National Expenditures on Local Amenities

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Consumers value nonmarket amenities such as climate, public goods, infrastructure, and pollution. They pay for these localized amenities indirectly, through spatial variation in housing prices, wages, and property taxes. In this paper, we develop a measure of indirect amenity expenditures that is consistent with principles of national accounting and fundamentals of spatial sorting behavior. We construct a county-level database of 75 amenities, match it to the location choices made by 5 million households, and develop the first estimates for implicit amenity expenditures in the United States. We find that expenditures exceeded 8% of personal consumption expenditures in 2000 ($562 billion).

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The national income and product accounts are the primary source of information on market activity in the United States. Since their inception, economists have suggested expanding the accounts to provide a richer description of nonmarket goods and services that affect the quality of life (Kuznets 1934, Nordhaus and Tobin 1972). Growing support for this idea led the National Research Council (1999) to recommend that the U.S. construct satellite accounts for nonmarket goods and services, culminating in the development of a new architecture for integrating nonmarket activity (Jorgenson, Landefeld and Nordhaus 2006). Despite these conceptual advances, there has been little progress on systematically measuring economic activity occurring outside of direct market transactions.[1]

The National Research Council (2005) identifies "environmental services," "local public goods," and "urban infrastructure" as top priorities for integrating nonmarket activity into the national accounts. While we rarely observe consumers purchasing these amenities directly, there is no doubt that they affect the economy. Local amenities contribute to GDP indirectly when spatial variation in their supply affects consumer expenditures on complementary private goods, such as housing. Numerous studies have used housing prices to estimate homebuyers' willingness to pay for local amenities. However, these studies typically analyze variation in a single amenity over a small number of counties. Inconsistency in study areas, time periods, and research designs makes it impossible to simply add up prior estimates for different amenities to get a consistent national figure. Furthermore, the lack of a comprehensive database on amenities has precluded prior studies from attempting to estimate national amenity expenditures directly.

In this paper we develop the first comprehensive estimates for indirect expenditures on local nonmarket amenities in the United States, using data on housing and labor market outcomes. Our approach begins from the fundamentals of

[1] Two notable exceptions are Landefeld, Fraumeni, and Vojtech (2009) who develop a prototype satellite account for household production and Muller, Mendelsohn and Nordhaus (2011) who develop a framework for integrating environmental externalities into the national accounts and provide estimates for industry-level air pollution damages.

spatial equilibrium in the presence of Tiebout sorting and Roy sorting.[2] When heterogeneous households sort themselves across the housing and labor markets based, in part, on their idiosyncratic job skills and preferences for amenities, the spatial variation in amenities gets capitalized into land values and wages.[3] As a result, people must pay to live in high amenity areas through some combination of higher housing prices, higher property taxes, and/or lower real wages. We refer to the real income that households forego in order to consume the amenities conveyed by the locations they choose as their "implicit amenity expenditures".

Developing a consistent macroeconomic measure of amenity expenditures requires addressing three key challenges: data, identification, and normalization. The *data challenge* is to measure the quantities of local amenities throughout the United States. The *identification challenge* is to develop a credible strategy for using spatial variation in property values, property taxes, wages, and amenities to identify the relative expenditures associated with moving between any two locations; i.e. the nominal change in consumption of private goods a household would experience by moving from its present location to a location with a different amenity bundle. The *normalization challenge* is to pin down real expenditures. This requires defining how far households would consider moving and accounting for moving costs and spatial variation in purchasing power, income taxes, and tax subsidies to homeowners. We address these challenges by building a comprehensive and detailed database on amenities, migration flows, moving costs, the tax code, and participation in the housing and labor markets.

As part of this analysis, we have constructed the first national database on nonmarket amenities in U.S. counties. For every county in the lower 48 states, we

[2] For surveys of the literature on Tiebout sorting and the role of amenities in equilibrium see Blomquist (2006), Kahn (2006), Epple, Gordon, and Sieg (2010), and Kuminoff, Smith, and Timmins (2013). Key papers on spatial Roy sorting include Dahl (2002) and Bayer, Kahn, and Timmins (2011). The way our model combines Tiebout sorting with Roy sorting is most closely related to Bayer, Keohane, and Timmins (2009) and Kuminoff (2013).

[3] Local amenities are a key determinant of where people choose to live. For example, the Census Bureau's 2001 American Housing Survey reports that 25% of recent movers listed the main reason for their move as: "looks/design of neighborhood", "good schools", "convenient to leisure activities", "convenient to public transportation", or "other public services."

collected data describing features of its climate and geography, environmental externalities, local public goods, transportation infrastructure, and access to cultural and urban amenities. Examples of the 75 specific amenities in our database include rainfall, humidity, temperature, frequency of extreme weather, wilderness areas, state and national parks, air quality, hazardous waste sites, municipal parks, crime rates, teacher-pupil ratios, child mortality, interstate highway mileage, airports, train stations, restaurants and bars, golf courses, and research universities.[4] We matched these amenities to the most comprehensive micro data on households and their location choices—the 5% public use sample from the 2000 Census. Thus, our analysis uses data on the housing prices, wages, and amenities experienced as a result of location choices made by over 5 million households.

In the first stage of our analysis, we calculate real wages and real housing expenditures for each household. Specifically, we adjust their gross wages for spatial variation in purchasing power and income tax burdens, and then we calculate their real housing expenditures, controlling for property taxes and tax subsidies to homeowners (Poterba 1992, Himmelberg, Mayer, and Sinai 2005). Our user-cost approach to calculating expenditures on owner occupied housing differs from the "rental equivalency" imputations in the National Income and Product Accounts. Similar to Prescott (1997), we argue that the user cost approach provides a more consistent measure of the economic cost of homeownership.

The second stage of our analysis uses a two-step, fixed effects estimator to extract the spatial variation in real wages and rents due to spatial variation in amenities. Our identification strategy relies on brute force. We demonstrate that *total* amenity expenditures are identified as long as any omitted amenity can be expressed as a linear function of the observed amenities.[5] The credibility of this

[4] In comparison, the most detailed data in the existing literature were developed by Blomquist, Berger, and Hoehn (1988), who collected information on 15 amenities provided by 253 urban counties. Their amenity data covers 8% of all U.S. counties, primarily describing climate, geography, and environmental externalities circa 1980.

[5] It would be nice to separately identify virtual prices for each of the 75 amenities as an intermediate step toward calculat-

strategy is supported by two points. First, amenities tend to exhibit a high degree of spatial correlation. Second, the size and diversity of our amenity database allows us to make a strong case that any omitted amenity will be highly correlated with several of the ones we observe. We control for sorting on unobserved job skill (i.e. spatial Roy sorting) by adapting Dahl's (2002) semiparametric sample selection correction for the wage equation. Our results are robust to using an alternative control function based on Bayer, Kahn, and Timmins (2011).

Finally, we use data on physical moving costs, financial moving costs, and historical migration flows to define a subset of locations in the contiguous U.S. where households in each location would be likely to consider moving. These "consideration sets" provide the final normalization needed to calculate real amenity expenditures. Under a variety of alternative definitions for the consideration sets, our estimates range from $385 billion to $632 billion for the year 2000. Our preferred point estimate of $562 billion is equivalent to 8.2% of personal consumption expenditures on private goods. These figures imply the average household sacrifices over five thousand dollars per year to consume the nonmarket amenities at their home location. Expenditures are generally higher in the west, mountains and northeast, and lower in the mid-west and south. Among major metropolitan areas, expenditures per household are highest in San Francisco, New York, and Los Angeles and lowest in Detroit, Baltimore, and Houston.

Our research makes several contributions to the literature. Most importantly: (i) we introduce the first national database of nonmarket amenities in U.S. counties; (ii) we develop a methodology for estimating aggregate amenity expenditures that is consistent with spatial sorting based on heterogeneous preferences and skills, and adjusts for spatial variation in moving costs, tax subsidies to homeownership, income taxes, and property taxes; and (iii) we present the first national

ing total expenditures. In an ideal world, this could be accomplished by running a field experiment that randomly assigns amenity levels to counties. This of course is infeasible for even one amenity, not to mention seventy five.

estimate of amenity expenditures, along with regional and county-level estimates. Thus, we directly address the National Research Council's call for developing satellite accounts for environmental services, public goods, and infrastructure.

The rest of the paper proceeds as follows. Section I uses a model of sorting in the housing and labor markets to define "implicit amenity expenditures." Section II summarizes the data. Section III explains our methodology, section IV presents the main results, and section V concludes. Additional modeling details and robustness checks are provided in a supplemental appendix.

I. Conceptual Framework

A. Dual-Market Sorting Equilibrium

We envision heterogeneous firms and working households sorting themselves across the landscape to maximize profits and utility. To formalize this idea, we first divide the nation into $j = 1,2, \ldots, J$ locations. Locations differ in the wages paid to workers, w_j, in the annualized after-tax price of land, which we call rent, r_j, and in a vector of K nonmarket amenities, $A_j = [a_{1j}, \ldots, a_{Kj}]$. We define "amenities" broadly to include all attributes of a location that matter to households but are not formally traded. Examples include climate, geography, pollution, public goods, opportunities for dining and entertainment, and transportation infrastructure. Some of these amenities are exogenous (e.g. climate, geography). Others may be influenced by Tiebout sorting through voting on property tax rates, social interactions, and feedback effects (e.g. school quality, pollution).

Heterogeneous households choose locations that maximize utility. They differ in their job skills, preferences for amenities, and in the set of locations they consider. Let $J_\alpha \subset J$ denote the subset of locations considered by a household of type α. If we define locations to be counties, for example, then the typical household may only consider a small subset of the 3000+ counties in the U.S.

Households enjoy the quality of life provided by the amenities in their chosen location. Each household supplies one unit of labor, for which it is paid according to its skills. A portion of this income is used to rent land, h, and the remainder is spent on a nationally traded private good, x.[6] Thus, households maximize utility by selecting a location and using their wages to purchase x and h,

$$\max_{h,x,j\in J_\alpha} \; U\left(x,h,A_j;\alpha\right): \quad w_j(\alpha) = x + r_j h + mc_{\alpha,j}. \tag{1}$$

Households also face differentiated costs of moving to a given location. This is represented by $mc_{\alpha,j}$. Notice that we use α to index all forms of household heterogeneity. Each α-type has a unique combination of preferences, skills, and moving costs, and considers a specific subset of the J locations.

The firm side of the model is analogous. β-type firms with heterogeneous production technologies and management styles choose locations that minimize their cost of producing the numeraire good, $C_j = C\left(w_j, r_j, A_j, mc_{\beta,j};\beta\right)$.[7]

A dual-market sorting equilibrium occurs when rents, wages, amenities, and location choices are defined such that markets for land, labor, and the numeraire good clear and no agent would be better off by moving. This implies that utility and costs are equalized across all of the locations occupied by households of each α-type and firms of each β-type. Denoting these subsets of occupied locations as J_α^*, J_β^* and rewriting utility in indirect terms, we have:

$$\bar{V}_\alpha = V\left(w_j, r_j, A_j, mc_{\alpha,j};\alpha\right) \quad \text{for all} \;\; j \in J_\alpha^*. \tag{2.a}$$

$$\bar{C}_\beta = C\left(w_j, r_j, A_j, mc_{\beta,j};\beta\right) \quad \text{for all}\; j \in J_\beta^* \;. \tag{2.b}$$

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[6] The composite good includes the physical characteristics of housing.

[7] Amenities may affect the cost of doing business. An example would be a firm with a dirty production technology facing stricter environmental regulations if it locates in a county that violates federal standards for air quality. Firms may also face heterogeneous costs of moving physical capital to a given location.

Under the assumption that each location provides a unique bundle of amenities, we can use hedonic price and wage functions to describe the spatial relationships between rents, wages, and amenities that must be realized in equilibrium:

(3) $$r_j = r\left[A_j; F(A), G(\alpha), H(\beta)\right] \quad \text{and} \quad w_j = w\left[A_j; F(A), G(\alpha), H(\beta)\right],$$

where *F*, *G*, and *H* denote the distributions of amenities, households, and firms.[8]

Spatial variation in rents and wages determines the implicit price of consuming amenities. Consider air quality. There are two ways to induce a household to move to a smoggier location: higher wages or lower rents. The extent to which movers are compensated through wages, relative to rents, will depend on the spatial distribution of air quality as well as the extent to which air quality affects the cost of production and the quality of life.

B. Implicit Expenditures on Amenities

We define a household's *implicit amenity expenditures* to be the amount of income it chooses to sacrifice in order to consume the amenities conveyed by its preferred location. To define this concept formally let x^* and h^* represent the household's consumption at its utility-maximizing location, and let q_α represent amenity expenditures for an α-type household. Then we have,

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

Thus, q_α is the additional income a household would collect if it were to move from its present location to the least expensive location in its consideration set and rent a house identical to the one it occupies currently.[9] The least expensive loca-

[8] If each location has a distinct bundle of amenities, as in our application, it is trivial to prove that the equilibrium relationship between rents and amenities (or wages and amenities) can be described by a hedonic price function, as opposed to a correspondence. Alternatively, if multiple locations have identical amenity bundles, then mild restrictions on consumer preferences are sufficient to prove the existence of a price function. For details see Bajari and Benkard (2005).

[9] Amenity expenditures must be nonnegative because $mc_{\alpha,l}$ equals zero for the household's current location.

tion in J_α defines the household's reference point, $\acute{x}$, used to normalize the expenditure calculation. Different households may have different reference points due to heterogeneity in job skills, consideration sets, and moving costs.

In addition to providing the logic for our expenditure calculations, equation (4) illustrates how our model relates to "quality-of-life" rankings for urban areas and to research on developing satellite accounts for nonmarket goods. The connection to the quality-of-life literature begins with the observation that $q_\alpha = \acute{x} - x^*$ is simply the revealed preference notion of an income equivalent (Fleurbaey 2009). Income equivalents generally lack a precise welfare interpretation. In our case, a welfare interpretation for q_α would require strong assumptions. In particular, (2)-(3) simplify to Roback's (1982) model of compensating differentials if households and firms are assumed: (i) to consider locating in every jurisdiction: $J_\alpha = J_\beta = J$; (ii) to be freely mobile: $mc_{\alpha,j} = mc_{\beta,j} = 0 \ \forall \ \alpha, \beta$; and (iii) to be homogenous.[10] Under these restrictions, q_α defines the representative agent's Hicksian willingness to pay for the associated amenity bundle. This interpretation underlies the literature on ranking cities by a universal measure for the quality-of-life (e.g. Blomquist, Berger, and Hoehn 1988, Gyourko and Tracy 1991, Kahn 2006, Blomquist 2006). Relaxing the full information, free mobility, and homogeneity assumptions does not compromise our ability to calculate amenity expenditures—which is our main objective. However, it does prevent us from interpreting expenditures as welfare measures or as an index of the quality of life that would be agreed upon by all households.

The connection to satellite accounting is based on the fact that the national in-

[10] To obtain the result from Roback (1982) differentiate indirect utility, $dV = 0 = \frac{\partial V}{\partial w} dw_j + \frac{\partial V}{\partial r} dr_j + \frac{\partial V}{\partial q}\frac{\partial q}{\partial a} da_{kj}$, and apply Roy's identity to obtain $p_{kj} \equiv h_j \left(\frac{dr_j}{da_{kj}}\right) - \frac{dw_j}{da_{kj}} = \left(\frac{\partial V}{\partial q}\frac{\partial q}{\partial a}\right) / \frac{\partial V}{\partial w}$. The implicit price of an amenity, p_{kj}, is defined by the rent differential times land rented, minus the wage differential. The second equality indicates that the equilibrium value for p_{kj} reveals the representative agent's willingness to pay for one unit of the amenity. Roback (1988), Albouy (2009), Bayer, Keohane, and Timmins (2009), and Kuminoff (2013) characterize dual-market sorting equilibria under more general conditions. Introducing moving costs (Bayer, Keohane, and Timmins) or non-separable forms of heterogeneity in household preferences or skills (Kuminoff) undermines our ability to interpret expenditure measures in welfare theoretic terms. Kuminoff also demonstrates existence of equilibria.

come and product accounts (NIPA) track wage income and housing expenditures. These measures will conflate the market values of land and labor with the implicit prices of amenities. This is an important point and deserves repeating. To the extent that spatially delineated amenities are capitalized into rents and/or wages, our current national accounting system will capture implicit expenditures on localized amenities. The challenge is to extract this information from observable features of the spatial distribution of rents, wages, and amenities. Disentangling the amenity components of wages and rents would be a significant step toward establishing satellite accounts for nonmarket goods and services (Kuznets 1934, 1946, Nordhaus and Tobin 1972, Nordhaus 2000, National Research Council 1999, 2005, Jorgenson, Landefeld, and Nordhaus 2006, Stiglitz et al. 2009).

II. Data

We have collected data on 75 amenities conveyed by each of the 3,108 counties comprising the contiguous United States.[11] Using information on house location, we matched these amenities to public use microdata records from the 2000 Census of Population and Housing, describing 5.2 million households and their participation in the housing and labor markets. Our national database on households and amenities is the first of its kind. The closest comparison is to Blomquist, Berger, and Hoehn (1988) who assembled data on 15 amenities for 253 urban counties circa 1980, in order to develop "quality-of-life" rankings.

A. Amenities

Table 1 reports summary statistics for the amenities we collected. As a baseline for comparison, we also report means for the subset collected by Blomquist, Berger, and Hoehn (1998) [henceforth BBH]. Column (1) reports 1980 means for

[11] Unfortunately, we were unable to obtain data on several amenities in Alaska and Hawaii. We chose to omit these states, rather than the amenities. Omitting Alaska and Hawaii is unlikely to have a significant impact on our approximations to national amenity expenditures because, in 2000, the two states jointly accounted for less than 0.75% of GDP.

the BBH amenities. Column (2) reports year 2000 means for our full set of amenities in the 253 urban counties studied by BBH. Finally, column (3) reports year 2000 means for our full set of amenities in all 3,108 counties.[12]

Table 1: Amenity Summary Statistics

	1980	2000		
	BBH	BBH	Nation	
	Mean	*Mean*	*Mean*	*Sources**
	(1)	(2)	(3)	(4)
GEOGRAPHY AND CLIMATE				
Mean precipitation (inches p.a., 1971-2000)	32.00	38.22	38.64	NOAA-NCDC
Mean relative annual humidity (%, 1961-1990)	68.30	67.76	67.25	NOAA-NCDC
Mean annual heating degree days	4,326	4,632	4,914	NOAA-NCDC
Mean annual cooling degree days	1,162	1,295	1,300	NOAA-NCDC
Mean wind speed (m.p.h., 1961--1990)	8.89	8.91	9.13	NOAA-NCDC
Sunshine (% of possible)	61.10	59.51	60.21	NOAA-NCDC
Heavy fog (no. of days with visibility ≤ 0.25 mi.)	15.80 †	20.30	21.42	NOAA-NCDC
Percent water area	--	9.99	4.59	ICPSR
Coast (=1 if on coast)	0.33	0.29	0.10	NOAA-SEAD
Non-adjacent coastal watershed (=1 if in watershed)	--	0.21	0.11	NOAA-SEAD
Mountain peaks above 1,500 meters	--	7.10	7.40	ESRI
Rivers (miles per sq. mile)	--	0.24	0.20	USDI-NPS
Federal land (percentage of total land area)	--	9.17	12.58	USGS-NA
Wilderness areas (percentage of total land area)	--	1.14	0.87	USGS-NA
National Parks (percentage of total land area)	--	0.80	0.53	USGS-NA
Distance (km) to nearest National Park	--	71.81	97.19	USDI-NPS
Distance (km) to nearest State Park	--	22.68	32.81	USDI-NPS
Scenic drives (total mileage)	--	0.21	0.16	USGS-NA
Average number of tornados per annum (1950-2004)	--	0.44	0.27	USGS-NA
Property damage from hazard events ($000s, per sq. mile)	--	59.75	31.17	USGS-NA
Seismic hazard (index)	--	2,029	1,984	USGS-NA
Number of earthquakes (1950-2000)	--	3.47	0.93	USGS-NA
Land cover diversity (index, range 0-255)	--	146.37	121.62	USGS-NA
ENVIRONMENTAL EXTERNALITIES				
NPDES effluent dischargers (PCS permits, 1989-1999)	1.51	17.52	4.29	EPA-TRI
Landfill waste (metric tons, 2000)	4,770	4,112	1,300	EPA-TRI
Superfund sites	0.88	2.73	0.52	EPA-TRI
Treatment, storage and disposal facilities	46.40	34.74	5.19	EPA-TRI
Large quantity generators of hazardous waste	--	221.83	33.42	EPA-TRI
Nuclear power plants	--	0.06	0.02	USDOE-INSC
PM2.5 (μg per m^3)	--	13.51	12.83	EPA-AQS
PM10 (μg per m^3)	73.20 ‡	23.61	23.21	EPA-AQS
Ozone (μg per m^3)	--	10.07	9.34	EPA-AQS
Sulfur dioxide (μg per m^3)	--	1.49	1.36	EPA-AQS
Carbon monoxide (μg per m^3)	--	5.95	8.59	EPA-AQS
Nitrogen dioxide (μg per m^3)	--	5.66	4.37	EPA-AQS
National Fire Plan treatment (percentage of total area)	--	0.11	0.14	USGS-NA
Cancer risk (out of 1 million equally exposed people)	--	4.14	1.80	EPA-NATA
Neurological risk	--	0.10	0.06	EPA-NATA

[12] Variables that were measured at a finer level of spatial resolution than a county were aggregated to the county level. For some of the geographic and environmental variables, we use irregularly-spaced NOAA and EPA source data from which we then produce county-level data. In these cases, we spatially interpolated the amenity data to the population-weighted county centroids via universal kriging. Universal kriging produces superior results to simpler techniques such as inverse distance weighting because it permits the spatial variogram to assume functional forms that include directional dependence.

Respiratory risk	--	5.41	1.98	EPA-NATA
LOCAL PUBLIC GOODS				
Local direct general expenditures ($ per capita)	--	3.44	2.93	COG97
Local exp. for hospitals and health ($ per capita)	--	47.05	564.60	COG97
Local exp. on parks, rec. and nat. resources ($ pc)	--	15.83	126.71	COG97
Museums and historical sites (per 1,000 people)	--	8.53	1.73	CBP
Municipal parks (percentage of total land area)	--	1.54	0.25	ESRI
Campgrounds and camps	--	6.42	2.30	CBP
Zoos, botanical gardens and nature parks	--	1.82	0.36	CBP
Crime rate (per 100,000 persons)	647	4,784	2,653	ICPSR
Teacher-pupil ratio	0.080	0.092	0.107	COG97
Local expenditure per student ($, 1996-97 fiscal year)	--	37.05	19.51	COG97
Private school to public school enrollment (%)	--	23.54	13.13	2000 Census
Child mortality (per 1000 births, 1990--2000)	--	7.31	7.52	CDC-NCHS
INFRASTRUCTURE				
Federal expenditure ($ pc, non-wage, non-defense)	--	5,169	4,997	COG97
Number of airports	--	2.13	1.23	USGS-NA
Number of ports	--	0.27	0.05	USGS-NA
Interstate highways (total mileage per sq. mile)	--	0.09	0.03	USGS-NA
Urban arterial (total mileage per sq. mile)	--	0.26	0.05	USGS-NA
Number of Amtrak stations	--	1.19	0.25	USGS-NA
Number of urban rail stops	--	7.50	0.81	USGS-NA
Railways (total mileage per sq. mile)	--	0.48	0.27	USGS-NA
CULTURAL AND URBAN AMENITIES				
Number of restaurants and bars (per 1,000 people)	--	0.92	1.01	CBP
Theatres and musicals (per 1,000 people)	--	0.02	0.01	CBP
Artists (per 1,000 people)	--	0.18	0.11	CBP
Movie theatres (per 1,000 people)	--	0.02	0.02	CBP
Bowling alleys (per 1,000 people)	--	0.02	0.03	CBP
Amusement, recreation establishments (per 1,000 people)	--	0.42	0.32	CBP
Research I universities (Carnegie classification)	--	0.24	0.03	CCIHE
Golf courses and country clubs	--	16.15	3.79	CBP
Military areas (percentage of total land area)	--	1.18	0.83	USGS-NA
Housing stress (=1 if > 30% of households distressed)	--	0.37	0.16	USDA-ERS
Persistent poverty (=1 if > 20% of pop. in poverty)	--	0.03	0.12	USDA-ERS
Retirement destination (=1 if growth retirees > 15%)	--	0.07	0.14	USDA-ERS
Distance (km) to the nearest urban center	--	10.98	33.59	PRAO-JIE09
Incr. distance to a metropolitan area of any size	--	0.20	35.80	PRAO-JIE09
Incr. distance to a metro area > 250,000	--	23.11	54.90	PRAO-JIE09
Incr. distance to a metro area > 500,000	--	32.09	39.36	PRAO-JIE09
Incr. distance to a metro area > 1.5 million	--	76.45	86.79	PRAO-JIE09

Notes: The amenity data were constructed from the following sources: CCIHE: Carnegie Classification of Institutions of Higher Education; CBP: 2000 County Business Patterns published by the Census Bureau; CDC-NCHS: Centers for Disease Control and Prevention, National Center for Health Statistics; COG97: 1997 Census of Governments; EPA-AQS: 2000 data for criteria air pollutants from the Air Quality System produced by the Environmental Protection Agency (EPA); EPA-NATA: 1999 National-Scale Air Toxics Assessment conducted by the EPA; EPA-TRI: 2000 Toxic Release Inventory published by the EPA; ESRI: Environmental Systems Research Institute ArcGIS maps; ICPSR: U.S. County characteristics complied by the Inter-university Consortium for Political and Social Research ICPSR2008; NOAA-SEAD: Strategic Environmental Assessments Division of the National Oceanic and Atmospheric Administration; NOAA-NCDC: National Climatic Data Center of the National Oceanic and Atmospheric Administration; PRAO-JIE09: Partridege et al. (2009); USDA-ERS: Economic Research Service of the US Department of Agriculture; USDI-NPS: National Park Service of the US Department of the Interior; USDOE-EERE: Energy Efficiency and Renewable Energy, US Department of Energy; USDOE-INSC: International Nuclear Safety Center at the US Department of Energy; USGS-NA: National Atlas of the US Geological Survey. † The unit in the BBH visibility variable is miles, rather than total days with a minimum visibility of less than 0.25 miles. ‡ BBH use data on total suspended particulates (TSP), a precursor measure to PM10.

Most of the BBH amenities were fairly constant between 1980 and 2000. In cases where we do see large changes, they appear to be due to changes in the way a variable is measured and reported, or refinements on our part. For example, we refine the definition of a "coastal" county to distinguish between counties that are physically adjacent to the coast and counties that are part of a coastal watershed, but not physically adjacent. Similarly, in the case of particulate matter (PM), we replaced total suspended particulates with measures of $PM_{2.5}$ and PM_{10} to reflect changes in the way the Environmental Protection Agency (EPA) monitors air pollution. The two largest changes are an increase in the number of Superfund sites per county (from 0.88 to 2.73) and an increase in entities requiring water pollution permits (from 1.51 to 16.67). Both increases reflect expansions of EPA's regulatory programs in the 1980s and 1990s.[13]

The amenities that BBH collected emphasize climate, geography, and environmental externalities. Other important amenities were excluded due to limits on data availability at the time of their study. We were able to collect many of the missing amenities with help from the sources cited in column (4). New geographic amenities include mountains, rivers, proximity to state and national parks, and measures of the frequency, intensity, and damages of hazardous events such as tornadoes, earthquakes, floods, and hurricanes. Earthquakes, for example, have been found to be important for property values in California (Brookshire et al. 1985) and the risk of damage from hurricanes is important in the Gulf Coast and South Atlantic regions (Strobl 2011). We have also added several externalities that are known to affect property values and migration patterns, such as cancer risk (Davis 2004) and the toxicity of air pollutants (Banzhaf and Walsh 2008).

Gyourko and Tracy (1991) suggest that local public goods are just as important as geography and the natural environment in determining the quality of life.

[13] In the late 1980s, large increases in the Superfund budget allowed more sites to be added. Likewise, the NPDES permitting system was expanded to regulate entities that only discharge pollution during storms.

Motivated by their analysis, we assembled data on numerous public goods. Examples include crime rates, the teacher-pupil ratio, child mortality, and municipal parks and museums. Some of these output measures seem too crude to reflect the quality of the underlying amenity. As a proxy for quality, we added selected input measures such as per capita expenditures on health, education, and parks.

A household's location also defines their opportunities for consuming private goods and entertainment. The idea that the diversity of consumption opportunities enhances the quality of life is important to urban economic models of the "consumer city", both as a driver of growth and in determining the wage structure (Glaeser et al. 2001, Lee 2010). Therefore, we developed several measures of the concentration of cultural and urban amenities (major research universities, theatres, restaurants and bars, golf courses, etc.). As an additional proxy, we measure the distance from each county to the nearest small (less than 0.25 million), medium (0.25m to 0.5m), large (0.5m to 1.5m), and really large (greater than 1.5m) metropolitan area. These measures will help to distinguish non-metro counties that are just outside a major metro area, but close enough to enjoy its shopping and entertainment, from counties that are located far from metro areas.

Finally, transportation infrastructure may influence the quality of life. The importance of congestion is well documented. Other influences may be more subtle. For example, Burchfield et al. (2006) find that metro areas with less public transportation tend to have more sprawl and Baum-Snow (2007) demonstrates that interstate highways led to a significant increase in sprawl. To help control for these effects, we measured the mileage of interstate highways and urban arterials per square mile. We also collected data on the concentration of railways, train stations, shipping ports, and airports as proxies for the ease of travel.

B. Geography

Table 2 reports summary statistics for three groups of counties. The first group consists of the same 253 urban counties studies by BBH. These counties cover less than 10% of land area in the lower 48 states, but account for almost half of its population. They are a subset of the second group comprising metropolitan statistical areas (MSA). Using the MSA definitions from the 2000 Census, metropolitan counties contain 80.3% of the U.S. population and 29.7% of its land area. The final group of counties covers the contiguous U.S. This is our study area.

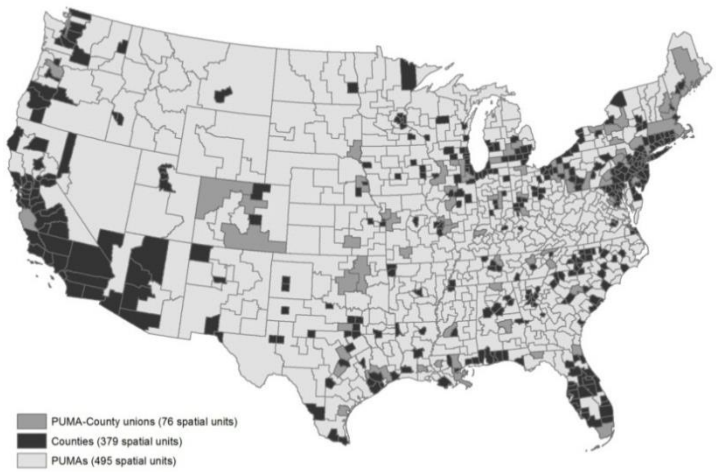
Table 2: Geographic Coverage and Population Coverage

		Geography		
		BBH counties	*Metropolitan counties* *	*All counties* †
No. of counties		253	1,085	3,108
No. of PUMAs		1,061	1,835	2,057
PUMAs per county		4.19	1.69	0.67
Population	1980	110,617,710	170,867,817	226,545,805
	2000	138,618,694	224,482,276	279,583,437
Pop. Coverage ‡	1980	48.8%	75.4%	100.0%
	2000	49.6%	80.3%	100.0%
Pop. density (per mi^2)	1980	419	197	77
	2000	525	259	94
Land area (mi^2)		263,840	865,437	2,959,064
Water area (mi^2)		25,273	61,081	160,820
Total area (mi^2)		289,113	926,518	3,119,885
Areal coverage‡		9.3%	29.7%	100.0%
No. obs from PUMS	workers	4,833,916	8,875,172	10,198,936
	households	2,587,457	4,795,515	5,484,870

Notes: PUMAs must have a minimum census population of 100,000. * Using 1980 or 2000 OMB definitions of metropolitan statistical areas. † Contiguous United States only. ‡ Alaska and Hawaii are excluded.

We obtained data on 5.2 million households containing 10.2 million workers from the 5% public-use microdata sample (PUMS) of the 2000 Census. Their residential locations are identified at the level of a “public use microdata area” or PUMA. Because each PUMA must have a population of at least 100,000, PUMA size varies inversely with density. Most metropolitan counties are subdivided into several PUMAs. In contrast, a single PUMA can span several rural counties.[14]

Figure 1: Geography Used to Match Rents, Wages, and Amenities



Note: The figure depicts the 950 locations that we use to calculate amenity expenditures. Every location is a direct aggregation of U.S. counties. There are 379 individual counties containing multiple PUMAs; 495 individual PUMAs containing multiple counties; and 76 county clusters containing PUMAs that overlap county borders.

We merged PUMS data with the amenities in table 1 at the highest possible spatial resolution. This resulted in aggregating the 3,108 counties into 950 locations shown in figure 1. Of these 950 locations, 379 are metropolitan counties. They cover 60% of the U.S. population. In rural areas where one PUMA covers multiple counties we aggregate amenities to the PUMA level using county population weights.[15] The resulting 495 PUMAs contain 25% of the population. We believe this aggregation is a reasonable approximation. Because the affected counties are rural, residents are more likely to have to cross county lines within the PUMA to access public goods, urban infrastructure, and cultural amenities. Finally, PUMAs occasionally overlap county borders without encompassing both counties. In these cases, we merged the adjacent counties. There are 76 such

[14] The most densely populated county (New York County, NY) has 66,951 people per square mile and is covered by ten PUMAs. At the opposite extreme, Loving County, TX—which is the least populous *and* the least densely populated county in the US—has only 0.09 people per square mile; its corresponding PUMA covers fourteen counties.

[15] Population-weighted amenities can be thought of as the average amenities experienced by residents in a given PUMA (as opposed to applying area-weights which would yield average amenities associated with parcels of land inside a PUMA).

PUMA-county unions, representing 15% of the population. Thus, each of the 950 locations is a county or the union of adjacent counties. Our estimation procedures treat each location as offering a distinct bundle of amenities.

C. Calculating real wages and real housing expenditures

We use the PUMS data as a starting point for deriving real wages and real housing expenditures. Our derivations adjust the raw Census data on nominal wages and self-reported housing values to control for spatial variation in the tax code and purchasing power. Specifically, we follow Gyourko and Tracy (1991) and Albouy (2009) in adjusting gross wages for state and federal income tax rates and for the cost of living (excluding housing).[16]

To calculate real housing expenditures we adapt the user cost methodology (Poterba 1984, 1992, Himmelberg, Mayer, and Sinai 2005). Our approach differs from the way housing is treated in NIPA. Unlike their "rental equivalency" imputation for expenditures on owner-occupied housing, the user cost methodology attempts to measure the real economic cost of homeownership.[17] Importantly, this includes direct payments for local public goods via property taxes.

Given that the homeownership rate was 67.5% in 2000, translating homeowners' self-assessed housing values into a measure of annualized expenditures is an important step in our analysis. It requires controlling for the tax benefits of homeownership. In 2003, some 40 million households claimed an average of $9,500 in mortgage interest deductions and almost $3,000 in property tax deductions. This renders the homeownership subsidy as one of the most prominent features of the American tax code. Moreover, the spatial incidence of benefits is uneven. Gyourko and Sinai (2003) place the average annual benefits for owner-occupied households at $917 in South Dakota compared to $8,092 in California.

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[16] Our calculations are documented in the supplemental appendix.

[17] The rental equivalency approach attempts to measure the foregone rent that homeowners could collect if they were to rent their house. For details and discussion see Prescott (1997) and Poole et al. (2005)

Spatial variation in the homeownership subsidy and property tax rates affects the appropriate discount rate by which housing values are converted into rents. This important point has been overlooked by previous studies. For example, BBH used a constant rate of 7.86% based on simulations by Peiser and Smith (1985) for an ownership interval from 1987-90 under a scenario of anticipated rising inflation. Subsequent studies adopted the same constant rate of 7.86% (Gyourko and Tracy, 1991, Gabriel and Rosenthal 2004, Albouy 2008, Chen and Rosenthal 2008). If regional variation in the homeownership subsidy and property taxes is not trivial, then incorrectly assuming a uniform discount rate will tend to overstate (understate) expenditures in areas with below (above) average housing costs.

To translate housing values into a spatially explicit measure of rents, we define an individual's annual cost of home ownership $\tilde{r}_{ij}$ in location j as

$$(5) \qquad \tilde{r}_{ij} = P_{ij}\left[rf + \omega_j - \tau_{ij}\left(rm + \omega_j\right) + \delta_t - \gamma_{t+1} + \varepsilon_t\right],$$

where P_{ij} is the self-reported property value; rf is the risk free rate (10-year average of 3-month T-bill rates); rm is the mortgage rate (10-year average of 30-year fixed rate mortgage); ω_j is the property tax rate (including state and local taxes); τ_{ij} is the marginal income tax rate; δ_t is the depreciation rate; γ_{t+1} is the expected capital gain; and ε_t is the owner's risk premium. Thus, imputed rents can be derived as $\tilde{r}_{ij} = P_{ij}\phi_{ij}$, where ϕ_{ij} represents the user cost of housing.

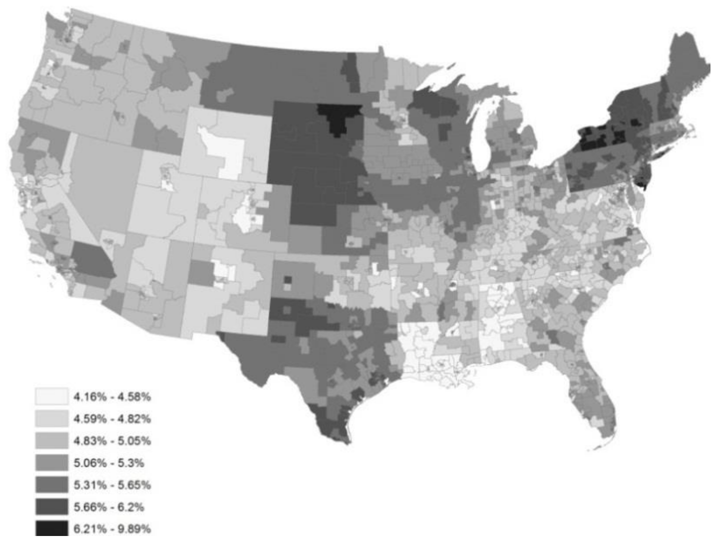
The third term in brackets, $\tau_{ij}\left(rm + \omega_j\right)$, represents the subsidy to homeowners due to the deductibility of mortgage interest payments and property taxes.[18] We impute ω_j from reported property tax payments and house values. It has a mean of 1.54% in our national sample.[19] For τ_{ij}, we use average effective marginal income tax rates for 1999 which we collect from the NBER TAXSIM mod-

[18] Since Himmelberg, Mayer, and Sinai (2005) report that less than half of tax-filing homeowners actually itemize, we reduce the tax subsidy in our calculations by one half. But even without itemizing, all homeowners receive some tax subsidy as imputed rents do not have to be reported as taxable income.

[19] Summary statistics are reported in appendix table A2.

el. Finally, using the estimates from Harding, Rosenthal, and Sirmans (2007), we set $rf = 0.045$, $rm = 0.055$, $\delta_t = 0.025$, $\gamma_{t+1} = 0.038$ (long-run inflation of 2% plus real appreciation of 1.8%), and $\varepsilon_t = 0.02$.

Figure 2: Spatial Variation in the User Cost of Housing, by PUMA



Note: The user cost of housing is the discount factor by which imputed rents are calculated from self-reported house values. Each color on the map represents a range of values. See the text for additional details.

Our estimates suggest a national average user cost of 5.12%, with a range from 4.16% to 9.89%. This implies a range of values for the price-to-rent ratio of 24.0 to 10.1, with an average of 19.5.[20] Figure 2 illustrates the spatial variation in our estimates. The user cost of housing varies greatly across metro areas, and there are also significant within-metro differences.

III. Approximating Amenity Expenditures

We use our measures for real wages, real housing expenditures, and amenities in each of the $j = 1,2,\dots,950$ locations to approximate implicit amenity expendi-

[20] In comparison, the 7.86% figure used in BBH and subsequent studies would imply a price-to-rent ratio of 12.7. Focusing our user cost estimates more narrowly on the 253 urban counties studied by BBH has very little impact on the results. The average user cost increases marginally to 5.16%.

tures. First we estimate *relative* expenditures for each location. Then we normalize our estimates to approximate *real* expenditures by adding information on moving costs and the set of alternative locations considered by each household. The remainder of this section describes our approach to calculating relative expenditures. Normalizations are explained in section IV.

A. Relative expenditures

Multiplying the amenities in each location by their implicit prices provides a linear approximation to relative expenditures. Equation (6) illustrates how we make the calculation using the results from hedonic rent and wage regressions.

$$Q_j = \sum_{k=1}^{K} a_{kj} \left[\frac{d\tilde{r}_j}{da_{kj}} \left(X_{ij}^r, A_j, \beta \right) - \frac{dw_j}{da_{kj}} \left(X_{mj}^w, A_j, \gamma \right) \right]. \quad (6)$$

In the equation, β and γ are parameter vectors describing the shapes of the empirical analogs to the price and wage functions from (3), and $\{X_{ij}^r, X_{mj}^w\}$ are Census PUMS variables describing the physical characteristics of $i = 1, \ldots, I$ houses and the demographic characteristics of $m = 1, \ldots, M$ workers who live in location j.[21]

We estimate β and γ in two stages. First we regress rents and wages on the Census PUMS variables, adding fixed effects for locations to each regression. Then we regress the estimated fixed effects on amenities. Our main specification of the first-stage model is based on a semi-log parameterization,

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

(7.b) *wage function*: $\ln w_{mj} = X_{mj}^w \gamma_1 + \lambda_j^w + \nu_{mj}$,

where $\tilde{r}_{ij}$ denotes household i's annual expenditures on housing, w_{mj} denotes

[21] Control variables in the rent regression include: rooms, bedrooms, size of building, age of building, acreage, type of unit, condominium status, and quality of kitchen and plumbing facilities. The model also includes interactions between all variables and an indicator for renter status. In the wage regression the control variables include: experience measured as age-schooling-6, experience^2, gender*experience, gender*experience^2, 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, and military status. All variables are also interacted with indicators for Census divisions.

worker m's annual wages, λ_j^r, λ_j^w are the location fixed effects, and $\varepsilon_{ij}, \nu_{mj}$ are error terms that include unobserved attributes of houses and workers.[22]

After removing the variation in $\ln \tilde{r}_{ij}$ and $\ln w_{mj}$ that can be explained by the observable attributes of houses and workers, any remaining variation across counties will be absorbed by the location fixed effects: $\hat{\lambda}_j^r$, and $\hat{\lambda}_j^w$. However, the fixed effects will conflate the implicit prices for amenities with the implicit prices for latent attributes of houses and workers. We extract the variation in the fixed effects explained by localized amenities by estimating:

$$\text{(8)} \qquad \hat{\lambda}_j^r = A_j\beta_2 + \alpha^r + \xi_j^r \qquad \text{and} \qquad \hat{\lambda}_j^w = A_j\gamma_2 + \alpha^w + \xi_j^w.$$

The resulting estimates for β_2 and γ_2 are then used to calculate relative expenditures in each location.

It is important to reiterate that our second stage mitigates confounding by omitted attributes of workers and houses. To assess the practical implications of this point we compared our ranking of locations by expenditures to an alternate one where expenditures are calculated from the first-stage fixed effects (subsuming omitted attributes of workers and houses). The Spearman correlation was 0.83—far enough from 1 for our approach to provide a large improvement in accuracy.

A remaining concern with our model is that latent attributes of workers and houses (ξ_j^r, ξ_j^w) could be spatially correlated with amenities, biasing our estimates for β_2 and γ_2. This is less of a concern in the housing regression because Census micro data provide a fairly complete accounting of physical housing attributes. Indeed, the hedonic property value literature assumes that correlation between amenities and latent physical housing attributes is small enough to ignore. In contrast, there is widespread concern that Roy sorting biases wage regressions

[22] Equation (7.b) recognizes that a worker may or may not work in their home county. The maintained assumption is that two workers with identical skills, experiences, and demographics who live in the same county will also earn the same wage. In principle, one could extend our analysis to model spatial heterogeneity in the return to attributes using a semiparametric model similar to Black, Kolesnikova and Taylor (2009).

(e.g. Hwang, Reed, and Hubbard 1992; Dahl 2002; Bayer, Kahn, and Timmins 2011). This could pose a serious problem. In particular, if higher skilled workers tend to live in higher amenity areas, then γ_2 may conflate the negative effects of amenities on wages with the positive effects of latent human capital, biasing expenditures toward zero.

We address sorting on unobserved job skill by following Dahl's (2002) approach to using migration data to develop control functions for the first stage wage regression (7.b). Dahl's key insight is that a semiparametric sample selection correction for a spatial wage equation can be developed from migration probabilities. Therefore we extend the set of control variables, X_{mj}^{w}, to include second order polynomial functions of worker-specific migration probabilities. As in Dahl (2002), we calculate probabilites by assigning workers to thirty bins, based on their demographics: five levels of education {less than high school, high school, some college, college graduate, advanced degree} by marriage {0,1} by the age range of their children {all under 6 years, at least one between 6 and 18, none under 18}. Then we use information on each migrant's birth state and current location to determine the probability of that migration choice. For workers who stay in their birth state, we use both the retention probability and the probability for their first-best alternative location. This control function approach allows spatial sorting by unobserved skill to vary systematically across workers.

B. Identification

It would be nice to separately identify the virtual prices of every amenity as an intermediate step toward calculating total amenity expenditures. However, it is not realistic to do so.[23] Nor is it necessary. A credible approximation to total

[23] There is a vast literature on estimating virtual prices for amenities. Recent studies have made progress in developing research designs that mitigate omitted variable bias and other sources of confounding (for a review, see Kuminoff, Smith, and Timmins 2010). However, no study has developed a research design for the contiguous United States. This makes it highly improbable that one could develop a national research design for 75 separate amenities at the same time!

expenditures can be recovered as long as our amenity data are sufficiently comprehensive that any important amenity we have omitted is highly correlated with a linear function of the amenities we have collected.

To formalize this reasoning, consider one additional amenity, z_j. The ideal approximation to expenditures is

$$Q = A(\hat{\beta}_2 - \hat{\gamma}_2) + z(\hat{\kappa}^r - \hat{\kappa}^w) \ , \tag{9}$$

where $\hat{\kappa}^r$ and $\hat{\kappa}^w$ are consistent estimates for the rent and wage differentials arising from spatial variation in z_j.[24] If z_j is omitted from the econometric model, then the second-stage equation for rents takes the following form:

$$\hat{\lambda}_j^r = A_j\beta_2 + \alpha^r + \xi_j^r, \quad \text{where} \quad \xi_j^r = z_j\kappa^r + \epsilon_j \quad \text{and} \quad E\left[\epsilon_j \middle| A_j, z_j\right] = 0. \tag{10}$$

The probability limit of our estimator for β_2 is now

$$\text{plim } \hat{\beta}_2 = \beta_2 + \pi\kappa^r, \quad \text{where} \quad z = A'\pi + \eta \quad \text{and} \quad E\left[\eta_j \middle| A_j\right] = 0. \tag{11}$$

Since $\hat{\gamma}_2$ is defined analagously, our estimator for total expenditures can be written as

$$\text{plim } \hat{Q} = A(\beta_2 - \gamma_2) + (z - \eta)(\kappa^r - \kappa^w) \tag{12}$$

after some substitution.

Equations (11)-(12) formalize the intuition for our brute force approach to identification. There are two key points. First, notice that (11) provides a consistent estimator for the implicit prices of each observed amenity as $\pi \to 0$. Yet, the estimator for total expenditures in (12) is inconsistent. If $\pi = 0$, then $\eta = z$, and plim $\hat{Q} = Q - z(\kappa^r - \kappa^w)$. In other words, if we want to identify the implicit prices of individual amenities <u>and</u> calculate total expenditures, then we must rule out the possiblity of omitting any amenities! This is highly implausible,

[24] Since the dependent variables in the first stage of our model are measured in natural logs we must use the Halvorsen-Palmquist adjustment to correct the dependent variables prior to second stage estimation and convert the "percentage" coefficients into dollar values. This procedure is reflected in the hats on model coefficients.

which brings us to our second key point. If most of the spatial variation in omitted amenities can be explained by variation in observed amenities, then we can obtain a credible approximation to expenditures even if $\hat{\beta}_2$ and $\hat{\gamma}_2$ are inconsistent estimators for β_2 and γ_2. Specifically, as the R^2 from regressing z on A approaches 1, $\eta \to 0$ and plim $\hat{Q} \to Q$. This illustrates why collecting data on a comprehensive set of amenities is essential to developing a credible approximation to national amenity expenditures.

IV. Results

A. National Amenity Expenditures for the United States

Our estimates for U.S. amenity expenditures are based on the 950 locations in figure 1. Using all of the data from these locations, we estimate the model in (6)-(8) and calculate relative expenditures. To convert relative expenditures into real expenditures we must first take a stance on moving costs and define the subset of locations where each household would consider relocating.[25] Table 3 reports the sensitivity of our results to a variety of approaches.

First, if we naively assume that people are freely mobile and fully informed about the spatial distribution of rents, wages, and amenities, then households face an unconstrained consideration set spanning all 950 locations.[26] In this case, real expenditures at a location are defined by the difference between relative expenditures at that location and relative expenditures at the least expensive location. This calculation provides the upper bound on our range of estimates. The results imply that the average U.S. household implicitly spent $6,032 on localized amenities in the year 2000 through some combination of higher housing prices, higher

[25] A significant literature on migration highlights the role of amenities in the interregional re-distribution of population (Greenwood et al. 1991). See Molloy et al. (2011) for an overview of the literature and recent trends in the U.S.

[26] While households are assumed to be freely mobile within the contiguous United States, the cost of moving outside the U.S. is assumed to be prohibitively high. In principle, this constraint could be relaxed using data from Mexico and Canada. However, we doubt that this would lead to significant changes in our results once we control for moving costs.

property taxes, and lower wages, (row 1). Aggregating over households implies a national measure of $632 billion. However, these figures will be too high if moving costs are significant or if households do not consider all 950 locations.

Table 3: Implicit Expenditures on Amenities in the United States, 2000

Constraint for inclusion in the consideration set	Average number of locations considered	Share of Migrants 1995-2000	Expenditures / household		Total Expenditures ($billion)
			mean	st. dev.	
			A. Moving Costs Excluded		
(1) None	950	100%	6,032	3,081	632
(2) Emmigration Share > 0.1%	137	89%	5,855	3,156	614
(3) Immigration Share > 0.1%	135	89%	5,899	3,142	619
(4) Less than 250 miles away	82	67%	4,065	2,758	426
			B. Moving Costs Included		
(5) None	950	100%	5,550	3,010	582
(6) Emmigration Share > 0.1%	137	89%	5,341	3,102	560
(7) Immigration Share > 0.1%	135	89%	5,388	3,076	565
(8) Less than 250 miles away	82	67%	3,674	2,731	385

Notes: The first three columns describe the consideration set. For example, if the consideration set for a location is defined as all locations that accounted for at least 0.1% of emigration between 1995 and 2000, then the average consideration set consisted of 137 locations (out of 950). These consideration sets accounted for 89% of all emigration from 1995 to 2000. The last four columns report measures of real amenity expenditures based on each consideration set. See text for details.

To address the concern that households are unlikely to consider every location in the United States, we first restrict their consideration sets to include only those locations that accounted for greater than 0.1% of emigration (row 2) or immigration (row 3) from their present location between 1995 and 2000.[27] For example, the households living in Marin County, CA are assumed to be familiar with only the locations that accounted for at least 0.1% of migration to (or from) Marin. Imposing this constraint limits the typical consideration set to nearby locations (both urban and rural) and urban counties in the biggest metro areas, such as New

[27] Migration flows were calculated for all pairwise combinations of locations using the Census Bureau's county-to-county migration flow files. Our results are robust to using much larger thresholds on migration shares. This is discussed in section D.

York, Chicago, Phoenix, and Los Angeles.[28] This pattern seems consistent with evidence on migrant information networks (Pissarides and Wadsworth 1989).

The 0.1% threshold reduces the number of locations the average household is assumed to consider from 950 to 137 (emigration) or 135 (immigration). These locations account for 89% of all migration. It is somewhat surprising that reducing the size of the consideration set by 85% only reduces our expenditure measure by 2% to 3% (comparing row 1 with rows 2 and 3).[29] The reason for this can be seen from figure 3. Expensive locations are predominantly located along the coasts and in resort areas in the Rocky Mountains. Inexpensive locations are predominantly located in the mid-west, south, and Appalachian regions. However, expensive and inexpensive locations are not completely stratified. There are inexpensive areas in California's central valley and expensive areas in the mid-west, for example. When expensive and inexpensive areas are close together, the migration between them tends to be significant. Thus, the consideration sets for most of the expensive locations contain some inexpensive locations, which define their reference points in our expenditure calculations.

A second force behind the similarity in our expenditure measures in rows 1-3 is that some of the least expensive locations have significant migration flows. In particular, Wayne County, MI (i.e. Detroit) is one of the ten least expensive locations but accounts for significant migration flows to more than 400 other locations. To further investigate the importance of Wayne County as a reference point, we repeat our calculations after redefining the consideration set to be a 250 mile radius around the centroid of each location. This decreases expenditures more substantially to $426 billion (row 4 of table 3).

We consider 250 miles to be a conservative radius because the resulting circles

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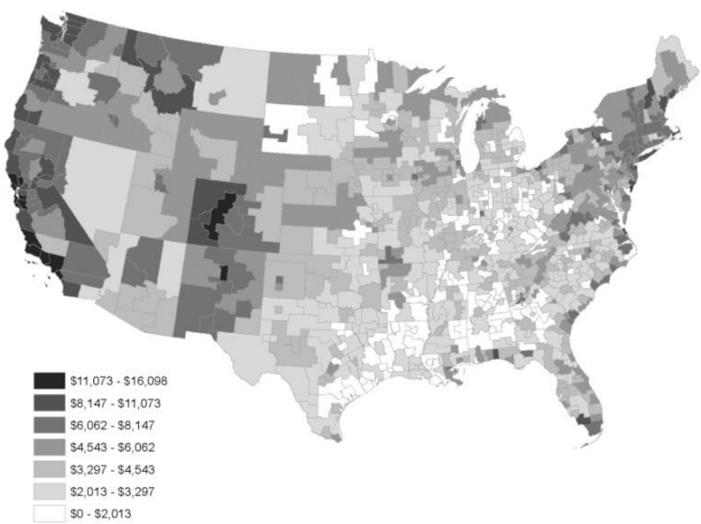
[28] An exception is that immigration-based consideration sets for rural locations are less likely to include distant metropolitan counties.

[29] Recall that real expenditures are defined by the difference between relative expenditures at a given location and relative expenditures at the least expensive alternative in the corresponding constrained consideration set.

only contain 67% of migration flows. Furthermore, 250 miles is roughly a 5-hour drive, close enough to take day trips to one's prior location. Physical proximity should mitigate the psychological cost of moving away from family and friends.[30]

Figure 3: Implicit Expenditures on Amenities by Location, 2000



Notes: Estimates for implicit amenity expenditures are based on 1995-2000 area-specific emigration shares of greater than 0.1% as a constraint for inclusion in the location specific consideration set (see text and table 3).

To formally address moving costs, we revise our calculations to account for the average physical and financial cost of moving between each pair of locations.[31] To calculate financial costs, we collected data on location-specific realtor fees, location-specific closing costs on housing sales, and search costs for home finding trips. To calculate the physical cost of a move, we used the calculator provided by movesource.com, along with information on the distance travelled, the weight of household goods transported based on the number of rooms in the origin location, and the cost of transporting cars. In the interest of brevity, our calculations are documented in section A3 of the supplemental appendix.

[30] This is among the reasons why empirical studies of Tiebout sorting and labor migration often treat working households as being fully informed and freely mobile within a single state or within a metropolitan region (Bayer, Keohane, and Timmins 2009, Kuminoff 2013, Kennan and Walker 2011).

[31] While we do not formally model migration , our empirical measures of distance- and migration-based moving cost are consistent with a migration model that endogenizes moving cost (Carrington et al, 1996).

Our estimate for the physical cost of moving differs for every pair of locations.[32] The average is $12,123 and the standard deviation is $2,729. We convert these one-time costs into annualized measures using a 37-year interval (reflecting the expected life years remaining for the average household head) and a real interest rate of 2.5%.[33] This implies the annual cost of a $10,000 move is $419.

When we account for the cost of moving, our estimates range from $385 to $582 billion (rows 5-8 of table 3). We consider $385 billion to be a conservative lower bound. The fact that one third of migrants moved further than 250 miles suggests that the expenditure reference points of the circular consideration sets will tend to be biased upward, causing us to understate expenditures. At the opposite extreme, if we assume that every household perceives Detroit to be its reference point, then $582 billion is a better measure. While this assumption is not implausible given the media coverage of Detroit's decline, it will lead us to overstate expenditures for households who are unfamiliar with the area. With this in mind we interpret $582 billion as a conservative upper bound.

Our preferred estimates are the ones derived from the migration-based consideration sets with moving costs. They imply a range of $560 to $565 billion. Taking the midpoint, $562, would suggest that implicit amenity expenditures were equivalent to 8.2% of personal consumption expenditures in 2000.

Finally, as a robustness check on the Dahl (2002) correction for Roy sorting, we repeat the estimation using an alternative procedure based on Bayer, Kahn, and Timmins (2011). Specifically, we multiply our raw wage data by the proportional correction factors they report by Census region and education level. This approach aims to remove the effect of latent human capital on wages prior to estimation. It increases our preferred expenditure measure from $562 to $591

[32] The average cost of moving between a pair of counties is not symmetric. Direction matters because the physical cost of a move depends on the weight of goods transported which, in turn, depends on the number of rooms in the *origin* location.

[33] There are two reasons why actual moving costs may be lower for job-related moves. First, some employers pay for part or all of the cost. Second, some costs for job-related moves can be deducted from federal income taxes. By ignoring these forms of compensation, we will tend to overstate moving cost, and understate amenity expenditures slightly.

billion. Thus, two different approaches to correcting for Roy sorting produce very similar results. This is not because the correction factors are small. If we do nothing to address the bias from Roy sorting, expenditures drop to $422 billion. The large positive increase that occurs when we implement either correction is consistent with the intuition that higher-skilled workers are more likely to live in higher-amenity areas, biasing our expenditures measures toward zero.

B. Regional Amenity Expenditures

Table 4 summarizes regional variation in amenity expenditures, using the Census Bureau's nine divisions. Expenditures are based on the emigration consideration set summarized in row 6 of table 3. Several interesting patterns emerge. First, the spatial concentration of expenditures supports the notion that the U.S. is a "coastal nation" in terms of nonmarket activity as well as market activity (Rappaport and Sachs, 2003). The coastal divisions account for nearly 70% of national amenity expenditures. Furthermore, expenditures per capita are generally higher in coastal areas, especially the Pacific division (CA, OR, and WA) which accounts for 14% of households but 28% of expenditures.

Table 4: Year 2000 Expenditures by Census Division

	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific
Mean income / household	58,428	56,229	51,690	47,532	49,512	41,677	45,785	48,527	59,300
Amenity expenditures / household	6,708	6,733	3,694	3,789	4,352	2,775	2,710	5,751	10,368
Amenity to income ratio	0.11	0.12	0.07	0.08	0.09	0.07	0.06	0.12	0.17
Number of households (million)	5.4	14.9	17.2	7.5	20.0	6.6	11.4	6.7	15.1
Amenity expenditures (billion)	36	100	64	28	87	18	31	39	157
Share of U.S. expenditures	0.06	0.18	0.11	0.05	0.16	0.03	0.06	0.07	0.28

Notes: Estimates for amenity expenditures are based on the emigration consideration set summarized in row 6 of table 3 and described in the text. New England = {ME, NH, VT, MA, CT, RI}. Middle Atlantic = {NY, NJ, PA}. East North Central = {WI, IL, IN, OH, MI}. West North Central = {ND, SD, NE, KS, MO, IA, MN}. South Atlantic = {DE, MD, DC, VA, WV, NC, SC, GA, FL}. East South Central = {KY, TN, AL, MS}. West South Central = {TX, OK, AR, LA}. Mountain = {MT, ID, WY, CO, UT, NM, AZ, NV}. Pacific = {WA, OR, CA}.

Second, expenditures tend to be lower in regions that are in economic decline, such as the Rust Belt, or that are structurally lagging such as parts of southern Appalachia. For example, expenditures per household in the East North Central division, which roughly coincides with the Great Lakes region, are less than half the size of expenditures in the Pacific division.[34]

Finally, if we look within the Census divisions the ranking of locations by expenditures makes intuitive sense. The least expensive locations include Baltimore, Detroit, Houston, and county aggregates comprised of small cities and towns in the south and mid-west. The most expensive locations include San Francisco, New York, Los Angeles, and county aggregates containing small cities and towns that are known for their amenities, such as Aspen, Bozeman, Martha's Vineyard, and Santa Fe. More broadly, a weighted least squares regression of expenditures on income implies an elasticity of 0.95.[35]

C. A Comparison to "Quality of Life" Rankings of Counties

To further examine the micro foundations for our national estimates in tables 3 and 4, we use our results to revisit Blomquist, Berger, and Hoehn's (1988) classic "quality of life" ranking of 253 urban counties by relative amenity expenditures.[36] Table 5 reports our top 20 and bottom 20 counties within this subset, along with the original BBH rankings.[37] This comparison provides an intuitive way to evaluate the impact of our data collection efforts and our refinements to the conventional approach to measuring compensating differentials.

[34] Similarly, households in the Pacific, who also have the highest regional incomes, give up the largest fraction of their potential incomes to consume localized amenities (17%). Households in the West South Central region give up the smallest fraction (6%).

[35] The unit of observation is a location (N=950) and the weights are the number of households. The p-value on the coefficient for average household income is zero out to four decimal places and R^2=0.80. If we replace average household income in the regression with median household income or income per capita the elasticities equal 0.95 and 0.94.

[36] As explained earlier, our objective is to measure amenity expenditures, not the quality of life. We put "quality of life" in quotes to reiterate that one must be willing to make strong assumptions about consumer heterogeneity to interpret any ranking of counties by amenity expenditures as a measure of the quality of life that all households would agree with.

[37] Complete econometric results and rankings for all counties can be produced from our data and code.

Table 5: Ranking 253 Urban Counties by Relative Expenditures

County, State	Core Business Statistical Area	Relative Expenditures	Our rank	BBH rank
		(1)	(2)	(3)
Marin, CA	San Francisco-Oakland-Fremont	11,966	1	142
San Francisco, CA	San Francisco-Oakland-Fremont	10,863	2	105
San Mateo, CA	San Francisco-Oakland-Fremont	9,726	3	112
Santa Clara, CA	San Jose-Sunnyvale-Santa Clara	9,197	4	88
Los Angeles, CA	Los Angeles-Long Beach-Santa Ana	8,883	5	58
Santa Barbara, CA	Santa Barbara-Santa Maria	8,805	6	22
Santa Cruz, CA	Santa Cruz-Watsonville	8,537	7	79
Alameda, CA	San Francisco-Oakland-Fremont	7,918	8	94
Orange, CA	Los Angeles-Long Beach-Santa Ana	7,580	9	41
Ventura, CA	Oxnard-Thousand Oaks-Ventura	7,224	10	23
New York, NY	New York-Northern New Jersey-Long Island	6,804	11	216
Contra Costa, CA	San Francisco-Oakland-Fremont	6,755	12	211
Monterey, CA	Salinas	6,306	13	16
San Diego, CA	San Diego-Carlsbad-San Marcos	6,216	14	27
Lane, OR	Eugene-Springfield	5,197	15	35
Nassau, NY	New York-Northern New Jersey-Long Island	5,136	16	60
Middlesex, NJ	New York-Northern New Jersey-Long Island	4,998	17	204
King. WA	Seattle-Tacoma-Bellevue	4,674	18	158
Clackamas, OR	Portland-Vancouver-Beaverton	4,629	19	138
Washington, OR	Portland-Vancouver-Beaverton	4,629	20	148
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Porter, IN	Chicago-Naperville-Joliet	-2,266	234	205
Monroe, MI	Monroe	-2,305	235	208
Butler, OH	Cincinnati-Middletown	-2,455	236	121
Bibb, GA	Macon	-2,534	237	4
Lafayette, LA	Lafayette	-2,535	238	139
Shelby, TN	Memphis	-2,541	239	137
Wichita, TX	Wichita Falls	-2,584	240	210
Jefferson, MO	St. Louis	-2,592	241	242
Will, IL	Chicago-Naperville-Joliet	-2,700	242	230
Tarrant, TX	Dallas-Fort Worth-Arlington	-2,730	243	212
McLennan, TX	Waco	-3,079	244	189
Jefferson, AL	Birmingham-Hoover	-3,084	245	251
Galveston, TX	Houston-SugarLand-Baytown	-3,097	246	197
Etowah, AL	Gadsden	-3,159	247	157
Ouachita, LA	Monroe	-3,221	248	109
Brazoria, TX	Houston-SugarLand-Baytown	-3,395	249	250
East Baton Rouge Parish, LA	Baton Rouge	-3,860	250	168
Wayne, MI	Detroit-Warren-Livonia	-4,005	251	249
Jefferson, TX	Beaumont-Port Arthur	-4,861	252	196
Harris, TX	Houston-SugarLand-Baytown	-5,137	253	241

Notes: BBH rank denotes the corresponding county ranking from Blomquist, Berger, and Hoehn (1988).

The top ranked county in our model is Marin County, CA and the bottom ranked county is Harris County, TX. A freely mobile household who chooses to live in Marin instead of Harris would pay an extra $17,103 per year (11,966 + 5,137). To put this statistic in perspective, it is equivalent to 20% of the average household's income. The underlying thought experiment is the following: if the average Marin County household were to move to Harris, be paid according to its education and experience, and rent a house that is identical to the one it currently occupies, then the Marin County household would gain an extra $17,103 of real income each year. What do Marinites "buy" when they sacrifice this income? Located directly north of San Francisco, Marin is a coastal county with a mild climate, clean air, some of the best public schools in California, a large share of land in parks, and the lowest rate of child mortality. Its residents also have easy access to the cultural and urban amenities of San Francisco.

More generally, the top counties tend to be located on the West Coast and/or in large metro areas.[38] Furthermore, 13 of the top 20 are in the San Francisco Bay area, the Los Angeles metro area, and the New York metro area. A quick comparison between columns (2) and (3) is sufficient to see that our measures of relative expenditures are positively correlated with those of BBH ($\rho = 0.29$). Therefore, the implied measures of real expenditures will also be similar. For example, if we treat the 253 counties studied by BBH as the consideration set and ignore moving costs, then our average measure of expenditures per household in the 253 urban counties is $6,670. If we use the CPI to convert BBH's 1980 results to year 2000 dollars, then their implied expenditure measure is $4,269.

However, there are three generic differences between our results and BBH. First, our rankings display higher spatial correlation, as can be seen from the clusters of adjacent San Francisco and New York counties in column (2). This is because our analysis quintuples the number of amenities and most amenities are

[38] This is broadly consistent with Albouy's (2008) finding that large cities tend to have large fixed effects in hedonic regressions of property values and wages on the characteristics of houses and workers. However, we cannot make a direct comparison because fixed effects conflate the implicit prices of amenities with omitted attributes of workers and houses.

spatially correlated. Second, most counties move dramatically in the rankings. Thirteen of our top 20 counties advance more than 50 places relative to BBH and nine advance more than 100 places. The largest increase is Rockland County, New York (#236 in BBH; #28 in our study). Rockland is approximately 10 miles north of Manhattan and is among the top 10 counties in the nation, ranked by median household income. Bibb County, Georgia has the largest decrease (#4 in BBH; #237 in our study). Its low ranking is not surprising. Bibb has the second highest rate of child mortality and 19% of its population falls below the poverty line. Finally, our measures for relative expenditures are also positively correlated with year 2000 income per capita $(\rho = 0.46)$, consistent with empirical evidence on Tiebout sorting.[39] Overall, applying our new data and methods to the same 253 counties studied by BBH produces patterns that seem intuitively plausible.

D. Caveats and Future Research

There are several caveats to our results that provide opportunities for future research. First, the specific thresholds that we used to define consideration sets in our national analysis are admittedly arbitrary. One could make a case for larger or smaller thresholds for migration shares or distance cutoffs. Likewise, one could make a case for different approaches to annualizing the one-time cost of a move. We have experimented with conservative alternatives in each dimension and found that the order of magnitude of our main result is robust.[40] For example, increasing the threshold immigration share from 0.1% to 1.0% would reduce expenditures from $560 billion to $253 billion. However, moving to a 1.0% threshold would also reduce the share of migrants covered from 89% to 57% and it would reduce the average number of locations in the consideration set from 135

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[39] In comparison, the expenditure measures that BBH produced for 1980 are essentially uncorrelated with year 2000 income per capita $(\rho = -0.06)$. We suspect this reflects the limited amenity data that were available at the time of the BBH study and changes in the spatial distribution of income and amenities between 1980 and 2000. See Kuminoff, Smith, and Timmins (2013) for a review of the evidence on income stratification from the literature on Tiebout sorting.
[40] The data and code in our supplemental appendix can be modified to consider any alternative consideration set.

to 14. In our opinion, this represents an excessively narrow definition for the consideration set that fails to adequately capture empirical migration patterns.

Second, our expenditure measures are unlikely to capture the full impact of nonmarket amenities on the U.S. economy. We have limited our analysis to the effects of amenities on housing prices, wages, and property taxes. While we expect this to reflect the majority of implicit expenditures, the resulting measures are surely incomplete. For example, access to trails may increase the local demand for running shoes and mountain bikes; likewise, air pollution may reduce agricultural yields and expenditures on recreation. By omitting these effects, our current expenditure measures will tend to provide lower bounds.

Third, as we noted earlier, amenity expenditures do not generally provide an exact measure of willingness to pay. Developing measures of social welfare that adjust for health, longevity, leisure, and environmental quality is an important and challenging area for research (e.g. see Becker, Philipson, and Soares 2005, Fleurbaey 2009, Stiglitz et al. 2009, Jones and Klenow 2011). We conjecture that it should be possible to define plausible conditions for interpreting our estimates as lower bounds on Hicksian compensating differentials for amenity bundles.

Finally, it is important to reiterate that our expenditure measures only cover one of several important areas for satellite accounting. We have not attempted to measure the value of natural resource stocks (e.g. forests, fish) or ecosystem services (e.g. watershed purification and wetland buffers against hurricanes). Nor have we attempted to impute the value of home production and leisure. Thus, our account of implicit amenity expenditures only represents one dimension of the complete set of satellite accounts recommended by the National Research Council (1999, 2005) and envisioned by Jorgenson, Landefeld and Nordhaus (2006).

V. Conclusion

We have developed the first national estimates for amenity expenditures using a new database of 75 nonmarket amenities that we built for U.S. counties. Our results for the year 2000 suggest that households reduced their potential personal consumption expenditures by more than 8% ($562 billion) in order to consume nonmarket amenities at their home locations. This figure is several times larger than one might expect from examining data on direct expenditures on local public goods. For example, households' reported property tax payments ($137 billion) are less than a quarter of their amenity expenditures. Our results suggest that most spending on nonmarket amenities occurs indirectly through sales of complementary private goods, especially housing and labor.

Our new methodology for measuring nonmarket amenity expenditures addresses some of the top priorities for satellite accounting set by the National Panel to Study the Design of Nonmarket Accounts (2005).[41] The next step in formalizing a new satellite account would be to clarify the mapping between amenity expenditures and NIPA architecture. For example, increased expenditures on housing due to amenities will be largely reflected in the "housing service" category in NIPA's personal consumption expenditure table.[42] In contrast, it would be more challenging to derive a mapping for the wages forgone in order to live in a high amenity area. One would need a general equilibrium model to translate foregone wages into increased labor demand and/or corporate profits.

Results from our analysis have three additional implications for the literature on pricing nonmarket amenities. First, we find that spatial Roy sorting places a large downward bias on expenditures. The problem is that higher skill workers are more likely to locate in higher amenity areas, causing the opposing effects of

[41] Specifically, we have addressed the priority of tracking implicit expenditures on environmental services, local public goods, and urban infrastructure. Our estimates are also consistent with the double-entry nature of NIPA since our approach can be related to equilibrium compensating differentials that give rise to nonmarket expenditures.

[42] According to the Bureau of Labor Statistics (BLS), annual expenditures on housing (excluding utilities) were just over $1 trillion in 2000. BLS imputes rental rates for owner occupied housing by sampling the rental prices of houses. Since these estimates vary across markets, rental rates are higher in high amenity areas and therefore will overlap substantially with our measures of amenity expenditures derived from the 5% census sample of the housing market. However, their "rental equivalency" imputations for owner-occupied housing ignore some of the economic costs and benefits of homeownership, such as the mortgage interest deduction on personal income taxes. In principle, one could derive a mapping between the two approaches and use it to highlight where housing-related amenity expenditures enter NIPA

amenities and latent human capital to be conflated in the wage regression. This mechanism provides a spatial analog to Hwang, Reed, and Hubbard's (1992) model of occupational Roy sorting in which higher skill workers choose both pecuniary and non-pecuniary compensation. When we adapt features of the estimators from Dahl (2002) or Bayer, Kahn, and Timmins (2011) to mitigate the resulting bias, expenditures increase by 33% to 40%. This is striking because spatial Roy sorting has been ignored by most prior research on pricing amenities.[43] Second, researchers who use data on housing prices from multiple metropolitan areas should be aware of the tremendous spatial variation in the real economic cost of homeownership. Our estimates for the annual user cost of housing vary across residential locations from as low as 4.16% to as high as 9.89%. Finally, we have demonstrated a new way to use information on migration and the financial cost of moving to relax the somewhat dubious assumptions of free mobility and full information that often underlie estimates for amenity value.

More broadly, our work addresses key issues in environmental macroeconomics. In a recent assessment of this emerging literature, Smith (2012) discusses two challenges for researchers: (i) developing consistent and spatially comprehensive data on environmental amenities, while characterizing heterogeneity in consumers and in their exposure to those amenities; and (ii) relaxing the standard assumption that utility must be separable in environmental quality and consumption of private goods. The amenity database we built begins to address the first challenge, and our expenditure measures provide a means to address the second. In a model where marginal utility of consumption (or leisure) depends on environmental quality, spatial variation in amenities will affect labor/leisure choices and amenity expenditures. Therefore, spatial variation in the environmental sub-component of our aggregate expenditure measures could provide some of the information need-

[43] Bayer, Kahn, and Timmins (2011) make a similar observation, and Bayer, Keohane, and Timmins (2009) and Hamilton and Phaneuf (2012) provide notable counterexamples.

ed to calibrate the parameters of a nonseparable utility function, building on the model proposed by Rogerson (2013). This would be an interesting direction for research. Equally important is the need to track how amenity expenditures are affected by changes in the broader economy. With this in mind, we are currently working on assembling data to update our estimates for 2010.

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A1. Data

All of our data used in the hedonic wage and housing regressions is taken from the 5% sample of the public use microdata (PUMS) in the 2000 Census. We restrict our sample to non-farm households and person records above the age of 18 for which we construct a measure of hourly wages and monthly housing expenditure.

i. *Hourly wages*

We compute implied hourly wages for full-time workers from self-reported annual income, weeks worked and hours worked per week. Full-time workers are defined using the standard BLS definition as persons who work at least 35 hours or more per week.

In order to assess the impact of regional variations in the burden of federal and state income taxes on quality-of-life estimates, we derive a measure of hourly after-tax wages. For this purpose, we use estimates of average marginal tax rates for federal and state income taxes for 1999 from the NBER's TAXSIM database (Feenberg and Coutts 1993). We also account for differences in the level of state excise tax rates which are obtained from from the Book of States (Council of State Governments, 2000) minus food tax exemptions (share weighted).[44] The summary statistics of hourly after-tax wages across our three samples are also shown in table A1.

[44] See: Council of State Governments. 2000. *The Book of the States, Vol 33.* The Council of State Governments, Lexington, KY.

Table A1: Person record summary statistics

	Mean	*Std. Dev.*	*Min.*	*Max.*
BBH counties				
Age	39.48	13.2	18	93
Weeks worked in 1999	45.11	12.7	1	52
Hours per week in 1999	39.93	11.97	5	99
Wage/salary income in 1999	34,592	40,794	10	347,000
Gross hourly wage	19.02	24.19	1.50	500
Hourly wage (after federal taxes)	14.15	17.98	1.09	385.70
Average marginal federal tax rate (%)	25.59	1.61	20.29	27.51
N. Obs	3,223,602			
MSAs				
Age	39.74	13.35	18	93
Weeks worked in 1999	45.00	12.81	1	52
Hours per week in 1999	39.82	11.95	5	99
Wage/salary income in 1999	32,775	38,538	10	385,000
Gross hourly wage	18.10	23.05	1.50	500
Hourly wage (after federal taxes)	13.49	17.15	1.09	390.70
Average marginal federal tax rate (%)	25.46	1.63	20.29	27.51
N. Obs	5,827,743			
Conterminous US				
Age	39.80	13.37	18	93
Weeks worked in 1999	44.89	12.89	1	52
Hours per week in 1999	39.83	12.02	5	99
Wage/salary income in 1999	32,047	38,250	20	385,000
Gross hourly wage	17.62	22.51	1.50	500
Hourly wage (after federal taxes)	13.17	16.84	1.09	395.95
Average marginal federal tax rate (%)	25.39	1.59	20.29	27.51
N. Obs	6,630,030			

ii. *Local cost-of-living and non-housing goods*

Although the cost of living varies substantially across regions, wages are usually deflated using a single, nation-wide deflator, such as the CPI-U calculated by the BLS. The use of a nation-wide deflator is potentially problematic given that more than 40% of the CPI-U is determined by housing costs. The local CPI-U released by the BLS and the ACCRA Cost-of-Living Indices are the two local price indices that are most widely used in empirical work. However, both measures have shortcomings: the local CPI-U is only produced for 23 of the largest metropolitan areas. Furthermore, there are slight differences in the composition of the underlying consumption baskets across cities and the index is normalized to 1 in a given year, thus precluding cross-sectional comparisons. The use of the ACCRA CoLI, on the other hand, might prove problematic due to features of its theoretical design, data collection, and sampling design, as discussed by Koo, Phillips, and Sigalla (2000).[45]

The lack of reliable regional cost-of-living indices thus means that most empirical studies do not deflate nominal wages beyond the adjustment in the cost of housing services, as measured by local rents. However, recent work on urban compensating differentials suggests that non-housing goods might also play an important role in determining the local cost-of-living. In order to account for the local variation in the price of non-housing goods, we follow Moretti (forthcoming) who proposes an index that allows the cost of housing and non-housing consumption to each vary across metropolitan areas. While the city-level CPI-U published by the BLS is limited in its geographical coverage, it can still be used to estimate what share of non-housing costs varies with the local cost of housing. The local CPI-U for city j in year t is a weighted average of housing costs, HC_j^t, and non-housing costs (NHC_j^t) such that

$$\text{(A1)} \qquad \mathrm{BLS}_j^t = \alpha \mathrm{HC}_j^t + (1-\alpha)\mathrm{NHC}_j^t,$$

where α is the CPI weight used by the BLS for housing expenditure. Non-housing costs can now be expressed as consisting of an element that varies systematically with housing costs and an element that evolves independently form

[45] Koo, J., K.R. Phillips, and F.D. Sigalla. 2000. "Measuring Regional Cost of Living." *Journal of Business and Economic Statistics*. 18(1): 127-136.

housing cost, i.e. $NHC_j^t = \pi HC_j^t + \upsilon_j^t$. Using first-differenced prices to avoid non-stationarity then gives the regression $\Delta BLS_j^t = \beta \Delta HC_j^t + \varepsilon_j^t$, which in turn can be used to back-out an estimate of π by estimating $\hat{\beta}$, since $\hat{\pi} = \frac{\hat{\beta} - \alpha}{1 - \alpha}$. We use panel data on the small sample of 23 MSAs for which a local BLS CPI is available from 1976-2000 to obtain the fixed-effects estimate for β which yields:

(A2) $$\Delta BLS_j = \underset{(0.07)}{1.792} + \underset{(0.01)}{0.619} \quad \Delta HC_j + \varepsilon_j \qquad R^2 = 0.74.$$

With $\alpha =$ 0.427 according to the BLS CPI-U weights in 2000, we can then impute the systematic component of non-housing costs for all MSAs based on their housing cost, i.e. $\hat{\pi} HC_j^{2000}$ with $\hat{\pi} = 0.332$. Lastly, we compute a local price index as the weighted sum of the cost of housing, the component of non-housing costs that varies with housing, and the component of non-housing costs that does not vary with housing. Our parameter estimates are close to Moretti's estimates of $\hat{\pi} =$ 0.35 which corresponds to $\hat{\beta} =$ 0.63 in 2000.[46]

iii. *Self-reported housing values*

In the long form of the 2000 Census (question 51), housing values are self-reported in 24 intervals from ``less than $10,000" to a top-coded category of ``$1,000,000 or more". This implies that the data on housing values, our dependent variable for the housing hedonic regressions, is both interval censored and left- and right-censored. Using an ad-hoc OLS regression on the midpoints of the intervals of such grouped data could lead to inconsistent estimates, because it

[46] Albouy (2008) uses ACCRA data to run a regression similar to equation (2) and obtains a slightly smaller value of $\hat{\pi} =$ 0.26. See Albouy, D.Y. 2008. "Are Big Cities Bad Places to Live? Estimating Quality-of-Life across Metropolitan Areas." NBER Working Paper No. 14472.

might not adequately reflect the true uncertainty concerning the nature of the exact values within each interval and because it might also inadequately deal with the left- and right-censoring issues in the tails. We address this issue by comparing the parameters from estimating the housing regression via OLS using the interval mid-points to those from using the more appropriate maximum-likelihood interval estimator.

As a result of our large sample sizes combined with a large number of intervals, we do not find a significant differences between the two sets of estimates. This suggests that the consequences of grouping are unlikely to be important for our application. Furthermore, the root mean-square errors for the two estimators are very similar which suggests that the loss of precision due to using interval midpoints is relatively small and confirms the large-sample findings of Stewart (1983).[47]

Finally, although owners tend to overstate the value of their homes compared to actual sales values, Kiel and Zabel (1999) provide evidence that the magnitude of the overvaluation is relatively small (5%), and—more importantly—that the valuation errors are not systematically related to characteristics of the homeowners, structural characteristics of the house, or the neighbourhood.[48] This implies that empirical estimates based on self-reported house values will provide unbiased estimates of the hedonic prices of both house and amenity characteristics. The summary statistics for the housing sample are reported in table A2.

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[47] We adjust the top-coded housing values by multiplying them by 1.5. See Stewart, M.B. 1983. "On Least Squares Estimation when the Dependent Variable is Grouped." *Review of Economic Studies*. 50(4): 737-753.

[48] See Kiel, K.A. and J.E. Zabel. 1999. "The Accuracy of Owner-Provided House Values: The 1978-1999 American Housing Survey." *Real Estate Economics*. 27(2): 263-298.

Table A2: Housing summary statistics

	Mean	*Std. Dev.*	*Min.*	*Max.*
BBH counties				
Number of rooms	5.41	2.03	1	9
Number of bedrooms	2.57	1.12	0	5
Acreage	0.86	2.02	0.1	15
Property value	106,632	153,198.1	5,000	1,000,000+
Gross rent	222.59	393.54	4	2,833
Effective property tax rate (%)	1.37	0.94	0	11.49
User cost of housing (%)	4.53	0.65	3.22	13.20
Price-rent ratio	22.08	3.17	31.06	7.58
Monthly housing expenditures ($)	665.47	479.67	50	4,290.42
Workers per household	1.75	1.39	0	4
N. Obs	2,395,116			
MSAs				
Number of rooms	6.18	1.69	1	9
Number of bedrooms	2.98	0.9	0	5
Acreage	1.31	2.80	0.1	15
Property Value	96,201	136,991	5,000	1,000,000+
Gross rent	190.69	358.33	0	2,833
Effective property tax rate (%)	1.28	0.93	0	11.49
User cost of housing (%)	4.47	0.62	3.22	13.20
Price-rent ratio	22.37	3.25	31.06	7.58
Monthly housing expenditures ($)	600.15	463.32	50	3,926.11
Workers per household	1.77	1.38	0	4
N. Obs	4,392,406			
Conterminous US				
Number of rooms	6.15	1.68	1	9
Number of bedrooms	2.97	0.89	0	5
Acreage	1.52	3.08	0.1	15
Property value	92,535.94	132,544	5,000	1,000,000+
Gross Rent	175.19	340.25	0	2,917
Effective property tax rate (%)	1.28	0.95	0	12.49
User cost of housing (%)	4.48	0.68	3.22	13.20
Price-rent ratio	22.32	3.24	31.06	7.58
Monthly housing expenditures ($)	571.19	450.82	50	3,926.11
Workers per household	1.76	1.38	0	4
N. Obs	5,163,123			

A2. Hedonic Rent and Wage Regressions

Table A3 reports results from four specifications of the hedonic housing and wage regressions, using the BBH sample of 253 counties. As a baseline for comparison, model (1) simply restates the results from BBH's Box-Cox model based on 1980 data. Model (2) repeats the estimation after updating the amenity variables to the year 2000 and drawing on the 5% PUMA sample. Models (3) and (4) are estimated using our two-stage approach. Model (3) only uses the amenities from BBH and model (4) includes all of the amenities in table 1. For brevity, we do not report results for all of the new amenities.

Table A3: Hedonic estimates of housing and wage differentials

	BBH (1980) Box-Cox (1)		*BBH* (2000) Box-Cox (2)		*Our Main Specification* (2000) FGLS (3)		FGLS (4)	
	Rent	Wage	Rent	Wage	Rent	Wage	Rent	Wage
Precipitation	-1.047	-0.014	2.963	0.123	0.565	0.212	-0.068	-0.116
	(0.149)	(0.004)	(0.184)	(0.025)	(0.096)	(0.044)	(0.130)	(0.065)
Humidity	-2.127	0.007	-1.532	0.060	-0.164	0.028	0.247	-0.004
	(0.251)	(0.006)	(0.333)	(0.046)	(0.173)	(0.079)	(0.237)	(0.119)
Heating degree days	-0.014	0.000	-0.099	-0.003	-0.011	-0.003	0.001	0.002
	(0.001)	0.000	(0.003)	(0.000)	(0.002)	(0.001)	(0.003)	(0.001)
Cooling degree days	-0.076	0.000	-0.275	-0.009	-0.035	-0.010	-0.011	0.002
	(0.002)	(0.000)	(0.004)	(0.001)	(0.002)	(0.001)	(0.005)	(0.003)
Wind speed	11.880	0.096	59.190	2.401	8.199	2.455	-1.922	-1.578
	(0.867)	(0.022)	(2.442)	(0.335)	(1.299)	(0.592)	(1.930)	(0.968)
Sunshine	2.135	-0.009	5.491	0.126	1.171	0.237	0.620	0.024
	(0.235)	(0.006)	(0.532)	(0.073)	(0.279)	(0.127)	(0.359)	(0.180)
Coast	32.510	-0.031	132.910	3.760	21.042	4.095	14.154	3.052
	(2.470)	(0.063)	(4.060)	(0.561)	(2.157)	(0.984)	(4.337)	(2.175)
Violent crime	0.043	0.001	0.002	0.000	0.000	0.000	0.000	0.000
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Teacher-pupil ratio	635.300	-5.451	422.899	33.434	26.844	14.891	109.050	59.028
	(71.600)	(1.850)	(57.014)	(8.375)	(15.822)	(7.223)	(23.707)	(23.612)
Visibility	-0.830	-0.003	-8.318	-0.487	-1.136	-0.459	-0.119	-0.096
	(0.110)	(0.003)	(0.286)	(0.040)	(0.157)	(0.071)	(0.190)	(0.095)
TSP/PM10	-0.534	-0.002	3.514	0.229	0.203	0.227	0.044	-0.003
	(0.058)	(0.001)	(0.340)	(0.047)	(0.179)	(0.082)	(0.214)	(0.107)
NPDES dischargers	-7.458	-0.005	-0.214	0.000	-0.042	-0.008	-0.033	-0.017
	(0.461)	(0.012)	(0.059)	(0.008)	(0.031)	(0.014)	(0.032)	(0.016)
Landfill waste	0.010	0.000	-0.001	0.000	0.000	0.000	0.000	0.000

	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Superfund sites	13.420 (0.693)	0.107 (0.017)	14.958 (0.432)	0.617 (0.058)	2.424 (0.225)	0.913 (0.102)	0.343 (0.303)	0.443 (0.152)
Waste disposal sites	0.218 (0.024)	0.001 (0.001)	-0.346 (0.018)	-0.007 (0.003)	-0.058 (0.009)	-0.018 (0.004)	-0.010 (0.019)	-0.008 (0.010)
Central city	40.750 (2.540)	-0.454 (0.065)	32.541 (10.407)	-3.024 (1.411)	4.811 (5.944)	-5.783 (2.711)	5.875 (5.812)	-6.800 (2.915)
Amenities	BBH 16		BBH 16		BBH 16		Table 1	
Adj. R^2	0.6624	0.3138	0.4312	0.2841	0.5186	0.3515	0.7148	0.4880
N.Obs.(1000)	34	46	2,395	3,224	2,395	3,224	2,395	3,224
Log-likelihood	-219,013	-124,403	-38,694	-61,796	--	--	--	--
Box-Cox parameter	0.200	0.100	0.877	0.873	--	--	--	--

Notes: Standard errors are shown in parentheses below the parameter estimates. Coefficients for the Box-Cox regressions are linearized. Parameters are multiplied by10 to facilitate readability and comparison. The dependent variable for the rent regression is the log of actual or imputed monthly housing expenditures. Control variables include: rooms, bedrooms, size and age of building, acreage, type of unit and condominium status, quality of kitchen and plumbing facilities, renter status and renter status interaction terms for each of these variables. The dependent variable for the wage regression is the log of hourly wages. Control variables include: experience (age-schooling-6), experience squared, gender interaction with experience and experience squared, marital status, race, gender interaction with marital status, age and children under 18, educational attainment and/or enrollment, citizen status, employment disability, NAICS-based industry and occupational class, and military status.

Most parameters are significant across all four specifications with the common result that the estimated rent equation fits the data better than the wage equation. Moving from model (1) to (2), we see that updating the data and expanding the sample produces much larger estimates for the Box-Cox parameters. While this makes it difficult to compare the magnitudes of individual coefficients, there are several changes in signs, previewing the fact that updating the data used by BBH produces large changes in their "quality-of-life" rankings.

Model fit improves substantially when we add the full set of amenities, moving from model (3) to (4). Point estimates for coefficients typically decrease in absolute magnitude and their standard errors increase because the original BBH amenities are correlated with the new amenities we have added. One notable exception is the coefficient on the teacher-pupil ratio. Its increase is driven by our addition of an interaction term between the teacher-pupil ratio and the share of students attending private schools. We added this term to recognize that the extent to which variation in public school input levels, such as the teacher-pupil ratio, gets capitalized into housing prices depends on the share of parents who choose to participate in the public school system.

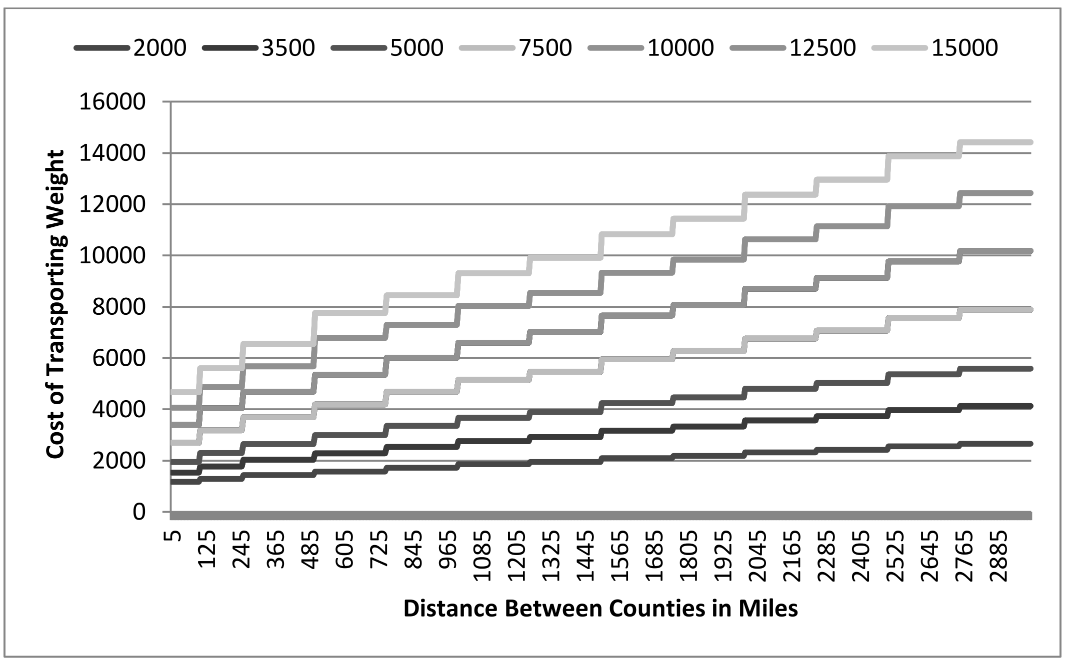
A3. Moving Costs

We calculated average moving costs between counties by combining information on both the average physical and financial costs of moving. The physical cost of the move includes cost of transporting household goods, vehicles and the people in the household. The financial costs included information on realtor fees, location-specific closing costs and search costs from trips to search for a new residence.

i. Physical Costs

The first step in calculating physical costs was to calculate the linear distance in miles between the population weighted centroids from each county in the United States to every other county. The next step was to use the PUMS data to calculate the average number of bedrooms and the fraction of renters in each of the counties. Based on the average number of bedrooms in a county, we used the "weight estimator guide" at www.movesource.com to calculate the weight (in pounds) that the average sized household would be transporting from their "origin" county to their "destination" county. The average number of bedrooms in the counties ranged from a minimum of 1.36 to a maximimum of 3.46. Based on the weight estimator guide, counties with an average number of bedrooms between 1 and 2 were assigned a transportation weight that varied linearly between 3,500 (for a 1 bedroom) and 5,000 (for a 2 bedroom) pounds. For counties with an average number of bedrooms between 2 and 3, transportation weight ranged between 5,000 and 7,500 pounds and for counties with an average number of bedrooms between 3 and 4 the transportation weight ranged between 7,500 and 10,000 pounds. We assumed that renters in a county shipped on average 1500 pounds less than homeowner households such that our calculated cost to move between counties also depends on the fraction of renters in the origin county. The underlying parameters from the movesource.com moving calculator were used to calculate the cost of shipping based on the weight of the move and the distance between counties for each origin/destination county combination. Figure A1 shows the cost of transporting various weights (between 2000 pounds and 15000 pounds) for distances between 5 miles and 3000 miles using the movesource.com calculator.

Figure A1: Physical Cost Matrix



We also assumed that all households transport two vehicles to their new location. The cost of this transportation was based on the IRS's mileage rate for the year 2000 which was 32.5 cents a mile. Thus the vehicle transportation cost was calculated by multiplying 65 cents by the number of miles between the origin and destination counties. Finally, we assume that a household stays in a hotel every 500 miles along their move and incurs some additional daily expenses for food, etc. We apply the average room rate in 2000 (according to the American Hotel and Lodging Association) of $86 to each of these hotel stays and assume that a household's per diem is $100 per 500 miles. Thus, total physical costs of moving are the summation of the cost of transporting household goods, transporting vehicles, hotel stays and per diem costs as a household moves from an origin county to a destination county.

ii. *Financial Costs*

Financial costs also vary by renter and homeowner. We assume that homeowners (not renters) must pay closing costs to sell their house in their origin county. Our calculations are based on Bankrate.com's 2005 survey which provides average closing costs by state. We also assume that homeowners (not renters) pay a real estate agent 3% to facilitate selling their house and a real estate agent 3% to buy a house. Thus, we calculate these costs as 3% of the average housing value in the origin county and 3% of the average housing value in the destination county. We assume that both homeowners and renters pay to search for a new residence. These "finding costs" for moves within 60 miles, between 60 and 180, between 180 and 500, between 500 and 1000, and greater than 1,000 miles are assumed to be 0, 250, 500, 1,000 and 2,000 dollars. These finding costs reflect our best guess for the search costs when travel is local, requires at least a day, requires an overnight stay, or likely requires plane tickets in order to look for a new residence in the destination county.

Total financial costs are calculated by summing up the financial costs of searching for a new residence (for renters and homeowners) and the costs of buying and selling a home (for homeowners only). The weight assigned to the homeowner and the renter calculations is again based on the fraction of renters in a county. The total moving cost used in the final robustness check of the paper is calculated by summing the physical and financial costs we have described above.

A4. Amenity Database and Stata Code

The Stata file *amenity.dta* contains our county level database on amenities. The zip file *results.zip* contains data and code to replicate all of the tables in the paper. It also includes instructions to produce expenditure measures for specific counties, PUMAs, or puma-county unions. See the *readme.pdf* file for details.