The Role of Local Amenities in the National Economy

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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 and wages. In this paper, we develop a macroeconomic measure of indirect amenity expenditures that is consistent with microeconomic fundamentals of spatial equilibrium and principles of national income accounting. We construct a county-level database of 75 amenities, match it to location choices made by 5 million households, and develop the first estimates for aggregate amenity expenditures in the United States. We find amenities accounted for 6% of personal consumption expenditures in 2000 ($422 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 these local amenities affect the economy, we rarely observe consumers purchasing them directly. Some effects are simply excluded from the national accounts. For example, industrial production generates air pollutants that increase premature mortality. Muller, Mendelsohn, and Nordhaus (2011) place the latent value of these external damages at $184 billion. Other effects are hidden within the national accounts. Local amenities contribute to GDP indirectly when spatial variation in their supply affects consumer expenditures on complementary private goods, such as housing.

In this paper we develop the first comprehensive estimates for indirect expenditures on localized amenities in the United States, using data on housing and labor market outcomes. Our approach begins from the microeconomic fundamentals of spatial equilibrium.[2] When heterogeneous households sort themselves

[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.
[2] For surveys of the literature on Tiebout sorting and the role of amenities in spatial equilibrium see Blomquist (2006), Kahn (2006), Epple, Gordon, and Sieg (2010), and Kuminoff, Smith, and Timmins (2010). Our model of spatial equilibrium is most closely related to Roback (1982,1988), Bayer, Keohane, and Timmins (2009), and Kuminoff (2010).

across the housing and labor markets based, in part, on their idiosyncratic preferences for amenities, the spatial variation in those amenities gets capitalized into land values and wages.[3] As a result, people must pay to live in high amenity areas through higher housing prices, lower real wages, or both. 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 implicit 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, wages, and amenities to identify their implicit prices. With data on quantities and estimates for prices, we can approximate the relative amenity expenditures associated with moving between any two locations; i.e. the nominal change in income 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, property taxes, and tax subsidies to homeowners. We address these challenges by drawing on the most comprehensive and detailed data available on amenities, migration flows, moving costs, state and federal tax codes, 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 collected data describing features of its climate and geography, environmental externalities, local public goods, transportation infrastructure, and access to cul-

[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."

tural 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. It would be nice to separately identify virtual prices for each of the 75 amenities as an intermediate step toward calculating 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. Our identification strategy relies instead on brute force. We demonstrate that *total* expenditures are identified as long as any

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[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.

omitted amenity can be expressed as a linear function of the observed amenities. The credibility of this identification 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 is likely to be highly correlated with several of the ones we observe.

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 expenditures. Under a variety of alternative definitions for the consideration sets, we generate conservative bounds on amenity expenditures that range from $271 billion to $526 billion for the year 2000. Our preferred point estimate of $422 billion is equivalent to 6.2% of personal consumption expenditures on private goods. These figures imply the average household sacrifices close to four thousand dollars per year to consume the nonmarket amenities at their chosen location. Expenditures are generally higher in the West and Northeast and lower in the Midwest and South. Expenditures per household are highest on the California coast and lowest in the Detroit metropolitan area.

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 microeconomic fundamentals of spatial equilibrium, accounts for observed and unobserved sources of consumer heterogeneity, and adjusts for spatial variation in moving costs, tax subsidies to homeownership, income taxes, and property taxes; and (iii) we present the first national estimate of nonmarket amenity expenditures. Thus, our work directly addresses the National Research Council's priority for research on developing satellite accounts for environmental services, local public goods, and urban infrastructure.

The rest of the paper proceeds as follows. Section I begins from a stylized model of sorting in the housing and labor markets and uses it to define "implicit amenity expenditures." Section II summarizes the data. Section III explains our methodology and section IV presents the main results. Additional modeling details and robustness checks are provided in a supplemental appendix. Finally, section V concludes by discussing next steps in developing a formal satellite account of amenity expenditures.

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 $j = 1,2, \dots, J$ locations. Locations differ in the rental cost of land, r_j, the wages paid to workers, w_j, and in a vector of K nonmarket amenities, $A_j = [a_{1j}, \dots, a_{Kj}]$. We define "amenities" broadly to include all of the attributes of a location that matter to households but are not formally traded. Examples include climate, geography, pollution, local public goods, opportunities for dining and entertainment, and transportation infrastructure. Some of these amenities are exogenous (e.g. climate, geography). Others may be indirectly influenced by sorting behavior as a result of voting, social interactions, and feed-back 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 con-sider. 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.[5] Thus, households maximize utility by selecting a location and using their wages to purchase x and h,

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

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, $C_j = C(w_j, r_j, A_j, mc_{\beta,j}; \beta)$.[6]

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:

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

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

Under the assumption that each location provides a unique bundle of amenities,

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

[6] 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.

we can use hedonic price and wage functions to describe the spatial relationships between rents, wages, and amenities that must be realized in equilibrium:

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

where *F*, *G*, and *H* denote the distributions of amenities, households, and firms.[7]

Spatial variation in rents and wages determines the implicit prices of consuming amenities. Consider air quality. There are two ways to induce a household to move to a smoggier location: lower rent or higher wages. 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,

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

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.[8] The least expensive location in J_α defines the household's reference point, $\acute{x}$, used to normalize the ex-

[7] 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).

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

penditure 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 the Roback (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.[9] 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 income and product accounts (NIPA) track wage income and housing expenditures.

[9] 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 (2010) 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.

In a dual-market sorting equilibrium, these measures will conflate the market values of land and labor with the implicit prices of localized 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 the observable features of the spatial distribution of rents, wages, and amenities. Disentangling the amenity components of wages and rents would represent a major 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.[10] 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

[10] 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.[11]

Table 1: Amenity Summary Statistics

	1980 BBH *Mean*	2000 BBH *Mean*	2000 Nation *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

[11] 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.[12]

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.

[12] 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. Therefore we also 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.

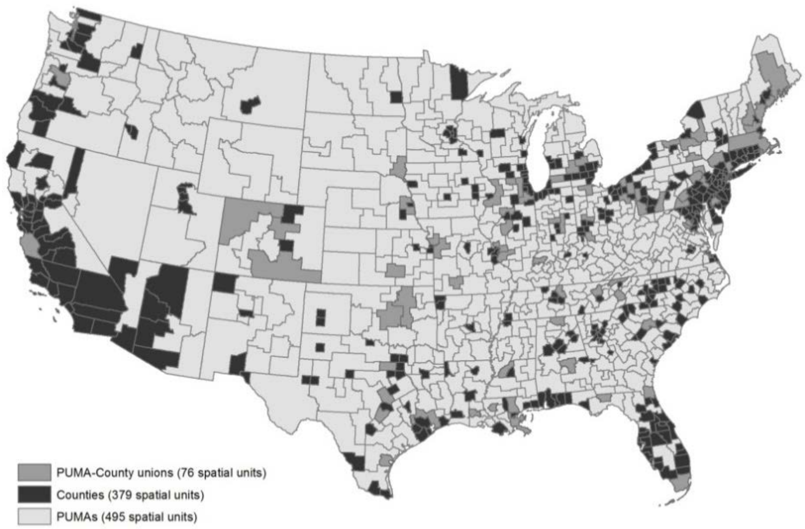
Table 2: Geographic Coverage and Population Coverage

		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.[13]

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.[14] The resulting 495 PUMAs contain 25% of the population. Finally, PUMAs occasionally overlap county borders without encompassing both counties. In these cases, we merged the adjacent counties. There are 76 such PUMA-county unions, representing 15% of the population. Thus, each of the 950

[13] 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.

[14] We believe this is a reasonable approximation for the affected areas, which are typically rural. 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).

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).[15]

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.[16]

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.

Spatial variation in the homeownership subsidy, along with spatial variation in property tax rates, affects the appropriate discount rate by which housing values

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

are converted into rents. This important point has been overlooked by previous studies of spatial relationship between amenities and rents. 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 bias estimates for amenity expenditures. The uniformity assumption 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

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

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; τ_{ij} is the individual's 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.[17] We impute ω_j from reported property tax payments and house values. It has a mean of 1.54% in our national sample.[18] For τ_{ij}, we use average effective marginal income tax rates for 1999 which we collect from the NBER TAXSIM mod-

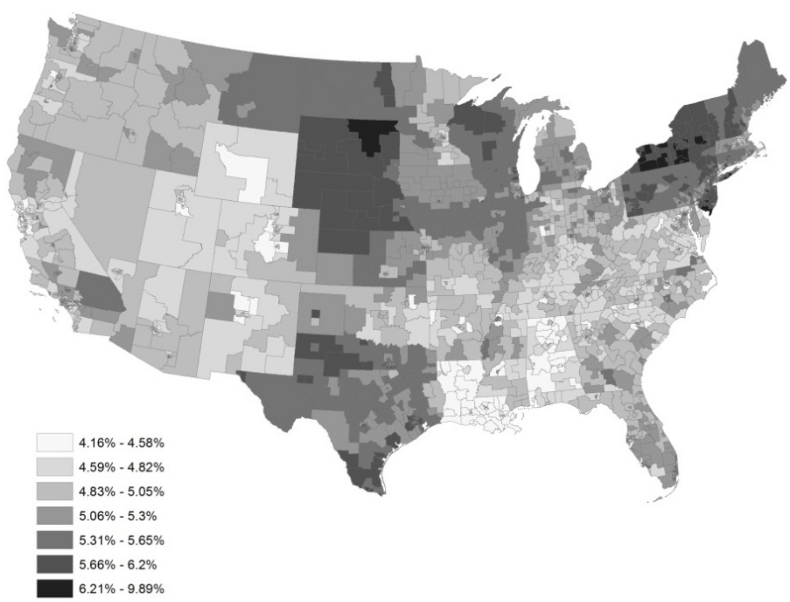
[17] Since Himmelberg, Mayer, and Sinai (2005) report that less than half of tax-filing homeowners actually itemize, we reduce the tax subsidy in our calculations by one half. But even without itemizing, all homeowners receive some tax subsidy as imputed rents do not have to be reported as taxable income.

[18] 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 $\varepsilon_t = 0.02$.

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.[19] 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.

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. See the text for a detailed description.

III. Approximating Amenity Expenditures

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

[19] 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.

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

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.[20]

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,

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

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

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

[20] Control variables in the rent regression include: rooms, bedrooms, size of building, age of building, acreage, type of unit, condominium status, quality of kitchen and plumbing facilities, renter status, renter*rooms, renter*bedrooms, renter*size of building, renter*age of building, renter*acreage, renter*type of unity, renter*condo status, renter*quality of kitchen, and renter*quality of plumbing facilities. 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, military status.

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.[21] For example, the PUMS data describe the size and layout of each house, but they do not describe the quality of building materials. Likewise, we have information about each worker's level of education, but not the quality of their education.

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:

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

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 amenity expenditures to an alternative one where expenditures are calculated from the first-stage fixed effects (i.e. 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.

B. Identification

It would be nice to separately identify the virtual prices of every amenity as an

[21] 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).

intermediate step toward calculating total amenity expenditures. However, it is not realistic to do so.[22] Nor is it necessary. A credible approximation to total 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

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

where $\hat{\kappa}^r$ and $\hat{\kappa}^w$ are consistent estimates for the rent and wage differentials arising from spatial variation in z_j.[23] 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 $\pi \to 0$.

[22] 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!

[23] 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.

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, 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.[24] Table 3 reports the sensitivity of our results to a variety of alternative 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.[25] In this case, real expenditures at a location are defined by the difference between relative expendi-

[24] 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.

[25] 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.

tures 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 $5,015 on localized amenities in the year 2000 through higher housing prices, lower wages, or both (row 1). Aggregating over households implies a national measure of $526 billion. This is equivalent to 7.5% of personal expenditures on private consumption or 8.6% of household income. 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: mean	Expenditures / household: st. dev.	Total Expenditures ($billion)
		A. Moving Costs Excluded			
(1) None	950	100%	5,015	1,851	526
(2) Emmigration Share > 0.1%	137	89%	4,473	1,891	469
(3) Immigration Share > 0.1%	135	89%	4,609	1,852	483
(4) Less than 250 miles away	82	67%	2,984	1,654	313
		B. Moving Costs Included			
(5) None	950	100%	4,492	1,800	471
(6) Emmigration Share > 0.1%	137	89%	3,955	1,841	415
(7) Immigration Share > 0.1%	135	89%	4,091	1,798	429
(8) Less than 250 miles away	82	67%	2,586	1,603	271

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 three columns report measures of real 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.[26] 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. After imposing this constraint, the typical consideration set is limited to nearby locations (both urban and rural) and urban counties in the best known metro areas, such as New York, Chicago, Phoenix, and Los Angeles.[27] This pattern seems consistent with evidence on migrant information networks (Pissarides and Wadsworth 1989).

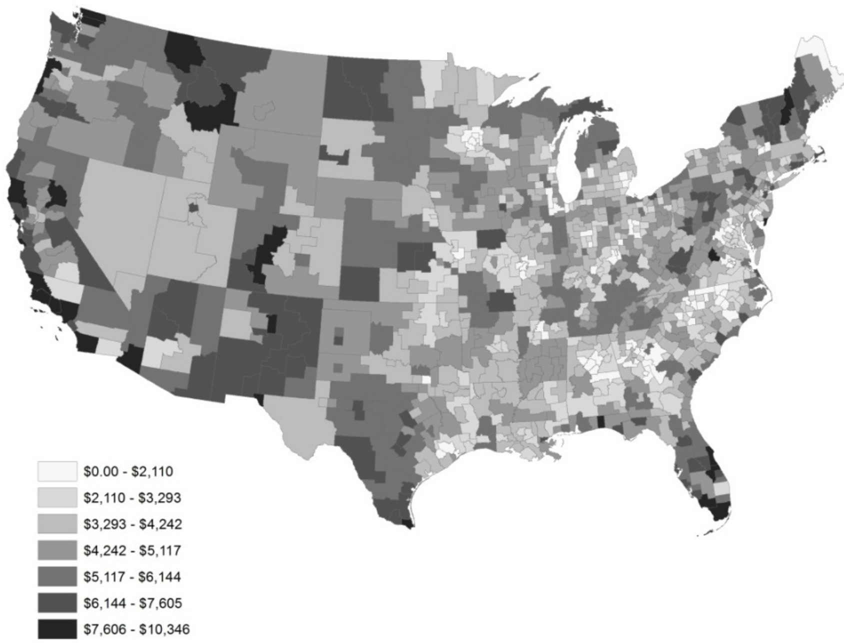
The 0.1% threshold reduces the number of locations the average household is assumed to consider from 950 to 137 (emigration) or 135 (immigration). These locations account for 89% of all migration. It is somewhat surprising that reducing the size of the consideration set by 85% only reduces our expenditure measure by 8% to 11% (comparing row 1 with rows 2 and 3).[28] 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 and Appalachian regions. However, expensive and inexpensive locations are not completely segregated. 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.

[26] 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.

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

[28] 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.

Figure 3: Implicit Expenditures on Amenities in U.S. Counties, 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).

A second force behind the similarity in our expenditure measures in rows 1-3 is that the location with the lowest relative expenditures, Wayne County, MI, (i.e. Detroit) 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 $313 billion (row 4 of table 3).

We consider 250 miles to be a conservative radius because the resulting circles contain only 67% of migration flows. Furthermore, 250 miles is roughly a 5-hour drive, close enough to take short trips back to one's original location. Physical proximity should mitigate most of the psychological cost of moving away from family and friends.[29]

As a final robustness check, we revise our calculations to account for the average physical and financial cost of moving between each pair of locations.[30] 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.)

Our estimate for the physical cost of moving differs for every pair of locations.[31] 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%.[32] This implies the annual cost of a $10,000 move is $419.

When we account for the cost of moving, our estimates range from $271 to $471 billion. These results are shown in rows 5-8 of table 3. We consider $271 billion to be a conservative lower bound. The fact that one third of migrants moved further than 250 miles suggests 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 per-

[29] 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 2010, Kennan and Walker 2011).

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

[31] Also note that 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 average number of rooms in the *origin* location.

[32] 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 moving costs for job-related moves can be deducted from federal income taxes. By ignoring these forms of compensation, we will tend to overstate the physical and financial costs of a move, which may cause us to understate amenity expenditures slightly.

ceives Detroit to be its reference point, then $471 billion is the appropriate 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 $471 billion as a conservative upper bound.

Our preferred estimates are the ones derived from the migration-based consideration sets with moving costs included. They imply a range of $415 to $429 billion. Taking the midpoint of this range, $422, would suggest that implicit amenity expenditures were equivalent to 6.2% of personal consumption expenditures in 2000.

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 60% 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 21% of expenditures.

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 roughly half the size of expenditures in the Pacific division. Similarly, households in the Pacific, who also have the highest regional incomes, spend the largest fraction of their incomes on localized amenities (10%). Households in the East North Central region spend the smallest fraction (6%). More broadly, a weighted least squares regression of expenditures on income implies an elasticity of 1.48 for the average household, suggesting that amenities are a luxury good.[33]

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	3,865	4,149	3,228	3,157	3,645	3,291	3,677	4,168	5,839
Amenity to income ratio	0.07	0.07	0.06	0.07	0.07	0.08	0.08	0.09	0.10
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)	21	62	56	24	73	22	42	28	88
Share of U.S. amenity expenditures	0.05	0.15	0.13	0.06	0.18	0.05	0.10	0.07	0.21

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}.

Finally, if we look within the Census divisions the ranking of locations by expenditures makes intuitive sense. Amenity expenditures are the lowest in Detroit and they tend to be the highest in coastal California. The 25 most expensive locations include 8 counties on the California coast: Marin, San Francisco, Los Angeles, Santa Barbara, Santa Cruz, Ventura, San Luis Obispo, and San Diego. The top 25 locations also include several county aggregates containing cities and towns that are well known for their amenities, such as Aspen, Bozeman, Charlottesville, the Florida Keys, Martha’s Vineyard, Puget Sound, and Santa Fe.

C. A Comparison to “Quality of Life” Rankings of Counties

To further examine the micro foundations for our national estimates in tables 3

[33] The unit of observation in the regression is a location (N=950) and the weights are the number of households in each location. The p-value on the coefficient for average household income is zero out to four decimal places and R^2=0.76. If we replace average household income in the regression with median household income or income per capita the elasticities change to 1.48 and 1.47 respectively.

and 4, we use our amenity data and methods to revisit Blomquist, Berger, and Hoehn's (1988) classic "quality of life" ranking of 253 urban counties by relative amenity expenditures.[34] Table 5 reports results for our top 25 and bottom 25 counties, along with the original BBH rankings.[35] This comparison provides an intuitive way to evaluate the impact of our data collection efforts and our refinements to the standard hedonic approach to measuring compensating differentials.

Table 5: Ranking 253 Urban Counties by Relative Expenditures

County, State	Core Business Statistical Area	Relative Expenditures (1)	Our rank (2)	BBH rank (3)
Marin, CA	San Francisco-Oakland-Fremont	12,227	1	142
San Mateo, CA	San Francisco-Oakland-Fremont	8,378	2	112
San Francisco, CA	San Francisco-Oakland-Fremont	7,608	3	105
Santa Cruz, CA	Santa Cruz-Watsonville	7,001	4	79
Santa Clara, CA	San Jose-Sunnyvale-Santa Clara	6,219	5	88
Santa Barbara, CA	Santa Barbara-Santa Maria	6,133	6	22
Alameda, CA	San Francisco-Oakland-Fremont	5,258	7	94
Ventura, CA	Oxnard-Thousand Oaks-Ventura	5,041	8	23
Orange, CA	Los Angeles-Long Beach-Santa Ana	4,915	9	41
Los Angeles, CA	Los Angeles-Long Beach-Santa Ana	4,885	10	58
King, WA	Seattle-Tacoma-Bellevue	4,048	11	158
San Diego, CA	San Diego-Carlsbad-San Marcos	3,856	12	27
Monterey, CA	Salinas	3,742	13	16
Nassau, NY	New York-Northern New Jersey-Long Island	3,718	14	60
Pierce, WA	Seattle-Tacoma-Bellevue	3,572	15	98
Boulder, CO	Boulder	3,465	16	12
Contra Costa, CA	San Francisco-Oakland-Fremont	3,150	17	211
Rockland, NY	New York-Northern New Jersey-Long Island	3,121	18	236
Monmouth, NJ	New York-Northern New Jersey-Long Island	3,095	19	92
Bergen, NJ	New York-Northern New Jersey-Long Island	2,738	20	219
Suffolk, NY	New York-Northern New Jersey-Long Island	2,598	21	49
Passaic, NJ	New York-Northern New Jersey-Long Island	2,376	22	70
Broward, FL	Miami-Fort Lauderdale-Miami Beach	2,343	23	11
Larimer, CO	Fort Collins-Loveland	2,181	24	13
New York, NY	New York-Northern New Jersey-Long Island	2,150	25	216
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
Saginaw, MI	Saginaw-Saginaw Township North	-2,719	229	224

[34] 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.

[35] Complete econometric results and rankings for all 253 counties can be produced using the data and code described in the supplemental appendix. Table A3 provides a summary.

Harris, TX	Houston-Sugar Land-Baytown	-2,729	230	241
Calhoun, MI	Battle Creek	-2,763	231	233
Wyandotte, KS	Kansas City	-2,767	232	144
Montgomery, OH	Dayton	-2,768	233	104
Allegheny, PA	Pittsburgh	-2,829	234	202
Macomb, MI	Detroit-Warren-Livonia	-2,838	235	248
Oakland, MI	Detroit-Warren-Livonia	-2,876	236	203
DuPage, IL	Chicago-Naperville-Joliet	-2,888	237	186
St. Clair, IL	St. Louis	-2,964	238	195
Forsyth, NC	Winston-Salem	-3,016	239	45
Spartanburg, SC	Spartanburg	-3,087	240	57
Ouachita, LA	Monroe	-3,113	241	109
Etowah, AL	Gadsden	-3,148	242	157
Kern, CA	Bakersfield	-3,250	243	83
Kent, MI	Grand Rapids-Wyoming	-3,261	244	244
Elkhart, IN	Elkhart-Goshen	-3,367	245	160
Will, IL	Chicago-Naperville-Joliet	-3,367	246	230
Lexington, SC	Columbia	-3,414	247	110
Rock, WI	Janesville	-3,430	248	117
Gaston, NC	Charlotte-Gastonia-Concord	-3,557	249	76
Franklin, OH	Columbus	-3,574	250	180
Stearns, MN	St. Cloud	-3,687	251	67
East Baton Rouge, LA	Baton Rouge	-4,244	252	168
Wayne, MI	Detroit-Warren-Livonia	-5,146	253	249

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 Wayne County, MI. A freely mobile household who chooses to live in Marin instead of Wayne would pay $17,373 per year to consume the amenities Marin provides. 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 Detroit, 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 $17,373 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. Of the top 25 counties, 13 are in California and two more are in Washington State. Furthermore, 17 of the top 25 are in the San Francisco Bay area, the Los Angeles metro area, and the New York metro area.[36]

A quick comparison between columns (2) and (3) is sufficient to see that our rankings are positively correlated with those of BBH ($\rho = 0.27$). However, there are three generic differences. First, our rankings display higher spatial correlation, as can be seen from the clusters of adjacent San Francisco and New York Area counties in column (2). This is because our analysis quintuples the number of amenities and most amenities are spatially correlated. Second, most counties move dramatically in the rankings. Thirteen of our top 25 counties advance more than 50 places relative to BBH and eight advance more than 100 places. The largest increase is Rockland County, New York (#236 in BBH; #18 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; #205 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 positively correlated with income per capita ($\rho = 0.43$), consistent with evidence from the empirical literature on Tiebout sorting.[37]

Overall, applying our new data and methods to the same 253 counties studied by BBH produces a ranking that seems intuitively plausible for the year 2000. Compared to BBH our rankings exhibit higher spatial correlation and higher correlation with income, consistent with the micro literature on Tiebout sorting.

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[36] 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.

[37] In comparison, the expenditure measures that BBH produced for 1980 are slightly negatively correlated with year 2000 income per capita ($\rho = -0.06$). This lack of stratification by income is surprising. We suspect that it reflects the limited amenity data that were available at the time of the original BBH study and perhaps changes in the spatial distribution of income and amenities between 1980 and 2000. See Kuminoff, Smith, and Timmins (2010) for a review of the evidence on income stratification from the literature on Tiebout sorting.

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.[38] For example, increasing the threshold immigration share from 0.1% to 1.0% would reduce expenditures from $415 billion to $218 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 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 the markets for housing and labor. While we expect these markets to reflect the majority of implicit expenditures, the resulting measures are surely incomplete. For example, access to hiking and biking 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 will not generally provide an exact measure of aggregate willingness to pay. Developing measures of social welfare that adjust for health, longevity, leisure, and environmental quality is an extremely important and challenging area for research (e.g. see Fleurbaey 2009,

[38] The data and code in our supplemental appendix can be modified to consider any alternative consideration set.

Stiglitz et al. 2009, Jones and Klenow 2011). Muller, Mendelsohn, and Nordhaus (2011) take an important step in this direction by developing a framework to integrate external damages from air pollution into the national accounts, using estimates for the value of statistical life-years lost. Since these health effects are unlikely to be fully capitalized into land values and wages, they will not be fully reflected in our measure of amenity expenditures.[39] More generally, we conjecture that it should be possible to define sufficient conditions for interpreting our expenditure measures as lower bounds on Hicksian compensating differentials for amenity bundles. This would be a useful direction for further research.

Fourth, our expenditure measures are not adjusted for the spatial analog to Roy sorting. While we have utilized the most detailed micro data available on worker characteristics, it is still possible that unobserved skill induces some spatial sorting in the labor market. The direction of any bias caused by this form of sorting is indeterminate and confined to the wage component of our expenditure measures. Bayer, Khan, and Timmins (2011) take the first step toward addressing this issue. They characterize strategies for recovering unconditional wage distributions from cross-section data on workers who sort over spatially delineated amenities and wages. However, their positive identification results rely on the ability to observe groups of workers with identical preferences over amenities. Extending their approach to allow unrestricted preference heterogeneity, consistent with our model of spatial equilibrium, would be a challenging and interesting extension.

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

[39] Muller, Mendelsohn, and Nordhaus (2011) calibrate the value of statistical life years lost using a central estimate for the value of a statistical life (VSL). VSL measures are often imputed from hedonic wage equations, identified by variation in rates of accidental on-the-job deaths; as opposed to spatial variation in longevity due to air pollution per se.

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. Toward a Satellite Account of Amenity Expenditures

Our estimates suggest that more than 6% of personal consumption expenditures in the year 2000 reflect the capitalized value of local amenities. While spatial variation in these amenities is capitalized into prices for land and labor, the amenities themselves are not formally traded. Creating a satellite account to track their contribution to GDP would have tremendous value. According to the National Research Council (1999) the guiding principle in developing a satellite account is to obtain a "better measure of final output"—however experimental—that reflects the tradeoffs consumers make between market and nonmarket goods and services.[40] Our progress on tracking environmental services, local public goods, and urban infrastructure, in particular, addresses the top priorities set by the National Panel to Study the Design of Nonmarket Accounts (2005).

As we noted at the outset, two of the primary challenges in developing a satellite account of nonmarket goods is acquiring information on prices and quantities. The national database we have assembled on amenities addresses the "quantities" challenge and our brute force approach to estimating total implicit expenditures addresses the "prices" challenge. Furthermore, our estimates are consistent with the double-entry nature of NIPA since our approach can be related to equilibrium compensating differentials that give rise to measures of nonmarket expenditures.

One of the next steps in developing a formal satellite account is to clarify the mapping between our estimates for amenity expenditures and estimates of "personal income" and "personal consumption expenditures" in NIPA. Satellite

[40] Examples of existing satellite accounts include the U.S. Research and Development Satellite Account which estimates the impact of R&D on GDP, and the U.S. Travel and Tourism Satellite Accounts which tries to more accurately measure the contribution of travel and tourism to the economy.

accounts naturally overlap with NIPA. The challenge is to document where the overlap occurs. For example, much of the increased expenditures on housing due to amenities will be reflected in the "housing service" category in NIPA's personal consumption expenditure table.[41] However, their "rental equivalency" imputations for owner-occupied housing ignore some of the economic costs and benefits of homeownership that are captured by our user cost methodology, 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. It would be more challenging to derive the 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.

We are currently working on updating our calculations for 2010. In principle, our methodology could be implemented on an annual basis to parallel the national accounting system. Given the Census Bureau's recent move from decennial population surveys to the annual American Community Survey, most of the census information we have used will be provided on an annual basis. Some of the amenity variables we have collected are updated every year; others are not. This is not a problem for amenities that are approximately constant from year to year. However, additional resources would be required to ensure that data on time-varying amenities are collected and reported in a timely and consistent manner. In our opinion, the potential benefits to consistently measuring amenity expenditures far outweigh the costs to overcoming the data hurdles involved.

[41] 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.

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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).[42] The summary statistics of hourly after-tax wages across our three samples are also shown in table A1.

[42] 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).[43]

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

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

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

[43] 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. $\text{NHC}_j^t = \pi\text{HC}_j^t + \upsilon_j^t$. Using first-differenced prices to avoid non-stationarity then gives the regression $\Delta\text{BLS}_j^t = \beta\Delta\text{HC}_j^t + \varepsilon_j^t$, which in turn can be used to back-out an estimate of π by estimating $\hat{\beta}$, since $\hat{\pi} = \dfrac{\hat{\beta} - \alpha}{1 - \alpha}$. 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) $$\underset{}{\Delta\text{BLS}_j} = \underset{(0.07)}{1.792} + \underset{(0.01)}{0.619}\ \Delta\text{HC}_j + \varepsilon_j \quad R^2 = 0.74.$$

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. $\hat{\pi}\text{HC}_j^{2000}$ 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.[44]

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

[44] 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).[45]

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.[46] 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.

[45]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.
[46] 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)		*BBH* (2000)		*Our Main Specification* (2000)			
	Box-Cox		Box-Cox		FGLS		FGLS	
	(1)		(2)		(3)		(4)	
	Rent	Wage	Rent	Wage	Rent	Wage	Rent	Wage
Precipitation	-1.047 (0.149)	-0.014 (0.004)	2.963 (0.184)	0.123 (0.025)	0.565 (0.096)	0.212 (0.044)	-0.068 (0.130)	-0.116 (0.065)
Humidity	-2.127 (0.251)	0.007 (0.006)	-1.532 (0.333)	0.060 (0.046)	-0.164 (0.173)	0.028 (0.079)	0.247 (0.237)	-0.004 (0.119)
Heating degree days	-0.014 (0.001)	0.000 0.000	-0.099 (0.003)	-0.003 (0.000)	-0.011 (0.002)	-0.003 (0.001)	0.001 (0.003)	0.002 (0.001)
Cooling degree days	-0.076 (0.002)	0.000 (0.000)	-0.275 (0.004)	-0.009 (0.001)	-0.035 (0.002)	-0.010 (0.001)	-0.011 (0.005)	0.002 (0.003)
Wind speed	11.880 (0.867)	0.096 (0.022)	59.190 (2.442)	2.401 (0.335)	8.199 (1.299)	2.455 (0.592)	-1.922 (1.930)	-1.578 (0.968)
Sunshine	2.135 (0.235)	-0.009 (0.006)	5.491 (0.532)	0.126 (0.073)	1.171 (0.279)	0.237 (0.127)	0.620 (0.359)	0.024 (0.180)
Coast	32.510 (2.470)	-0.031 (0.063)	132.910 (4.060)	3.760 (0.561)	21.042 (2.157)	4.095 (0.984)	14.154 (4.337)	3.052 (2.175)
Violent crime	0.043 (0.003)	0.001 (0.000)	0.002 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Teacher-pupil ratio	635.300 (71.600)	-5.451 (1.850)	422.899 (57.014)	33.434 (8.375)	26.844 (15.822)	14.891 (7.223)	109.050 (23.707)	59.028 (23.612)
Visibility	-0.830 (0.110)	-0.003 (0.003)	-8.318 (0.286)	-0.487 (0.040)	-1.136 (0.157)	-0.459 (0.071)	-0.119 (0.190)	-0.096 (0.095)
TSP/PM10	-0.534 (0.058)	-0.002 (0.001)	3.514 (0.340)	0.229 (0.047)	0.203 (0.179)	0.227 (0.082)	0.044 (0.214)	-0.003 (0.107)
NPDES dischargers	-7.458 (0.461)	-0.005 (0.012)	-0.214 (0.059)	0.000 (0.008)	-0.042 (0.031)	-0.008 (0.014)	-0.033 (0.032)	-0.017 (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.

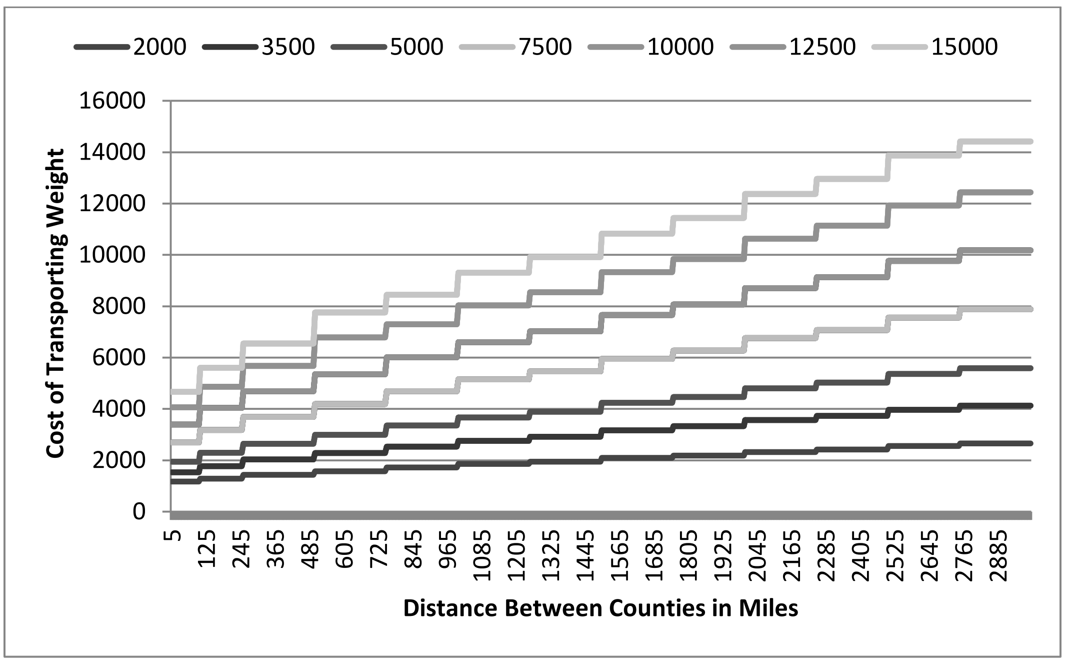
A3. Moving Costs

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.