

# National Expenditures on Local Amenities

---

David S. Bieri\*   Nicolai V. Kuminoff†   Jaren C. Pope‡

\* Department of Urban and Regional Planning, Virginia Tech

† Department of Economics, Arizona State University and NBER

‡ Department of Economics, Brigham Young University

June 2016

# National Accounting for Nonmarket Goods

---

- NIPA—the most important measure of economic activity for a nation—is incomplete and misleading (Kuznetz 1934, Nordhaus and Tobin 1972, National Academy of Sciences 2005)
- Satellite Accounting (NAS 2005; NBER 2006)
  - Top priorities: environmental services, pollution, local public goods, urban infrastructure
  - Track consumption and implicit expenditures on each amenity
- Environmental macroeconomics and policy
  - EPA wants to know how environmental policies affect jobs, welfare, and growth.
  - Calibrating environmental macro models (Smith 2012, Rogerson 2013, Shimer 2013)
  - Developing national amenity measures (Smith and Woolah 2014, Kaiser and Shapiro 2016)
- Key challenge: identify tradeoffs between market & nonmarket consumption

# Research Objectives

---

1. Assemble a national database of nonmarket amenities in U.S. counties.
2. Refine the “quality of life” rankings method to measure relative expenditures (Rosen 1979, Roback JPE 1982).
3. Develop national estimates for local amenity expenditures.

Note: we do not value natural resource stocks (Fenichel and Abbott JAERE 2014) or interpret our results as a quality of life index (Albouy et al. NBER 2013) or attempt to measure the full economic impact of any particular amenity on the economy (Muller, Mendelsohn, and Nordhaus AER 2011).

# The Spatial Landscape

---

- $j=1, \dots, J$  locations: rents, wages, amenities =  $r_j, w_j, A_j$ .
- “Amenities”: any location-specific attributes that matter to households but are not formally traded (e.g. climate, geography, pollution, public goods, opportunities for dining and entertainment, and transportation infrastructure).
- $\alpha$  – type households: differ in their job skills, preferences for amenities, moving costs, and information sets:  $J_\alpha \subset J$ .
- Utility maximization: numeraire ( $x$ ); housing ( $h$ ); amenities ( $A$ )

$$\max_{h, j \in J_\alpha} U(x, h, A_j; \alpha) : w_j(\alpha) = x + r_j h + mc_{\alpha, j}.$$

# Dual Market Sorting Equilibrium

---

- Analagous model for firms:  $C_j = C(w_j, r_j, A_j, mc_{\beta,j}; \beta)$ .
- Dual-Market Sorting Equilibrium: rents, wages, amenities, and location choices are defined such that no agent is better off by moving.
- Equilibrium Conditions:

$$\bar{V}_\alpha = V(w_j, r_j, A_j, mc_{\alpha,j}; \alpha) \quad \text{for all } j \in J_\alpha^*$$

$$\bar{C}_\beta = C(w_j, r_j, A_j, mc_{\beta,j}; \beta) \quad \text{for all } j \in J_\beta^*$$

$$r_j = r[A_j; F(A), G(\alpha), H(\beta)] \quad \& \quad w_j = w[A_j; F(A), G(\alpha), H(\beta)]$$

# Implicit Amenity Expenditures

---

- A household's implicit amenity expenditure is the amount of income the household chooses to sacrifice in order to consume the amenities conveyed by its preferred location.
- Let  $x^*$  and  $h^*$  represent the household's consumption at its utility-maximizing location, and let  $q_\alpha$  represent amenity expenditures for an  $\alpha$ -type household. Then we have,

$$q_\alpha = \acute{x} - x^*, \quad \text{where} \quad \acute{x} = \max_{l \in J_\alpha} w_l(\alpha) - r_l h^* - mc_{\alpha,l},$$

*Suppose you were to pay to move from your current location to the least expensive location in your consideration set. How much additional income would you have left over after buying an identical house?*

# Implicit Amenity Expenditures

---

- A household's implicit amenity expenditure is the amount of income the household chooses to sacrifice in order to consume the amenities conveyed by its preferred location.
- Let  $x^*$  and  $h^*$  represent the household's consumption at its utility-maximizing location, and let  $q_\alpha$  represent amenity expenditures for an  $\alpha$ -type household. Then we have,

$$q_\alpha = \acute{x} - x^*, \quad \text{where} \quad \acute{x} = \max_{l \in J_\alpha} w_l(\alpha) - r_l h^* - mc_{\alpha,l},$$

*a revealed preference “income equivalent” (Fleurbaey JEL 2009)  
and a lower bound on willingness to pay (Banzhaf NBER 2016).*

# Key Data Components

---

1. County level data on 75 amenities (3,108 counties).
2. Census PUMS 5% file on households (5.5 million households)
  - a. real household wages (adjusting for cost of living, Moretti AEJ 2013)
  - b. real house rent (adjusting for property taxes, Poterba AER 1992)
3. County-to-county migration flow files (1995 to 2000)
4. County-to-county moving cost calculator (physical & financial)

# Assembling Data on 75 Amenities

---

Step 1: Update data on 15 amenities tracked by Blomquist, Berger, and Hoehn (AER, 1988).

1. precipitation
2. heating degree days
3. wind speed
4. coastal
5. TSP
6. landfill waste
7. treatment/storage/disposal sites
8. teacher-pupil ratio
9. humidity
10. cooling degree days
11. sunshine
12. central city
13. NPDES dischargers
14. superfund sites
15. violent crime

# Assembling Data on 75 Amenities

---

Step 2: Review literature to identify other environmental amenities affecting housing prices and/or wages. Examples:

- **Earthquake risk** (Brookshire et al. JPE 1985)
- **Cancer risk** (Davis, AER 204)
- **Hurricane risk** (Hallstrom and Smith, JEEM 2006; Strobl REStat 2011)
- **Fire risk** (Loomis, JFE 2005)
- **Air pollutant toxicity** (Banzhaf and Walsh AER 2008)
- **Nuclear power plants** (Clark and Nieves JEEM 1994)
- **Proximity to open space** (Irwin and Bockstael AJAE 2001; Walsh JUE 2006; Kuminoff JARE 2009; Klaiber and Phaneuf JEEM 2010)

# Step 2 continued...

---

## LOCAL PUBLIC GOODS (Gyourko and Tracy, JPE 1991)

expenditures for hospitals and health, expenditures on parks and recreation, expenditures per student, child mortality, museums and historical sites, zoos, botanical gardens and nature parks, campgrounds and camps

## INFRASTRUCTURE (Burchfield et al. QJE 2006; Baum-Snow QJE 2007)

# airports, # ports, interstate highway mileage, urban arterial mileage, # Amtrak stations, # urban railway stops, railway mileage

## CULTURAL / URBAN (Glaeser et al. JEG 2001; Lee JUE 2010)

restaurants & bars, theatres & musicals, movie theatres, bowling alleys, research I universities, golf courses and country clubs, military areas, distance to nearest urban center, distance to metro area, distance to metro area w > 250,000, distance to metro area w > 500,000, distance to metro area > 1.5 million, housing stress indicator, persistent poverty indicator, retirement destination indicator

# Amenities

## GEOGRAPHY AND CLIMATE

Mean precipitation (inches p.a., 1971-2000)
Mean relative annual humidity (% , 1961-1990)
Mean annual heating degree days
Mean annual cooling degree days
Mean wind speed (m.p.h., 1961--1990)
Sunshine (% of possible)
Heavy fog (no. of days with visibility > 0.25 mi.)
Percent water area
Coast (=1 if on coast)
Non-adjacent coastal watershed (=1 if in watershed)
Mountain peaks above 1500 meters
Rivers (miles per sq. mile)
Federal land (percentage of total land area)
Wilderness areas (percentage of total land area)
National Parks (percentage of total land area)
Distance (km) to nearest National Park
Distance (km) to nearest State Park
Scenic drives (total mileage)
Average number of tornados per annum (1950-2004)
Property damage from hazard events (\$000s, per mi <sup>2</sup> )
Seismic hazard (index)
Number of earthquakes (1950-2000)
Land cover diversity (index, range 0-255)

## ENVIRONMENTAL EXTERNALITIES

NPDES effluent dischargers (PCS permits, 1989-1999)
Landfill waste (metric tons, 2000)
Superfund sites
Treatment, storage and disposal facilities
Large quantity generators of hazardous waste
Nuclear power plants
PM2.5 (g per m3)
PM10 (g per m3)
Ozone (g per m3)
Sulfur dioxide (g per m3)
Carbon monoxide (g per m3)
Nitrogen dioxide (g per m3)
National Fire Plan treatment (percentage of total area)
Cancer Risk
Neurological risk
Respiratory risk

## LOCAL PUBLIC GOODS

Local direct general expenditures (\$ per capita)
Local exp. for hospitals and health (\$ per capita)
Local exp. on parks, rec. and nat. resources (\$ pc)
Museums and historical sites (per 1,000 people)
Municipal parks (percentage of total land area)
Campgrounds and camps
Zoos, botanical gardens and nature parks
Crime rate (per 100,000 persons)
Teacher-pupil ratio
Local expenditure per student (\$, 1996-97 fiscal year)
Private school to public school enrollment (%)
Child mortality (per 1000 births, 1990--2000)

## INFRASTRUCTURE

Federal expenditure (\$ pc, non-wage, non-defense)
Number of airports
Number of ports
Interstate highways (total mileage per mi <sup>2</sup> )
Urban arterial (total mileage per mi <sup>2</sup> )
Number of Amtrak stations
Number of urban rail stops
Railways (total mileage per mi <sup>2</sup> )

## CULTURAL AND URBAN AMENITIES

Number of restaurants and bars (per 1,000 people)
Theatres and musicals (per 1,000 people)
Artists (per 1,000 people)
Movie theatres (per 1,000 people)
Bowling alleys (per 1,000 people)
Research I universities (Carnegie classification)
Golf courses and country clubs
Military areas (percentage of total land area)
Housing stress (=1 if > 30% of households distressed)
Persistent poverty (=1 if > 20% of pop. in poverty)
Retirement destination (=1 if growth retirees > 15%)
Distance (km) to the nearest urban center
Incr. distance to a metropolitan area of any size
Incr. distance to a metro area > 250,000
Incr. distance to a metro area > 500,000
Incr. distance to a metro area > 1.5 million

**Sources:** (1) Carnegie classification of institutions of higher education; (2) County business patterns; (3) CDC, National Center for Health Statistics; (4) Census of Governments; (5) EPA air quality system; (6) EPA national scale air toxics assessment; (7) EPA toxic release inventory; (8) Environmental systems research institute ArcGIS maps; (9) U.S. county characteristics compiled by the Interuniversity Consortium for Political and Social Research; (10) NOAA strategic environmental assessments division; (11) NOAA, national climate data center; (12) Partridge et al. (2009); (13) USDA Economic Research Service; (14) National Park Service; (15) DOE, energy efficiency and renewable energy division (16) DOE International Nuclear Safety Center; (17) National atlas of the U.S. geological survey.

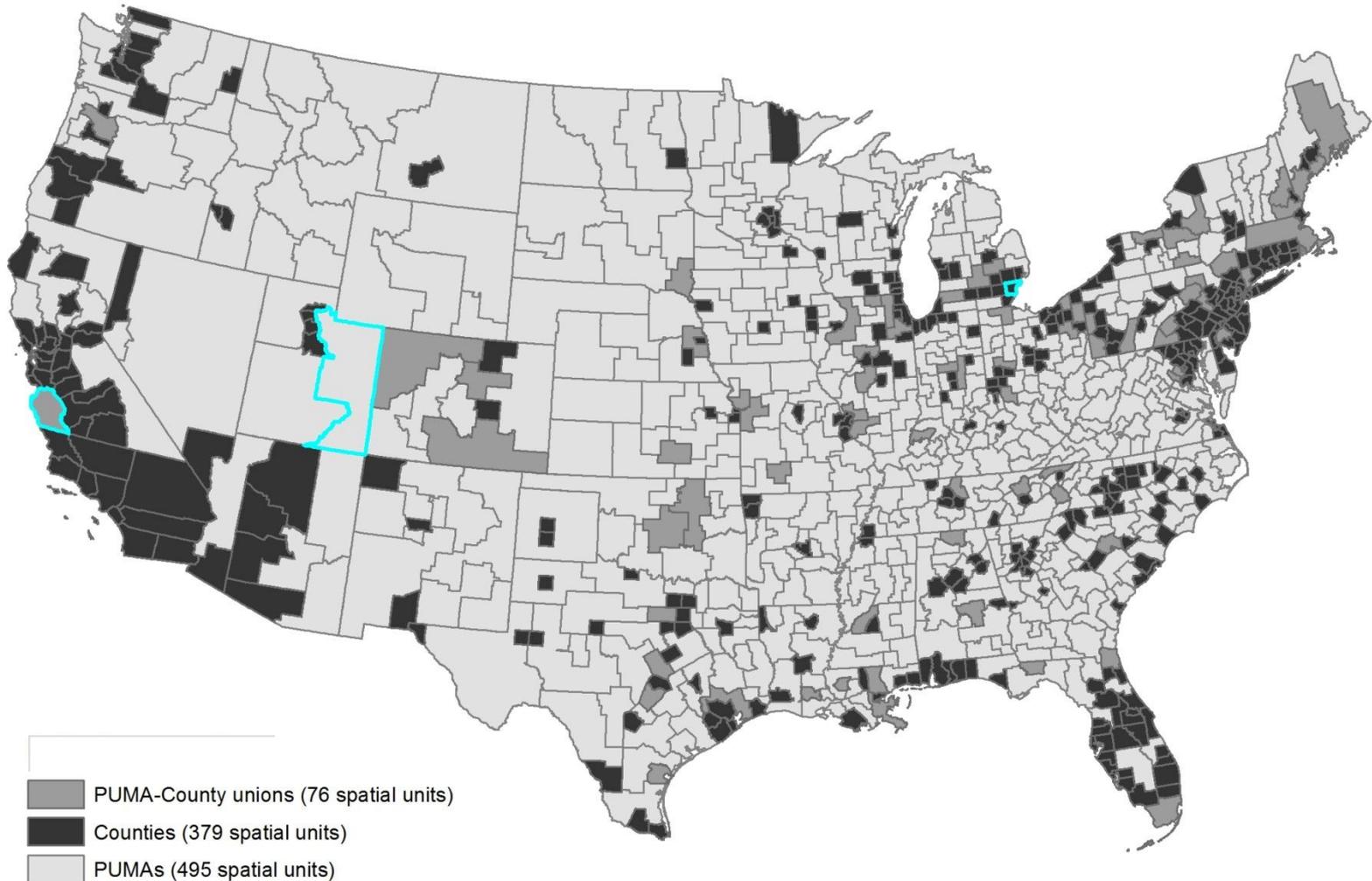
# Spatial Aggregation: 950 locations

---

Census data report an individual's home PUMA, not their county.  
( PUMA = Public Use Microdata Area – approximately 100k people )

- 60% of the population lives in highly populous counties that are divided into multiple PUMAs (e.g. Wayne County, MI).
- 25% of the population lives in less populous counties that are aggregated along with adjacent counties into a single PUMA. (e.g. Canyonlands National Park and Wasatch mountains, Utah).
- 15% of the population lives in counties that are joined by PUMAs (e.g Monterey and San Benito Counties, CA).

# From 3,108 Counties to 950 Locations



# The Consideration Set: 4 Scenarios

---

Constraint for inclusion in the consideration set	Average number of locations considered	Share of Migrants 1995-2000
(1) None	950	100%
(2) Emmigration Share > 0.1%	137	89%
(3) Immigration Share > 0.1%	135	89%
(4) Less than 250 miles away	82	67%

# Expenditure Calculations Overview

---

Relative  
Expenditures:

$$Q_j = \sum_{k=1}^K a_{kj} \left[ \frac{d\tilde{r}_j}{da_{kj}} (X_{ij}^r, A_j, \beta) - \frac{dw_j}{da_{kj}} (X_{mj}^w, A_j, \gamma) \right]$$

$X_{ij}^r$  &  $X_{mj}^w$ :

Census PUMS variables describing  $i=1, \dots, I$  houses and  $m=1, \dots, M$  workers who live in location  $j$ .

Real  
Expenditures:

$$q_\alpha = Q_j - \min_{l \in J_\alpha} (Q_l + mc_{\alpha,l})$$

- Calculate physical and financial moving costs and test alternative definitions for the consideration set

# Two-Stage Estimator for Relative Expenditures

---

## First Stage:

*rent function:*  $\ln \tilde{r}_{ij} = \underline{X_{ij}^r} \beta_1 + \lambda_j^r + \varepsilon_{ij}$

*wage function:*  $\ln w_{mj} = \underline{X_{mj}^w} \gamma_1 + \lambda_j^w + v_{mj},$

$X_{ij}^r =$  [rooms, bedrooms, size of building, age of building, acreage, type of unit, condominium status, quality of kitchen and plumbing facilities, renter status, renter\*rooms, renter\*bedrooms, renter\*size of building, renter\*age of building, renter\*acreage, renter\*type of unity, renter\*condo status, renter\*quality of kitchen, and renter\*quality of plumbing facilities ]

$X_{mj}^w =$  [experience measured as age-schooling-6, experience<sup>2</sup>, gender\*experience, gender\*experience<sup>2</sup>, marital status, race, gender\*marital status, age, children under 18, educational attainment, educational enrollment, citizen status, employment disability, NAICS-based industry class, NAICS-based occupation class, military status. ]

# Two-Stage Estimator for Relative Expenditures

---

## First Stage:

*rent function:*  $\ln \tilde{r}_{ij} = X_{ij}^r \beta_1 + \lambda_j^r + \varepsilon_{ij}$

*wage function:*  $\ln w_{mj} = X_{mj}^w \gamma_1 + \lambda_j^w + v_{mj}$

- Nearly all modern “quality of life” studies stop here, using the fixed effects to rank cities or metro areas.
- The problem is that the fixed effects conflate the implicit prices of amenities with latent attributes of houses and workers.

# Two-Stage Estimator for Relative Expenditures

---

## First Stage:

*rent function:*  $\ln \tilde{r}_{ij} = X_{ij}^r \beta_1 + \lambda_j^r + \varepsilon_{ij}$

*wage function:*  $\ln w_{mj} = X_{mj}^w \gamma_1 + \lambda_j^w + v_{mj},$

## Second Stage:

*rent function:*  $\hat{\lambda}_j^r = A_j \beta_2 + \alpha^r + \xi_j^r$

*wage function:*  $\hat{\lambda}_j^w = A_j \gamma_2 + \alpha^w + \xi_j^w,$

# Two-Stage Estimator for Relative Expenditures

---

*Are  $\beta_2$  and  $\gamma_2$  identified?*

$\xi_j^r, \xi_j^w$  contain:

1. omitted physical attributes of houses
2. omitted dimensions of human capital
3. omitted amenities

Second Stage:

*rent function:*

$$\hat{\lambda}_j^r = A_j \beta_2 + \alpha^r + \xi_j^r$$

*wage function:*

$$\hat{\lambda}_j^w = A_j \gamma_2 + \alpha^w + \xi_j^w,$$

# Implications of omitting a relevant amenity

---

Suppose we omit a relevant amenity,  $z$ .

We want to recover:  $Q = A(\beta_2 - \gamma_2) + z(\kappa^r - \kappa^w)$

We actually identify:

$\text{plim } \hat{\beta}_2 = \beta_2 + \pi\kappa^r$ , where  $z = A'\pi + \eta$  and  $E[\eta_j | A_j] = 0$

$\text{plim } \hat{Q} = A(\beta_2 - \gamma_2) + (z - \eta)(\kappa^r - \kappa^w)$

Implications: As  $\pi \rightarrow 0$ ,  $\text{plim } \hat{Q} \rightarrow A(\beta_2 - \gamma_2)$ . As  $\eta \rightarrow 0$ ,  $\text{plim } \hat{Q} \rightarrow Q$ .

# Results

---

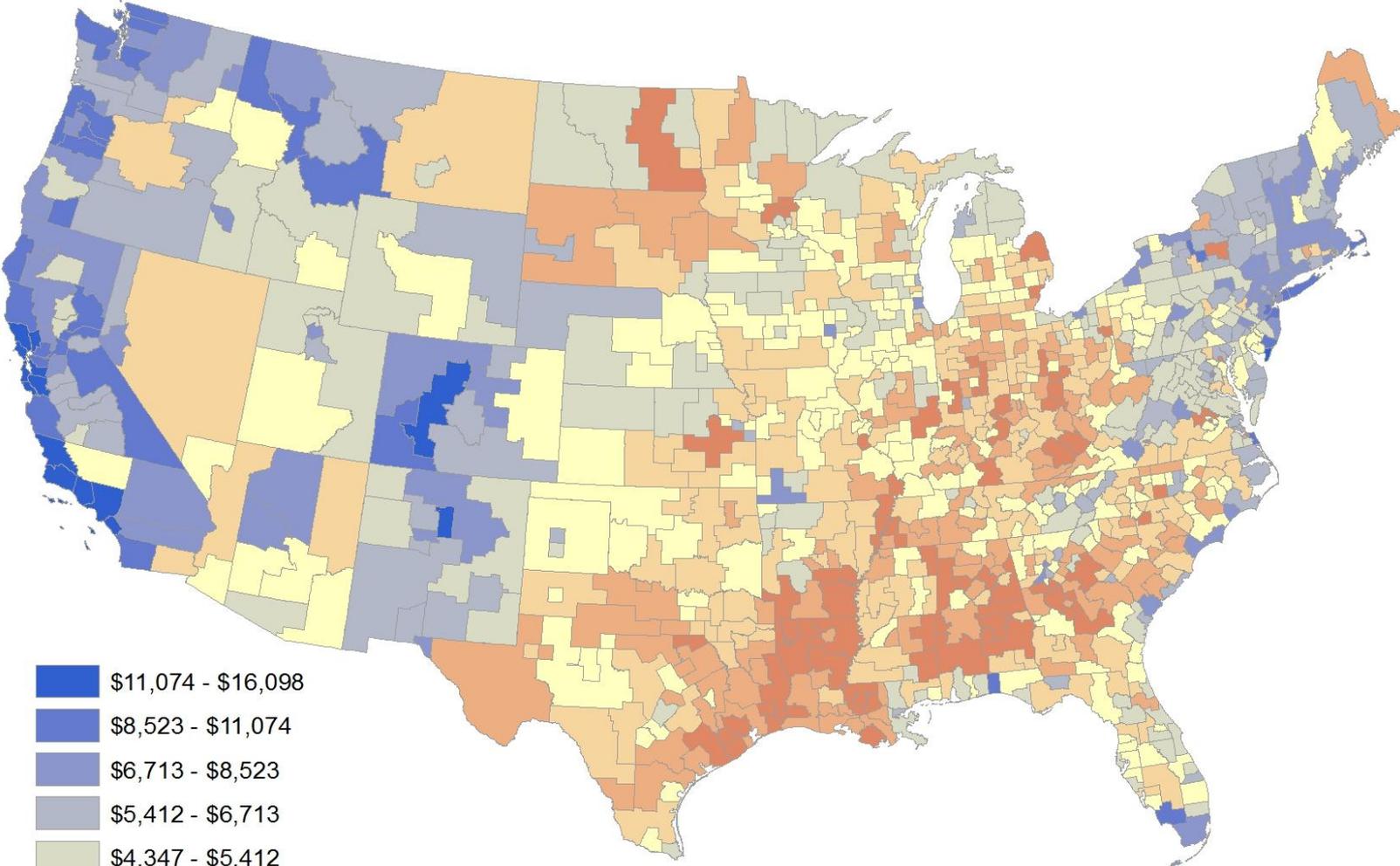
Constraint for inclusion in the consideration set	Average number of locations considered	Share of Migrants 1995-2000	<u>Expenditures / household</u>		Total Expenditures ( \$billion )
			mean	st. dev.	
None	950	100%	5,550	3,010	582
Emmigration Share > 0.1%	137	89%	5,341	3,102	560
Immigration Share > 0.1%	135	89%	5,388	3,076	565
Less than 250 miles away	82	67%	3,674	2,731	385

# Results

Constraint for inclusion in the consideration set	Average number of locations considered	Share of Migrants 1995-2000	<u>Expenditures / household</u>		Total Expenditures ( \$billion )
			mean	st. dev.	
None	950	100%	5,550	3,010	582
Emmigration Share > 0.1%	137	89%	5,341	3,102	560
Immigration Share > 0.1%	135	89%	5,388	3,076	565
Less than 250 miles away	82	67%	3,674	2,731	385

- Midpoint is \$562 billion or 8.2% of personal consumption expenditures
- Ignoring Roy sorting decreases expenditures from \$562 to \$422
- Elasticity of amenity expenditures to income is about 1.3

# Distribution of Amenity Expenditures



- \$11,074 - \$16,098
- \$8,523 - \$11,074
- \$6,713 - \$8,523
- \$5,412 - \$6,713
- \$4,347 - \$5,412
- \$3,351 - \$4,347
- \$2,437 - \$3,351
- \$1,454 - \$2,437
- \$0 - \$1,454

# Comparison to NIPA

---

Year 2000 personal consumption expenditures: \$6,830 billion

NIPA housing expenditures: \$1,010 billion

Our estimated amenity expenditures: \$385 to \$632 billion.

- Consistent with the goal of satellite accounting, our expenditure measures are based on market activity that shows up elsewhere in NIPA (housing, wages).
- Focus on environmental services, local public goods, and urban infrastructure addresses NRC's (2005) top priorities for satellite accounting.
- Formal satellite account would need to clarify mapping between amenity expenditures and NIPA architecture (e.g. housing services, wages, profit).