provider in region i hiring L inputs to produce quality δ takes productivity shifter A_i and regional output Q_i as given. Output quantity is

$$A_i \frac{H(Q_i)}{K(\delta)} L$$

- Given government-set reimbursement rate $\overline{R}$ and factor price w_i, the free-entry condition defines an isocost curve in (Q, δ) space:

$$\overline{R} = \frac{w_i K(\delta_i)}{A_i H(Q_i)} \equiv C(Q_i, \delta_i; w_i, A_i)$$

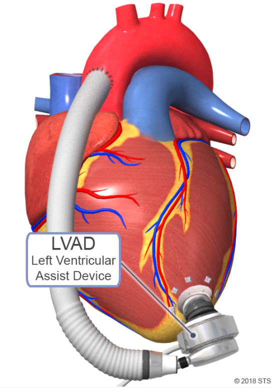
Autarky

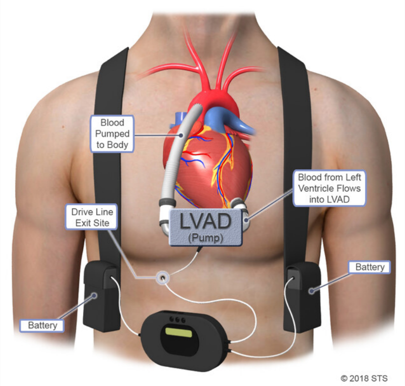


Log δ
Demand
Higher Demand
$(\Delta N > 0)$
$C = \overline{R}$
$(\alpha > 0)$
C
δ'
A
δ
B
$C = \overline{R}$
$(\alpha = 0)$
Log Q

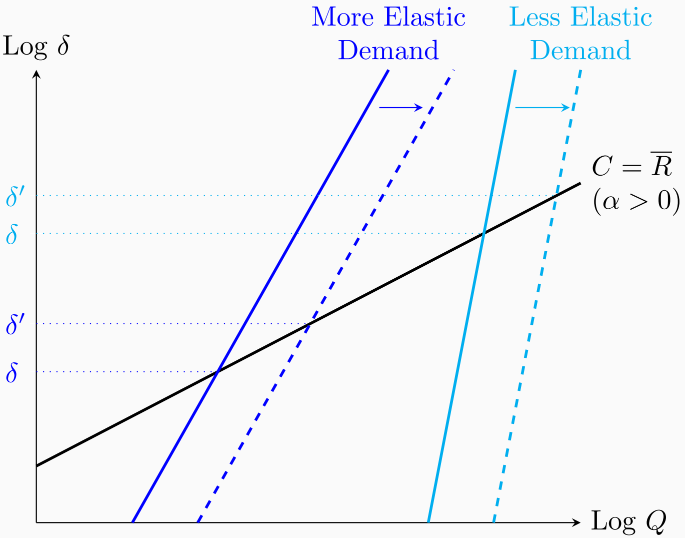
Common and rare procedures: 2 examples

- Colonoscopy (N=58,785 in our sample)
- Implanting LVAD—pump for severe heart failure patients (N=333)





Autarky: Common vs rare procedures



Trade

Preference shocks $\epsilon_{ik} \overset{\text{iid}}{\sim}$ T1EV $\implies$ Q_{ij} patients from j choosing i:

$$\mathbb{E}\left[Q_{ij}\right] = \frac{\delta_i \rho_{ij}}{\Phi_j} N_j \qquad \text{where } \Phi_j \equiv \sum_{i'} \delta_{i'} \rho_{i'j} \text{ is patient market access in } j$$

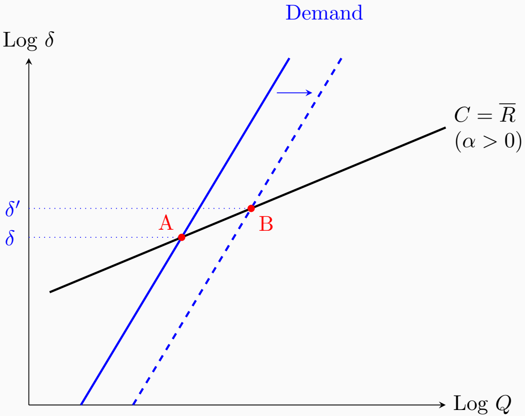
Trade follows gravity equation:

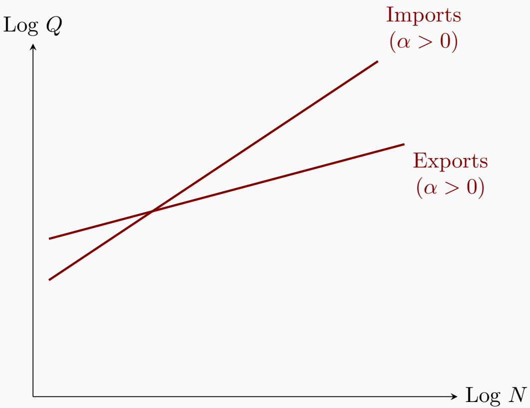
$$\ln \mathbb{E}\left[Q_{ij}\right] = \ln \delta_i + \ln \left(\frac{N_j}{\Phi_j}\right) + \ln \rho_{ij}$$

Market size and trade: N_j, δ_i, Φ_j

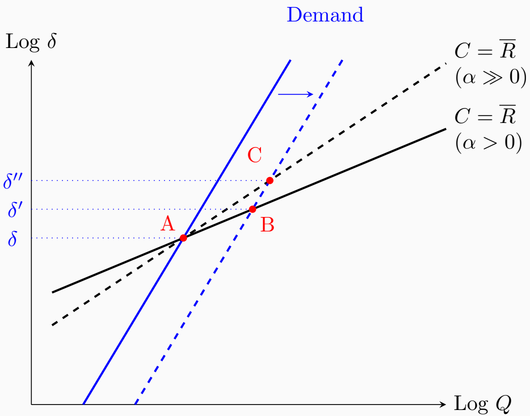
- Larger population (larger N_j) raises import demand
- With increasing returns ($\alpha > 0$): $\uparrow N_i \rightarrow \uparrow \delta_i \rightarrow \uparrow$ gross exports & $\uparrow \Phi_i$
- With sufficiently strong increasing returns ($\alpha \gg 0$):
  - $\uparrow N_i \rightarrow$ $\ln \delta_i$ increases faster than $\ln \left(\frac{N_i}{\Phi_i}\right)$: region i is net exporter
  - This effect is larger for rare services

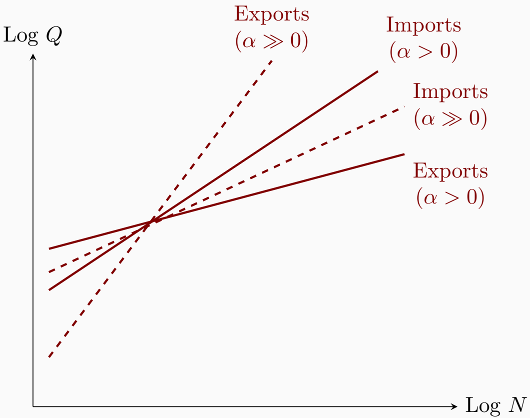
Trade: Weak home-market effect





Trade: Strong home-market effect





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Estimating regional quality and the scale elasticity

1. Exporter fixed effects from gravity regression reveal regional quality:

$$\ln \mathbb{E}\left(S_{ij}\right) = \underbrace{\ln \delta_i}_{\text{exporter FE}} + \underbrace{\ln \theta_j}_{\substack{\text{importer FE} \\ = N_j/\Phi_j}} + \gamma \ln \text{distance}_{ij}$$

2. Isocost curve implies estimating equation for α:

$$\widehat{\ln \delta_i} = \alpha \ln Q_i - \ln w_i + \ln A_i + \ln \overline{R}$$

Higher-quality output can reflect:

- larger scale ($Q_i \uparrow$),
- cheaper inputs ($w_i \downarrow$),
- exogenous productivity ($A_i \uparrow$) [e.g., sunk investments in quality]

Estimating the scale elasticity: empirical considerations

$$\ln \mathbb{E}\left(S_{ij}\right) = \underbrace{\ln \delta_i}_{\text{exporter FE}} + \underbrace{\ln \theta_j}_{\text{importer FE}} + \gamma \ln \text{distance}_{ij}$$

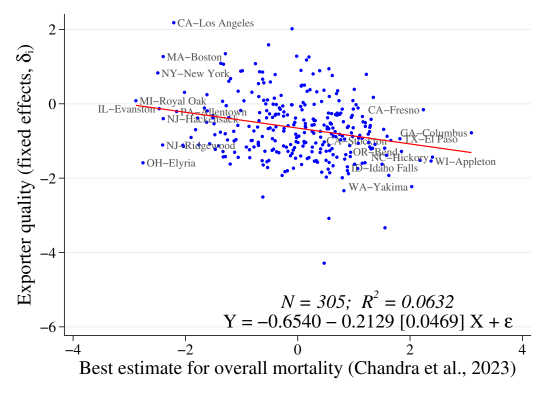
- Estimate by Poisson pseudo-maximum likelihood (PPML) due to zeros
- Distance: Log-linear, log-quadratic, or decile dummies

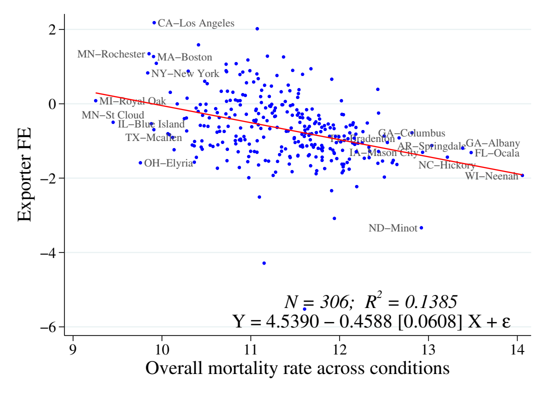
$$\widehat{\ln \delta_i} = \alpha \ln Q_i + \ln \overline{R} - \ln w_i + \ln A_i$$

- 3 instruments for $\ln Q_i$: population, 1940 population, bedrock depth
- Auxiliary evidence on factor prices w_i
- First-difference using 2013–2017 changes

Estimated HRR quality positively correlated with health outcomes

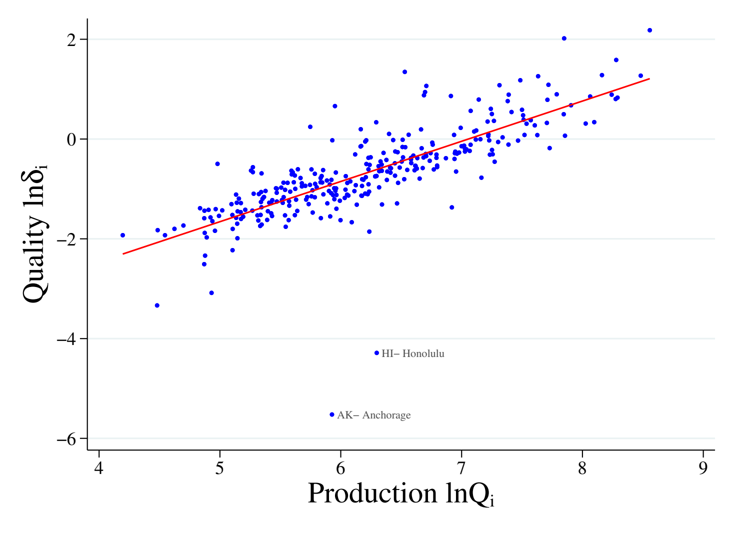
$$\ln \mathbb{E}\left(S_{ij}\right) = \underbrace{\ln \delta_i}_{\text{exporter FE}} + \underbrace{\ln \theta_j}_{\text{importer FE}} + \gamma \ln \text{distance}_{ij}$$





- Further support for clinical quality: Fischer et al., 2022; Battaglia, 2022; Petek, 2022

Quality $\sim$ isoelastic with respect to scale



Scale elasticity estimate $\hat{\alpha}$ (HRRs)

All services	Baseline	No Diagonal	Controls
OLS: 2017	0.806	0.961	0.786
	(0.031)	(0.047)	(0.041)
OLS: 2013–2017 difference	0.999	1.045	1.018
	(0.079)	(0.083)	(0.082)
2SLS: population (log)	0.800	0.905	0.777
	(0.037)	(0.057)	(0.050)
	[2141]	[2141]	[1621]
2SLS: population (1940, log)	0.697	0.924	0.633
	(0.063)	(0.093)	(0.070)
	[163]	[163]	[206]

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Estimating home-market effects using gravity regressions

Test for HME using the gravity equation à la Costinot et al. (2019):

$$\ln \mathbb{E}\left[Q_{ij}\right] = \ln \delta_i + \ln\left(\frac{N_j}{\Phi_j}\right) + \gamma \ln \text{distance}_{ij}$$

$$\ln \mathbb{E}\left(Q_{ij}\right) = \lambda_{\mathbf{X}} \ln \text{population}_i + \lambda_{\mathbf{M}} \ln \text{population}_j + \gamma \ln \text{distance}_{ij}$$

- $\lambda_{\mathbf{X}} > 0$ is a weak home-market effect: $\uparrow N_i \implies \uparrow$ gross exports
- $\lambda_{\mathbf{X}} > \lambda_{\mathbf{M}}$ is a *strong* home-market effect: $\uparrow N_i \implies \uparrow$ *net* exports

Panel estimation using 2013–2017 population changes:

$$\ln \mathbb{E}\left(Q_{ijt}\right) = \mu_{\mathbf{X}} \ln \text{population}_{it} + \mu_{\mathbf{M}} \ln \text{population}_{jt} + \phi_{ij} + \gamma_t \ln \text{distance}_{ij}$$

Gravity regression: Strong HME for aggregate medical services

	Cross-sectional PPML			IV: 1940 population	2013–2017 panel
$\lambda_\mathbf{X}$ Provider-market population (log)	0.671	0.681	0.671	0.757	0.939
	(0.0543)	(0.0505)	(0.0366)	(0.0547)	(0.151)
λ_M Patient-market population (log)	0.260	0.252	0.286	0.284	-0.205
	(0.0547)	(0.0501)	(0.0346)	(0.0467)	(0.148)
Distance (log)	-1.627	0.344		0.377	
	(0.0489)	(0.304)		(0.250)	
Distance (log, squared)		-0.199		-0.201	
		(0.0305)		(0.0247)	
Distance (log) $\times$ 2017					-0.00117
					(0.00667)
p-value for H_0: $\lambda_X \leq \lambda_M$	$<$0.001	$<$0.001	$<$0.001	$<$0.001	$<$0.001
Observations	93,636	93,636	93,636	93,636	162,678
Fixed effects					ij
Distance elasticity at mean		-1.59		-1.57	
Distance deciles			Yes		

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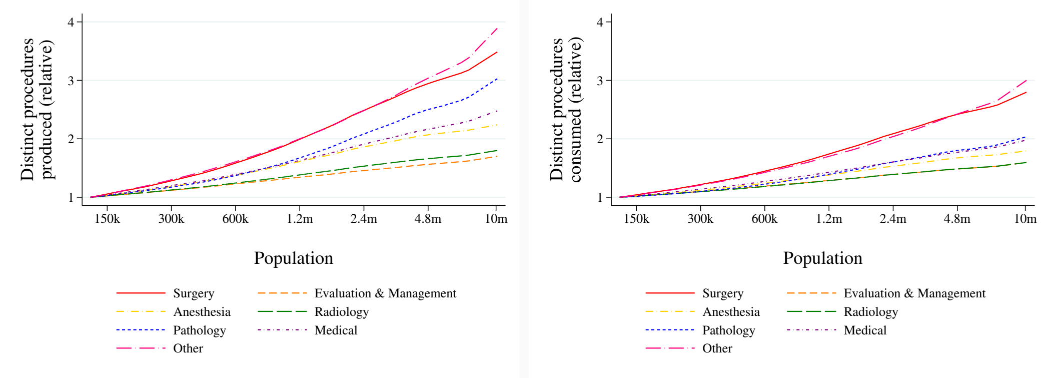
Larger markets produce greater set of procedures



Estimating procedure-level population elasticities

Examine spatial concentration of production and consumption by procedure

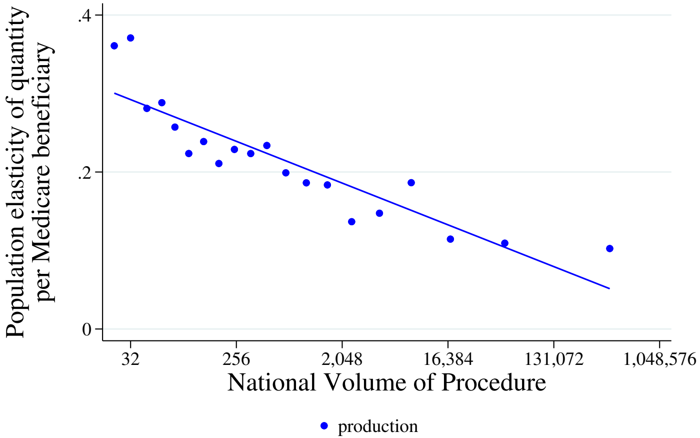
- Q_{pi} is the count of procedure p produced in region i
- Q_{pi}/M_i is production per Medicare beneficiary residing in region i

Estimate population elasticities of production and consumption by Poisson PML:

$$\ln \mathbb{E}\left[\frac{Q_{pi}}{M_i}\middle| \ln \text{population}_i\right] = \zeta_p + \beta_p \ln \text{population}_i$$

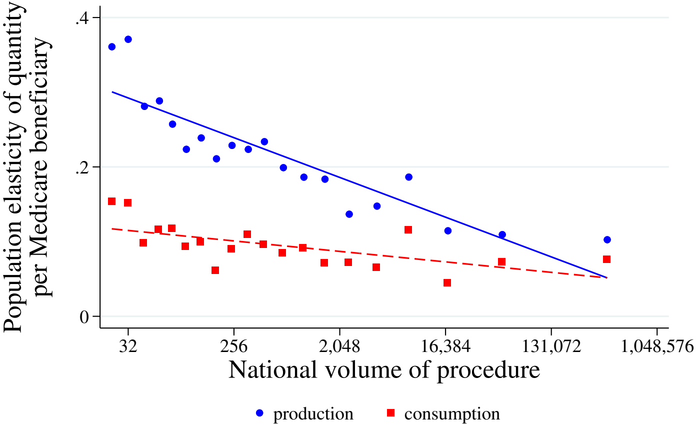
Then relate estimated population elasticity $\widehat{\beta}_p$ to p's national frequency

Population elasticity of production declines with frequency



Production fitted line: y = −0.025 (0.002) * x + 0.380 (0.016)
This plot depicts estimated population elasticities per Medicare beneficiary for 8,210 procedures produced at least 20 times nationally.

Population elasticity of consumption declines less with frequency



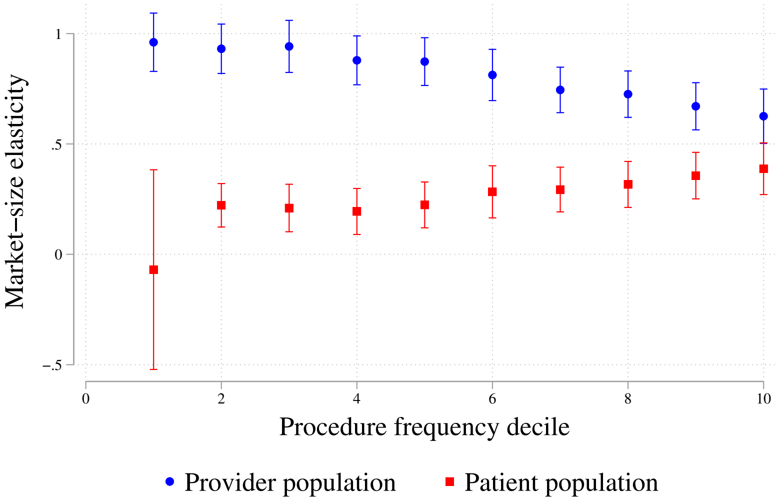
Production fitted line: y = −0.025 (0.002) * x + 0.380 (0.016)
Consumption fitted line: y = −0.007 (0.002) * x + 0.138 (0.014)
This plot depicts estimated population elasticities per Medicare beneficiary for 8,210 procedures produced at least 20 times nationally.

Example procedures: Trade in colonoscopy & LVAD

	Colonoscopy	LVAD Implant
Code	G0121	33979
N	58,785	333
Physicians	13,469	177
$\hat{\beta}_p^{\text{production}}$	-0.01	0.87
$\hat{\beta}_p^{\text{consumption}}$	-0.01	0.03
Share traded (HRR)	0.10	0.48
Share traded (CBSA)	0.11	0.48
Median distance traveled (km)	13.83	65.27
Share $>$ 100km	0.04	0.37

Stronger home-market effect for rarer procedures

$$\ln \mathbb{E}\left(S_{ij}\right) = \lambda_{\mathbf{X}} \ln \text{population}_i + \lambda_{\mathbf{M}} \ln \text{population}_j + \gamma \ln \text{distance}_{ij}$$



Stronger HME for rarer procedures (with region-pair FEs)

	Procedure		Procedure		Procedure		Diagnosis	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
λ_X Provider-market population (log)	0.618	0.605	0.603		0.606		0.601	
	(0.0516)	(0.0493)	(0.0493)		(0.0488)		(0.0489)	
λ_M Patient-market population (log)	0.360	0.364	0.366		0.364		0.371	
	(0.0519)	(0.0492)	(0.0492)		(0.0486)		(0.0486)	
μ_X Provider-market population (log) $\times$ rare			0.344	0.329	0.362	0.317	0.120	0.110
			(0.0447)	(0.0405)	(0.0452)	(0.0392)	(0.0232)	(0.0206)
μ_M Patient-market population (log) $\times$ rare			-0.241	-0.239	-0.250	-0.220	-0.0986	-0.0915
			(0.0606)	(0.0587)	(0.0612)	(0.0564)	(0.0186)	(0.0172)
p-value for H_0: $\lambda_X \leq \lambda_M$	0.005	0.006	0.007		0.005		0.008	
p-value for H_0: $\mu_X \leq \mu_M$			$<$0.001	$<$0.001	$<$0.001	$<$0.001	$<$0.001	$<$0.001
Observations	187,272	110,402	110,402	110,402	110,402	110,402	109,658	109,658
Distance Controls	Yes	Yes	Yes	Yes				
Distance [quadratic] controls					Yes	Yes	Yes	Yes
Patient-provider-market-pair FEs				Yes		Yes		Yes

Strong HME for specific common & rare services

	(1)	(2)	(3)	(4)	(5)	(6)
Procedure:	Colonoscopy	Cataract surgery	Brain tumor	Brain radiosurgery	LVAD	Colon removal
HCPCS code:	G0121	66982	61510	61798	33979	44155
λ_X Provider-market population (log)	0.454	0.349	0.932	1.107	1.332	0.871
	(0.0600)	(0.0819)	(0.0936)	(0.126)	(0.158)	(0.180)
λ_M Patient-market population (log)	0.391	0.521	0.162	0.191	0.115	-0.0729
	(0.0609)	(0.0711)	(0.0767)	(0.0943)	(0.136)	(0.159)
Distance (log)	-0.497	-0.0800	1.033	1.125	2.042	6.620
	(0.339)	(0.479)	(0.513)	(0.608)	(0.942)	(2.978)
Distance (log, squared)	-0.116	-0.170	-0.266	-0.272	-0.352	-0.850
	(0.0338)	(0.0474)	(0.0553)	(0.0628)	(0.0940)	(0.307)
p-value for H_0: $\lambda_X \leq \lambda_M$	0.280	0.891	$<$0.001	$<$0.001	$<$0.001	0.001
Observations	93,636	93,636	93,636	93,636	93,636	93,636
Distance elasticity at mean	-1.62	-1.66	-1.56	-1.54	-1.50	-1.58
Total count	58,785	43,547	1,922	754	333	112

Scale elasticity estimates $\hat{\alpha}$ for rare procedures

Rare services	Baseline	No Diagonal	Controls
OLS: 2017	0.972	1.119	0.938
	(0.035)	(0.048)	(0.041)
OLS: 2013–2017 difference	1.326	0.859	1.348
	(0.264)	(0.542)	(0.278)
2SLS: population (log)	0.941	1.074	0.897
	(0.041)	(0.053)	(0.053)
	[1581]	[1575]	[1143]
2SLS: population (1940, log)	0.857	1.078	0.797
	(0.065)	(0.089)	(0.072)
	[129]	[128]	[164]

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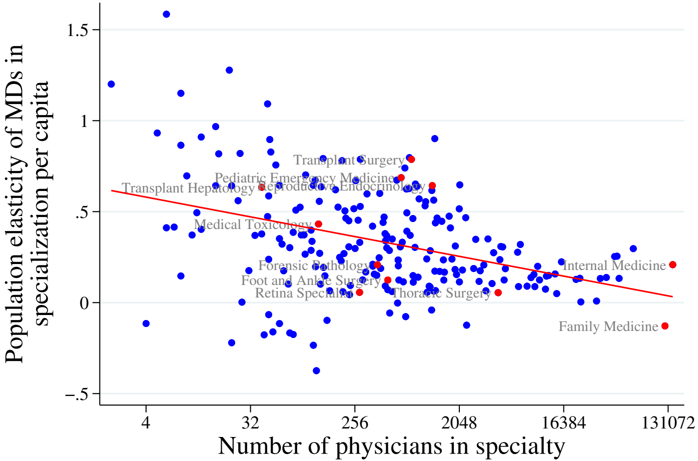
Rare specialties have higher population elasticities

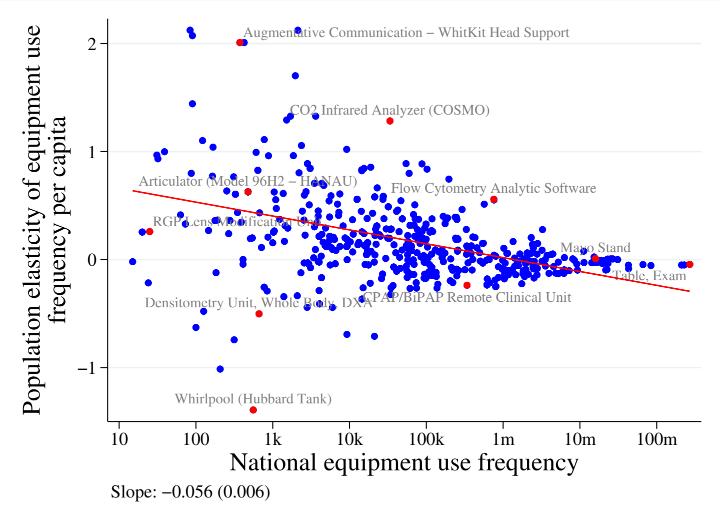


Slope: −0.052 (0.009)

One source of increasing returns could be division of labor among physicians

Pearson correlation: -0.446.
Fitted line: $y = -0.072(0.010)\ln x + 0.798(0.065)$
Plot excludes 2 observations with elasticity greater than 1.60.

Rarely used equipment has higher population elasticities



Another mechanism could be lumpy capital, namely expensive medical equipment

Pearson correlation: -0.450.

Fitted line: $y = -0.056(0.006)\ln x + 0.946(0.076)$

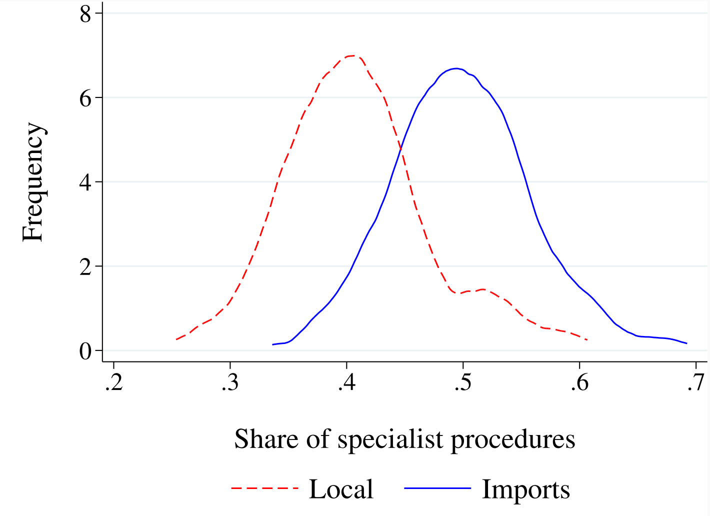
Plot excludes 11 observation with elasticity greater than 2.29.

- Empirical setting and geographic patterns
- Theoretical framework
- Regional increasing returns in medical services
  - Estimating the scale elasticity
  - Strong home-market effect for aggregate medical services
- Mechanisms
  - How market-size effects vary with procedure characteristics
  - Sources of increasing returns: Division of labor and lumpy capital
  - Travel to access specialized services
- Health policy with trade and increasing returns

Trade expands access to specialists, experience, and equipment

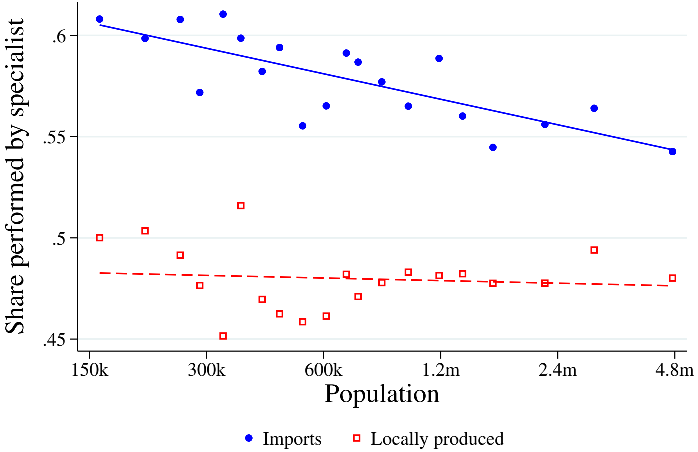
- Traded procedures are specialist-intensive...
- ...especially smaller markets' imports
- Small markets' locally-produced care uses "non-standard" specialties more
- Larger regions & imported care have more experienced physicians
- Larger regions & imported care use rare equipment more

Traded procedures are specialist-intensive



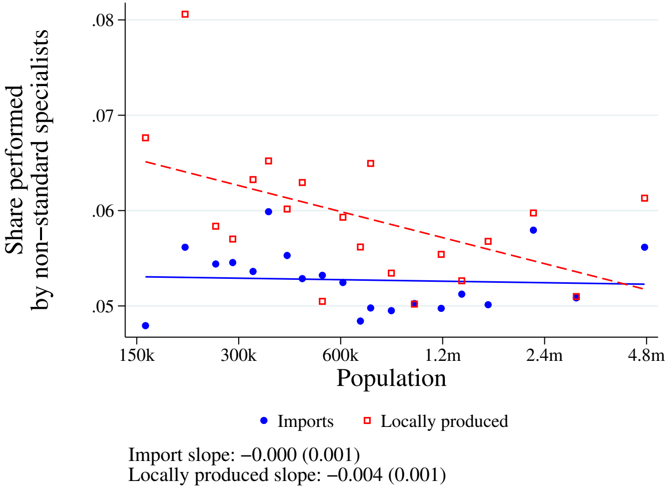
- Classify a procedure as "generalist" if performed by Internal Medicine, Family Medicine, and General Practice $\geq 70\%$ (2,492 procedures)
- Classify as "specialist" if top two specializations do $\geq 70\%$ (7,533 procedures)
- Imports are more likely to be specialty care than locally produced consumption

Smaller places more likely to import specialty procedures



Import slope: –0.018 (0.003)
Locally produced slope: –0.002 (0.004)

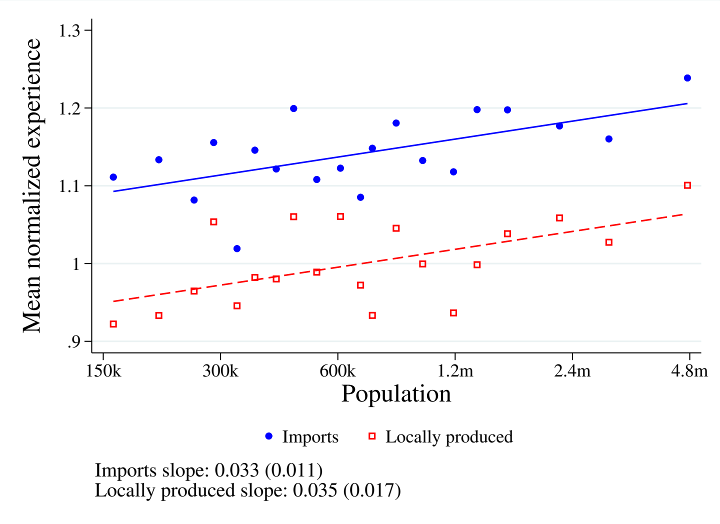
Care provided by “non-standard” specialties in smaller places



In smaller regions,

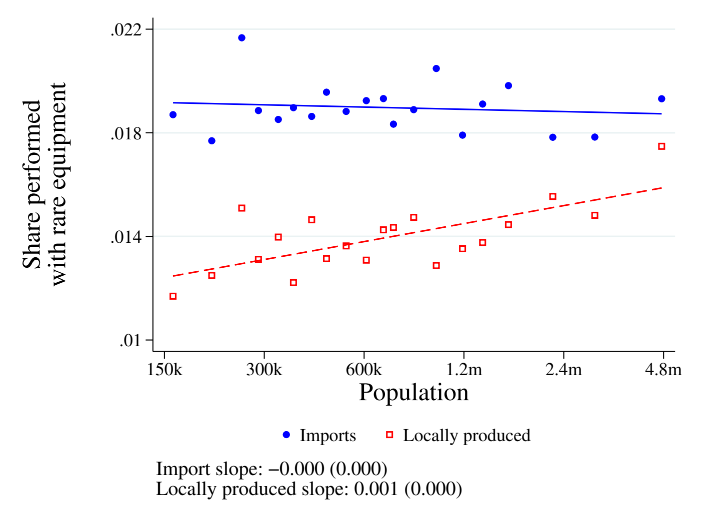
- locally produced care more likely performed by “non-standard” specialist
- imports less likely performed by “non-standard” specialist

Larger regions & imported care have more experienced physicians



- Physician experience: number of times billing the service code over past year (scaled by code's mean)
- Average experience across codes, weighted by spending (scaled by mean across HRRs)
- Imported care provided by more experienced physicians than locally provided care, at any population size

Larger regions & imported care use rare equipment more



- Imports are more likely performed with rare equipment
- Larger regions more likely to use rare equipment for locally produced care

- Empirical setting and geographic patterns
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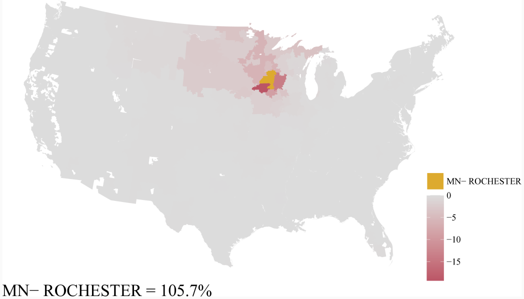
Counterfactual scenarios

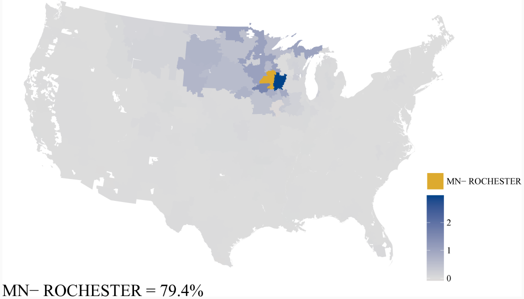
1. Increase reimbursements in one region
    - Spatial impacts on quality and access
    - Spillovers on neighbors
    - Heterogeneity by income
2. Subsidize imported care in one region
    - Spillovers on neighbors
    - Differences by population size
    - Subsidies required by income
3. Increase proximity to make US geography $\sim$ Germany
    - Reduces market access-income gradient

Counterfactual: Increase reimbursements in Rochester, MN

Change (%) in output quality δ_i

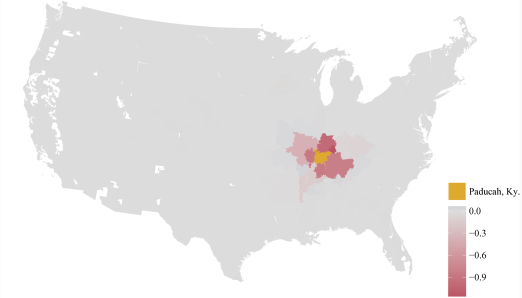


Change (%) in patient market access Φ_i



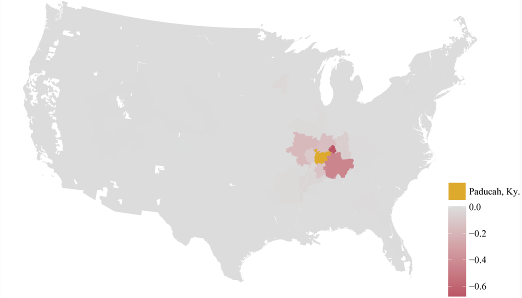
Counterfactual: Increase reimbursements in Paducah, KY

Change (%) in output quality δ_i



Paducah, Ky. = 51.2%

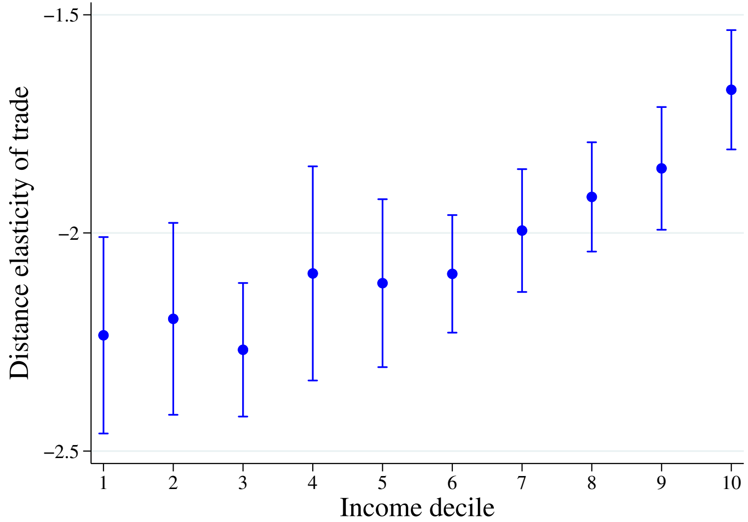
Change (%) in patient market access Φ_i



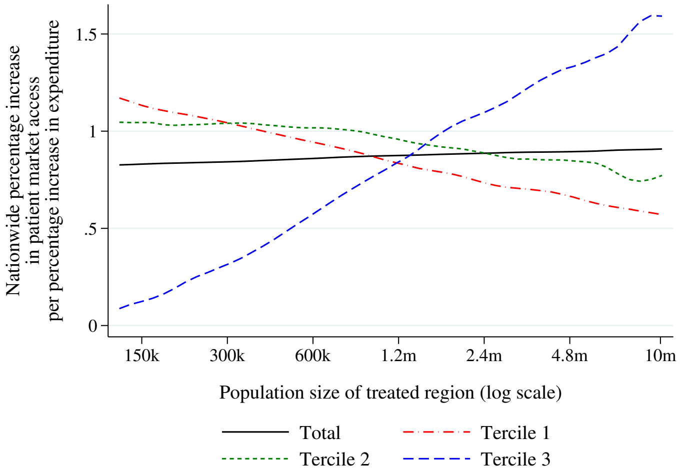
Paducah, Ky. = 30.9%

- Spillover negative with exports to Paducah
- Net spillovers depend on whether market is net exporter

Higher-SES patients are more willing to travel



Counterfactual scenarios: Raise reimbursements in one region



Two sources of contrast:

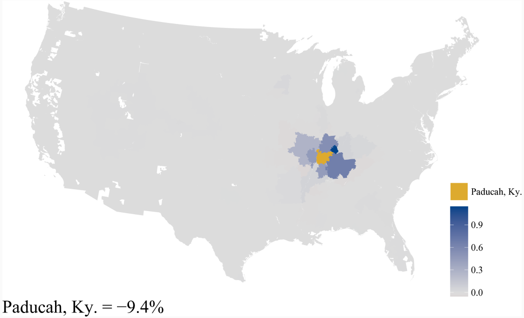
- Lower-income patients disproportionately live in smaller markets
- Higher-income patients travel more to high-quality providers

Boston example:

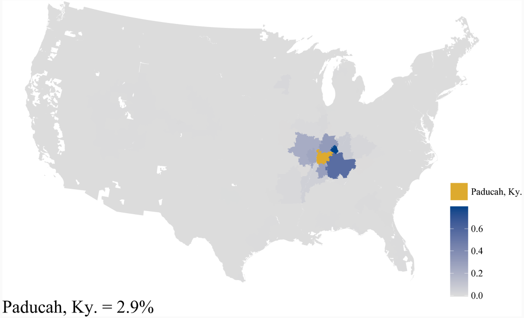
- Tercile 3 gains 70% more than tercile 1
- Difference due to share imported from Boston

Counterfactual: Subsidize imports for Paducah residents

Change (%) in output quality δ_i

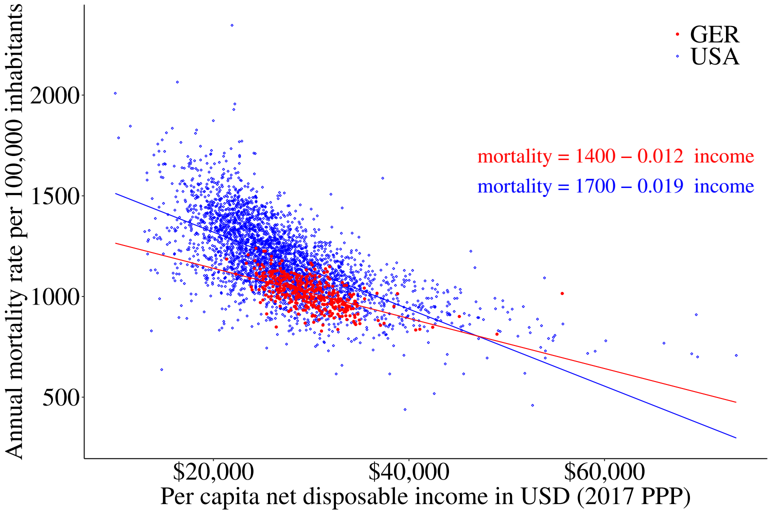


Change (%) in patient market access Φ_i



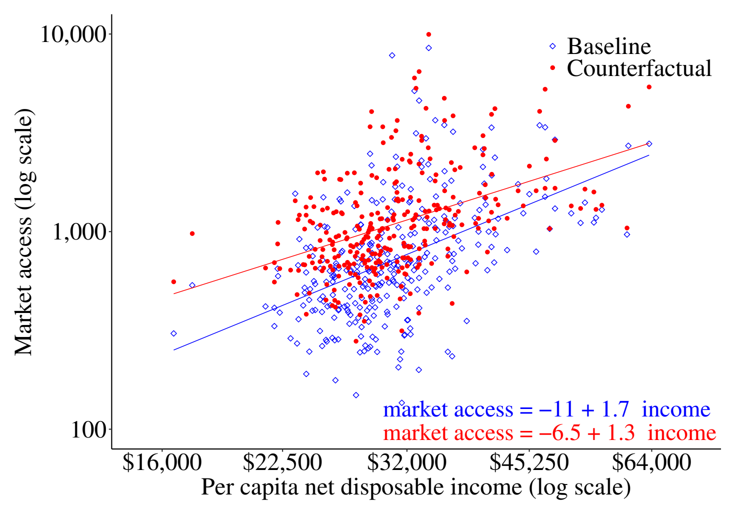
- Paducahans' imports $\rightarrow$ agglomeration benefits in neigboring regions
- Positive spillovers correlated with baseline exports to Paducah

Could geography explain US's steeper health-income gradient?



- United States has a steeper health-income gradient across regions than other OECD countries (e.g. Germany)
- Does USA's large size $\rightarrow$ costs of remoteness?

Counterfactual: Match German market-potential distribution



- Transforming the US geography to that of Germany (equivalent to broad travel subsidy)...
- ...reduces the Φ_i-income elasticity by 21%
- Rural areas have lower incomes
- Rural areas gain most in this counterfactual

Conclusions

Market Size and Trade in Medical Services

Findings:

- Domestic trade in medical services mimics trade in manufactures
  - But larger distance elasticity
  - Low-SES patients more sensitive to distance
- Scale economies $\rightarrow$ large markets are net exporters
- Market-size effects largest in lower-volume services

Counterfactual outcomes:

- Spillovers of production subsidies depend on net trade flows
- For net importers, travel subsidies have opposite spillovers
- Aggregate return highest in larger regions, but lower-income patients benefit from subsidizing smaller regions

Thank you