WHAT ARE CITIES WORTH? LAND RENTS, LOCAL PRODUCTIVITY, AND THE TOTAL VALUE OF AMENITIES

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Abstract—This paper models how to use widely available data on wages and housing costs to infer land rents, local productivity, and the total value of local amenities in the presence of federal taxes and locally produced nontraded goods. I apply the model to U.S. metropolitan areas with the aid of visually intuitive graphs. The results improve measures of productivity and feature large differences in land rents. Wage and housing cost differences across metropolitan areas are accounted for more by productivity than quality-of-life differences. Regressions using individual amenities reveal that the most productive and valuable cities are typically coastal, sunny, mild, educated, and large.

I. Introduction

THIS article demonstrates both analytically and graphically how to use widely available data on wages and housing costs to infer land rents and measure local productivity and the total value of local amenities. I use an intercity framework, based on Rosen (1979) and Roback (1982), that features two enhancements: federal taxes and a production sector for "home" goods, such as housing, which are not tradable across cities. Albouy (2009) demonstrates that federal taxes increase tax burdens in places where wage levels are high, creating local fiscal externalities. Roback (1982) briefly models home goods but ignores local productivity empirically, and uses a simpler model, equating land with housing, to estimate quality-of-life differences. The distinction between land and housing is important, as housing prices are often substituted for difficult-to-find land rents (see Mills, 1998, and Case, 2007) despite being influenced by other input costs, such as labor.[1] The modeling of home goods requires distinguishing the local productivity of firms selling home goods from the productivity of firms selling traded goods, that is, "home productivity" from "trade productivity." It also implies that without land rent data, the two productivities cannot be identified separately.

I apply the model to U.S. Census data and estimate local land rents and trade productivity. It assumes, as previous researchers did implicitly (Beeson & Eberts, 1989; Gabriel & Rosenthal, 2004; Shapiro, 2006) that home productivity is constant across cities. Relative to most previous estimates, enhanced estimates infer trade productivity relatively more from high housing costs than from high wages. Combining the value of trade productivity with the value of quality of life, from Albouy (2008), I measure each city's total amenity value, which goes beyond previous measures by accounting for nonresidential land, local labor costs, and federal tax externalities. The application ranks cities by their trade productivity and total amenity value, with San Francisco topping both lists. A variance decomposition suggests that trade productivity explains wage and housing cost differences across cities more than quality of life does.

I finish with an illustrative empirical analysis involving cross-sectional amenity regressions. This analysis is the first to simultaneously present the value of multiple amenities to both firms and households. A few amenities statistically predict most of the variation intrade productivity and total amenity value. My simple hedonic estimates of the impact of population and education levels on productivity are consistent with more sophisticated analyses. Measuring their value per acre, the most productive and valuable cities are not only large and educated, but also mild, sunny, and coastal.[2]

Albouy (2009) derives most of the theoretical results applied here, emphasizing how federal taxes distort local prices and location decisions. The analysis below goes further by estimating what amenities are related to tax payments. Albouy (2008) provides the complementary quality of life estimates. Albouy, Leibovici, and Warman (2013) use the framework presented here to analyze heterogeneous households with Canadian data. Building from this model, Albouy and Stuart (2014) predict population levels in U.S. Albouy and Ehrlich (2012) integrate a land value index using recent market transactions data, and estimate a cost function for housing together with differences in housing productivity.

II. Prices and the Value of Amenities across U.S. Cities

A. *An Intercity Model of Prices and Amenities with Taxes and Locally Produced Nontraded Goods*

Consider a system of cities, indexed by j, that share a homogeneous population of mobile households, N.

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[1] This paper does not address temporal issues that would make land rents deviate from land values by more than an interest rate, and so the terms *rents* and *values* are used interchangeably.

[2] Articles that consider the local productivity of firms with only the traded sector include Rauch (1993), Dekle and Eaton (1999), Haughwout (2002), Glaeser and Saiz (2004), and Chen and Rosenthal (2008). Rappaport (2008a, 2008b) is the only author who accounts for locally produced goods, although he restricts home productivity and trade productivity to be equal. Tabuchi and Yoshida (2000) use actual data on land rents, although later they conflate them with housing costs.

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Households consume a numeraire traded good, x, and a nontraded home good, y, with local price, p^j, measured by the flow cost of housing services. Firms produce traded and home goods out of land, capital, and labor. Within a city, factors receive the same payment in either sector. Land, L, within each city is homogeneous and immobile and is paid a city-specific price r^j. Capital, K, is supplied elastically at the price $\bar{\iota}$. Households are fully mobile, and each supplies a single unit of labor earning wage, w^j. Each owns an identical, nationally diversified portfolio of land and capital, providing nonlabor income, I; total income, $m^j \equiv I + w^j$, varies only with wages. Federal income tax payments of $\tau\left(m^j\right)$ are rebated lump sum. Cities differ in three general urban attributes: quality of life, Q^j; trade productivity, A_X^j; and home productivity, A_Y^j. These attributes depend on a vector of K individual urban amenities, $\mathbf{Z}^j = (Z_1^j, \ldots, Z_K^j)$.

This model of spatial equilibrium uses duality theory to elegantly map the three prices (r^j, w^j, p^j) one-to-one with the three attributes (Q^j, A_X^j, A_Y^j). This assumes that workers receive the same utility regardless of their location, while all firms make zero profit. Appendix A derives the following first-order approximations of these conditions, describing how prices covary with city attributes in terms of log differences from the national average, using hat notation, $\hat{x}^j = dx^j/x$. The zero-profit condition for home good producers implies that land rent differences are

$$\hat{r}^j = \frac{1}{\phi_L}\hat{p}^j - \frac{\phi_N}{\phi_L}\hat{w}^j + \frac{1}{\phi_L}\hat{A}_Y^j, \tag{1}$$

where ϕ_L and ϕ_N are the cost shares of land and labor in home production. The formula infers land rents from housing costs, $\hat{p}^j$, by first subtracting away labor costs $\phi_N \hat{w}^j$ (and home productivity $\hat{A}_Y^j$, if it is observed), and then scaling up the remainder by the inverse cost share, $1/\phi_L$. This rent measure is then used to infer land costs for traded good firms in their zero-profit condition. This condition implies that trade productivity differences are related to wages, housing costs, and home productivity by

$$\hat{A}_X^j = \frac{\theta_L}{\phi_L}\hat{p}^j + \left(\theta_N - \phi_N\frac{\theta_L}{\phi_L}\right)\hat{w}^j + \frac{\theta_L}{\phi_L}\hat{A}_Y^j, \tag{2}$$

where θ_L and θ_N are the cost shares in traded production. It is natural to assume traded production is less land intensive than home production: $\theta_L/\theta_N < \phi_L/\phi_N$. The mobility condition for households,

$$\hat{Q}^j = s_y\hat{p}^j - s_w(1-\tau')\hat{w}^j, \tag{3}$$

states that quality-of-life differences, $\hat{Q}^j$, valued as a fraction of income, are higher in areas that have high prices relative to wages, after adjusting for the marginal tax rate τ', where s_y is the effective share of income spent on home goods and s_w the share of income from labor. Adding up the value of amenities to households and firms, the total value of amenities is

$$\hat{\Omega}^j \equiv \hat{Q}^j + s_x\hat{A}_x^j + s_y\hat{A}_Y^j = \frac{s_R}{\phi_L}\hat{p}^j + \left(\tau' s_w - \frac{s_R\phi_N}{\phi_L}\right)\hat{w}^j + \frac{s_R}{\phi_L}\hat{A}_Y^j = s_R\hat{r}^j + \frac{d\tau^j}{m}, \tag{4}$$

where $s_R = s_y\phi_L + (1-s_y)\theta_L$ is the income share of land and $d\tau^j/m = \tau' s_w \hat{w}^j$ is the value of fiscal externalities from federal taxes. The total value measure reflects those externalities plus the value of local land. It accounts for nonresidential land and adjusts for labor costs in housing.

To calculate the differentials of interest from $\hat{w}^j$ and $\hat{p}^j$, I parameterize equations (1), (2), (3), and (4) according to tax rates and cost, income, and expenditure shares given by Albouy (2009) (explained in appendix B). These adjust for housing deductions and state and payroll taxes.[3] The parameterization produces the following formulas,

Differential	Full Model	Reduced Model
Land rent $\hat{r}^j$	$= 4.29(\hat{p}^j + \hat{A}_Y^j) - 2.64\hat{w}^j,$	$= \hat{p}^j$
Trade productivity $\hat{A}_X^j$	$= 0.11(\hat{p}^j + \hat{A}_Y^j) + 0.76\hat{w}^j,$	$= 0.025\hat{p}^j + 0.79\hat{w}^j$
Quality of life $\hat{Q}^j$	$= 0.32\hat{p}^j - 0.48\hat{w}^j,$	$= 0.077\hat{p}^j - 0.73\hat{w}^j$
Total amenity value $\hat{\Omega}^j$	$= 0.39(\hat{p}^j + \hat{A}_Y^j) + 0.01\hat{w}^j,$	$= 0.10\hat{p}^j$

Lacking land rent data, I impose the restriction that unobserved home productivity differences are zero, $\hat{A}_Y^j = 0$. This creates biases proportional to the housing cost coefficients, being large for land rents, small for trade productivity, and moderate for total value.

I characterize previous studies by a reduced model, which imposes $\phi_L = 1, \phi_N = 0, \hat{A}_Y^j = 0$, and $\tau' = 0$.[4] In estimating quality of life, Roback (1982) uses land values in equation (3), ignoring other input costs that affect the price of home goods, which Tolley (1974) explains are important. Subsequent analyses, such as Blomquist, Berger, and Hoehn (1988), Beeson and Eberts (1989), and Gyourko and Tracy (1989, 1991), use housing costs instead of land rents.[5] In estimating trade productivity, using these measures without the adjustments in equation (2) puts too little weight on housing costs and too much weight on wages. Even with the proper adjustments, low home productivity, $\hat{A}_Y^j$, may be confused for high trade productivity, $\hat{A}_X^j$, as long as data on actual land values are unavailable.

[3] Let τ'_F and τ'_S be the federal and state marginal tax rates, δ_F and δ_S be the deduction on home good purchases, and $\hat{w}_S^j$ and $\hat{p}_S^j$ be the wage and housing-cost differentials within state. The tax differential is then

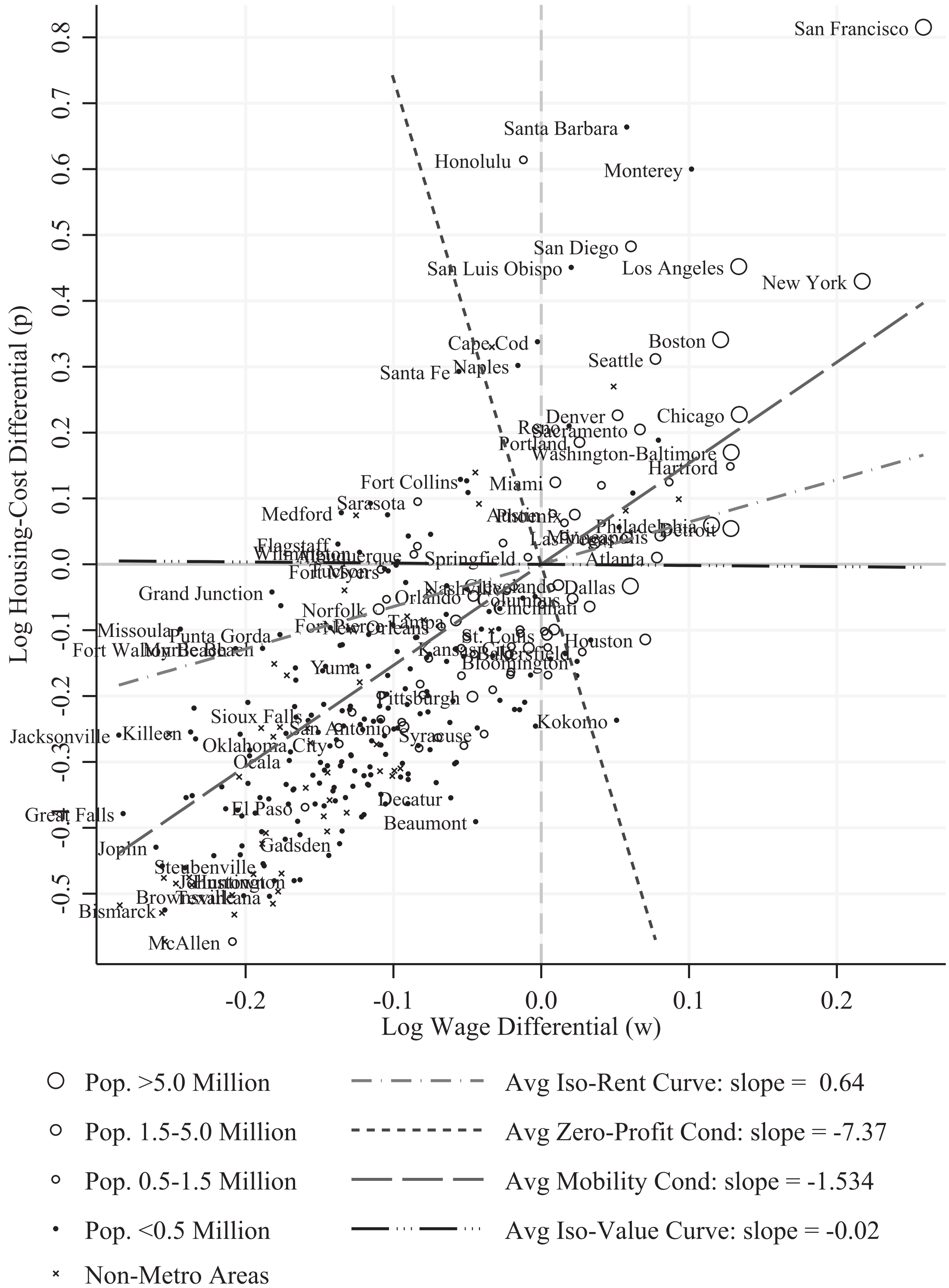
$$\frac{d\tau^j}{m} = s_w(\tau'_F\hat{w}^j + \tau'_S\hat{w}_S^j) - s_y(\delta_F\tau'_F\hat{p}^j + \delta_S\tau'_S\hat{p}_S^j). \tag{5}$$

The numbers in the text are regression based approximations. The wage differentials are modeled gross of payroll taxes paid by employers.

[4] The simplifications are closest to Beeson and Eberts (1989), although their parameterization imposes $\hat{r}^j = \hat{p}^j, \hat{A}_X = 0.028\hat{p}^j + 0.927\hat{w}^j, \hat{Q}^j = 0.073\hat{p}^j - 0.73\hat{w}^j, \hat{\Omega}^j = 0.064\hat{p}^j$.

[5] In work on intracity land rent gradients, Muth (1969) dervies an equation resembling equation (1). His insights were not used in work across cities.

FIGURE 1.—HOUSING COSTS VERSUS WAGE LEVELS ACROSS METRO AREAS, 2000



B. *Estimated Wage and Housing Cost Differentials*

I estimate wage and housing cost differentials, $(\hat{w}^j, \hat{p}^j)$ with the 5% sample of census data from the 2000 Integrated Public Use Microdata Series (IPUMS). The 276 cities are defined by 1999 OMB definitions of metropolitan statistical areas (MSAs); nonmetropolitan areas of each state are averaged together. The wage differentials are population-demeaned coefficients of indicator variables, one for each MSA, in a regression of the logarithm of hourly wages, controlling for worker characteristics. I use an analogous regression for housing costs, combining gross rents with imputed

FIGURE 2.—HOUSING COSTS AND INFERRED LAND RENTS

rents from owner-occupied units. Appendix C provides more details on the data and differential estimation.

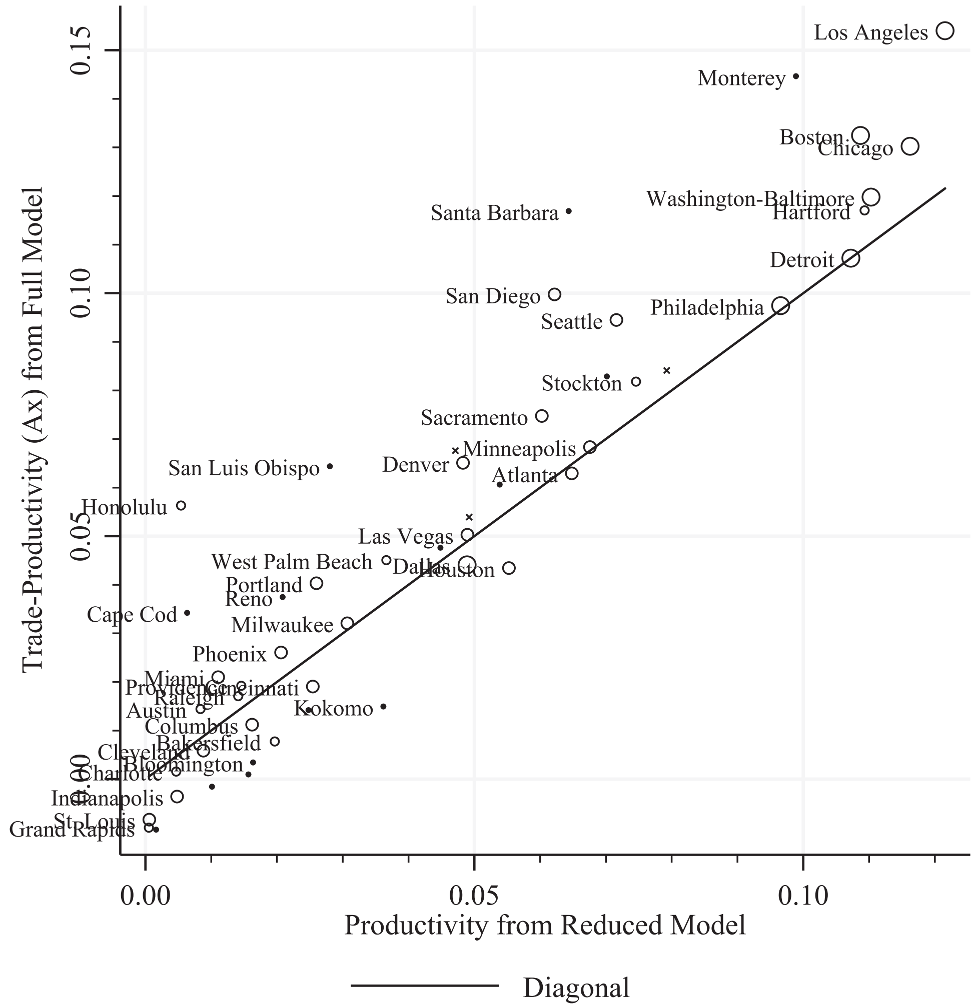
C. *Land Value, Trade Productivity, and Total Value Measures*

Figure 1 plots the wage and housing cost differentials across metro areas. It also draws four lines (or curves) describing the $(\hat{w}^j, \hat{p}^j)$ combinations, where the left-hand sides of equations (1), (2), (3), and (4) are 0 (i.e., at their national averages) with $\hat{A}_Y^j = 0$. The average iso-rent curve describes cities on equation (1) where $\hat{r} = 0$, namely, $\hat{p}^j = \phi_N \hat{w}^j$. The slope ϕ_N illustrates how home good prices rise with labor costs. The vertical distance between this line and a city's marker, scaled by $1/\phi_L$, provides that city's inferred land rent. Figure 2 plots the inferred land rent differentials against housing costs. It draws a diagonal with a slope one, and a line with slope $1/\phi_L$ that infers land results from housing costs when wages (and home productivity) are held at the national average, $\hat{w}^j = 0$. The dashed line's rotation around the origin from the diagonal illustrates the division of $\hat{p}^j$ by the cost share of land, ϕ_L. The vertical distance between the dashed line and the markers indicates the adjustments for labor costs.

The average zero-profit condition in figure 1 indicates cities with average trade productivity, $\hat{A}_X^j = 0$, according to condition (2) with $\hat{A}_Y^j = 0$. The slope, $\phi_N - \phi_L\theta_N/\theta_L$, gives the rate at which land costs, proxied through housing costs, need to fall with wage levels for firms to break even. Cities to the right of this line have above-average costs, indicating high trade productivity. The trade productivity estimates are graphed in figure 3 against those from the reduced model. The methodological refinement of putting more weight on housing costs is not enormous, but nonetheless changes the relative productivity of many cities, putting Boston in front of Washington, Denver in front of Atlanta, and Portland in front of Milwaukee.

The average mobility condition in figure 1, indicates cities with average quality of life, $\hat{Q}^j = 0$ in equation (3). The positive slope of $(1-\tau')s_w/s_y$ indicates how local costs increase with wage levels to keep real income levels from rising.

FIGURE 3.—TRADE PRODUCTIVITY ESTIMATES COMPARED



Households in cities above this line pay a premium relative to the wage level, which implies that their quality of life is above average (Albouy, 2008).

The average iso-value curve, equation (4) with $\hat{\Omega}^j = 0$, traces out cities with average total amenity values. The line is quite flat, as properly scaled housing costs indicate them well. The term for wages, $\tau' s_w - s_R \phi_N/\phi_L$—reflecting tax externalities net of labor cost adjustments—is almost 0 under the parameterization.

Figure 4 graphs the quality-of-life and trade productivity estimates, transforming figure 1 through a change of coordinate systems. The average mobility condition provides the horizontal axis for trade productivity, while the average zero-profit condition provides the vertical axis for quality of life. The axes are scaled so that equidistant attribute differences have equal value.

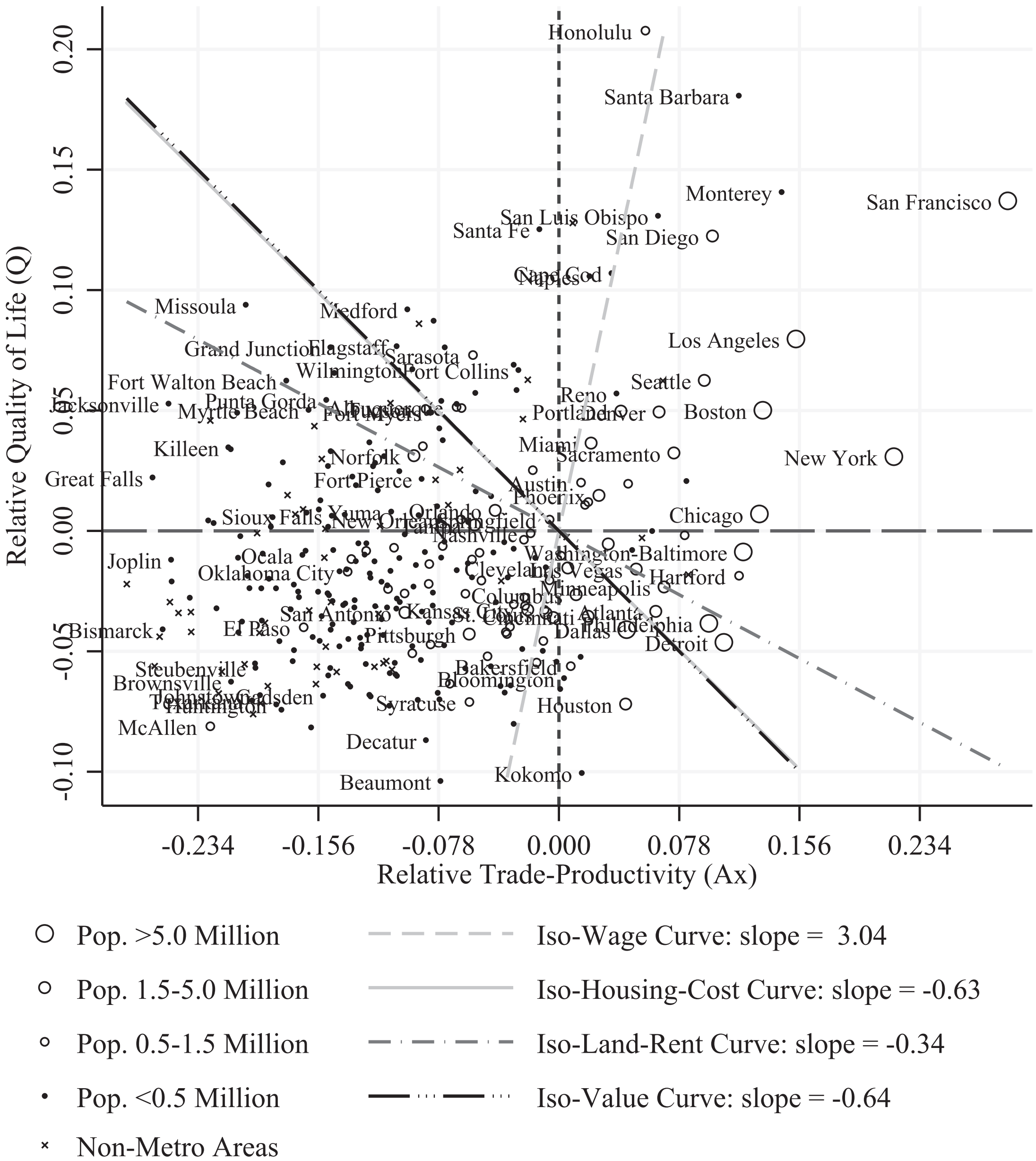
D. The Most Trade-Productive and Valuable Cities

Table 1 lists the estimated differentials for select cities, along with averages by census division and metro area size. Table 2 presents the top twenty rankings for trade productivity, quality of life, and total amenity value. Appendix table A1 presents a complete list of metro areas and nonmetro areas; appendix table A2 lists values by state.

The relationship between trade productivity and metro population, usually attributed to agglomeration economies, is illustrated in figure 5. The most trade-productive metro area is San Francisco, only the fifth largest (New York, the largest, is second). This exceptional productivity is ostensibly due to unparalleled innovations and knowledge spillover around Silicon Valley (Saxenian, 1994; Florida, 2008). The top ten most productive cities include five other large metros—Los Angeles, Boston, Chicago, Washington, and Detroit—and three small metros—Monterey, Santa Barbara, and Hartford, which are very close to much larger metros. The least productive metro, Great Falls, Montana, is remote, as are the two least productive states, Mississippi and North Dakota.

Combining quality of life and trade productivity, the most valuable metropolis is San Francisco. It is followed by six other Pacific cities—Santa Barbara, Honolulu, Monterey,

FIGURE 4.—ESTIMATED TRADE PRODUCTIVITY AND QUALITY OF LIFE, 2000



Axes are scaled for trade productivity and quality-of-life differences to be of equal value.

San Diego, Los Angeles, and San Luis Obispo—that offer exceptional quality of life and fairly high productivity. Next are large, highly productive, and somewhat amenable metros—New York, Boston, Seattle, Denver, Chicago, Portland, and Washington—and resort-like yet economically vibrant areas like Cape Cod, Naples, Santa Fe, and Reno. Further down the list are smaller cities in less crowded areas, such as in Arkansas, Oklahoma, West Virginia, Mississippi, and the Dakotas. The positive relationship between total amenity value and population size in figure 6 comes from both the strong relationship between size and productivity and the weak relationship between size and quality of life (Albouy, 2008). The estimates imply that the highest-value metro area, San Francisco, has land on average 100 times more valuable per acre than the lowest-value land in McAllen, Texas.

E. *Explaining the Variation of Prices across Cities*

The theory of spatial equilibrium asserts that price variation across cities reflects differences in quality of life and productivity. A variance decomposition of the total value of amenities yields

$$\mathrm{var}(\hat{\Omega}^j) = \mathrm{var}(\hat{Q}^j) + s_x^2 \mathrm{var}(\hat{A}_X^j) + 2 s_x \mathrm{cov}(\hat{Q}^j, \hat{A}_X^j).$$

TABLE 1.—WAGE, HOUSING COST, LAND RENT, QUALITY-OF-LIFE, PRODUCTIVITY, FEDERAL TAX, AND TOTAL AMENITY VALUE DIFFERENTIALS, 2000

		Observable Differentials			Amenity Type or Attribute			
	Population	Housing Costs (p)	Wages (w)	Inferred Land Rent (r)	Trade-Productivity (A_X)	Quality of Life (Q)	Federal Tax Payment (dτ/m)	Total Amenity Value (Ω)
Main city in MSA/CMSA								
San Francisco, CA	7,039,362	0.82	0.26	2.78	0.29	0.14	0.05	0.32
Santa Barbara, CA	399,347	0.66	0.06	2.69	0.12	0.18	−0.01	0.26
Honolulu, HI	876,156	0.61	−0.01	2.66	0.06	0.21	−0.02	0.24
Los Angeles, CA	16,373,645	0.45	0.13	1.57	0.15	0.08	0.02	0.18
New York, NY	21,199,865	0.43	0.22	1.24	0.22	0.03	0.05	0.17
Boston, MA	5,819,100	0.34	0.12	1.13	0.13	0.05	0.02	0.13
Seattle, WA	3,554,760	0.31	0.08	1.12	0.09	0.06	0.01	0.12
Chicago, IL	9,157,540	0.23	0.13	0.61	0.13	0.01	0.03	0.09
Washington, DC–Baltimore	7,608,070	0.17	0.13	0.37	0.12	−0.01	0.03	0.07
Miami, FL	3,876,380	0.12	0.01	0.51	0.02	0.04	0.00	0.05
Phoenix, AZ	3,251,876	0.08	0.02	0.26	0.03	0.01	0.01	0.03
Philadelphia, PA	6,188,463	0.06	0.12	−0.06	0.10	−0.04	0.03	0.02
Detroit, MI	5,456,428	0.05	0.13	−0.12	0.11	−0.05	0.03	0.02
Minneapolis, MN	2,968,806	0.04	0.08	−0.04	0.07	−0.02	0.02	0.02
Atlanta, GA	4,112,198	0.01	0.08	−0.17	0.06	−0.03	0.02	0.01
Cleveland, OH	2,945,831	−0.03	0.01	−0.17	0.01	−0.02	0.01	−0.01
Dallas, TX	5,221,801	−0.03	0.06	−0.31	0.04	−0.04	0.02	−0.01
Tampa, FL	2,395,997	−0.09	−0.06	−0.21	−0.05	0.00	−0.01	−0.03
St. Louis, MO	2,603,607	−0.11	0.00	−0.47	−0.01	−0.03	0.01	−0.04
Houston, TX	4,669,571	−0.11	0.07	−0.68	0.04	−0.07	0.02	−0.04
Kansas City, MO	1,776,062	−0.13	−0.01	−0.52	−0.02	−0.03	0.01	−0.05
Pittsburgh, PA	2,358,695	−0.20	−0.05	−0.73	−0.06	−0.04	−0.01	−0.08
San Antonio, TX	1,592,383	−0.25	−0.09	−0.80	−0.10	−0.03	−0.02	−0.10
El Paso, TX	679,622	−0.37	−0.16	−1.14	−0.17	−0.04	−0.03	−0.15
Huntington, WV	315,538	−0.48	−0.17	−1.60	−0.18	−0.07	−0.03	−0.19
Johnstown, PA	232,621	−0.48	−0.18	−1.56	−0.19	−0.07	−0.04	−0.19
Texarkana, TX	129,749	−0.50	−0.18	−1.66	−0.20	−0.07	−0.03	−0.20
Brownsville, TX	335,227	−0.50	−0.20	−1.60	−0.21	−0.06	−0.04	−0.20
Bismarck, ND	94,719	−0.52	−0.25	−1.55	−0.26	−0.04	−0.05	−0.21
McAllen, TX	569,463	−0.57	−0.21	−1.88	−0.23	−0.08	−0.04	−0.23
Census division								
Pacific	45,025,637	0.39	0.10	1.41	0.12	0.08	0.01	0.15
New England	14,016,468	0.20	0.07	0.68	0.07	0.03	0.01	0.08
Middle Atlantic	39,671,861	0.13	0.10	0.31	0.09	−0.01	0.02	0.05
Mountain	18,267,964	0.00	−0.05	0.14	−0.04	0.03	−0.01	0.00
East North Central	45,155,037	−0.07	0.01	−0.34	0.00	−0.03	0.01	−0.03
South Atlantic	51,769,160	−0.08	−0.04	−0.24	−0.04	−0.01	−0.01	−0.03
West South Central	31,444,850	−0.25	−0.08	−0.84	−0.09	−0.04	−0.01	−0.10
West North Central	19,237,739	−0.26	−0.11	−0.82	−0.11	−0.03	−0.02	−0.10
East South Central	17,022,810	−0.32	−0.12	−1.05	−0.13	−0.04	−0.02	−0.13
MSA population								
MSA, population > 5 million	84,064,274	0.33	0.16	1.00	0.16	0.03	0.03	0.13
MSA, population 1.5–4.9 million	57,157,386	0.04	0.02	0.09	0.02	0.00	0.01	0.02
MSA, population 0.5–1.4 million	42,435,508	−0.09	−0.04	−0.27	−0.04	−0.01	−0.01	−0.03
MSA, population < 0.5 million	42,324,511	−0.18	−0.10	−0.51	−0.10	−0.01	−0.02	−0.07
Non-MSA areas	55,440,227	−0.34	−0.16	−1.02	−0.16	−0.03	−0.03	−0.14
	Total				Standard Deviations			
United States	281,421,906	0.13	0.31	1.03	0.14	0.05	0.03	0.12

Wage and housing price data are taken from the U.S. Census 2000 IPUMS. Wage differentials are based on the average logarithm of hourly wages for full-time workers ages 25 to 55. Housing cost differentials are based on the average logarithm of rents and housing prices. Adjusted differentials are the city-fixed effects from individual-level regressions on extended sets of worker and housing covariates. See appendix C1, for more details. The inferred land rent, quality-of-life, trade productivity, and total amenity variables are estimated from the equations in section IIC, using the calibration in table A1, with additional adjustments for housing deductions and state taxes, described in note 3.

The relative importance of each attribute is determined by its variance term: if one attribute is made constant, then the covariance term collapses to 0, and only the variance of the other attribute remains. The model implies similar decomposition formulas for wages, housing costs, and land rents. These statistical decompositions provide an interesting accounting of equilibrium relationships but must be treated cautiously, as attributes may be endogenous. For example, high quality of life may raise population, leading to endogenous trade productivity gains from agglomeration.

Table 3 displays the decompositions for all prices. Overall, trade productivity accounts for a greater fraction of amenity value than quality of life. This can actually be seen in figure 4. Quality of life has a greater influence on land rents by a slight margin. Variations in nominal wages, as well as federal tax burdens—are driven mostly by trade

TABLE 2.—CENSUS METROPOLITAN AREA RANKINGS, 2000

	Trade Productivity	Quality of Life	Total Value
1	San Francisco	Honolulu	San Francisco
2	New York	Santa Barbara	Santa Barbara
3	Los Angeles	Monterey	Honolulu
4	Monterey	San Francisco	Monterey
5	Boston	San Luis Obispo	San Diego
6	Chicago	Santa Fe	Los Angeles
7	Washington-Baltimore	San Diego	San Luis Obispo
8	Hartford	Cape Cod	New York
9	Santa Barbara	Naples	Boston
10	Detroit	Missoula	Cape Cod
11	San Diego	Medford	Seattle
12	Philadelphia	Eugene	Naples
13	Seattle	Los Angeles	Santa Fe
14	Anchorage	Flagstaff	Denver
15	Stockton	Grand Junction	Chicago
16	Sacramento	Corvalis	Reno
17	Minneapolis	Sarasota	Sacramento
18	Denver	Bellingham	Portland
19	San Luis Obispo	Wilmington	Anchorage
20	Atlanta	Fort Collins	Washington-Baltimore

Rankings based from of data in table A1, which contains the full MSA/CMSA names. The quality-of-life ranking is originally from Albouy (2008).

productivity, contradicting Roback's (1982) claim that nominal wages vary more from quality of life differences. Housing cost variation is also driven mainly by trade productivity.

III. Individual Predictors of Amenity Value

Researchers commonly use the spatial equilibrium model to estimate the value of individual amenities $(Z_1^j, .., Z_K^j)$ through regression methods. I illustrate the potential impact of amenities on the measures derived above using seven mutually consistent linear regressions:

$$v^j = \sum_k Z_k^j \pi_{kv} + \varepsilon_v^j,$$

where $v \in \{\hat{w}, \hat{p}, \hat{A}_X, \hat{Q}, \hat{\Omega}, s_R\hat{r}, d\tau/m\}$. The amenity coefficients, π_{kv}, express the effect of a 1 unit increase in an amenity, and share the same interrelationships as their corresponding regressors, v. Cross-sectional regressions of this kind are subject to well-known empirical caveats (see Gyourko, Saiz, & Summers, 2008), including omitted variables, simultaneity, and multicollinearity. Estimates should not be interpreted causally.

The regressors, listed in table 4 and detailed in appendix C, include both natural amenities, relating to climate and geography, and "artificial" ones, relating to local inhabitants, including metropolitan population and the share of the adults with college degrees. These are not true amenities, but likely determine amenities that are key to local trade productivity, engendering agglomeration economies. The Wharton Residential Land-Use Regulatory Index (WRLURI) of Gyourko et al. (2008) controls for unobserved housing productivity differences. The coefficients are grouped, with effects on observed data $\hat{w}$ and $\hat{p}$ in columns 1 and 2; amenities to households and firms, $\hat{Q}$ and $\hat{A}_X$, in columns 3 and 4; the combined value, $\hat{\Omega}$, in column 5; and their split between land

FIGURE 5.—TRADE PRODUCTIVITY AND POPULATION SIZE

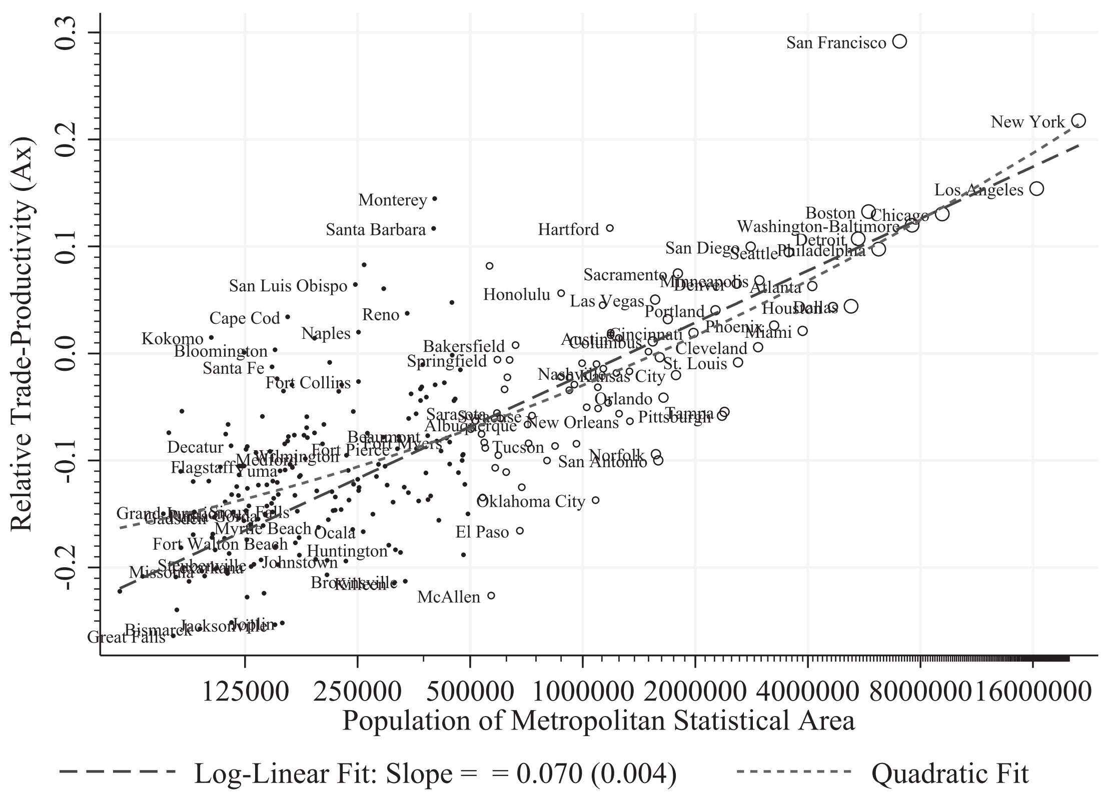


FIGURE 6.—TOTAL VALUE OF AMENITIES AND POPULATION SIZE

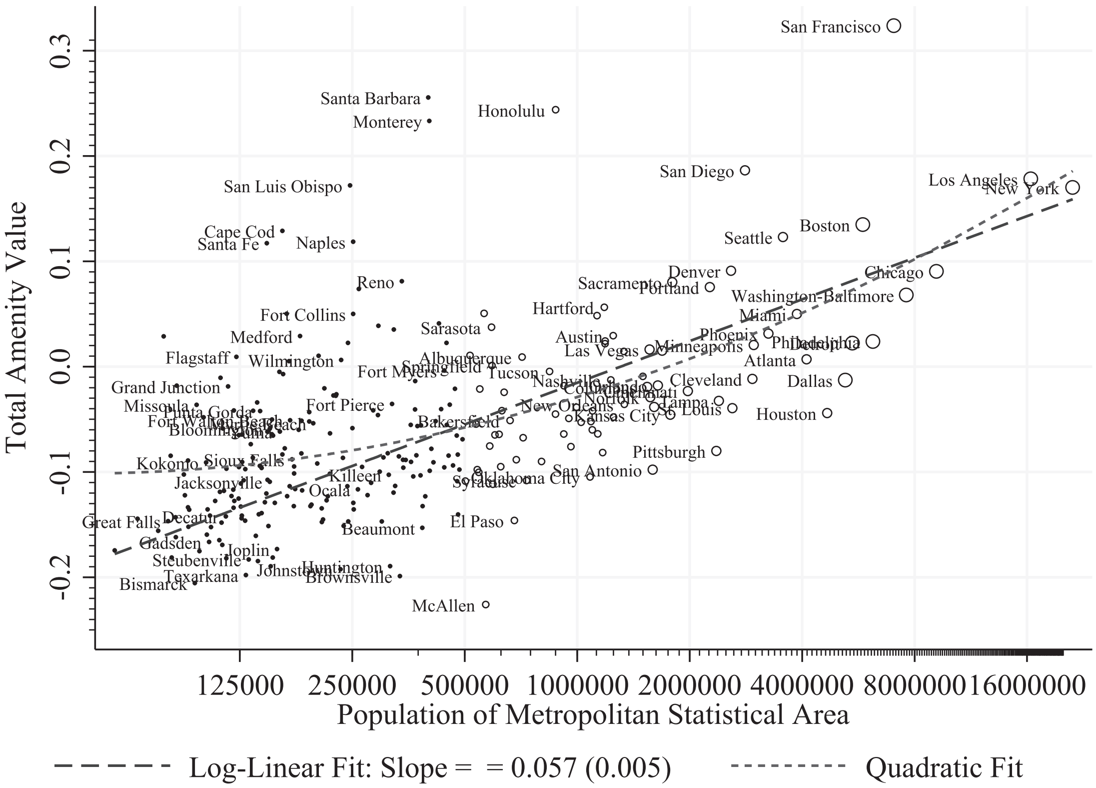


TABLE 3.—VARIANCE DECOMPOSITION OF TRADE PRODUCTIVITY AND QUALITY-OF-LIFE EFFECTS ON PRICE DIFFERENTIALS ACROSS METROPOLITAN AREAS, 2000

		Fraction of Variance Explained by		
	Variance (1)	Trade Productivity (3)	Quality of Life (2)	Covariance (4)
Inferred land rents	1.056	0.356	0.282	0.361
Wages	0.019	0.018	1.146	−0.164
Housing costs	0.098	0.177	0.488	0.335
Tax differential	0.001	0.113	1.318	−0.440
Total value	0.015	0.174	0.492	0.334

Variances are calculated across 276 metro areas and 49 nonmetro areas by state, weighted by population. Based on the model described in the text with federal taxes.

values and federal tax revenues, $s_R\hat{r}$ and $d\tau/m$, in columns 6 and 7.

The relationships between the natural amenities and trade productivity, new to the literature, reveal interesting patterns. Sunshine, coastal proximity, and low levels of heat (minus cooling degree days) appear to be amenities to firms, as well as to households. The relationship between latitude and productivity evokes findings in Hall and Jones (1999) that social capital is higher in northern areas. The positive estimate for coastal proximity may reflect savings in transportation costs; the negative effect of heat is more surprising but could have a physiological basis. Long ago, Montesquieu (1748) hypothesized that extreme heat inhibits the ability of humans to work. Recent studies find that both indoor and outdoor workers are less productive in warm temperatures ("Hot or Cold," 2008). Because most workplaces today are indoors with air conditioning, these estimates need further study.

The elasticity of wages with respect to population is estimated to be 5.2%, well inside the range surveyed by Rosenthal and Strange (2004) and Melo, Graham, and Noland (2009), despite concerns of endogenous migration. The elasticity of housing costs to population is 6.8%. Adding the wage and housing-cost elasticities with the proper weights, the elasticity for trade productivity is 4.8%. Doubling a city's population (an increase of 0.69 log points) increases the total value of its amenities by 1.8% of income, of which five-ninths is captured in local land values and the rest in federal taxes.

The estimates in the second row associate a 10 percentage point increase in college-educated adults (1.75 standard deviations) with 4 percentage point increases in wages and productivity and a 3 percentage point increase in quality of life. While these estimates may reflect selective migration, they resemble those of Moretti (2004) and Shapiro (2006), who use instrumental variable methods. In total, a 10% increase in college share is associated with a 5.8% increase in the total value of amenities, of which federal taxes expropriate one-tenth.

The coefficients of determination (R^2) reveal that this parsimonious set of amenities explains about 90% of the variations in trade productivity, land rents, and total amenity value. Population, education, sunshine, coastal proximity, average slope, mild temperatures, and northern latitude are

TABLE 4.—THE RELATIONSHIP BETWEEN INDIVIDUAL AMENITIES AND HOUSING COSTS, WAGES, QUALITY OF LIFE, TRADE-PRODUCTIVITY, LAND RENTS, FEDERAL TAXES, AND TOTAL AMENITY VALUES, 2000

			Observables		Amenity Type			Capitalization into	
	Mean	Standard Deviation	Housing Cost (1)	Wage (2)	Trade-Productivity (3)	Quality of Life (4)	Total Amenity Value (5)	Local Land Rents (6)	Federal Tax Payment (7)
Logarithm of metro population	14.67	1.48	0.068***	0.052***	0.048***	−0.004*	0.027***	0.015***	0.012***
			(0.008)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)	(0.001)
Percent of population with college degree	0.26	0.06	1.445***	0.367***	0.445***	0.295***	0.579***	0.519***	0.061**
			(0.274)	(0.114)	(0.113)	(0.064)	(0.110)	(0.098)	(0.028)
Whartron Residential Land-Use Regulatory Index (WRLURI)	0.00	1.00	0.005	−0.002	−0.001	0.003	0.002	0.003	−0.001
			(0.010)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.001)
Minus heating degree days (1,000s, base 65—extreme cold)	−4.18	2.12	0.035***	0.004	0.007	0.010***	0.014***	0.014***	0.000
			(0.011)	(0.006)	(0.005)	(0.004)	(0.004)	(0.004)	(0.002)
Minus Cooling Degree Days (1,000s, base 65—exreme heat)	−1.33	0.92	0.111***	0.019	0.027**	0.026***	0.043***	0.043***	0.001
			(0.021)	(0.012)	(0.011)	(0.006)	(0.008)	(0.007)	(0.003)
Annual sunshine (out of percent possible)	0.61	0.08	1.157***	0.260***	0.329***	0.247***	0.457***	0.424***	0.033*
			(0.134)	(0.075)	(0.068)	(0.042)	(0.054)	(0.051)	(0.019)
Log inverse distance to coast (ocean or Great Lake)	−3.76	1.41	0.067***	0.015***	0.019***	0.013***	0.026***	0.025***	0.001
			(0.008)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)	(0.001)
Average slope of land (percent)	1.56	1.47	0.021***	−0.003	0.000	0.008***	0.008***	0.010***	−0.002***
			(0.005)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Latitude (degrees)	37.57	4.94	0.007**	0.005*	0.005**	0.000	0.003**	0.002	0.001*
			(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)
Constant			−1.766	−1.054	−1.022	−0.061	−0.715	−0.467	−0.248
			(0.167)	(0.098)	(0.088)	(0.051)	(0.066)	(0.062)	(0.025)
Coefficient of determination (R^2)			0.91	0.88	0.90	0.76	0.91	0.89	0.82

There are 274 observations with complete data. Robust standard errors shown in parentheses. $^*p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$. Regressions weighted by metro population. Amenity variables are described in section III and Appendix C2. The coefficients on local land rents are multiplied by the factor $s_R = 0.10$ to be compatible with total amenity value.

all strongly associated with total amenity value. The results also imply that households are taxed for living in cities that are large, flat, sunny, northern, and educated.

Estimates based on the reduced model (characterizing previous research) are not shown, but produce different results in both magnitude and significance. Land rents effects diverge from those for housing costs when the federal tax differential matters, particularly for latitude. Reduced-model estimates of trade productivity, based almost entirely on wages, imply lower estimates for education, sunshine, and coastal proximity and would not be significant for extreme heat. Many researchers would also likely ignore impacts on nonresidential land, which the total value estimates include.

IV. Conclusion

The analysis in this paper highlights the importance of considering taxes and housing, separately from land, when determining the value of local productivity and amenities in general. Wage and housing cost data appear to be largely adequate for inferring local levels of productivity in tradables, and the resulting measures appear sensible. Statistically, local labor demand factors (productivity) are more important in determining local wages and housing costs than supply factors (quality of life). Furthermore, a limited number of variables explain over seven-eighths of the variation in wages, trade productivity, and total amenity value. Extensions of this model could do more with internal structure, population heterogeneity, and dynamics. Nevertheless, a clean and intuitive framework for understanding cross-sectional variation of widely available data sources is informative, easily applicable (see Albouy et al. 2013, for an application of this model to Canada), and useful for future work.

REFERENCES

Albouy, David, "Are Big Cities Bad Places to Live? Estimating Quality of Life across Metropolitan Areas," NBER working paper 14472 (2008).

——— "The Unequal Geographic Burden of Federal Taxation," *Journal of Political Economy* 117 (2009), 635–667.

Albouy, David, Fernando Leibovici, and Casey Warman, "Quality of Life, Firm Productivity, and the Value of Amenities across Canadian Cities," *Canadian Journal of Economics* 46 (2013), 379–411.

Albouy, David, and Gabriel Ehrlich, "Metropolitan Land Values and Housing Productivity," NBER working paper 18110 (2012).

Albouy, David, and Bryan Stuart, "Urban Population and Amenities: The Neoclassical Model of Location," NBER working paper 19919 (2014).

Beeson, Patricia E., and Randall W. Eberts, "Identifying Productivity and Amenity Effects in Interurban Wage Differentials," this REVIEW 71 (1989), 443–452.

Blomquist, Glenn C., Mark C. Berger, and John P. Hoehn, "New Estimates of Quality of Life in Urban Areas," *American Economic Review* 78 (1988), 89–107.

Carliner, Michael, "New Home Cost Components," *Housing Economics* 51 (2003), 7–11.

Case, Karl E., "The Value of Land in the United States: 1975–2005," in Gregory K. Ingram, Yu-Hung Hong, eds., *Proceedings of the 2006 Land Policy Conference: Land Policies and Their Outcomes* (Cambridge, MA: Lincoln Institute of Land Policy Press, 2007).

Chen, Yu, and Stuart Rosenthal, "Local Amenities and Life-Cycle Migration: Do People Move for Jobs or Fun?" *Journal of Urban Economics* 64 (2008), 519–537.

Dekle, Robert, and Jonathan Eaton, "Agglomeration and Land Rents: Evidence from the Prefectures," *Journal of Urban Economics* 46 (1999), 200–214.

Florida, Richard, *Who's Your City? How the Creative Economy Is Making Where You Live the Most Important Decision of Your Life* (New York: Basic Books, 2008).

Gabriel, Stuart A., and Stuart S. Rosenthal, "Quality of the Business Environment versus Quality of Life: Do Firms and Households Like the Same Cities?" this REVIEW 86 (2004), 548–444.

Glaeser, Edward L., and Albert Saiz, "The Rise of the Skilled City," Brookings-Wharton Papers on Urban Affairs (2004).

Gyourko, Joseph, Matthew Kahn, and Joseph Tracy, "Quality of Life and Environmental Comparisons," in E. Mills and P. Cheshire, eds., *Handbook of Regional and Urban Economics*, vol. 3 (Amsterdam: North-Holland, 1999).

Gyourko, Joseph, Albert Saiz, and Anita Summers, "New Measure of the Local Regulatory Environment for Housing Markets: The Wharton Residential Land Use Regulatory Index," *Urban Studies* 45 (2008), 693–729.

Gyourko, Joseph, and Joseph Tracy, "The Importance of Local Fiscal Conditions in Analyzing Local Labor Markets," *Journal of Political Economy* 97 (1989), 1208–1231.

——— "The Structure of Local Public Finance and the Quality of Life," *Journal of Political Economy* 99 (1991), 774–806.

Haughwout, Andrew, "Public Infrastructure Investments, Productivity and Welfare in Fixed Geographic Areas," *Journal of Public Economics* 83 (2002), 405–428.

Hall, Robert, and Charles Jones, "Why Do Some Countries Produce So Much More Output per Worker Than Others?" *Quarterly Journal of Economics* 114 (1999), 83–116.

"Hot or Cold, Weather Plays a Big Role in Job Productivity," *Engineering News Record*, August 11, 2008, p. 56.

Melo, Patricia C., Daniel J. Graham, and Robert B. Noland, "A Meta-Analysis of Estimates of Urban Agglomeration Economies," *Regional Science and Urban Economics* 39 (2009), 332–342.

Mills, Edwin S., "The Economic Consequences of a Land Tax," in Dick Netzer, ed., *Land Value Taxation: Can It and Will It Work Today?* (Cambridge, MA: Lincoln Institute of Land Policy Press, 1998).

Montesquieu, Baron de, *De l'esprit des lois* (1748).

Moretti, Enrico, "Workers' Education, Spillovers and Productivity: Evidence from Plant-Level Production Functions," *American Economic Review* 94 (2004), 656–690.

Muth, Richard F., *Cities and Housing* (Chicago: University of Chicago Press, 1969).

Rappaport, Jordan, "A Productivity Model of City Crowdedness," *Journal of Urban Economics* 65 (2008a), 715–722.

——— "Consumption Amenities and City Population Density," *Regional Science and Urban Economics* 38 (2008b), 533–552.

Rauch, James, "Productivity Gains from Geographic Concentration of Human Capital," *Journal of Urban Economics* 34 (1993), 380–400.

Roback, Jennifer, "Wages, Rents, and the Quality of Life," *Journal of Political Economy* 90 (1982), 1257–1278.

Rosen, Sherwin, "Wages-Based Indexes of Urban Quality of Life," in P. Mieszkowski and M. Straszheim, eds., *Current Issues in Urban Economics* (Baltimore, MD: Johns Hopkins University Press, 1979).

Rosenthal, Stuart S., and William C. Strange, "Evidence on the Nature and Sources of Agglomeration Economies" (pp. 2119–2171), in J. V. Henderson and J.-F. Thisse, eds., *Handbook of Regional and Urban Economics*, vol. 4 (Amsterdam: North Holland, 2004).

Saxenian, Annalee, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128* (Cambridge, MA: Harvard University Press, 1994).

Shapiro, Jesse M., "Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital," this REVIEW 88 (2006), 324–335.

Tabuchi, Takatoshi, and Atsushi Yoshida, "Separating Urban Agglomeration Economies in Consumption and Production," *Journal of Urban Economics* 48 (2000), 70–84.

Tolley, George, "The Welfare Economics of City Bigness," *Journal of Urban Economics* 1 (1974), 324–345.