turning knowledge into practice

The Value of Climate Amenities in the United States: Evidence from Migration Decisions

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Motivation

- Large literature on damages associated with climate change in the United States—but focus is on market impacts (agriculture, forestry)
- Amenity impacts of climate change—what people will pay for a warmer winter or cooler summer—could be an important component of damages, but few reliable estimates of these values exist
- Hedonic literature of the 1970s and 1980s has methodological shortcomings—assumes national labor and housing markets and ignores moving costs
- Discrete choice approach is more promising—but few studies have valued temperature and precipitation (Cragg and Kahn, 1997 a notable exception)

Our Approach

- Model the migration decisions of U.S. households who changed MSAs between 1995 and 2000
- Each household selects the metropolitan area (MSA) that maximizes its utility, taking moving costs into account
- Utility of each MSA depends on household earnings opportunities, cost of housing and MSA amenities
- Results allow us to estimate what a household would pay for changes in temperature and precipitation, by season; also to estimate impacts of climate on migration

The Challenges

- Must control for other factors that affect migration decisions that are correlated with climate:
  - Amenities that are more likely to be provided in cities with more desirable climates
  - Amenities that vary regionally
- Difficult to use multiple cross-sections since climate changes slowly
- We measure the preferences of migrants—they may not be representative of the entire population
- Approach is suited to valuing small changes in temperature and precipitation—large changes entail general equilibrium effects

Outline of Talk

- Econometric model
- Stylized facts about migration and climate in the U.S.
- Data
- Results

Household Location Choice

- For each location j (MSA) household i allocates its income between housing (H_{ij}) and expenditure on all other goods (C_{ij})

- max $U(C_{ij},H_{ij};A_j,MC_{ij})$ s.t. $C_{ij} + R_jH_{ij} = W_{ij}$

  – A_j = vector of amenities in city j
  – MC_{ij} = cost of moving from i's original location to j
  – R_j = cost of housing in city j
  – W_{ij} = household i's earnings in city j

- Substituting C_{ij} and H_{ij} into U( ) yields i's utility from MSA j, $U_{ij} = U(R_j,W_{ij},A_j,MC_{ij})$

Household Location Choice II

- Assume indirect utility function is of the form:

$$\ln U(R_j, W_{ij}, A_j, MC_{ij}) = \alpha \ln W_{ij} - \beta \ln R_j + MC_{ij} + g(A_j)$$

  - Consistent with Cobb-Douglas utility; β = fraction of income spent on housing. MC_{ij} specified on next slide

- Model choice of MSA using a Random Utility Model

$$V_{ij} = \ln U(R_j, W_{ij}, A_j, MC_{ij}) + \varepsilon_{ij}$$

  - ε_{ij} = unobserved component of utility, assumed i.i.d. Type Extreme Value
  - P(i chooses j) = P($V_{ij} \geq V_{ik}$ for all $k \neq j$)
  - Yields standard multinomial logit model

Moving Costs
(follows Bayer, Keohane and Timmins (2006))

$$MC_{ij} = \alpha_{M0} d_{ij}^{State} + \alpha_{M1} d_{ij}^{Division} + \alpha_{M2} d_{ij}^{Region}$$

where

$d_{ij}^{State} = 1$ if location j differs from the state in which household i lived in 1995

$d_{ij}^{Division} = 1$ if location j differs from the Census Division in which household j lived in 1995

$d_{ij}^{Region} = 1$ if location j differs from the Census Region in which household i lived in 1995

Estimation Strategy

- Approach follows Bayer, Keohane and Timmins (2006): Estimate discrete choice model with

  $\ln U(R_j, W_{ij}, A_j, MC_{ij}) = \alpha \ln W_{ij} + MC_{ij} + \delta_j$

  where $\delta_j = g(A_j) - \beta \ln R_j$

- Use McFadden sampling scheme (choice set = chosen city plus 19 randomly chosen MSAs)

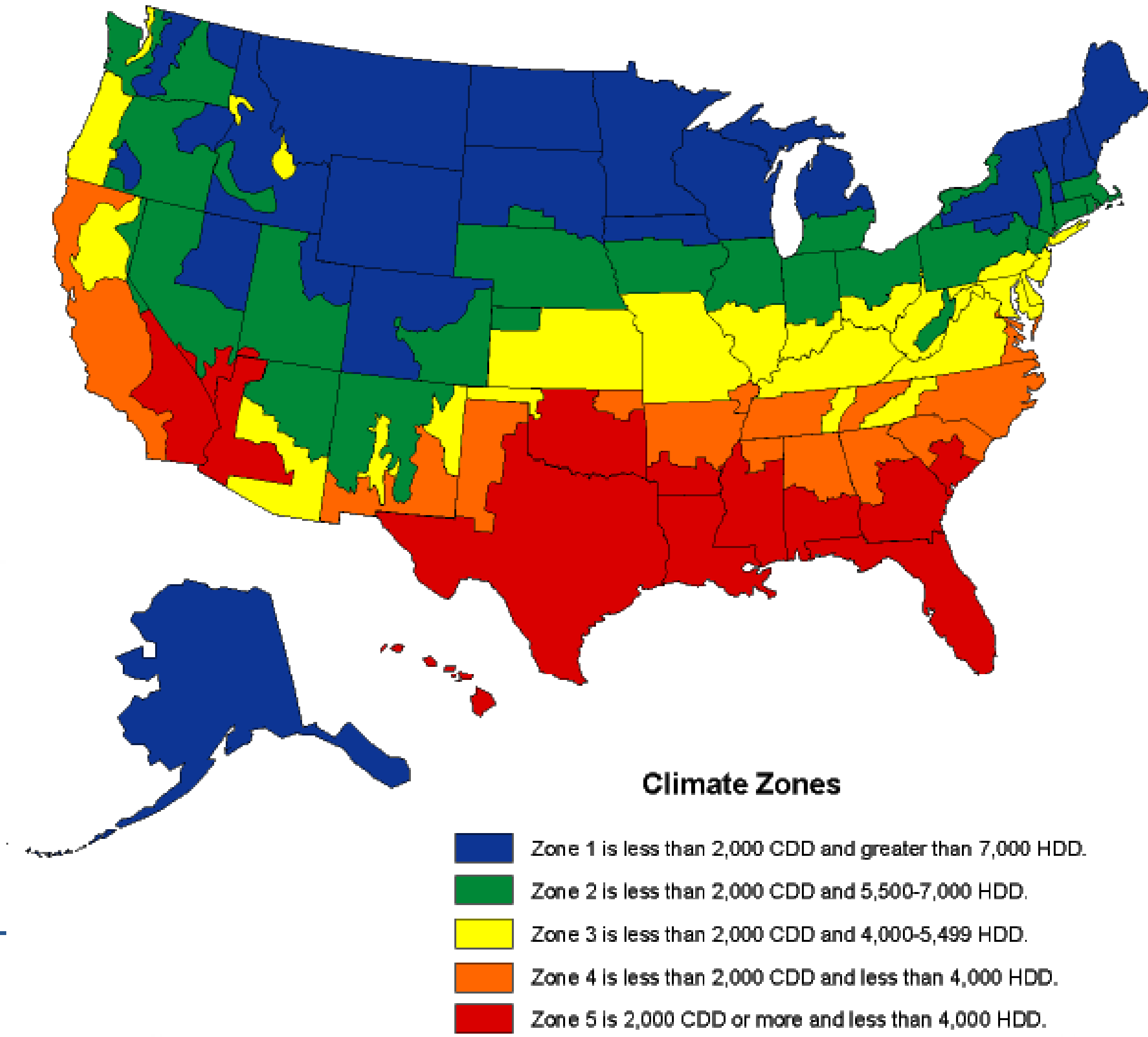
- Regress $\delta_j + \beta \ln R_j$ on location-specific amenities in second stage. $\beta = 0.25$

Estimation Strategy II

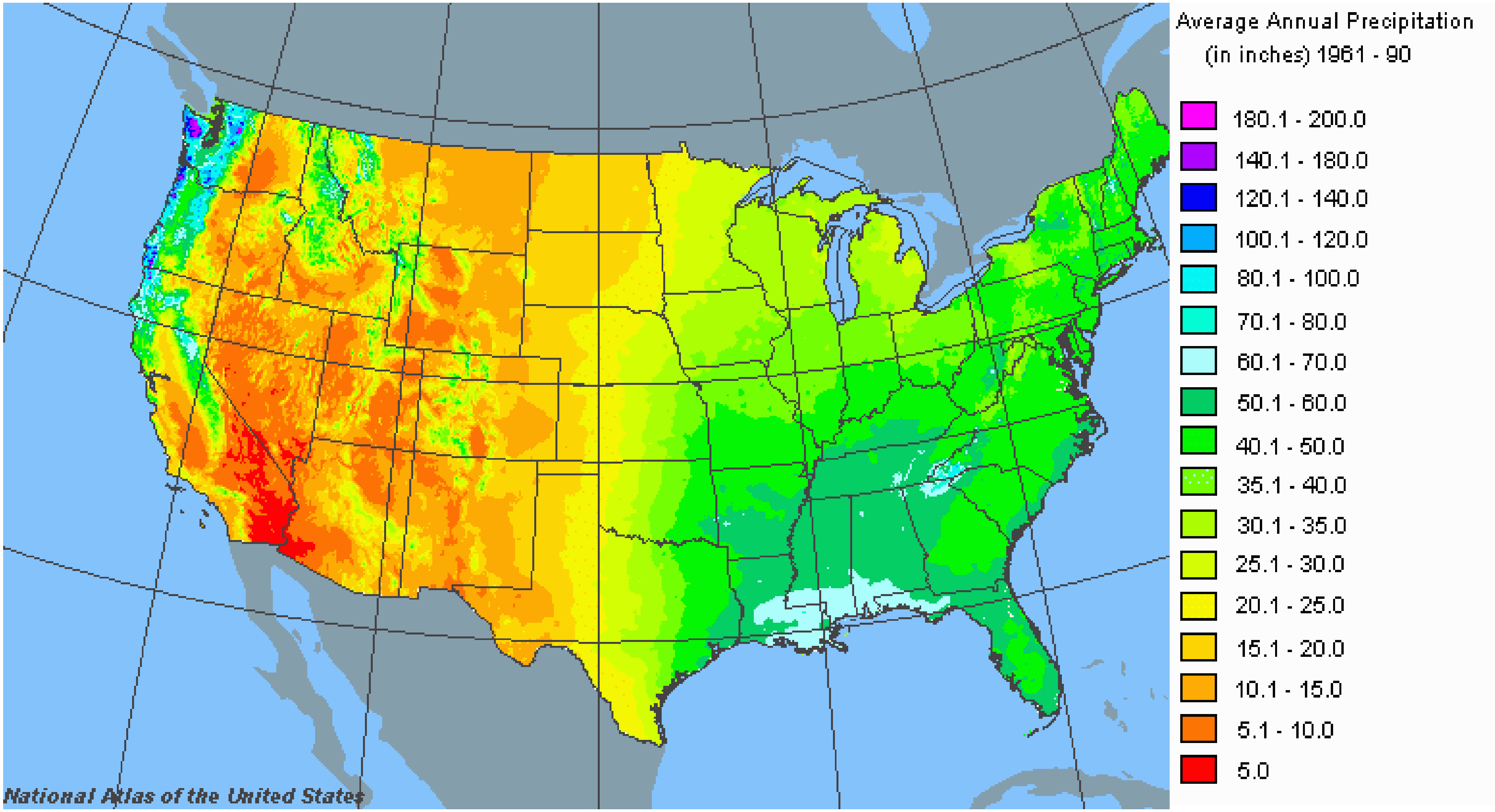
- To predict earnings in all MSAs estimate hedonic wage equation for each MSA
  - Include worker characteristics and occupation, but not location-specific amenities

- Estimate $\{R_j\}$ by estimating an hedonic housing equation with MSA-specific intercepts—the $\{R_j\}$
  - Housing costs include utility costs (to capture energy costs of different climates)
  - Explanatory variables include housing characteristics, but not location-specific amenities

Map of U.S. Climate Zones



Annual Average Precipitation, 1961-1990



Data

- 5% Public Use Microdata Sample of the 2000 Census
- 297 Metropolitan Statistical Areas
- Households who changed MSAs between 1995 and 2000

Migration Statistics

- Of households in PUMS who changed MSAs between 1995 and 2000:
  - Origin and destination MSA can be identified for 441,393 households
  - 61% changed states
  - 47% moved to a different Census division
  - 36% moved to a different Census region
  - Net migration to South and West

Origin and Destination of Migrants by Census Region (% of all hhs)

1995 region	Midwest	Northeast	South	West	Total (Origin)
Midwest	8.8%	1.2%	4.7%	3.0%	17.7%
Northeast	1.2%	12.6%	6.7%	2.3%	22.8%
South	2.7%	2.7%	22.6%	3.9%	31.9%
West	1.8%	1.3%	4.2%	20.3%	27.6%
Total (Destin.)	14.5%	17.8%	38.2%	29.5%	100%

CHARACTERISTICS OF MOVERS AND STAYERS

Characteristic	Movers	Stayers
High school or less	28.5%	44.7%
College graduate	23.4%	16.4%
Graduate degree	13.9%	8.5%
Age (years)	38.4	42.9
Household Wages (average)	$44,900	$43,900
Household Income (average)	$63,600	$56,900
2 or fewer members	67.2%	56.6%
4 or more members	19.5%	24.8%

How to Characterize Climate?

- Mean monthly temperature and precipitation
  - Focus on Winter and Summer averages to minimize collinearity problems
  - Enter in quadratic form to capture ideal temperature
- Heating and cooling degree days
  - Jan HDD = Σ (65 – Temp(i)) = 2015 – 31*Mean Jan Temp
- Temperature bins: number of days in temperature intervals
- Humidity, sunshine matter, too but more missing values

Amenity Variables Used in Second Stage

Variable	Mean	Std. Deviation
Annual Avg. PM10 (micrograms per cubic meter)	23.3	4.4
Total Crime Rate	0.037	0.015
Population Density (Persons Per Sq Mile)	471	970
Transportation Score	50.4	29.2
Recreation Score	52.6	28.7
Education Score	51.0	29.2
Arts Score	51.0	28.8
Healthcare Score	48.4	28.7
Mean Winter Temperature (Degrees Fahrenheit)	37.2	12.0
Mean Winter Precipitation (Inches)	9.4	4.94
Mean Summer Temperature (Degrees Fahrenheit)	73.3	5.74
Mean Summer Precipitation (Inches)	11.0	4.98
MSA on the Coast	0.31	0.47

Results from the First Stage Estimation (Migration Equation)

Variable	Coefficient	t-statistic
Log(household wages)	0.9720	18.46
State dummy	-1.9865	-134.08
Division dummy	-0.5239	-30.25
Regional dummy	-0.6895	-48.20
Number of Observations	75293	
Log Likelihood	-143768	
Number of Iterations	100	

Top 12 MSAs

Phoenix, AZ	1	3.655
Atlanta, GA	2	3.587
Washington, DC/MD/VA	3	3.514
Las Vegas, NV	4	3.323
Chicago-Gary-Lake, IL	5	3.311
Boston, MA	6	3.204
Tampa-St. Petersburg-Clearwater, FL	7	3.158
Los Angeles-Long Beach, CA	8	3.151
New York-Northeastern NJ	9	3.093
Denver-Boulder-Longmont, CO	10	3.042
Dallas-Fort Worth, TX	11	2.968
Philadelphia, PA/NJ	12	2.907

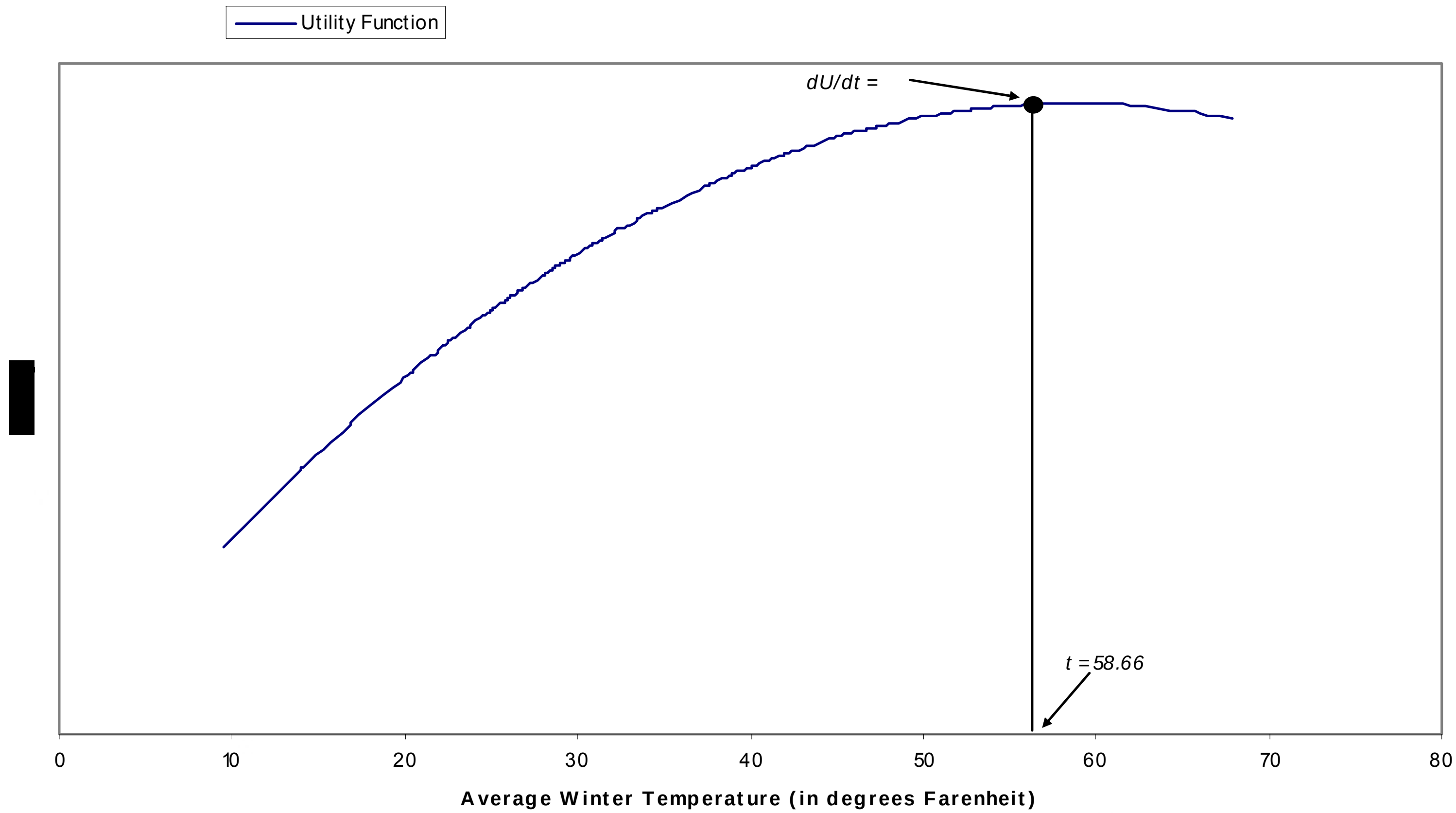
Bottom 12 MSAs

Houma-Thibodoux, LA	297	-1.177
Laredo, TX	296	-0.959
Kokomo, IN	295	-0.839
Altoona, PA	294	-0.821
Sioux Falls, SD	293	-0.815
Mansfield, OH	292	-0.717
Wausau, WI	291	-0.680
Gadsden, AL	290	-0.639
Sioux City, IA/NE	289	-0.635
Alexandria, LA	288	-0.628
Flint, MI	287	-0.583
Wichita Falls, TX	286	-0.525

Treatment of Climate Variables

- Winter, summer temperature and precipitation entered in quadratic form:
- Utility of winter temperature concave, peaks ≈ 58°F
- Summer temperature never significant
- Winter precipitation yields negative marginal utility that declines with level of precipitation
- Summer precipitation yields positive marginal utility that decreases with level of precipitation

Plot of Utility vs. Average Winter Temperature



Second Stage Estimates:
Quadratic Form for Temperature Variables
Marginal Effects of Climate Variables Evaluated at the Mean with p-values in parenthesis

Variable **# of Obs: 286**	**Includes Census Region Dummies (R sq: 0.769)**	**Includes Census Division Dummies (R sq: 0.783)**
Winter Temp.	.0304 (0.002)	.0291 (0.005)
Summer Temp.	-.0110 (0.531)	.0002 (0.991)
Winter Prec.	-.0296 (0.012)	-.0222 (0.128)
Summer Prec.	.0584 (0.0001)	.0375 (0.058)

Also included: PM10, CRIME RATE, POPDENSITY, MSA on COAST, SCORES for TRANSPORTATION, EDUCATION, RECREATION, ARTS, HEALTHCARE

WTP to increase average winter temperature by a degree: Examples

Name of MSA	Average Winter Temperature	WTP (as a % of income)
Washington, DC/MD/VA	34.83	3.35
Memphis, TN/AR/MS	40.02	2.62
Greenville, NC	44.67	1.97
San Jose, CA	50.03	1.21
Houston Brazoria, TX	54.17	0.63
Orlando, FL	60.11	-0.20
Naples, FL	65.53	-0.97

Conclusions

- Winter temperature is an amenity
  - Result is robust to specification, suggesting that MWTP for a 1˚F increase is about 3% of income at 37˚F, declining to zero at 58˚F
- Summer precipitation is an amenity; winter precipitation a disamenity
  - But . . . both results are sensitive to specification; a 1” increase in summer precipitation is worth about 4% of income
- Summer temperature neither an amenity or disamenity
  - Result NOT due to lack of variation—it does affect housing costs
  - Due to technology? (e.g. air conditioning)

Further Issues

- What can we say about the preferences of stayers?
- Model estimated using both movers and stayers suggests that stayers may not be in equilibrium
  - Coefficient and significance of wages in the utility function declines sharply when stayers are added to the sample
  - Models for movers only and movers-plus-stayers also estimated using moving costs calculated from birthplace (a la BKT) with similar results
- Suggests we cannot infer preferences of stayers from a model of locational equilibrium

Current Research

- Moving costs to represent trends in data better

  e.g. capture fact that households in NE more likely to move to the S than W

- Better amenity (especially climate) data

- Differences in preferences across demographic groups

- Are examining counterfactual climate scenarios over 1970-2000 to estimate impact on migration patterns

Hedonic Models II

- Marginal Willingness to Pay for an Amenity = Effect of the amenity on wages + Effect on property values
- Dozens of such studies in the 1970’s and 1980’s: Blomquist et al. (AER 1988), Gyourko and Tracy (JPE 1991)
- Studies assume that workers and firms are mobile and that national labor and housing markets are in equilibrium
- Subsequent literature has questioned this assumption
- Climate amenities may capture unobserved worker characteristics in hedonic wage equations

What Other Amenities Matter?

- Because of regional variation in temperature and precipitation, important to control for region, also proximity to coast
- For other amenities, rely on Places Rated Almanac to control for endogenous amenities that may be correlated with pleasant climate
  - Recreation, Arts, Healthcare, etc.
- Control for population density, air pollution, crime

Wage Regressions for each MSA

Based on:

- full time workers
- self employed individuals or those who report working in agriculture, farming, fishing or forestry are not included
- exclude military personnel and handicapped individuals

Note:

- Significant variation in returns to education, occupation across MSA
- Used to predict earnings for all persons in household in 2000
- Number of weeks and hours worked treated as constant for all MSAs

Cost Of Housing In Each MSA

Owners and renters are combined; user cost includes utilities

$$\ln(user\cos t_i) = R_0 + R_{OWN}\,OwnershipDummies + R_{BR}\,BedroomDummies$$
$$+ R_R\,RoomDummies + R_{KIT}\,KitchenDummy + R_P\,PlumbingDummy$$
$$+ R_{ACRE}\,Acreagedummies + R_{AGE}\,AgeofStructureDummies$$
$$+ R_{UNITS}\,UnitsStructureDummies + R_{MSA}\,MSADummies + error$$

When $\{R_j\}$ are regressed on climate variables, housing costs are lower in MSAs with colder winters and hotter summers. Precipitation does not have a statistically significant impact on housing costs.