# 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 $\rightarrow$ geographic concentration of production yields benefits
- Trade costs for services $\rightarrow$ proximity-concentration trade-off
- If patients vary in willingness to travel, 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 $\rightarrow$ home-market effect
- Implementation: Logit demand $\rightarrow$ gravity equation $\rightarrow$ quality estimates

Estimates:

- Domestic trade in medical services mimics trade in manufactures

  22% of production is exported; distance elasticity is about -1.7
- Home-market effects are pervasive; stronger in less common services
- Geographic concentration $\rightarrow \uparrow$ service quality, $\uparrow$ specialization ($\alpha \approx 0.6$)

# Counterfactual scenarios

Simple model generates rich depiction of proximity-concentration tradeoffs:

- Changes in output quality $\neq$ changes in patient market access
- Efficiency need not mean subsidizing *output* in markets with worst access
- Subsidizing production in one region generates "agglomeration shadow"
- Production subsidies and travel subsidies can impose contrasting spillovers on neighboring regions
- Lower-SES patients need larger travel subsidies to equalize access

# Contributions

Medical care: trade & 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

# Roadmap

- Theoretical framework
- Data description
- Market-size effects
  - Larger markets are net exporters of medical services
  - Gravity-based empirics show strong HME
- Rare procedures have stronger market-size effects
  - Gravity-based empirics by procedure frequency
  - Population elasticities by procedure
- Estimating the scale elasticity
  - Scale improves quality
  - Scale facilitates the division of labor
- Tradeoffs and counterfactual scenarios

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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

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

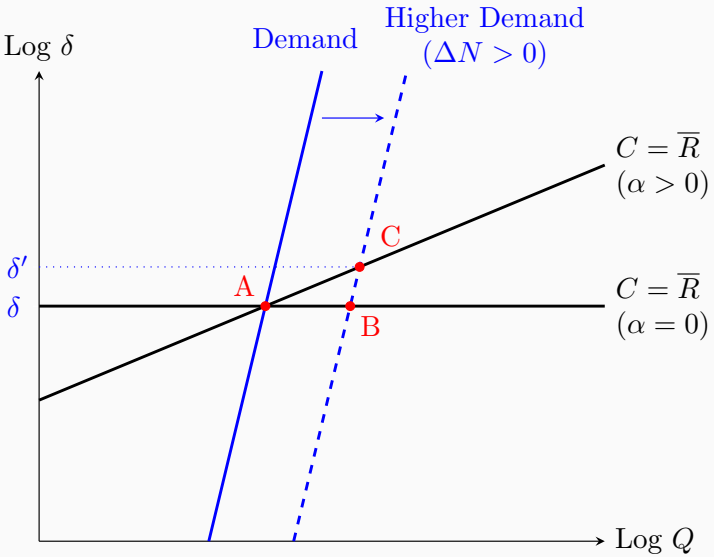
- Provider in region $i$ hiring $L$ inputs to produce quality $\delta$ takes productivity shifter $A_i$ and regional output $Q_i$ as given. Output quantity is

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

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

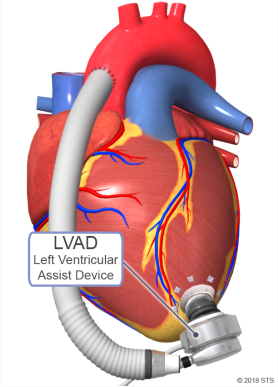
$$\overline{R} = \frac{w_i K(\delta_i)}{A_i H(Q_i)} \equiv C(Q_i, \delta_i; w_i, A_i)$$

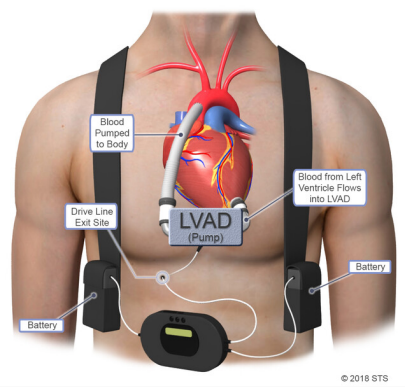
# Autarky


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

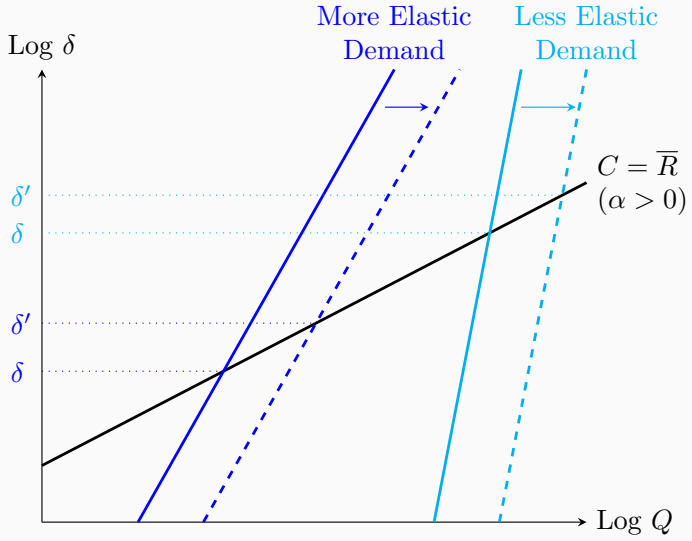
# Common and rare procedures: 2 examples

- Colonoscopy ($N$=58,798 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 $i$:

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

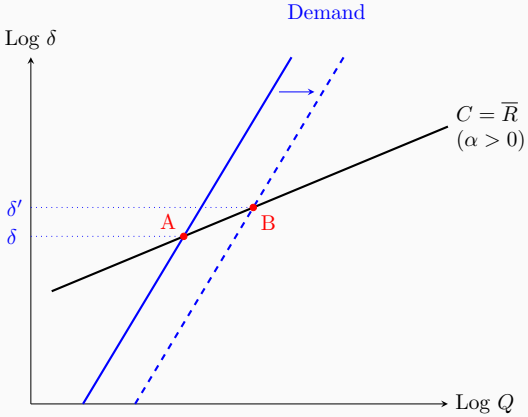
Trade follows gravity equation:

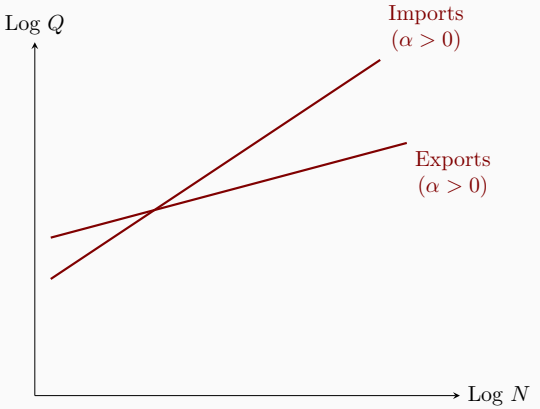
$$\ln \mathbb{E}\left[Q_{ij}\right] = \ln \delta_i + \ln\left(\frac{N_j}{\Phi_j}\right) + \ln \rho_{ij}$$

Market size and trade: $N_j$, $\delta_i$, $\Phi_j$

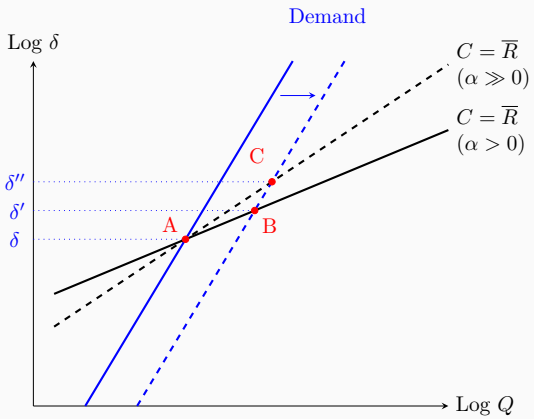
- Larger population (larger $N_j$) raises import demand
- With increasing returns ($\alpha > 0$): $\uparrow N_i \rightarrow \uparrow \delta_i \rightarrow \uparrow$ gross exports & $\uparrow \Phi_i$
- With sufficiently strong increasing returns ($\alpha \gg 0$):
  - $\uparrow N_i \rightarrow \ \ln \delta_i$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

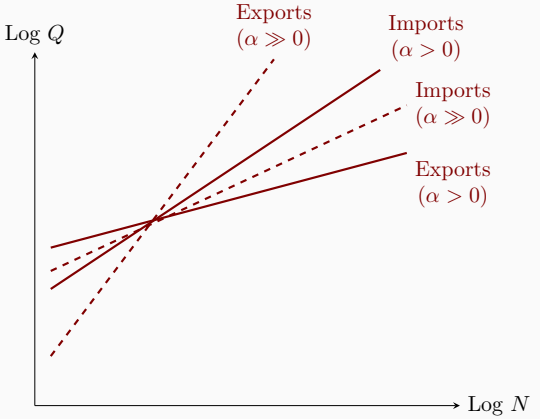
# Trade: Weak home-market effect



# Trade: Strong home-market effect



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# 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
  - Based on each procedure's estimated average cost
  - Constant across physicians within a region
  - Limited geographic variation (89 regions)
- Separate *professional* and *facility* fees
  - Professional fee $\rightarrow$ physician (we study these)
  - Facility fee $\rightarrow$ hospital (see appendix)

# Data

Medicare professional claims data for 2017

- Carrier (fee-for-service claims) file reports procedure, provider, date, payment
- Include all non-Emergency Department care provided by MD/DO
- 20% representative sample of patients contains $\sim$230 million claim lines
- 12,000+ 5-digit procedures in Healthcare Common Procedure Coding System (HCPCS)
- ZIP codes of patient and place of service

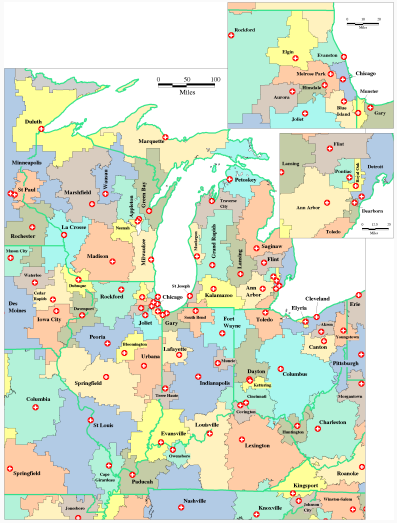
National Plan and Provider Enumeration System (NPPES)

- Physician ID, name
- Physician specialization and location

# Geographic units: Hospital referral regions

Our benchmark unit is a hospital referral region

- 306 HRRs defined by 1996 *Dartmouth Atlas*
- Aggregate patient ZIP codes based on major cardiovascular surgical procedures & neurosurgery in 1992-93 Medicare claims
- Each HRR has $\geq 1$ hospital where both performed
- Most common unit used in health econ
- Definition could mechanically minimize trade




Map 1.12. Great Lakes Hospital Referral Regions

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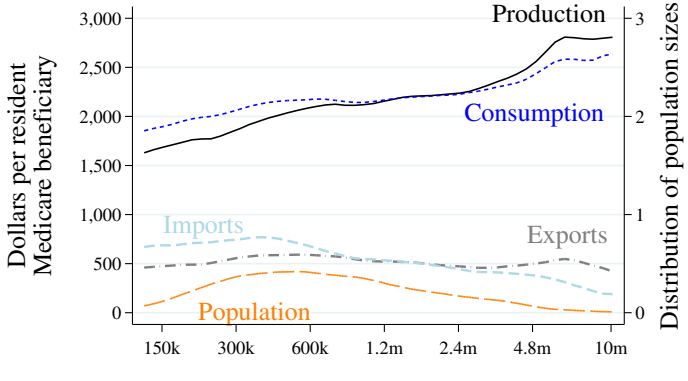
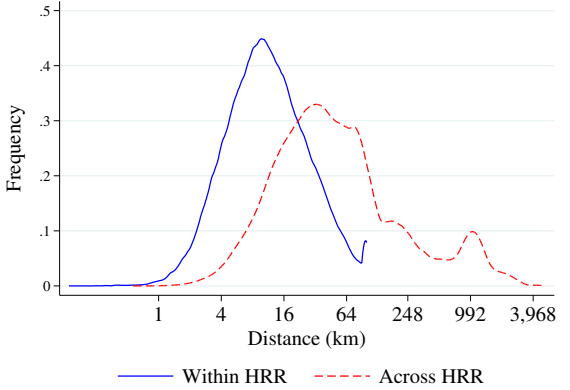
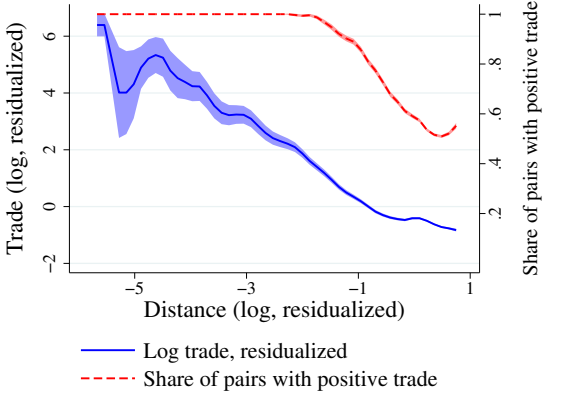
# Production, consumption, trade, and market size




Population elasticity (log–log regression slope) of transactions per resident Medicare beneficiary:
Production: 0.13 (0.02), Consumption: 0.06 (0.01)
Exports: −0.00 (0.05), Imports: −0.25 (0.03)

# Trade declines with distance



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# Estimating home-market effect: 1-step gravity regression

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

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

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

- $\lambda_{\mathbf{X}} > 0$ is a weak home-market effect: $\uparrow N_i \implies \uparrow$ gross exports
- $\lambda_{\mathbf{X}} > \lambda_{\mathbf{M}} > 0$ is a *strong* home-market effect: $\uparrow N_i \implies \uparrow$ *net* exports
- Estimate using Poisson pseudo-maximum likelihood (PPML) due to zeros

Two instruments:

- Population in 1940
- Depth to bedrock (data from Levy & Moscona, 2020)

# Gravity regression: Strong HME for aggregate medical services

| Estimation method: | (1) PPML | (2) PPML | (3) PPML | (4) IV |
|---|---|---|---|---|
| $\lambda_{\mathbf{X}}$ Provider-market population (log) | 0.638 | 0.643 | 0.645 | 0.597 |
| | (0.0634) | (0.0610) | (0.0455) | (0.0732) |
| $\lambda_{\mathbf{M}}$ Patient-market population (log) | 0.377 | 0.376 | 0.406 | 0.360 |
| | (0.0615) | (0.0587) | (0.0423) | (0.0521) |
| Distance (log) | -1.664 | 0.0996 | | 0.0796 |
| | (0.0501) | (0.307) | | (0.270) |
| Distance (log, squared) | | -0.178 | | -0.177 |
| | | (0.0299) | | (0.0265) |
| Observations | 93,636 | 93,636 | 93,636 | 93,636 |
| Distance elasticity at mean | | -2.46 | | -2.46 |
| Distance deciles | | | Yes | |

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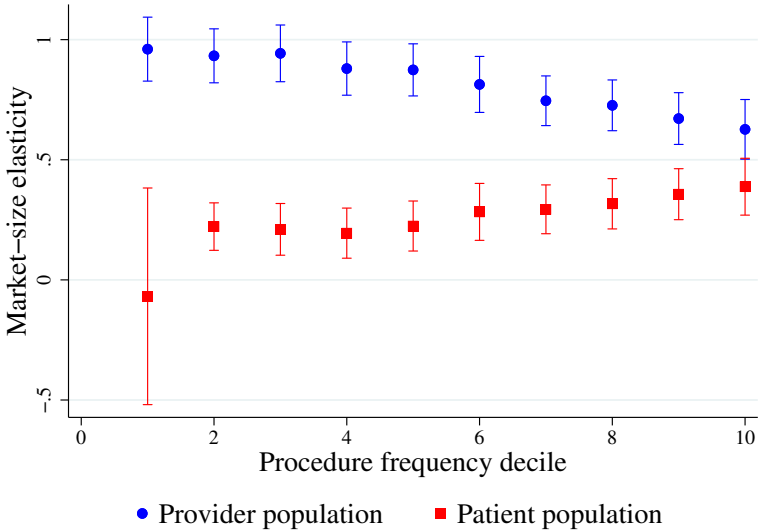
# HME stronger for rarer procedures



# HME stronger for rarer procedures (richer controls)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Provider-market population (log) | 0.638 | 0.624 | 0.623 | | 0.630 | |
| | (0.0634) | (0.0613) | (0.0614) | | (0.0598) | |
| Patient-market population (log) | 0.377 | 0.379 | 0.380 | | 0.379 | |
| | (0.0615) | (0.0590) | (0.0591) | | (0.0572) | |
| Provider-market population (log) × rare | | | 0.306 | 0.291 | 0.316 | 0.287 |
| | | | (0.0472) | (0.0455) | (0.0480) | (0.0458) |
| Patient-market population (log) × rare | | | -0.229 | -0.219 | -0.232 | -0.211 |
| | | | (0.0698) | (0.0671) | (0.0704) | (0.0658) |
| Observations | 187,272 | 113,468 | 113,468 | 113,468 | 113,468 | 113,468 |
| Distance controls | Yes | Yes | Yes | Yes | | |
| Distance [quadratic] controls | | | | | Yes | Yes |
| Patient-provider-market-pair FEs | | | | 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 |
| $\lambda_{\mathbf{X}}$ Provider-market population (log) | 0.515 | 0.466 | 0.928 | 1.149 | 1.251 | 0.998 |
| | (0.0692) | (0.0730) | (0.0885) | (0.119) | (0.168) | (0.164) |
| $\lambda_{\mathbf{M}}$ Patient-market population (log) | 0.351 | 0.437 | 0.192 | 0.166 | 0.182 | -0.146 |
| | (0.0694) | (0.0691) | (0.0726) | (0.0816) | (0.141) | (0.146) |
| Distance (log) | 0.436 | 0.948 | 0.997 | 1.518 | 2.168 | 3.090 |
| | (0.413) | (0.508) | (0.548) | (0.701) | (0.920) | (1.651) |
| Distance (log, squared) | -0.216 | -0.268 | -0.266 | -0.307 | -0.365 | -0.499 |
| | (0.0410) | (0.0503) | (0.0577) | (0.0712) | (0.0930) | (0.173) |
| Observations | 93,636 | 93,636 | 93,636 | 93,636 | 93,636 | 93,636 |
| Distance elasticity at mean | -2.66 | -2.89 | -2.81 | -2.89 | -3.06 | -4.06 |
| Total count | 58,798 | 43,604 | 1,922 | 752 | 333 | 112 |

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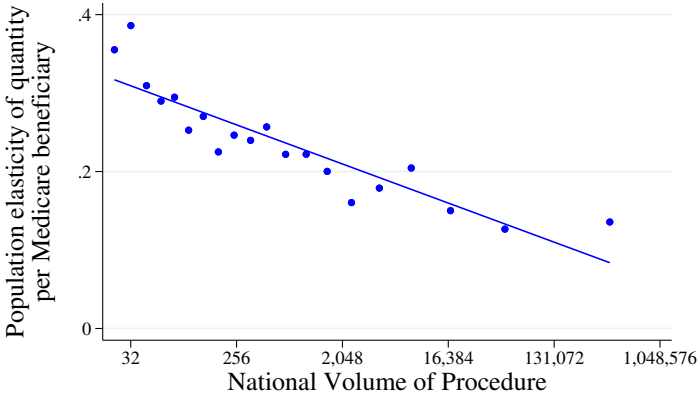
# Estimating procedure-level population elasticities

- $Q_{pi}$ is the count of procedure $p$ produced in region $i$
- $Q_{pi}/M_i$ is production per Medicare beneficiary residing in region $i$
- Use Poisson PML to estimate the population elasticity of economic activity

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

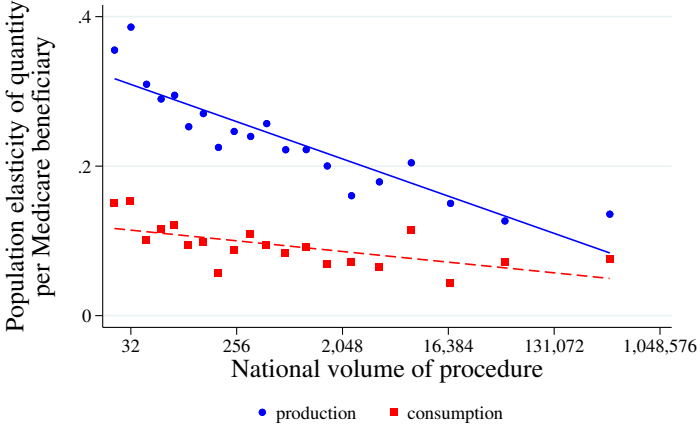
- We estimate elasticities for production and consumption
- Then relate estimated population elasticity $\widehat{\beta}_p$ to $p$'s national frequency

# Population elasticity of production declines with frequency




Production fitted line: y = −0.024 (0.002) * x + 0.391 (0.016)
This plot depicts estimated population elasticities per Medicare beneficiary for 8,253 procedures produced at least 20 times nationally.

# Population elasticity of consumption declines less with frequency



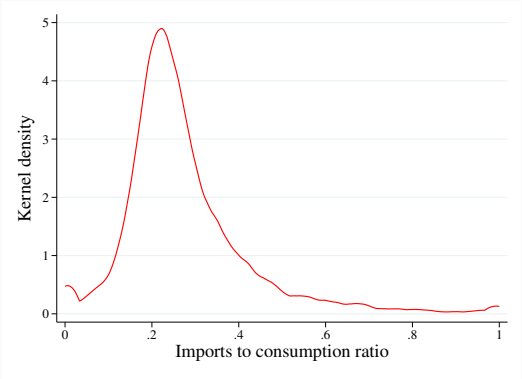

Production fitted line: y = −0.024 (0.002) * x + 0.391 (0.016)
Consumption fitted line: y = −0.007 (0.002) * x + 0.138 (0.014)
This plot depicts estimated population elasticities per Medicare beneficiary for 8,253 procedures produced at least 20 times nationally.

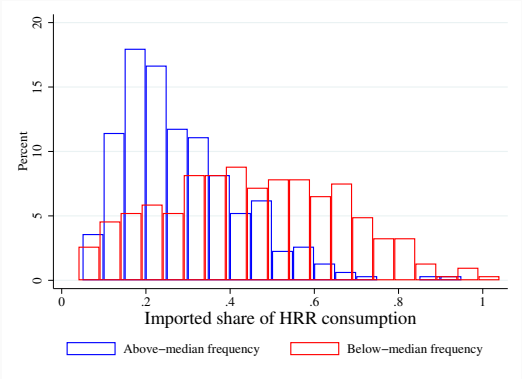
# Example procedures: Trade in colonoscopy & LVAD

| | Colonoscopy | LVAD Insertion |
|---|---|---|
| Code | G0121 | 33979 |
| N | 58,798 | 333 |
| Physicians | 13,475 | 177 |
| $\hat{\beta}_p^{\text{production}}$ | 0.00 | 0.71 |
| $\hat{\beta}_p^{\text{consumption}}$ | -0.01 | 0.03 |
| Share traded (HRR) | 0.15 | 0.50 |
| Share traded (CBSA) | 0.15 | 0.48 |
| Median distance traveled (km) | 18.44 | 65.50 |
| Share $>$ 100km | 0.06 | 0.37 |

# Imports play a larger role in less-common procedures

- Imported share of consumption varies widely across procedures
- Imported share of consumption larger for less-common procedures



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# Estimating the scale elasticity: 2-step estimator

1. Estimate exporter fixed effects from gravity regression:

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

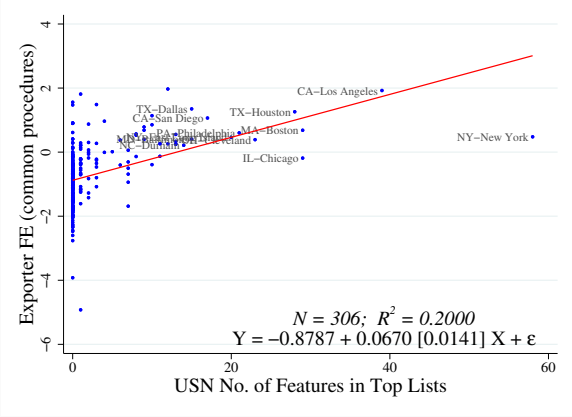
2. Isocost curve implies estimating equation for $\hat{\alpha}$:

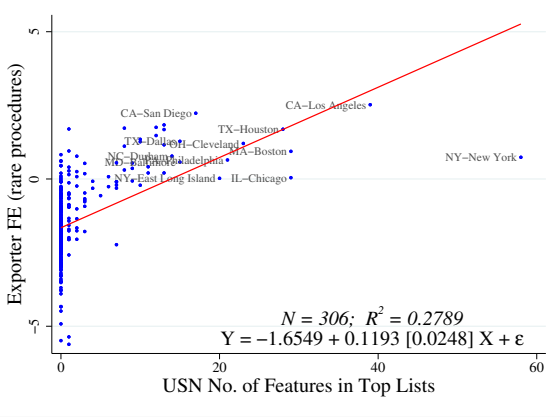
$$\widehat{\ln \delta_i} = \alpha \ln Q_i + \ln \overline{R} - \ln w_i + \ln A_i$$

- High-quality locations can be:
  - large ($Q_i \uparrow$),
  - cheap ($w_i \downarrow$),
  - or idiosyncratic ($A_i \uparrow$) [e.g., Mayo Clinic's historical investment in quality or reputation]
- 3 instruments for $\ln Q_i$: population, 1940 population, bedrock depth

# Exporter fixed effects are correlated with other quality measures

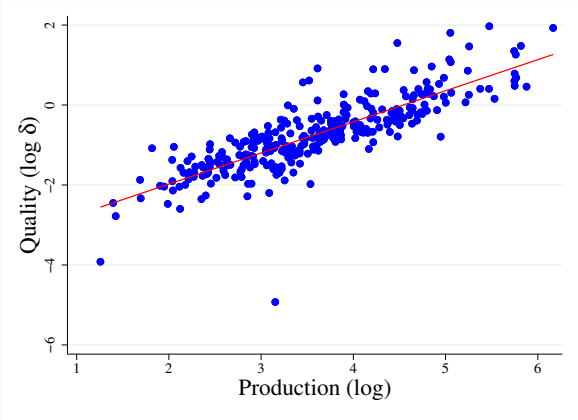
HRRs with more USNWR-ranked hospitals export more, especially rare services




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

# Scale improves quality: $\alpha \approx 0.6$




| Panel A: All services | No Controls | | Controls | |
|---|---|---|---|---|
| | No Diag | Diag | No Diag | Diag |
| OLS | 0.804 | 0.778 | 0.884 | 0.793 |
| | (0.044) | (0.030) | (0.046) | (0.038) |
| 2SLS: population (log) | 0.799 | 0.716 | 0.871 | 0.721 |
| | (0.049) | (0.030) | (0.052) | (0.037) |
| 2SLS: population (1940, log) | 0.660 | 0.550 | 0.640 | 0.559 |
| | (0.093) | (0.069) | (0.082) | (0.059) |
| Panel B: Rare services | | | | |
| OLS | 1.089 | 0.945 | 1.124 | 0.956 |
| | (0.045) | (0.030) | (0.046) | (0.033) |
| 2SLS: population (log) | 1.033 | 0.910 | 1.072 | 0.920 |
| | (0.049) | (0.037) | (0.051) | (0.041) |
| 2SLS: population (1940, log) | 0.951 | 0.832 | 0.940 | 0.832 |
| | (0.081) | (0.061) | (0.073) | (0.055) |

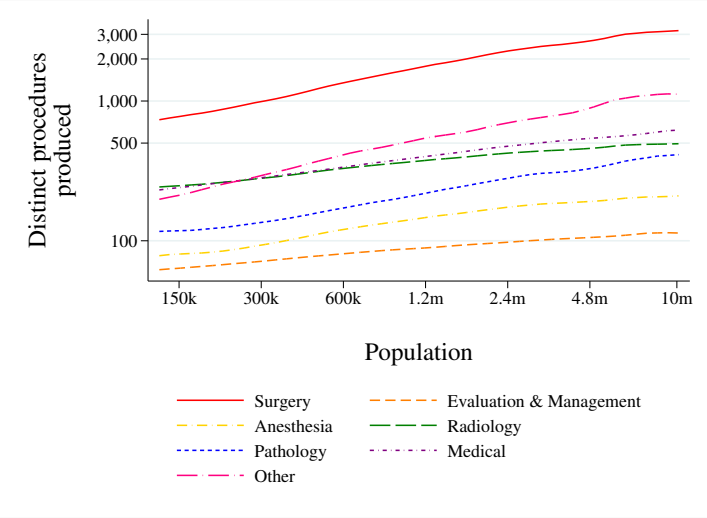
Control is HRR's Medicare geographic adjustment factor

- Theoretical framework
- Data description
- Market-size effects
  - Larger markets are net exporters of medical services
  - Gravity-based empirics show strong HME
- Rare procedures have stronger market-size effects
  - Gravity-based empirics by procedure frequency
  - Population elasticities by procedure
- Estimating the scale elasticity
  - Scale improves quality
  - Scale facilitates the division of labor
- Tradeoffs and counterfactual scenarios

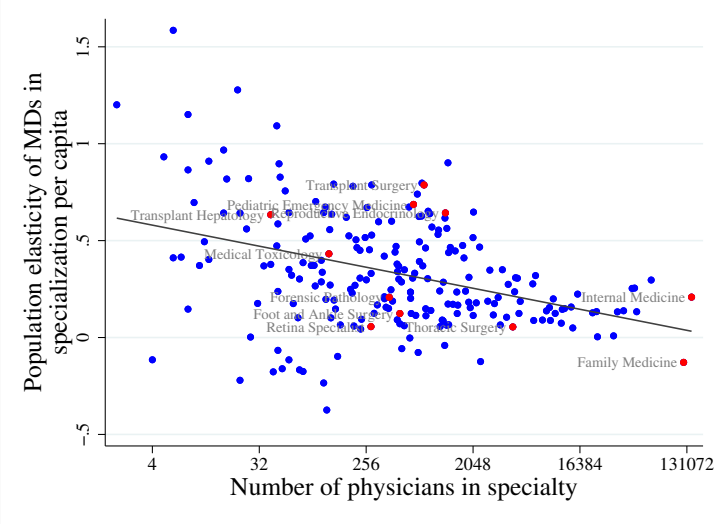
# Trade expands access to specialists and experience

- Larger markets produce greater set of procedures
- Rare specialties are more concentrated in larger markets
- Traded procedures are specialist-intensive...
- ...especially smaller markets' imports
- Small markets' locally-produced care may be from "non-standard specialties"
- Larger regions & imported care have more experienced physicians

# Larger markets produce greater set of procedures



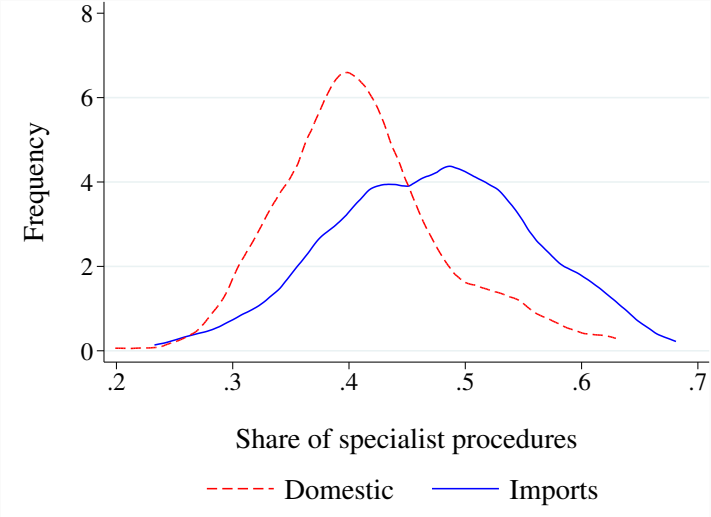
# Rare specialties have higher population elasticities




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

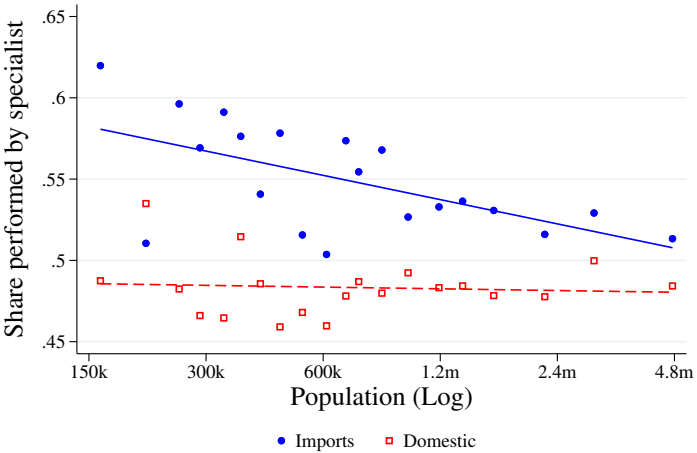
Pearson correlation: -0.446.
Fitted line: $y = -0.072(0.010)\ln x + 0.798(0.065)$
Plot excludes 2 observations with elasticity greater than 1.60.

# Traded procedures are specialist-intensive



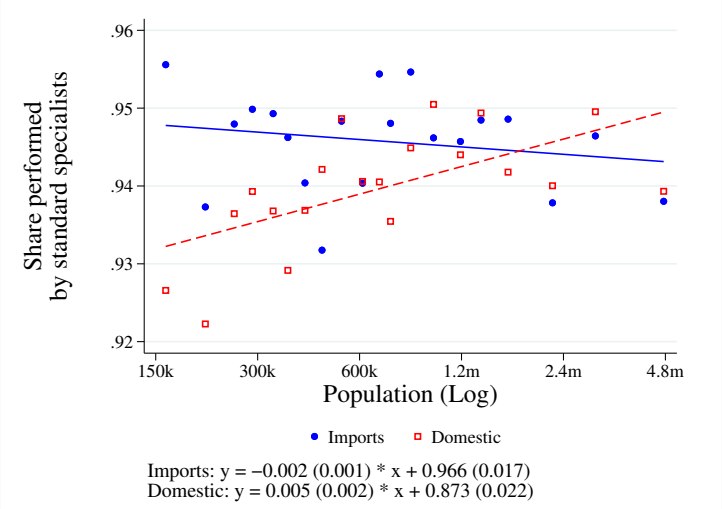

- Classify a procedure as "generalist" if performed by Internal Medicine, Family Medicine, and General Practice $\geq 70\%$ (2,492 procedures)
- Classify as "specialist" if top two specializations do $\geq 70\%$ (7,533 procedures)
- Imports are more likely to be specialty care than locally produced consumption

# Smaller places more likely to import specialty procedures




Imports: y = −0.021 (0.005) * x + 0.837 (0.071)
Domestic: y = −0.002 (0.004) * x + 0.510 (0.060)

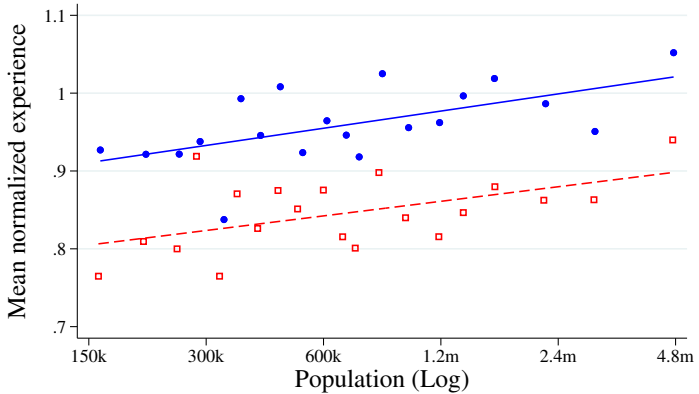
# Care provided by "non-standard" specialties in smaller places




In smaller regions,

- domestically produced care less likely performed by "standard" specialist
- imports more likely performed by "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
- Imported care provided by more experienced physicians than locally provided care, at any population size

- Theoretical framework
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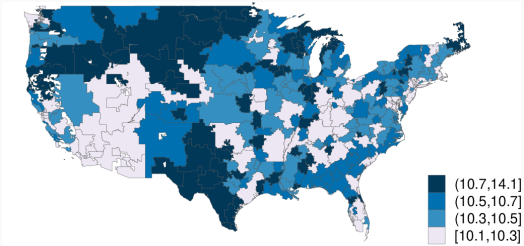
# Counterfactual scenarios

1. Increase reimbursements nationally
    - Spatial impacts on quality and access
2. Increase reimbursements in one region
    - Spatial impacts on quality and access
    - Spillovers on neighbors
    - Heterogeneity by income
3. Subsidize imported care in one region
    - Spillovers on neighbors
    - Differences by population size
    - Subsidies required by income

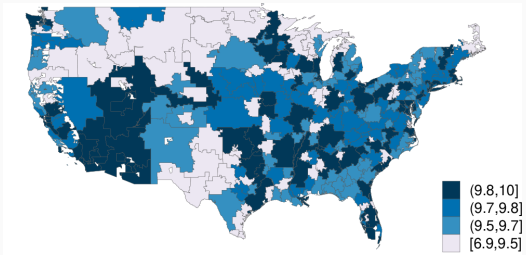
# Counterfactual scenario: Increase reimbursements in all HRRs

Change (%) in output quality $\delta_i$




Cutoffs: Percentiles 25, 50, 75.

Change (%) in patient market access $\Phi_i$

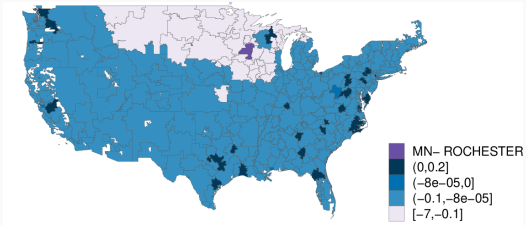



Cutoffs: Percentiles 25, 50, 75.

- "Patient market access": patients' value of all the care in their choice set
- $\Phi_j \equiv \sum_i \delta_i \rho_{ij}$

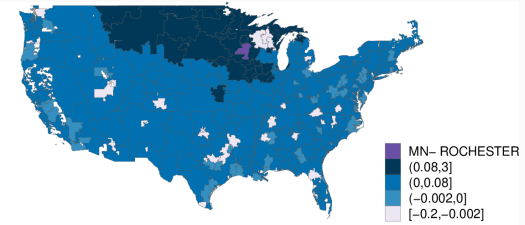
# Counterfactual: Increase reimbursements in Rochester, MN

Change (%) in output quality $\delta_i$




MN– ROCHESTER = 61.3%

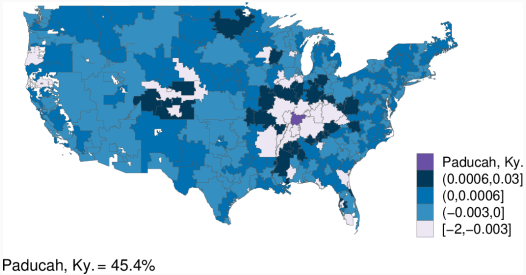
Change (%) in patient market access $\Phi_i$




MN– ROCHESTER = 45.4%

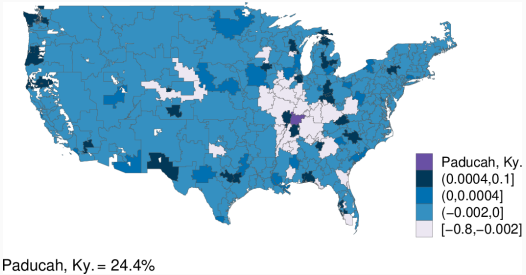
# Counterfactual: Increase reimbursements in Paducah, KY

Change (%) in output quality $\delta_i$




Paducah, Ky. = 45.4%

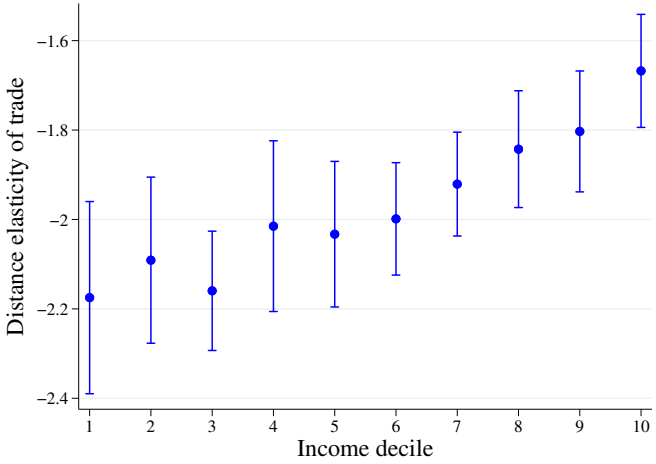
Change (%) in patient market access $\Phi_i$




Paducah, Ky. = 24.4%

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

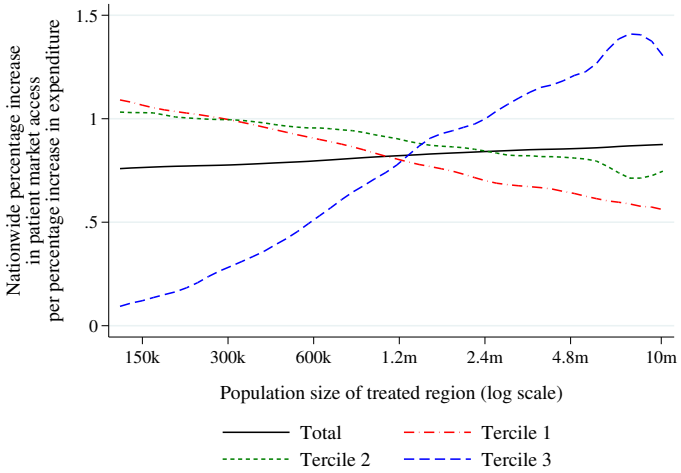
# Higher-SES patients are more willing to travel




- Gain from nationwide reimbursement increase is 20% larger for highest- vs. lowest-income tercile
- This difference is explained by baseline trade patterns (outside option)

*Note:* Coefficient on log distance estimated separately for each decile of the national ZIP-level median-household-income distribution. 95% CIs using standard errors clustered by both patient HRR and provider HRR.

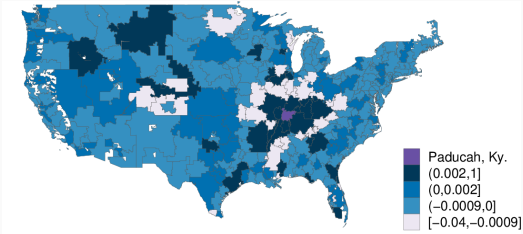
# Counterfactual: Increase reimbursements in one region at a time




- Net spillovers depend on whether market is net exporter
- Lower-income patients disproportionately live in smaller markets...
- ...so benefit disproportionately from reimbursement increases in smaller markets

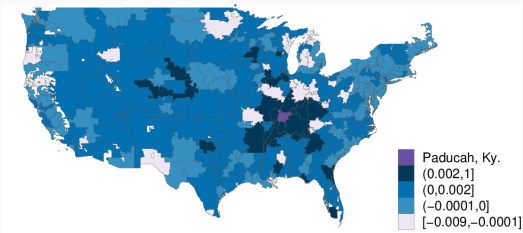
# Counterfactual: Subsidize imports for Paducah residents

Change (%) in output quality $\delta_i$




Paducah, Ky. = −7.1%

Change (%) in patient market access $\Phi_i$




Paducah, Ky. = 5.8%

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

# Conclusions

# Market Size and Trade in Medical Services

Findings:

- Domestic trade in medical services mimics trade in manufactures
  - But larger distance elasticity
  - High-SES patients less 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