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David Albouy

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ABSTRACT

This article examines and quantifies the relationship between local amenities and prices in an equilibrium model, demonstrating the role of non-traded goods and federal taxes. I derive formulae using factor shares to infer local land rents, productivity, and the total value of amenities from wage and housing-cost data, applying them to U.S. metropolitan areas. The formulae address how ñwage multipliers,ò heterogeneity in non-traded firm productivity, and tax-driven amenity value expropriation affect price capitalization. Wage and housing-cost variations across metros are driven more by productivity than quality-of-life differences. The most productive and valuable cities are typically coastal, sunny, mild, educated and large.

David Albouy
Department of Economics
University of Illinois at Urbana-Champaign
214 David Kinley Hall
Urbana, IL 61801-3606
and NBER
albouy@illinois.edu

1 Introduction

Standard economic theory predicts that land rents will completely reflect, or "capitalize," differences in the value of local amenities when all other factors of production are mobile (see, e.g. Ricardo 1817, George 1879, Tiebout 1956, Arnott and Stiglitz 1979). This prediction forms the basis of hedonic methods used to value individual amenities, such as clean air or public infrastructure (see, e.g. Oates 1969). In the model of Rosen (1979) and Roback (1982), the degree to which amenities raise the productivity of firms or improve the the quality of life of households may be identified using local wage levels in addition to rents.

This article examines how local prices, including land rents, depend on various types of amenities in an intercity Rosen-Roback framework in far greater depth than previous research; it is also the first to quantify this dependence in a parameterized simulation. Furthermore, I demonstrate both analytically and graphically how to use widely-available data on wages and housing costs to infer land rents, create improved measures of local productivity, and separate how firms and households value amenities differently. I apply the model to data on U.S. metropolitan areas to calculate the aggregate value of local amenities to firms and households in each city, and consider the relationship of these values to individual amenities, both natural and man-made.

The inter-city Rosen-Roback framework used here features two enhancements over commonly-used simpler models: federal taxes, and a production sector for "home" goods, such as housing, which are not tradable across cities. Federal taxes increase tax burdens in places where wages are high and housing prices are low (Albouy 2009), causing feedback effects on capitalization processes that have yet to be explained fully. Robackôs popular article (1982) briefly presents a tax-free model with home goods, but she does little to explain or quantify her abstract solutions. Her empirical exercise ignores local productivity, and uses a simpler model, equating land with housing, to estimate quality-of-life differences only, which the analysis here implies is invalid. This is largely because home-good production requires local labor, creating "wage multiplier" effects that alter how amenity values are capitalized into housing costs and wages (Tolley 1974), but not land rents. Such a distinction is important as housing costs are often substituted for difficult-to-find land rents ï see Mills (1998) and Case (2007).[1]

The model also distinguishes the local productivity of firms producing traded goods from those producing non-traded goods, i.e., "trade-productivity" from "home productivity." One challenge raised here is how amenities that improve trade-productivity increase wages and non-traded prices, while amenities that improve home-productivity have the opposite effect. Consequently, without land-rent data, cities good at producing tradables cannot be identified from cities bad at producing non-tradables, unless further restrictions are imposed. Since non-traded production is much more land-intensive, typical data on wages and housing costs should be adequate for identifying trade-productivity, but inadequate for identifying home-productivity. The simulation also reveals that wage levels reflect only a quarter of the value of household (or "quality-of-life") amenities, but one-and-a-quarter the value of trade-productive amenities. Land values capitalize amenity values for households by twice as much as those for firms producing traded goods due to federal-tax effects. On the other hand, through various effects, housing costs reflect roughly ninety percent of the value of both quality-of-life and trade-productive amenities.

To estimate local trade-productivity, the empirical application assumes that home-productivity is constant across cities ï which is implicit in related applications ï Beeson and Eberts (1989), Gabriel and Rosenthal (2004), and Shapiro (2006) ï which equate land with housing. The improved trade-productivity estimates are based on how high local wages and housing costs are, putting less weight on the former and more on the latter than previous measures. Adding the values of local productivity and quality-of-life, from Albouy (2008), produces a novel measure of ñtotal amenity value," which is divided between local land rents and federally expropriated taxes. The application ranks cities by their trade-productivity and total amenity value, with San Francisco topping both lists. Furthermore, a variance decomposition suggests that trade-productivity explains wage and housing-cost differences more than quality-of-life.

[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. In general, it is more appropriate to think of prices here as referring to flow rather than asset values. "Capitalization" technically refers to land and housing prices, as opposed to rents, although in practice it refers to how amenities affect the present value of the stream of rents, with little concern for how amenities might affect discounting.

The illustrative empirical analysis on the value of individual amenities 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 in trade-productivity and total amenity value. Simple cross-sectional hedonic methods produce estimates of the impact of population and education levels on productivity consistent with more sophisticated analyses (e.g. Moretti 2004, Rosenthal and Strange 2004). Measuring their value per acre, the most productive and valuable cities are not only large and educated, but also mild, sunny, and coastal.[2]

This article is part of a larger body of research applying and refining the Rosen-Roback model with local-good production and federal taxes, first introduced in Albouy (2009). As the title suggests, the article here presents new and unique results about identifying local productivity, inferring land rents, and describing how amenity values are capitalized into local prices. The Albouy (2009) article emphasizes how federal taxes distort local prices and location decisions, while the analysis below describes how taxes affect the capitalization of amenities, using intuitive formulae and quantifying the amounts. It also estimates what individual amenities are correlated with tax payments. Albouy (2008) presents quality-of-life estimates that are complementary to local productivity in accounting for the total value of amenities. By focusing on households and ignoring land and production, the paper says nothing on capitalization. Albouy and Stuart (2013) build from the analysis below and uses the quality-of-life and trade-productivity estimates to predict population densities in U.S. metropolitan areas with surprising accuracy. Albouy and Ehrlich (2012) also build from the analysis below: they construct a land-value index using recent market transactions data, and use it to estimate a cost function for housing and measure differences in housing productivity.[3]

[2]Articles that consider the local productivity of firms with only the tradeable 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 that accounts for locally produced goods, although he restricts home-productivity and trade-productivity to be equal. His model excludes taxes. It is used for simulation purposes, without analytical solutions or applications to data.

[3]The implications of the findings in this work are discussed section 4.5.

2 The Relationship between Amenities and Equilibrium Prices

2.1 Model Set-up and Notation

I model a system of cities, indexed by j, each small relative to the national economy. Cities share a homogenous population of mobile households. Households consume a numeraire traded good, x, and a non-traded "home" good, y, with local price, p^j. The price of home goods is measured by the flow cost of housing services.[4]

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 homogenous and immobile. Land is paid a city-specific price r^j, which determine its supply, $L^j(r^j)$. Capital, K, is fully mobile across cities and is paid the price $\bar{\imath}$ everywhere. The supply of capital in each city, K^j, is perfectly elastic at this price, while the national level of capital may be fixed or free. Households, N, are fully mobile, have identical tastes and endowments, and each supplies a single unit of labor. Because households care about local prices and quality of life, wages, w^j, may vary across cities. Nationally, the total number of households is $N^{TOT} = \sum_j N^j$.

Households own identical, nationally-diversified, portfolios of land and capital. Payments to these factors are rebated lump sum: $R = \frac{1}{N_{TOT}} \sum_j r^j L^j$ from land and $I = \frac{1}{N_{TOT}} \sum_j \bar{\imath} K^j$ from capital. Total income, $m^j \equiv R + I + w^j$, varies across cities only as wages vary.[5] Households pay a federal income tax of $\tau(m)$, which the federal government redistributes in uniform lump-sum payments. As deductions and state taxes play a minor role, they are discussed in Appendix A.

Cities differ in three general "urban attributes:" (i) quality of life, Q^j; (ii) trade-productivity, A_X^j; and (iii) home-productivity, A_Y^j. These attributes depend on a vector of unspecified city amenities, $\mathbf{Z}^j = (Z_1^j, ..., Z_K^j)$, through functions $Q^j = \widetilde{Q}(\mathbf{Z}^j)$, $A_X^j = \widetilde{A_X}(\mathbf{Z}^j)$, and $A_Y^j = \widetilde{A_Y}(\mathbf{Z}^j)$. A

[4]Think of housing goods as a subset of non-tradable goods. Theoretically, housing costs may proxy for cost-differences in all locally-provided goods. Non-housing goods, such as haircuts and restaurant meals, are considered to be a composite commodity of traded goods and non-housing home goods, with price p^j. I discuss multiple types of home goods in Appendix D.2, which shows that if housing is more land-intensive than non-housing home goods, then housing will more strongly reflect amenity values.

[5]As argued in Helpman and Pines (1980), as well as Albouy (2009), assuming only wages depend on location is the most appropriate assumption for mobile households.

consumption amenity, e.g., safety or clement weather, improves quality of life: $\partial \widetilde{Q}/\partial Z_k > 0$. Analogously, for a trade-productive amenity, e.g., navigable water or agglomeration economies, $\partial \widetilde{A_X}/\partial Z_k > 0$; and for a home-productive amenity, e.g., flat geography or the absence of land-use restrictions, $\partial \widetilde{A_Y}/\partial Z_k > 0$. An amenity may affect more than one attribute, or affect an attribute negatively: flat land may be an amenity to housing producers and a disamenity to households. A priori the two productivities may be uncorrelated. San Francisco may be great at making software and terrible at making housing. Nationally, each attribute has an average value of one.

2.2 Equilibrium Conditions

The utility function $U(x, y; Q^j)$, representing household preferences, is quasi-concave over x and y, and increases in quality of life, Q^j. The dual expenditure function for a household, $e(p^j, u; Q^j)$, measures the cost of consumption needed to attain utility u, increases in p^j, and decreases in Q^j. Because households are fully mobile, all inhabited cities offer the same utility, $\bar{u}$.[6] Thus, firms in cities with high prices or low quality of life compensate their workers with greater after-tax income:

$$e(p^j, \bar{u}; Q^j) = w^j + R + I - \tau(w^j + R + I). \tag{1}$$

Operating under perfect competition, firms produce traded and home goods according to the functions $X = A_X^j F_X(L_X, N_X, K_X)$ and $Y = A_Y^j F_Y(L_Y, N_Y, K_Y)$, where F_X and F_Y are concave and exhibit constant returns to scale, so that any returns to scale are embedded within the factor-neutral productivities, A_X^j and A_Y^j. All factors are fully employed, mobile across sectors within each city, and thus, have a single price in each city. The unit cost of producing a traded good is $c_X(r^j, w^j, \bar{\imath}; A_X^j) = c_X(r^j, w^j, \bar{\imath})/A_X^j$ where $c(r, w, i) \equiv c(r, w, i; 1)$.[7] A symmetric defin-

[6]Formally, $e(p^j, u; Q^j) \equiv \min_{x,y}\{x + p^j y : U(x, y; Q^j) \geq u\}$. The use of a single index Q^j assumes that amenities are weakly separable from consumption. The model generalizes to one with heterogenous workers that supply different fixed amounts of labor if these workers are perfect substitutes in production, have identical homothetic preferences, and earn equal shares of income from labor. Additonally, the mobility condition need not apply to all households, but only a sufficiently large subset of mobile marginal households (Gyourko and Tracy 1989). Appendix D.1 discusses the case with multiple household types that vary in preferences and skills.

[7]Unit cost is $c_X(r^j, w^j, \bar{\imath}; A_X^j) \equiv \min_{L,N,K}\{r^j L + w^j N + \bar{\imath} K : A_X^j F(L, N, K) = 1\}$. Appendix D.1 demonstrates that productivity differences that are not Hicks-neutral have similar impacts on relative prices across cities, but

ition holds for the unit cost of a home good, c_Y. Firms make zero profits in equilibrium. Therefore, for given output prices, more productive cities pay higher rents and wages, equal to the marginal revenue products of land and labor. In equilibrium, the following zero-profit conditions hold:

$$c_X(r^j, w^j, \bar{\imath})/A_X^j = 1 \tag{2}$$

$$c_Y(r^j, w^j, \bar{\imath})/A_Y^j = p^j. \tag{3}$$

This model of spatial equilibrium in (1), (2), and (3) 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). When all three prices are observed, the three attributes are exactly identified. Since these equations are equilibrium conditions, they hold even when the attributes are endogenous, e.g., if they change with population N^j. If prices were different, firms or households would move. Thus, the dual conditions are well-suited for measuring attribute values through prices. The conditions are less suited for counter-factual comparative statics as they do not capture feedback on amenities $\mathbf{Z}^j$. This makes it more difficult to estimate the value of individual amenities. For example, lowering crime, Z_1^j, may increase Q^j, increasing the population $N^j = Z_2^j$, which could then change Q^j, A_X^j, or A_Y^j.[8]

As mentioned earlier, Roback (1982) presents the same three-equation model without taxes, but uses data on land rents in a simplified two-equation model, which reduces equation (3) to $r^j = p^j$. As explained below, this "reduced model" is quite problematic when local labor is used to make non-traded goods (see Tolley 1974) and when home-productivity differs across cities. Starting with Blomquist et al. (1988), Beeson and Eberts (1989), and Gyourko and Tracy (1989, 1991), subsequent analyses have used the two-equation model, but replaced land rents with housing values. This is an improvement for modeling households, who consume housing directly, but problematic for firms, who use land as an input.[9] The three-equation model is more realistic and

not on quantities.

[8]To appreciate the potential complexity of comparative statics, say that N^j increases A_X^j so that $A_X^j = A_{X0}^j (N^j)^\alpha$, where $\alpha > 0$, and A_{X0}^j is exogenous. If a city's transportation network improves, increasing A_{X0}^j, this will attract new workers, raising N^j and further increasing A_X^j, confounding the effect. Yet, one may measure the value of the transportation improvement by controlling for population if α can be properly estimated.

[9]While Roback (1982) applies her two-equation model with actual land values, she also expresses strong doubts

sensible to parameterize, as I do in the next section.

2.3 Expenditure and Cost-share Parameters

For households, denote the share of gross expenditures spent on traded goods and home goods as $s_x^j \equiv x^j/m^j$ and $s_y^j \equiv p^j y^j/m^j$; denote the shares of income received from land, labor, and capital income as $s_R^j \equiv R/m^j$, $s_w^j \equiv w^j/m^j$, and $s_I^j \equiv I/m^j$. For firms, denote the cost-shares of land, labor, and capital in the traded-good sector as $\theta_L^j \equiv r^j L_X^j/X^j$, $\theta_N^j \equiv w^j N_X^j/X^j$ and $\theta_K^j \equiv \bar{\imath} K_X^j/X^j$; denote equivalent cost-shares in the home-good sector as ϕ_L^j, ϕ_N^j, and ϕ_K^j. Finally, denote the shares of land, labor and, capital used to produce traded goods as $\lambda_L^j \equiv L_X^j/L^j$, $\lambda_N^j \equiv N_X^j/N^j$, and $\lambda_K^j \equiv K_X^j/K^j$. Assume home goods are more cost-intensive in land relative to labor than traded goods, both absolutely, $\phi_L^j \geq \theta_L^j$, and relatively, $\phi_L^j/\phi_N^j \geq \theta_L^j/\theta_N^j$, implying $\lambda_L^j \leq \lambda_N^j$. To keep track of the notation, table 1 summarizes the key parameters, which without superscripts, refer to national averages. The "chosen" parameterized values come from Albouy (2009), which Appendix B.1 reviews and discusses. The following column presents values from Beeson and Eberts (1989), an exampled of a "reduced model."[10] The key parameters are λ_L, λ_N and the marginal tax rate, τ'.

about the quality of her land value data and their ability to capture the value of productive amenities.

[10]Nationally, the parameters obey the following identities: (i) $s_w + s_I + s_R = 1$; (ii) $\theta_L + \theta_K + \theta_N = 1$; (iii) $\phi_L + \phi_K + \phi_N = 1$; (iv) $s_w = s_x\theta_N + s_y\phi_N$; (v) $s_I = s_x\theta_K + s_y\phi_K$; (vi) $s_R = s_x\theta_L + s_y\phi_L$. (vii) $\lambda_L = s_x\theta_L/s_R$, (viii) $\lambda_N = s_x\theta_N/s_w$. Other reduced models with $\phi_L = 1, \lambda_N = \phi_N = 0$ include Shapiro (2006), who proposes values of $\theta_L = 0.1, \theta_N = 0.75$, and $s_y/s_w = 0.32$, implying $\lambda_L = 0.20$ and $\lambda_N = 1$;Gabriel and Rosenthal (2004) use values implying $\lambda_L = 0.5$ and $\lambda_N = 1$. Roback (1982, p.1273) considers a case with $s_y/s_w = 0.035$, which is too limited to provide other parameter values. The chosen values here are similar to Rappaport (2008a, 2008b) except that he more narrowly confines home goods to housing, using a smaller $s_y = 0.18$ and a larger $\phi_L = 0.35$. His implied $\lambda_L = 0.17$ is quite similar, whereas $\lambda_N = 0.87$ is smaller.

TABLE 1: MODEL PARAMETERS AND POSSIBLE VALUES

Parameter	Notation	Chosen Value	"Reduced Model"
Home-goods share	s_y	0.36	0.073
Income share to land	s_R	0.10	0.064
Income share to labor	s_w	0.75	0.73
Traded-good cost-share of land	θ_L	0.025	0.028
Traded-good cost-share of labor	θ_N	0.825	0.927
Home-good cost-share of land	ϕ_L	0.233	1.0
Home-good cost-share of labor	ϕ_N	0.617	0.0
Share of land used in traded good (derived)	λ_L	0.17	0.40
Share of labor used in traded good (derived)	λ_N	0.70	1.0
Average marginal tax rate on labor (see below)	τ'	0.361	0.0
Deduction rate for home-goods (see Appendix)	δ	0.291	0.0

*"Reduced model" parameterization from Beeson and Eberts (1989); it refers generally to $\phi_N = \tau' = \delta = 0$

2.4 Log-Linearization of the Equilibrium Conditions

To deepen the analysis and for empirical application, I log-linearize conditions (1), (2), and (3). These conditions relate each city's price differentials to its attribute differentials. The differentials are in logarithms: for any z, $\hat{z}^j = d\ln z^j = dz^j/\bar{z} \cong (z^j - \bar{z})/\bar{z}$ approximates the percent difference in city j of z, relative to the national geometric average $\bar{z}$. The one exception to this notation is $\hat{Q}^j \equiv -(\partial e/\partial Q)(1/\bar{m})dQ^j$, which is the dollar value of a change in Q^j divided by income.

Log-linearized versions of (1), (2), and (3) describe how prices co-vary with city attributes.[11]

$$-s_w(1-\tau')\hat{w}^j + s_y\hat{p}^j = \hat{Q}^j \tag{4a}$$

$$\theta_L\hat{r}^j + \theta_N\hat{w}^j = \hat{A}_X^j \tag{4b}$$

$$\phi_L\hat{r}^j + \phi_N\hat{w}^j - \hat{p}^j = \hat{A}_Y^j \tag{4c}$$

These equations are first-order approximations of the equilibrium conditions around a nationally-representative city, and thus use national shares.[12]

Each equilibrium condition states that the relative value of a city's amenities is measured implicitly by how much households or firms will pay for them. Equation (4a) measures local quality of life from how high the cost-of-living, $s_y\hat{p}^j$, is relative to after-tax nominal income, $s_w(1-\tau')\hat{w}^j$. Equation (4b) measures local trade-productivity, $\hat{A}_X^j$, from how high the labor costs, $\theta_N\hat{w}^j$, and land costs, $\theta_L\hat{r}^j$, are in traded-good production. Equation (4c) measures local home-productivity, $\hat{A}_Y^j$, from how high the labor costs, $\phi_N\hat{w}^j$, and land costs, $\phi_L\hat{r}^j$, are in home-good production relative to the home-good price, $\hat{p}^j$.

The equations so far resemble that of Albouy (2009), which uses the same framework, but considers different issues. Henceforth, the insights below are largely new and focus on issues of missing land rents, local productivity, and amenity values. With data on wages, home-good prices, and land rents, equations (4a) to (4c) produce estimates of the attribute differentials $\hat{Q}^j$, $\hat{A}_X^j$, and $\hat{A}_Y^j$. With only data on wages and home-good prices, $\hat{Q}^j$ is still uniquely identified, but the two

[11] When simply linearized with Shephard's Lemma, the equations are

$$-(\partial e/\partial Q)dQ^j = \bar{y}\cdot dp^j - (1-\tau')\cdot dw^j$$
$$dA_X^j = \overline{(L_X/X)}\cdot dr^j + \overline{(N_X/X)}\cdot dw^j$$
$$\bar{p}\cdot dA_Y^j = \overline{(L_Y/Y)}\cdot dr^j + \overline{(N_Y/Y)}\cdot dw^j - dp^j$$

The first equation is log-linearized by dividing through by $\bar{m}$, and the third, by dividing by $\bar{p}$. As shown by Hochman and Pines (1993), it is the marginal tax rate on wage income that matters.

[12] Most of these first-order expressions hold exactly in a Cobb-Douglas economy, where elasticities of substitution are one. In fact, these elasticities appear to be slightly less than one (Albouy 2009, Albouy and Stuart 2013), but close enough that they matter little for the fairly small range of observed wages and housing costs observed in the United States. As discussed in Appendix B.3, second-order approximations of the equilibrium conditions, which account for endogenous shifts of the share values, do not produce appreciably different inferences under plausible parametrizations except at the very extremes of the data.

productivities, $\hat{A}_X^j$ and $\hat{A}_Y^j$, are not.

2.5 Inferring Land Rents and Trade-Productivity from Housing Costs

When applied to housing, the zero-profit condition for home-good producers (4c) demonstrates how housing costs differ from land rents, except in a reduced model where $\phi_L = 1$ and $\phi_N = \hat{A}_Y^j = 0$. Solving for land rents, we can summarize the difference in three ways:

$$\hat{r}^j = \frac{1}{\phi_L}\left(\hat{p}^j - \phi_N \hat{w}^j\right) + \frac{1}{\phi_L}\hat{A}_Y^j \tag{5}$$

First, labor costs, $\phi_N \hat{w}^j$, must be subtracted away to isolate housing-cost differences due to land. Second, the observable remainder, $\hat{p}^j - \phi_N \hat{w}^j$, must be divided by ϕ_L, the cost share of land. The intuition here is simple: if a 1-percent housing-price difference comes from land, and land is 1/4 of the cost, then the land-price difference must be 4-percent. Third, land rents should be adjusted for home-productivity, $\hat{A}_Y^j$: cities with high home-productivity have housing prices that are low relative to the value of land. Independent information on home-productivity is typically unavailable, meaning land rents will be under-estimated in home productive areas.[13]

Local trade productivity may be inferred from wages and housing costs by substituting (5) into (4b), leading to

$$\hat{A}_X^j = \frac{\theta_L}{\phi_L}\hat{p}^j + \left(\theta_N - \phi_N \frac{\theta_L}{\phi_L}\right)\hat{w}^j + \frac{\theta_L}{\phi_L}\hat{A}_Y^j. \tag{6}$$

This formula differs from that implied by the reduced model, $\hat{A}_X^j = \theta_L \hat{p}^j + \theta_N \hat{w}^j$, in three ways. First, the housing-cost differential has a higher weight $\theta_L/\phi_L \geq \theta_L$, to match land's cost share in housing. Second, the wage differential has a lower weight $\theta_N - \phi_N \theta_L/\phi_L \leq \theta_N$: this adjustment undoes double-counting of labor-costs in housing. Finally, there is a term for high home-productivity. Without it, land costs in the traded sector are understated: the magnitude of this error depends on the ratio $\theta_L/\phi_L \leq 1$. When only wages and home-good prices are observed, low

[13] The first two components of (5) are examined as early as Muth (1970), although he does not consider local productivity.

home-productivity may be mistaken for high trade-productivity, as both are consistent with high wages and high housing costs.[14]

2.6 The Capitalization of Amenity Values and their Total Value

Inverting the linear system of equations (4a) to (4c) reveals how the three urban attributes influence the three prices. To ease comparison, I multiply each price differential by its income share, so that each equation expresses the change in total land, labor, and home-good values relative to local income. Thus, a one-percent increase in $s_R \hat{r}^j$ represents an increase in land values equal to one percent of local income. Each attribute is also multiplied by its weight relative to income. Accordingly, a one-percent increase in $s_x \hat{A}^j_x$ has a value equal to a one-percent increase in local income.

With these normalizations, I express prices in terms of urban attributes, using only the fractions of land and labor in traded-good λ_L and λ_N, and the marginal tax rate τ':

$$s_R \hat{r}^j = \frac{l}{m} dr^j = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'} \left[\hat{Q}^j + \left(1 - \frac{1}{\lambda_N}\tau'\right) s_x \hat{A}^j_X + s_y \hat{A}^j_Y \right] = s_R \hat{r}^j_* - \tau' s_w \hat{w}^j, \tag{7a}$$

$$s_w \hat{w}^j = \frac{w}{m} dw^j = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'} \frac{1}{\lambda_N} \left[-\lambda_L \hat{Q}^j + (1-\lambda_L) s_x \hat{A}^j_X - \lambda_L s_y \hat{A}^j_Y \right] = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'} s_w \hat{w}^j_*, \tag{7b}$$

$$s_y \hat{p}^j = \frac{y}{m} dp^j = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'} \frac{1}{\lambda_N} \left\{ (\lambda_N - \lambda_L) \hat{Q}^j + (1-\tau') \left[(1-\lambda_L) s_x \hat{A}^j_X - \lambda_L s_y \hat{A}^j_Y \right] \right\}, \tag{7c}$$

The subscript "$*$" denotes differentials with $\tau' = 0$ and $l^j \equiv L^j / N^j$ is the land-to-labor ratio.

The expression on land rents (7a) is closely related to the total value of amenities as Ω. The log-difference of this value equals the weighted value of attribute differences: $\hat{\Omega}^j \equiv \hat{Q}^j + s_x \hat{A}^j_X + s_y \hat{A}^j_Y$. With $\tau' = 0$, $\hat{\Omega}^j = s_R \hat{r}^j_*$, expressing the classical result that land values fully capitalize amenity values.[15] With federal taxes, this result breaks down, since local land values also capitalize federal-

[14] To aid intuition, consider two extreme cases. In the first case, traded goods are made without land, i.e. $\theta_L = 0$. Then, trade-productivity is proportional the wage level, $\hat{A}^j_X = \theta_N \hat{w}^j$. This may be a reasonable approximation if θ_L is small, but not if the variation in $\hat{r}^j$ is much larger than $\hat{w}^j$. In the second case, the cost shares in both sectors are the same, i.e. $\theta_L = \phi_L$, and $\theta_N = \phi_N$. Then, $\hat{A}^j_X - \hat{A}^j_Y = \hat{p}^j$ as the input costs are the same in each sector: home-good prices may be used to infer input costs in tradables only insofar as home-productivity remains constant.

[15] Wihout taxes, the linearized version of (7a) is $\overline{(L/N)} dr^j = -(\partial e / \partial Q) dQ^j + \overline{(X/N)} dA^j_X + \overline{(pY/N)} dA^j_Y = d\Omega^j$.

tax payments, captured in the "tax differential" $d\tau^j/m \equiv \tau' s_w \hat{w}^j$. This differential is normalized to express how much relative to the the national average households in a city pay in taxes as a fraction of their income.

To understand the influence of taxes, it is key to understand wage differences, seen in (7b).The bracketed term demonstrates how wage levels fall with quality-of-life and home-productive amenities in so far as land is used in traded production: firms lower wages to offset higher land costs in proportion to the fraction of land they use, λ_L. Higher trade-productivity directly increases wages: after accounting for the land-price change, the increase is proportional to $1 - \lambda_L$.

The term $1/\lambda_N$ outside the brackets expresses Tolley's (1974) wage multiplier. It results from local workers purchasing home goods from other local workers. To derive the multiplier, ignore taxes for now, and say that equilibrium wages without home-good price changes would equal $\hat{w}_0$. Because home producers must offer the same wages as traded producers and make zero profits, home-good prices rise by ϕ_N this amount, $\hat{p}_0 = \phi_N \hat{w}_0$. Because workers are mobile, firms need to compensate workers for the increase in cost-of-living of $s_y \phi_N \hat{w}_0$ by $1/s_w$ that amount in wages, leading to a further wage increase of $\hat{w}_1 - \hat{w}_0 = \phi_N \left(s_y/s_w\right) \hat{w}_0 = \left(1 - \lambda_N\right) \hat{w}_0$.This leads to further increases in costs-of-living and feedback effects on wages, given by the sum $\hat{w}_\infty = \sum_{k=0}^{\infty}(\hat{w}_{k+1} - \hat{w}_k) + \hat{w}_0 = \sum_{k=0}^{\infty} \left(1 - \lambda_N\right)^k \hat{w}_0 = (1/\lambda_N)\hat{w}_0$.

The term $1/\left(1 - \tau' \lambda_L/\lambda_N\right) \geq 1$ throughout (7b) expresses Albouy's (2009) tax multiplier. A wage differential of $\hat{w}_*$ leads to an additional tax payment of $\tau' s_w \hat{w}_*$. This payment is capitalized into land lower values, causing wages to rise by a premium of $\tau' \lambda_L \hat{w}_*$. This premium is subject to Tolley's wage multiplier, causing wages to rise further to $(\tau' \lambda_L/\lambda_N)\hat{w}_*$. This wage increase is then subject to taxation, causing further tax effects. Compounding these effects results in the multiplier $\sum_{k=0}^{\infty} \left(\tau' \lambda_L/\lambda_N\right)^k \hat{w}_* = [1/\left(1 - \tau' \lambda_L/\lambda_N\right)]\hat{w}_*$. The second equality in (7b) expresses how the tax multiplier amplifies how wages vary with amenities.

Per capita, $\overline{(L/N)}dr^j$ is the change in land value, $-(\partial e/\partial Q)dQ^j$ is the improvement in quality-of-life per resident, $\overline{(X/N)}dA_X^j$ and and $\overline{(pY/N)}dA_Y^j$ are the per-capita decrease in tradable and non-tradable costs. The solutions in (7) are derivable from equations in Albouy (2009), which contains an expression similar to (7b). The expressions except that those those here are relative to income, and use factor (not cost) shares, λ, making them neater and more interpretable.

Because of federal taxes, land rents over-capitalize quality-of-life and home-productive amenities to the extent that amenities lower wages: this simplifies to the tax multiplier in (7a) increasing the capitalization of those amenities. Land values under-capitalize trade-productive amenities, as they directly raise wages and tax burdens, creating a reduction proportional to the tax rate times the wage multiplier, $\tau'(1/\lambda_N)$, seen in (7a).[16] The total value of amenities is reflected in locally appropriated land rents and federally expropriated tax revenues, $\hat{\Omega}^j = s_R\hat{r}^j + \tau' s_w \hat{w}^j$. $\hat{\Omega}^j$ captures differences in the social value of land, while $s_r\hat{r}^j$ captures the private value, subtracting the fiscal externality in federal taxes.

When land data are unavailable, researchers may use (5) to infer differences in total amenity values, resulting in the following expression:

$$\hat{\Omega}^j = \frac{1}{1-\lambda_L}\left\{s_y\hat{p}^j + \left[\tau'\left(1-\lambda_L\right) - \left(1-\lambda_N\right)\right]s_w\hat{w}^j\right\} + \frac{1}{1-\lambda_L}s_y\hat{A}_Y^j, \tag{8}$$

This measure is increasing in home expenditures, $s_y\hat{p}^j$, and accounts for land used in the traded sector multiplying by $1/(1-\lambda_L)$. The bracketed term associated with wages is of ambiguous sign: high wages signal high federal-tax revenues, but also high labor costs in housing. The measure also misses differences in home-productivity by $1/(1-\lambda_L)$ of their value. Even if we give up on measuring the value of home-productivity, the value of the remaining amenities will still be somewhat biased as $\hat{\Omega}^j - s_y\hat{A}_Y^j = \hat{Q}^j + s_x\hat{A}_X^j - [\lambda_L/(1-\lambda_L)]s_y\hat{A}_Y^j$.

Equation (7c) expresses how amenities are capitalized into the price of housing services and other locally-produced goods. Overall, home-good prices capitalize amenities quite differently than land rents. First, they are subject to the wage multiplier. Second, they lose the value of quality-of-life amenities seen in lower wages (the λ_N pre-multiplying $\hat{Q}^j$ undoes the wage multiplier).[17]

[16] Wihout taxes, the linearized version of (7a) is $\overline{(L/N)}dr^j = -(\partial e/\partial Q)dQ^j + \overline{(X/N)}dA_X^j + \overline{(pY/N)}dA_Y^j = d\Omega^j$. Per capita, $\overline{(L/N)}dr^j$ is the change in land value, $-(\partial e/\partial Q)dQ^j$ is the improvement in quality-of-life per resident, $\overline{(X/N)}dA_X^j$ and and $\overline{(pY/N)}dA_Y^j$ are the per-capita decrease in tradable and non-tradable costs. The solutions in (7) are the same as in Albouy (2009), but expressed relative to income, and using the factor (not cost) shares, λ.

[17] Roback (1982, p. 1265) reports a linear analogue to equation (7c) without taxes in her equation 9, expressed in derivatives of cost and indirect utility functions. Roback states that the effect of improvements in quality-of-life on home-good prices is ambiguous. It is unambiguous if home goods are relatively land intensive, meaning $\lambda_N > \lambda_L$.This condition underpins Roback's assumption that the determinant in her equation 9 (Δ^*) is greater than zero.

Third, home-goods capture the value of productive amenities only in so-far as they affect wages, meaning they may over-capitalize trade-productivity and under-capitalize home-productivity. The value of productive amenities are then only capitalized net of taxes, $(1 - \tau')$. After accouting for the tax multiplier, federal taxes reduce the capitalization of both kinds of production amenities, but increase that of quality-of-life amenities.

In combination, (7b) and (7c) underscores how trade- and home-productivity are not separately identifiable without land rents. Trade-productivity raises the wages of workers, increasing the demand for local goods, raising their price so that household expenditures rise in proportion to the after-tax wage bill. Home-productive amenities lower the price of home goods through greater supply; these lower prices attract workers and allow firms to pay them less. The two productivities change wages and housing-cost in the same proportion in opposite directions.

In Appendix A.1, I amend the above formulae to account for tax benefits for housing lower tax burdens, using tax differential of $d\tau^j/m = \tau'(s_w\hat{w}^j - \delta s_y\hat{p}^j)$, where $\delta \in [0, 1]$ is the fraction of deductible expenses. These benefits lower tax burdens in areas with high home-good prices, i.e., those with high quality of life or trade-productivity, or low home-productivity. Amending (7) reveals that a higher δ raises the tax multiplier and causes prices to capitalize quality-of-life amenities more, and both types of productive amenities less.

3 Parameterized Capitalization Predictions

Using the capitalization formulas in (7), Table 2 reports how a one dollar increase in the value of a local attribute is capitalized into local prices. To highlight the importance of federal taxes and non-traded production, the coefficients in panel A eliminate taxes and the wage multiplier by changing the parameterization so that $\tau' = 0$ and $\lambda_N = 1$; panel B re-introduces the wage multiplier, which has a parameterized value of $1/\lambda_N = 1.42$. Panel C cumulatively adds federal taxes on wages at a rate of $\tau' = 0.36$, leading to a tax multiplier of 1.09; panel D adds refinements for housing tax-benefits and state taxes, raising the tax multiplier to 1.17.

The first rows of panel A and B demonstrate how land rents capitalize the value of all amenities dollar-for-dollar in the absence of federal taxes. In Panel A, we see 81 percent of quality-of-life values are capitalized into higher home-good prices, with 19 percent capitalized into lower wages, so that real income falls in proportion by 100 percent. With the wage multiplier in B, wages capitalize slightly more. The full wage multiplier effect is seen in how wages capitalize trade-productivity, increasing it from 81 to 119 percent: more than dollar-for-dollar. These wage effects from productivity are fully offset by higher local home-good prices. Wages and home-good prices are barely affected by home-productivity, never reflecting more than a quarter of their value.

Federal taxes change some of the capitalization effects more than others. Moving straight to Panel D, land rents capitalize only 63 percent of trade-productive amenity values, while the federal government expropriates the remaining 37 percent. Meanwhile, the federal government implicitly subsidizes quality-of-life amenities at a rate of 19 percent, and home-productive amenities at a rate of 8 percent. A local government maximizing land rents has twice the incentive to provide amenities to households than to traded-producing firms.

Taxes amplify wage differentials by roughly 10 percent, so that wages capitalize quality-of-life amenities at 27 cents on the dollar. This figure is low for studies (e.g. Moore 1998) that value quality-of-life amenities using nominal wages alone. Wages reflect an even higher percentage of their value at 128 percent, suggesting that wage-only measures of productivity — often seen in the agglomeration literature — may overstate differences in total factor productivity.[18]

For home-good prices, taxes increase the capitalization of quality-of-life to 90 percent and decrease that of productivity to 92 percent. Home-good prices capitalize the value of quality-of-life and trade-productivity differences more accurately than land rents considered in isolation. Home-productivity remains hard to detect with any land data.

[18] Rappaport (2008b) finds a capitalization effect of quality of life on wages similar to the one here without taxes, as his calibration implies similar values of λ_L. For other amenities his results differ as λ_N and τ' play more of a role. His numerical simulations also account for non-linearities using constant-elasticity-of-substitution (CES) utility and production functions.

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

4.1 Wage and Housing-Cost Differentials

I estimate wage and housing-cost differentials exactly as in Albouy (2009) – following Gabriel and Rosenthal's (2004) methodology – using the 5-percent sample of Census data from the 2000 Integrated Public Use Microdata Series (IPUMS). I define cities at the Metropolitan Statistical Area (MSA) level using 1999 OMB definitions. I treat Consolidated MSAs as a single city (e.g. New York includes Long Island and northern New Jersey), and create a single non-metropolitan area for each state.[19] This classification produces a total of 325 "cities" of which 276 are actual metropolitan areas and 49 are non-metropolitan areas.

I regress the logarithm of hourly wages on worker characteristics and indicator variables for each metro area. The population-demeaned coefficients on the indicator variables are taken as the city wage differentials. I use an analogous regression for housing costs, combining gross rents with imputed rents from owner-occupied units. Imputed rents are the sum of utility costs and a user-cost imputed from housing values and a multiplier based on interest rates, tax rates, maintenance, depreciation and capital gains. Appendix C provides more details on the variables and estimation procedure. [20]

4.2 Land-Value, Trade-Productivity, and Total-Value Measures

With wage and housing-cost differentials, I infer land-rent, quality-of-life, trade-productivity, and total-value differentials using equations (4a), (5), (6), (8). These are parameterized according to

[19] I use Consolidated MSAs to acknowledge the strong interdependence of productivity among areas within an MSA. Non-metropolitan areas by state are included for completeness. They may be thought of as an average for those areas.

[20] As shown in Appendix C.2, adjusting for local variation in user costs, such as from capital gains, has relatively minor effects on the housing-cost differentials. The adjustment tends to lower the cost somewhat in the least expensive cities, but does little to change the overall picture.

the values in Table 1, and adjusted slightly for housing deductions and state taxes.[21]

$$\hat{r}^j = 4.29\hat{p}^j - 2.75\hat{w}^j \ (+4.29\hat{A}_Y^j) \tag{5*}$$

$$\hat{Q}^j = 0.32\hat{p}^j - 0.49\hat{w}^j \tag{4a*}$$

$$\hat{A}_X^j = 0.11\hat{p}^j + 0.79\hat{w}^j \ (+0.11\hat{A}_Y^j) \tag{6*}$$

$$\hat{\Omega}^j = 0.39\hat{p}^j + 0.01\hat{w}^j \ (+0.39\hat{A}^j). \tag{8*}$$

Without land-value data, I assume there are no home-productivity differences across cities, i.e., $\hat{A}_Y^j = 0$, for all j. This assumption is implicit in, and far weaker than, the assumption that housing and land are identical. The parentheses contain the biases that result from unobserved home-productivity differences: the bias appears to be large for land rents, small for trade-productivity, and moderate for total value. Otherwise, the total value is well-approximated by housing costs, as the coefficient on wages in equation (8) is close to zero.

Figure 1 plots the wage and housing-cost differentials across metro areas, together with four lines, or "curves", describing the $(\hat{w}^j, \hat{p}^j)$ combinations where the left-hand sides of equation are zero, i.e., at their national averages. The iso-rent curve describes the points on (5) where $\hat{r} = 0$, namely $\hat{p}^j = \phi_N \hat{w}^j$. The slope ϕ_N illustrates how housing prices rise with construction costs. The vertical distance between this line and a city's marker, scaled by $1/\phi_L$, provides that city's inferred land rent, since land accounts for the remaining costs. Figure 2 plots the inferred land-rent differentials against housing costs. It draws a line for how these rents are inferred from housing costs if wages 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 indicate the adjustments for labor costs.

Back to Figure 1, the second line is the mobility condition, (4a), in cities with average quality of life, $\hat{Q}^j = 0$. As explained in Albouy (2008), the positive slope of $(1-\tau')s_w/s_y$ indicates how

[21] The actual formulas are somewhat more complex becaue of state-tax differences. These are accounted for by interacting state tax and deudction rates with price and wage differences within-state only. The simplified formulas presented are close approximations based on regression estimates.

local costs increase with wage levels to keep real consumption levels from rising. Households in cities above this line pay a premium relative to the wage level, which implies that their quality of life is above average.

The third line indicates cities with average trade-productivity, $\hat{A}_X^j = 0$, using the combined zero-profit conditions in (6). The slope of the combined condition, $\phi_N - \phi_L \theta_N / \theta_L$, gives the rate at which land costs, proxied through housing costs, need to fall with wage levels for firms to break even. Cities above this line have above-average costs, indicating high trade-productivity. These cities could instead have low home-productivity, although the parameterization suggests the observed variation would require very large differences in home-productivity. The trade-productivity estimates are graphed in Figure 3 against those we would infer from a reduced model that imposes $\phi_L = 1, \phi_N = 0$ and keeps the same values of θ_L and θ_N. The methodological refinement of putting more weight on housing costs is not enormous, but nonetheless changes the relative rankings of many cities, putting Los Angeles in front of Chicago, Boston in front of Detroit, and Denver in front of Las Vegas.

Back again to Figure 1, the fourth line is an iso-value curve, (8), with $\hat{\Omega}^j = 0$. It traces out cities with average total amenity values. As housing costs indicate them well, the line is quite flat.

Figure 4 graphs the quality-of-life and trade-productivity estimates together. This graph transforms 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 are of equal value. The four curves pass through the coordinate change. The downward slope of the iso-rent curve has a weaker slope than the iso-value curve, reflecting how rents capitalize quality-of-life in greater proportion than trade-productivity. The iso-housing-cost curve has almost the same slope as the iso-value line, as it capitalizes each attribute in almost equal proportions. The upward-sloping iso-wage curve illustrates how wages capitalize productivity positively, and quality of life negatively by a smaller proportion.

4.3 The Most Trade-Productive and Valuable Cities

Table 3A lists the estimated wage, housing-cost, land-rent, quality-of-life, trade-productivity, federal-tax, and total-amenity-value differentials for select cities. The table also lists average values by Census division, and metro-area size. Table 3B presents the top 20 rankings for trade-productivity, quality of life, and total amenity value. Appendix Table A1 presents a complete list of metro areas and non-metro areas; Appendix Table A2 lists values by state.

The tendency for trade-productivity to increase with metro population, usually attributed to agglomeration economies, is illustrated in Figure 5. The most trade-productive metro area is San Francisco, which includes Silicon Valley. It is surprising that the most productive metro is only the fifth largest, while New York, the largest, is second. Yet, the exceptional degree of knowledge spillovers and innovation in the San Francisco Bay Area is well documented (Saxenian 1994, Florida 2008). The top ten most productive cities contains five other large metros – Los Angeles, Chicago, Boston, Washington, and Detroit (back in 2000) – and three small metros – Monterrey (officially "Salinas"), Santa Barbara, and Hartford. The most plausible explanation for why these small metros are so productive is that they are close to much larger metros (San Francisco, Los Angeles, and Boston). In contrast, the least productive metro area, Great Falls, MT, is remote, as are the two least productive states, South and North Dakota.

Combining quality-of-life and trade-productivity, the most valuable metropolis is San Francisco: it has the highest productivity and the fourth highest quality of life. It is followed by six other Pacific cities – Santa Barbara, Honolulu, Monterrey, San Diego, Los Angeles, and San Luis Obispo – that offer exceptional quality of life and fairly high productivity. Next, are a number of large, highly productive, and somewhat amenable metros – New York, Seattle, Boston, Denver, Chicago, and Portland – as well as resort-like, yet economically vibrant, metros like Cape Cod, Santa Fe, Naples, Reno, and Fort Collins.

Further down the list are smaller cities in less crowded areas, such as in Arkansas, Oklahoma, West Virginia, Mississippi, and the Dakotas. The relationship between total amenity value and city size is quite apparent in Figure 6: it combines the strong relationship between size and productivity, seen above, and the weak relationship between size and quality of life (Albouy 2008). The estimates suggest that an acre of land in the San Francisco Bay Area is on average 100 times more valuable than an acre in McAllen, TX (Hidalgo County), with the lowest value.[22]

4.4 Explaining the Variation of Prices across Cities

The theory of spatial equilibrium asserts that price variation across cities reflects differences in amenities, reduced here to two attributes: quality of life and trade-productivity. A variance decomposition of the total value of amenities yields:

$$var(\hat{\Omega}^j) = var(\hat{Q}^j) + s_x^2 var(\hat{A}_X^j) + 2s_x cov(\hat{Q}^j, \hat{A}_X^j). \tag{10}$$

One way to assess the relative importance of each attribute is to compare the two variance terms: if one attribute is made constant, then the covariance term collapses to zero, and only the variance of the other attribute remains. From the equations in (7), it is straightforward to derive similar decomposition formulae for wages, housing costs, and land rents.[23] This statistical decomposition must be treated cautiously as attributes may be endogenous, especially the numbers in Panel B, which remove taxes. For example, as discussed in Section 2.2, high quality of life may raise population, leading to endogenous trade-productivity gains from agglomeration; federal taxes may interact with these feedback effects. The decomposition does provide an interesting accounting of equilibrium relationships, and should describe some causal effects if the endogenous feedback is weak, as the analysis in Albouy and Stuart (2013) suggests.

Table 4 displays the decompositions for the prices, with Panel A giving the case with taxes,

[22]The results change only slightly if housing-cost measures based only on rental units are used. Rent measures better represent the situation in central cities, where 45% of households are renters, rather than in suburbs, where only 27% are renters. Rent-only measures tend to be somewhat lower in places with many renters, like California, and in cities like Detroit, where the central city and suburbs offer very different amenities. Using only rents tends to lower quality-of-life and trade-productivity estimates in cities where rents are low relative to housing prices..

[23]This decomposition is unlike the one in Beeson and Eberts (1989) and Deitz and Abel (2008), who decompose each differential into its productivity and quality-of-life component. For instance, San Francisco's wage differential of 0.26 is 119 percent "explained" by its higher productivity (which alone rasies it to 0.31) and -19 percent "explained" by its higher quality of life (which alone lowers it -0.05).

and Panel B without. Overall, trade-productivity accounts for a greater fraction of amenity value than quality-of-life. This is seen in Figure 4: when population-weighted, the width of the spread of cities along the trade-productivity axis is greater the height of the spread than along the quality-of-life axis. Quality-of life does have a greater influence on land rents by a slight margin. Variations in nominal wages – as well as federal-tax burdens – are driven almost entirely by trade-productivity. This contradicts Roback's (1982) claim that nominal wages vary more from quality-of-life.[24] If trade-productivity determines labor demand, and quality of life determines labor supply, then labor demand is more important in determining wage levels. Housing-cost variation also appears to be driven mainly by trade-productivity.[25]

Panel B presents a counter-factual distribution of rents, wages, and housing-costs with federal taxes removed, holding the attributes fixed. In this case, productivity differences would be even more important in determining land rents and housing costs.

4.5 Comparison with Land Data from Market Transactions

I now consider the validity of the current article in light of new work by Albouy and Ehrlich (2012), which builds on the analysis here. They collect 2005-10 data on land transactions to produce an index of land values comparable across metro areas. Their samples are much smaller than the Census, making the indices prone to sampling error. Nevertheless, they find two-thirds of the variation in housing prices is explained by land values and wages, with cost estimates similar to the ones here. Land values are far more dispersed than housing costs, as predicted, and housing-productivity differs substantially and appears influenced by geography and land-use regulations.

The findings are generally supportive of the results here with three caveats. First, cities with high land values tend to have lower housing productivity, meaning that inferred land values in these cities may be too high. Second, housing-productivity is negatively correlated with trade-

[24]Roback (1982) concludes that "the combined evidence seems persuasive that the regional differences in earnings can be largely accounted for by regional differences in local amenities," referring to quality-of-life amenities only. Using different time periods does not change the preponderance of trade-productivty in determining wage levels.

[25]It is not clear from the analysis which type of amenity is more important in affecting household location choices. This is explored in Albouy and Stuart (2013).

productivity. This causes estimates of trade-productivity with inferred land values to be slightly biased and exaggerated. Third, the elasticity of substitution between land and non-land inputs in housing production is estimated just below one, although imprecisely. If so, a second-order approximation of (3) – described in Appendix B.3 – will produce better inferred land values than the first-order approximation in (5).

Albouy and Ehrlich's conclusions are open to the criticism that transaction data may not reflect the value of non-transacted land because vacant land may be negatively selected (Mills 1992, Case 1995), particularly in high-value areas. If so, land values and home-productivity may be underestimated in cities with high land values, possibly negating the caveats above. Furthermore, the data come from the housing boom-and-bust period, when land and housing prices may have inaccurately reflected local amenities, particularly for housing production. These problems aside, data on land transactions are still thin, proprietary, and available only for recent years.[26] The lessons derived in the absence of land-value data, derived here, are more practical for most researchers.

5 The Value of Individual Amenities

Researchers commonly use the spatial equilibrium model to estimate the value of individual amenities $(Z_1^j, .., Z_K^j)$ through regression methods. One branch of the literature, starting with Roback (1982), focuses on quality of life; another, exemplified by Rauch (1993), focuses on trade-productivity. Here, I analyze them together, similar to Haughwout (2002), except that I examine multiple amenities with taxes and home-production. I illustrate the inter-relationships by running seven, mutually-consistent regressions, assumed to be linear for simplicity:

$$v^j = \sum_k Z_k^j \pi_{kv} + \varepsilon_v^j, \tag{11}$$

[26] Such problems may also present in the time series of land values presented by Nichols et al. (2013), which are not comparable cross-sectionally. Davis and Palumbo (2007) infer the costs of land rents across metropolitan areas by subtracting construction costs, obtained from R.S. Means, from observed housing data. In many ways, this methodology is similar to the one in equation (5), and subject to similar caveats. Their methodology also implicitly assumes that new suburban houses are representative.

where $v \in \{\hat{w}, \hat{p}, \hat{Q}, \hat{A}_X, \hat{r}, d\tau/m, \hat{\Omega}\}$. In this linear system, the amenity coefficients, π_{kv}, express the effect of a one-unit increase in an amenity to the regressor. The amenity coefficients, π_{kv}, share the same interrelationships as their corresponding regressors, v, in the above equations, e.g. from (5), $\pi_{rk} = (1/\phi_L)\pi_{pk} - (\phi_N/\phi_L)\pi_{wk}$ for each k.

The regressions use two types of amenity measures, shown in Table 5. The first type measure "natural" amenities, such as climate and geography: heating-degree days (which measure cold) and cooling-degree days (which measure heat) per year, sunshine out of the fraction possible, latitude, average inverse distance to a major coast, and average slope of terrain – Appendix C lists the data sources. The second type measure "artificial" amenities that depend on local inhabitants, including metropolitan (MSA/CMSA) population and the share of the adults with college degrees. These are not true amenities, *per se*, but likely determine amenities that are key to local trade-productivity, engendering agglomeration economies and knowledge spillovers. I also include the Wharton Residential Land-Use Regulatory Index (WRLURI), by Gyourko et al. (2008) to control for housing-productivity differences, which may contaminate the estimates of $\hat{r}$, $\hat{A}_X$, and $\hat{\Omega}$ if $\hat{A}_Y \neq 0$.

These regressions estimate the impact of individual amenities on observed wages and housing costs, $\hat{w}$ and $\hat{p}$ in columns 1 and 2 of Table 5. Columns 3 and 4 report regressions separating the value of the amenity to households and to firms, $\hat{Q}$ and $\hat{A}_X$. Their combined value, $\hat{\Omega}$, is expressed in column 7; how the capitalization of total value is split between land values and federal tax revenues, $s_R\hat{r}$ and $d\tau/m$, is in columns 5 and 6.

Cross-sectional regressions of this kind are subject to well-known empirical caveats (see Gyourko et al. 1999) due to omitted variables, simultaneity, multi-collinearity, and small samples. Including more variables may not alleviate these caveats, partly because there are more potential variables than observations. Adding endogenous variables can bias estimates further, as can adding exogenous variables if the variable list is incomplete. Ultimately, researchers are unsure of the "true" specification in this setting – a problem shared with cross-country regressions (see Sala-i-Martin 1997) – and so each variable may proxy for several amenities. To test robustness,

Appendix Table A3 reports results excluding the second set of endogenous amenities; Appendix Table A4 includes additional endogenous amenities and population characteristics. For the variables common to these specifications, the same conclusions generally apply.[27]

The first row of table 5 estimates an elasticity of wages with respect to population of 3.8 percent. This effect may be endogenous to more workers choosing to live in more productive areas, but the estimates are squarely inside the range of estimates surveyed in Rosenthal and Strange (2004) and Melo et al. (2009). The elasticity of housing-costs to population is larger at 5.6 percent. The results in an elasticity of trade-productivity of 3.6 percent, close to that for wages, and an elasticity of quality of life of zero. In total, the estimates suggest that doubling city population (an increase of 0.69 log points) increases the total value of its amenities by 1.5 percent of income, of which three-fifths is capitalized in local land values and two-fifths is appropriated in federal taxes. Thus, federal taxes should dampen the incentives for local landowners to welcome growth in their cities.

The estimates in the second row associate a ten-percentage point increase in college-educated adults (1.3 standard deviations) with 7-percentage point increases in wages and productivity, and a 1.8 percentage point increase in quality of life. Of course, highly-educated workers may be most attracted to a city with high quality of life and productivity. Nevertheless, the results resemble those of Moretti (2004) and Shapiro (2006), who use more rigorous methods involving instrumental variables. In total, a ten-percent increase in college share is associated with a 7-percent increase in the total value of amenities, of which federal taxes expropriate one-fifth.

The positive coefficients on the regulatory land-use index (WRLURI) for trade-productivity, land rents, and total value are consistent with the prediction that regulations lower housing-productivity. The effects are small and insignificant, suggesting our inferred measures are not biased badly by

[27]The coefficients on the natural amenity variables in Table A3 are almost all larger in absolute magnitude than in Table 5 as amenable areas are more populated, and the college-educated live more in northern and coastal areas. Table A4 includes variables for race (percent black, percent Hispanic), age (percent under 18, over 65), culture, restaurants and bars, air quality and crime. Most of these variables are insignificant, with the main exception of air quality. Clean air is positively associated with trade-productivity, quality of life, and total amenity value. Cities with cleaner industries tend to be more productive, running against the more causal view that allowing firms to pollute will lower their costs.

unobserved housing-productivity.

The relationships between the natural amenities and trade-productivity, new to the literature, reveal interesting patterns. Sunshine, coastal proximity, low levels of cold (minus heating degree days) and low levels of heat (minus cooling degree days) appear to be amenities to firms as well as households. The positive estimate for coastal proximity may reflect savings in transportation costs; the climate effects are more surprising, but could have a physiological basis. Montesquieu (1748) hypothesized long ago that extreme temperatures inhibit the ability of humans to work. Engineering studies find that both indoor and outdoor workers are less productive in warm temperatures (Engineering News Record 2008). Yet, the magnitudes of the regression coefficients here in times of modern indoor climate control raise concerns about their validity. Finally, the small but significant positive effect of latitude on productivity evokes findings in Hall and Jones (1999) that social capital is higher in northern areas, even within the United States.

The coefficients of determination reveal that this parsimonious set of amenities explain 88 percent of trade-productivity, and over 90 percent of land rents and total amenity value. Population, education, sunshine, coastal proximity, average slope and mild temperatures are all strongly associated with overall amenity value. The results also imply that households are taxed for living in cities that are large, flat, cool, coastal, and educated.

6 Conclusion

The above analysis goes far beyond existing work to improve our understanding of how the relationship between prices and amenities depends on factor shares, wage multipliers, and federal taxes. It also helps researchers recover those values from available data sources, while understanding how data limitations may influence their results. Land values are necessary for determining the total value of local amenities, especially in non-traded production. However, land values are not entirely sufficient because of federal taxes. Fortunately, wage and housing-cost data alone appear to be largely adequate for inferring local levels of productivity in tradables: the proposed measure improves on wage-alone measures by capturing land inputs and accounting for potentially confouding effects due to wage and tax multipliers. The resulting city rankings appear largely sensible. Statistically, it appears that local labor demand factors are more important in determining local wages and housing costs than supply factors. Furthermore, a limited number of variables explain over seven-eights of the variation in wages, trade-productivity and total amenity value.

This results presented here should be of use to future researchers. As already alluded to, the framework may be used to infer local housing productivity with land-rent data (Albouy and Ehrlich, 2012), or provide a starting point for understanding differences in population density (Albouy and Stuart, 2013). Extensions of the model with local production could do more with internal structure, population heterogeneity, and dynamics. Nevertheless, understand what may be inferred from basic cross-sectional variation in housing costs and wages, should be a useful stepping stone towards more complex models and richer data.

References

Albouy, David (2008) "Are Big Cities Bad Places to Live? Estimating Quality-of-Life across Metropolitan Areas." NBER Working Paper No. 14472. Cambridge, MA.

Albouy, David (2009) "The Unequal Geographic Burden of Federal Taxation." *Journal of Political Economy*, 117, pp. 635-667.

Albouy, David and Gabriel Ehrlich (2012) "Metropolitan Land Values and Housing Productivity" NBER Working Paper No. 18110. Cambridge, MA.

Albouy, David and Bryan Stuart (2013) "Urban Population and Amenities." mimeo, University of Illinois.

Arnott, Richard and Joseph Stiglitz (1979) "Land Rents, Local Expenditures, and Optimal City Size." *Quarterly Journal of Economics*, 93, pp. 471-500.

Beeson, Patricia E. (1991) "Amenities and Regional Differences in Returns to Worker Characteristics." *Journal of Urban Economics*, 30, pp. 224-241.

Beeson, Patricia E. and Randall W. Eberts (1989) "Identifying Productivity and Amenity Effects in Interurban Wage Differentials." *The Review of Economics and Statistics,* 71, pp. 443-452.

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

Boskin, Michael J., Laurence J. Kotlikoff, Douglas J. Puffert, and John B. Shoven (1987) "Social Security: A Financial Appraisal Across and Within Generations." *National Tax Journal*, 40, pp. 19-34.

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

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

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

Davis, Morris and Michael Palumbo (2007) "The Price of Residential Land in Large U.S. Cities." *Journal of Urban Economics*, 63, pp. 352-384.

Deitz, Richard and Jason Abel (2008) "Have Amenities Become Relatively More Important Than Firm Productivity Advantages in Metropolitan Areas?" Federal Reserve Bank of New York Staff Report No. 344.

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

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

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

Gabriel, Stuart A. and Stuart S. Rosenthal (2004) "Quality of the Business Environment versus Quality of Life: Do Firms and Households Like the Same Cities?" *The Review of Economics and Statistics*, 86, pp.548-444.

George, Henry (1879) *Progress and Poverty:* An Inquiry into the Cause of Industrial Depressions and of Increase of Want with Increase of Wealth: The Remedy. Garden City, NY: Doubleday, Page & Co. 1912.

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

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

Gyourko, Joseph and Joseph Tracy (1989) "The Importance of Local Fiscal Conditions in Analyzing Local Labor Markets." *Journal of Political Economy*, 97, pp. 1208-31.

Gyourko, Joseph and Joseph Tracy (1991) "The Structure of Local Public Finance and the Quality of Life." *Journal of Political Economy*, 99, pp. 774-806.

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

Haughwout, Andrew and Robert Inman (1996) "State and Local Assets and Liabilities, 1972-1992." Woodrow Wilson School, Princeton University, mimeo.

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

Hall, Robert and Charles Jones (1999) "Why Do Some Countries Produce So Much More Output per Worker than Others?" *Quarterly Journal of Economics* 114(1), pp. 83-116.

Hochman, Oded and David Pines. (1993) "Federal Income Tax and its Effects on Inter- and Intracity Resource Allocation." *Public Finance Quarterly* 21, 276-304.

Keiper, Joseph S., Ernest Kurnow, Clifford D. Clark, and Harvey H. Segal (1961) *Theory and Measurement of Rent.* Philadelphia: Chilton & Co.

Krueger, Alan B. (1999) "Measuring Labor's Share." *American Economic Review*, 89, pp. 45-51.

Malpezzi, Stephen, Gregory H. Chun, and Richard K. Green (1998) "New Place-to-Place Housing Price Indexes for U.S. Metropolitan Areas, and Their Determinants." *Real Estate Economics,* 26, pp. 235-274.

McDonald, J.F. (1981) "Capital-Land Substitution in Urban Housing: A Survey of Empirical Estimates." *Journal of Urban Economics*, 9, pp. 190-211.

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

Mills, Edwin S. (1998) "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.

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

Moore, Thomas Gale (1998) "Health and Amenity Effects of Global Warming." *Economic Inquiry*, 36(3), pp. 471-488.

Moretti, Enrico (2004) "Workers' Education, Spillovers and Productivity: Evidence from Plant-Level Production Functions" *American Economic Review.* 94(3), 2004, pp. 656-690.

Moretti, Enrico (2013) "Real Wage Inequality." *American Economic Journal: Applied Economics* 5(1), pp. 65-103.

Oates, Wallace (1969) "The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis." *Journal of Political Economy*, 77, pp. 957-971.

Peiser, Richard B. and Lawrence B. Smith (1985) "Homeownership Returns, Tenure Choice and Inflation." *American Real Estate and Urban Economics Journal*, 13, pp. 343-60.

Poterba, James M. (1998) "The Rate of Return to Corporate Capital and Factor Shares: New Estimates using Revised National Income Accounts and Capital Stock Data." Carnegie-Rochester Conference Series on Public Policy, 48, pp. 211-246.

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

Rappaport, Jordan (2008b) "Consumption Amenities and City Population Density." *Regional Science and Urban Economics*, 38, pp. 533-552.

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

Ricardo, David (1817) *Principles of Political Economy and Taxation*. London: John Murray.

Roback, Jennifer (1980) "The Value of Local Urban Amenities: Theory and Measurement." Ph.D. dissertation, University of Rochester.

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

Roback, Jennifer (1988) "Wages, Rents, and Amenities: Differences among Workers and Regions." *Economic Inquiry*, 26, pp. 23-41.

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

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

Rudd, Jeremy B. (2000) "Assessing the Productivity of Public Capital with a Locational Equilibrium Model" Finance and Economics Discussion Series 2000-23. Washington: Board of Governors of the Federal Reserve System.

Ruggles, Steven, Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander (2004) *Integrated Public Use Microdata Series: Version 3.0*. Minneapolis: Minnesota Population Center.

Sala-i-Martin, Xavier (1997) "I Just Ran Two Million Regressions." *American Economic Review* 87(2), pp. 178-183.

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

Shapiro, Jesse M. (2006) "Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital." *The Review of Economics and Statistics*, 88, pp. 324-335.

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

Thorsnes, Paul (1997) "Consistent Estimates of the Elasticity of Substitution between Land and Non-Land Inputs in the Production of Housing." *Journal of Urban Economics*, 42, pp. 98-108.

Tiebout, Charles M. (1956) "A Pure Theory of Local Expenditures." *Journal of Political Economy,* 64, pp. 416-424.

Tolley, George (1974) "The Welfare Economics of City Bigness." *Journal of Urban Economics*, 1, pp. 324-45.

Valentinyi, Ákos and Berthold Herrendorf (2008) "Measuring Factor Income Shares at the Sectoral Level." *Review of Economic Dynamics*, 11, pp. 820-835.

TABLE 2: PREDICTED EFFECTS OF ATTRIBUTES ON THE VALUE OF LAND RENTS, WAGES, AND HOME-GOOD PRICES

Attribute (or Type of Amenity)	Increase in Value from a One-Dollar Increase in Attribute Value		
	Quality of Life $\hat{Q}^j$	Trade Productivity $s_x \hat{A}_X^j$	Home Productivity $s_y \hat{A}_Y^j$
	(1)	(2)	(3)
Panel A: Eliminating Wage Multiplier; Federal Taxes Neutral			
Land Rents $s_R \hat{r}^j$	1.00	1.00	1.00
Wages $s_w \hat{w}^j$	-0.20	0.81	-0.20
Home-Good Prices $s_y \hat{p}^j$	0.81	0.81	-0.20
Panel B: Wage Multiplier Accounted For; Federal Taxes Neutral			
Land Rents $s_R \hat{r}^j$	1.00	1.00	1.00
Wages $s_w \hat{w}^j$	-0.23	1.19	-0.23
Home-Good Prices $s_y \hat{p}^j$	0.77	1.19	-0.23
Panel C: Parameterization with Wage Multiplier and Federal Taxes on Wages			
Land Rents: $s_R \hat{r}^j$	1.09	0.53	1.09
Wages $s_w \hat{w}^j$	-0.25	1.30	-0.25
Home-Good Prices $s_y \hat{p}^j$	0.84	0.83	-0.16
Federal Tax Payment $d\tau^j / \bar{m}$	-0.09	0.47	-0.09
Panel D: Realistic Parmaterization with Wage Multiplier, Federal and Taxes on Wages and Housing Benefits			
Land Rents: $s_R \hat{r}^j$	1.17	0.66	1.07
Wages $s_w \hat{w}^j$	-0.27	1.27	-0.24
Home-Good Prices $s_y \hat{p}^j$	0.90	0.93	-0.18
Federal Tax Payment $d\tau^j / \bar{m}$	-0.17	0.34	-0.07

Panels A and B are based on formulae in (7) using the parameterization in Table 1 with no federal taxes. Additionally, Panel A forces λ_N=1 by setting s_y = 0.108, φ_N=0, φ_L=1 ,and θ_N= 0.842, making it a reduced model somewhat different than the Beeson and Eberts (1989) parameterization in Table 1. Panel C accounts for federal taxes on wages only. Panel D also includes housing deductions and state taxes, as explained in the Appendix.

TABLE 3A: WAGE, HOUSING COST, LAND RENT, QUALITY-OF-LIFE, PRODUCTIVITY, FEDERAL TAX, AND TOTAL AMENITY VALUE DIFFERENTIALS, 2000

		Adjusted Differentials			Amenity Values			
	Population Size	Wages	Housing Costs	Inferred Land Rent	Quality of Life	Trade-Productivity	Federal Tax Differential	Total Amenity Value
Main city in MSA/CMSA								
San Francisco CA	7,039,362	0.26	0.81	2.78	0.14	0.29	0.05	0.32
Santa Barbara CA	399,347	0.07	0.66	2.65	0.18	0.13	-0.01	0.26
Honolulu HI	876,156	-0.01	0.61	2.62	0.20	0.06	-0.02	0.24
Monterey CA	401,762	0.10	0.59	2.24	0.14	0.14	0.01	0.23
San Diego CA	2,813,833	0.06	0.48	1.89	0.12	0.10	0.00	0.19
Los Angeles CA	16,373,645	0.13	0.45	1.57	0.08	0.15	0.02	0.18
New York NY	21,199,865	0.21	0.41	1.18	0.03	0.21	0.04	0.16
Seattle WA	3,554,760	0.08	0.31	1.10	0.06	0.10	0.01	0.12
Boston MA	5,819,100	0.12	0.29	0.93	0.03	0.13	0.02	0.12
Denver CO	2,581,506	0.05	0.24	0.89	0.05	0.07	0.01	0.10
Chicago IL	9,157,540	0.14	0.22	0.59	0.01	0.13	0.03	0.09
Portland OR	2,265,223	0.02	0.17	0.68	0.05	0.04	0.00	0.07
Washington-Baltimore DC	7,608,070	0.13	0.15	0.31	-0.01	0.12	0.03	0.06
Miami FL	3,876,380	0.00	0.13	0.54	0.04	0.02	0.00	0.05
Phoenix AZ	3,251,876	0.03	0.08	0.24	0.01	0.03	0.01	0.03
Detroit MI	5,456,428	0.13	0.05	-0.13	-0.05	0.11	0.04	0.02
Philadelphia PA	6,188,463	0.11	0.05	-0.09	-0.04	0.10	0.03	0.02
Minneapolis MN	2,968,806	0.08	0.02	-0.14	-0.03	0.07	0.03	0.01
Atlanta GA	4,112,198	0.08	0.01	-0.15	-0.03	0.06	0.02	0.01
Cleveland OH	2,945,831	0.01	-0.03	-0.17	-0.02	0.01	0.01	-0.01
Dallas TX	5,221,801	0.06	-0.04	-0.34	-0.04	0.05	0.02	-0.01
Tampa FL	2,395,997	-0.06	-0.08	-0.20	0.00	-0.05	-0.01	-0.03
St. Louis MO	2,603,607	0.01	-0.10	-0.46	-0.03	-0.01	0.01	-0.04
Houston TX	4,669,571	0.07	-0.11	-0.68	-0.07	0.05	0.03	-0.04
Pittsburgh PA	2,358,695	-0.04	-0.21	-0.77	-0.05	-0.05	-0.01	-0.08
San Antonio TX	1,592,383	-0.09	-0.25	-0.85	-0.04	-0.10	-0.02	-0.10
Oklahoma City OK	1,083,346	-0.13	-0.28	-0.83	-0.02	-0.14	-0.02	-0.11
McAllen TX	569,463	-0.21	-0.57	-1.86	-0.08	-0.23	-0.04	-0.23
Census Division								
Pacific	45,025,637	0.10	0.39	1.42	0.08	0.12	0.01	0.16
New England	13,922,517	0.07	0.19	0.61	0.03	0.07	0.01	0.07
Middle Atlantic	39,671,861	0.09	0.13	0.28	-0.01	0.09	0.02	0.05
Mountain	18,172,295	-0.06	0.00	0.16	0.03	-0.04	-0.02	0.00
East North Central	45,155,037	0.02	-0.07	-0.33	-0.03	0.00	0.01	-0.03
South Atlantic	51,769,160	-0.04	-0.08	-0.25	-0.01	-0.04	-0.01	-0.03
West South Central	31,444,850	-0.08	-0.24	-0.83	-0.04	-0.09	-0.01	-0.10
West North Central	19,237,739	-0.11	-0.25	-0.80	-0.03	-0.11	-0.02	-0.10
East South Central	17,022,810	-0.12	-0.32	-1.02	-0.04	-0.13	-0.02	-0.12
MSA Population								
MSA, Pop > 5 Million	84,064,274	0.16	0.32	0.96	0.03	0.16	0.03	0.13
MSA, Pop 1.5-4.9 Million	57,157,386	0.03	0.04	0.08	0.00	0.02	0.01	0.02
MSA, Pop 0.5-1.4 Million	42,435,508	-0.03	-0.09	-0.29	-0.01	-0.04	-0.01	-0.04
MSA, Pop < 0.5 Million	42,324,511	-0.10	-0.19	-0.52	-0.01	-0.10	-0.02	-0.07
Non-MSA areas	55,440,227	-0.16	-0.32	-0.91	-0.02	-0.16	-0.04	-0.13
United States	281,421,906	0.13	0.30	1.00	0.05	0.13	0.03	0.12
	total				*standard deviations*			

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 C.1. for more details. The inferred land-rent, quality-of-life, trade-productivity, and total-amenity variables are estimated from the equations in section 4.2, using the calibration in Table 1, with additional adjustments for housing deductions and state taxes, described in Appendix A.

TABLE 3B: CENSUS METROPOLITAN AREA RANKINGS, 2000

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

Rankings based off of data in Appendix Table A1, which contains the full MSA/CMSA names. The quality-of-life ranking is originally from Albouy (2009)

TABLE 4: VARIANCE DECOMPOSTION OF QUALITY-OF-LIFE AND TRADE-PRODUCTIVITY EFFECTS ON PRICE DIFFERENTIALS ACROSS CITIES

		Variance Decomposition Fraction of variance explained by		
	Variance (1)	Quality of Life (2)	Productivity (3)	Covariance (4)
Panel A: With Federal Taxes				
Land Rents	1.002	0.370	0.287	0.342
Wages	0.019	0.018	1.132	-0.150
Housing Costs	0.093	0.184	0.498	0.318
Tax Differential	0.001	0.113	1.276	-0.398
Total Value	0.015	0.181	0.503	0.317
Panel B: Federal Taxes Geographically Neutral				
Land Rents	1.459	0.181	0.503	0.317
Wages	0.017	0.015	1.120	-0.134
Housing Costs	0.126	0.097	0.642	0.262
Tax Differential	0.000	.	.	.
Total Value	0.015	0.181	0.503	0.317

Variances are calculated across 276 metro areas and 49 non-metro areas by state, weighted by population.

TABLE 5: THE RELATIONSHIP BETWEEN INDIVIDUAL AMENITIES AND HOUSING COSTS, WAGES, QUALITY OF LIFE, PRODUCTIVITY, LAND RENTS, FEDERAL TAXES, AND TOTAL AMENITY VALUES

			Observables		Amenity Type		Capitalization Into		Total
	Mean	Standard Deviation	Housing Cost (1)	Wage (2)	Quality of Life (3)	Trade Productivity (4)	Local Land Rents (5)	Federal Tax Payment (6)	Amenity Value (7)
Logarithm of Metro Population	14.63	1.32	0.056***	0.038***	-0.001	0.036***	0.013***	0.009***	0.022***
			(0.007)	(0.004)	(0.002)	(0.004)	(0.002)	(0.001)	(0.003)
Percent of Population College Graduates	0.26	0.07	1.718***	0.714***	0.213***	0.748***	0.540***	0.152***	0.692***
			(0.169)	(0.069)	(0.042)	(0.067)	(0.062)	(0.017)	(0.067)
Whartron Residential Land-Use Regulatory Index (WRLURI)	0.05	0.93	0.008	0.004	0.001	0.004	0.002	0.001	0.003
			(0.012)	(0.007)	(0.004)	(0.006)	(0.005)	(0.002)	(0.005)
Minus Heating-Degree Days (1000s)	-4.38	2.15	0.039***	0.014**	0.006	0.015***	0.013***	0.003*	0.016***
			(0.010)	(0.006)	(0.004)	(0.005)	(0.004)	(0.002)	(0.004)
Minus Cooling-Degree Days (1000s)	-1.28	0.89	0.105***	0.017	0.025***	0.025**	0.040***	0.001	0.041***
			(0.018)	(0.012)	(0.007)	(0.010)	(0.007)	(0.003)	(0.007)
Sunshine (percent possible)	0.60	0.08	1.248***	0.290***	0.260***	0.363***	0.455***	0.038	0.493***
			(0.129)	(0.089)	(0.044)	(0.078)	(0.048)	(0.023)	(0.052)
Inverse Distance to Coast (Ocean or Great Lake)	0.04	0.04	0.078***	0.024***	0.013***	0.027***	0.027***	0.003***	0.030***
			(0.008)	(0.005)	(0.002)	(0.004)	(0.003)	(0.001)	(0.003)
Average Slope of Land (percent)	1.68	1.59	0.023***	-0.006*	0.010***	-0.002	0.011***	-0.003***	0.009***
			(0.005)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)
Latitude (degrees)	37.76	4.86	0.009**	0.008**	-0.001	0.007***	0.002	0.002**	0.004**
			(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)	(0.002)
Constant			-1.771	-1.020	-0.078	-0.996	-0.478	-0.237	-0.716
			(0.168)	(0.149)	(0.061)	(0.129)	(0.058)	(0.038)	(0.067)
R-squared			0.92	0.84	0.75	0.88	0.91	0.77	0.92

282 observations with complete data. Robust standard errors shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. Regressions weighted by the sum of individuals in a city, each according to their predicted income in an average city. Amenity variables are described in Section 4.2 and Appendix C.3.

Figure 1: Housing Costs versus Wage Levels across Metro Areas, 2000

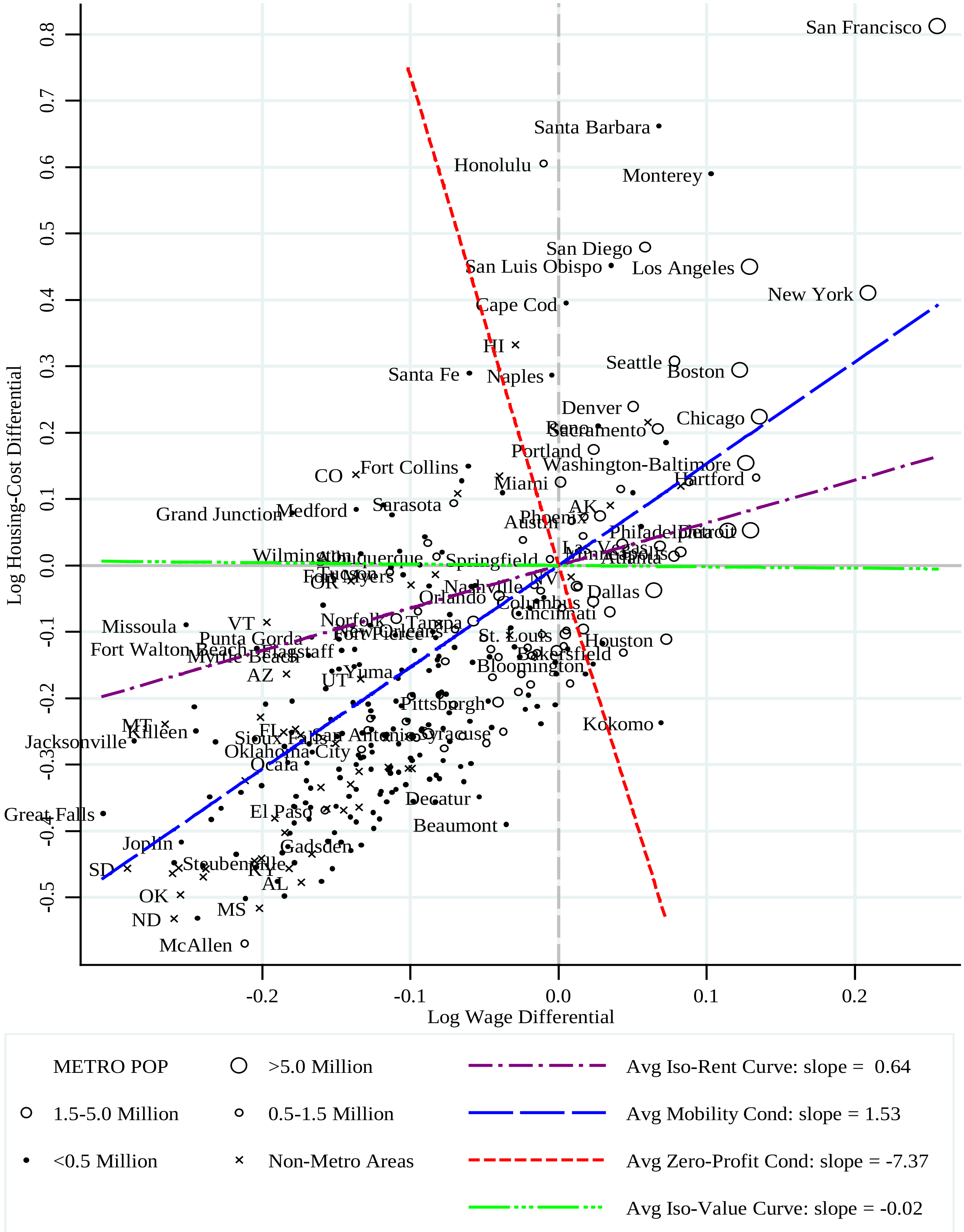


Figure 2: Housing Costs and Inferred Land Rents

Figure 3: Trade-Productivity Estimates Compared

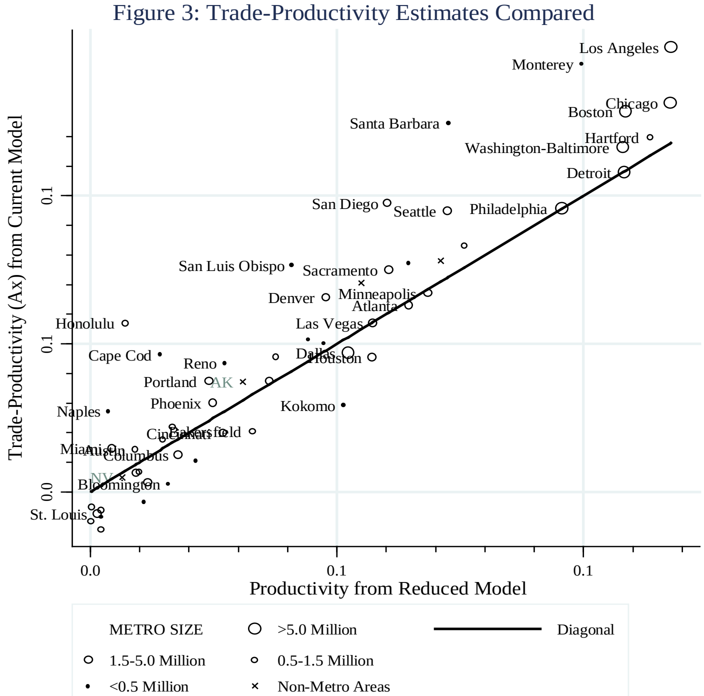


Figure 4: Estimated Trade-Productivity and Quality of Life, 2000

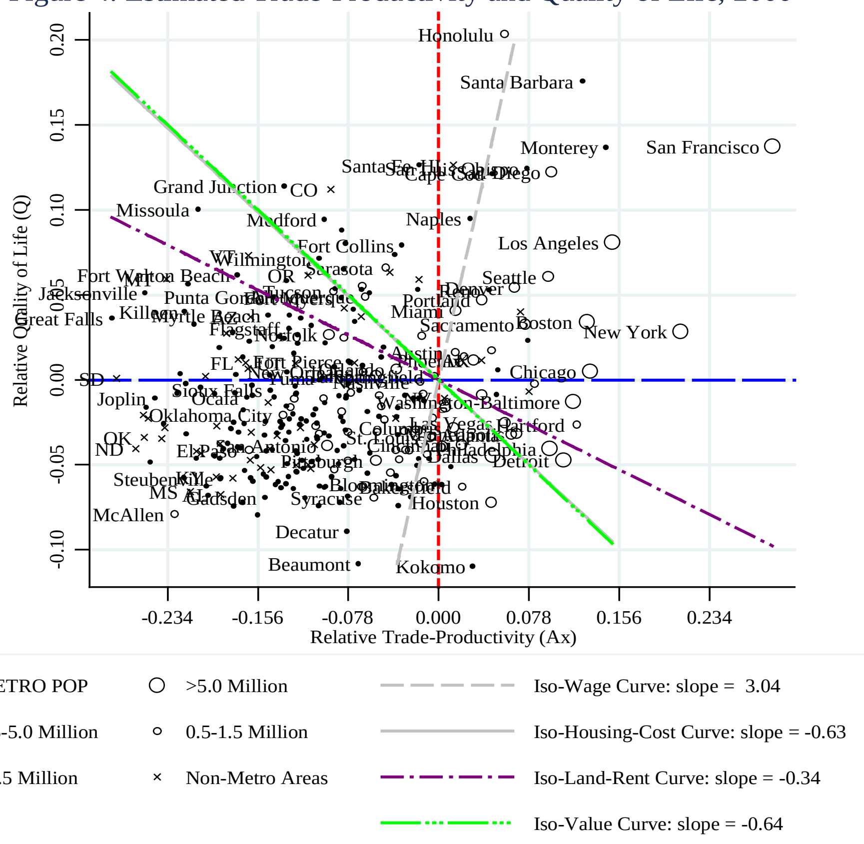


Figure 5: Trade-Productivity and Population Size

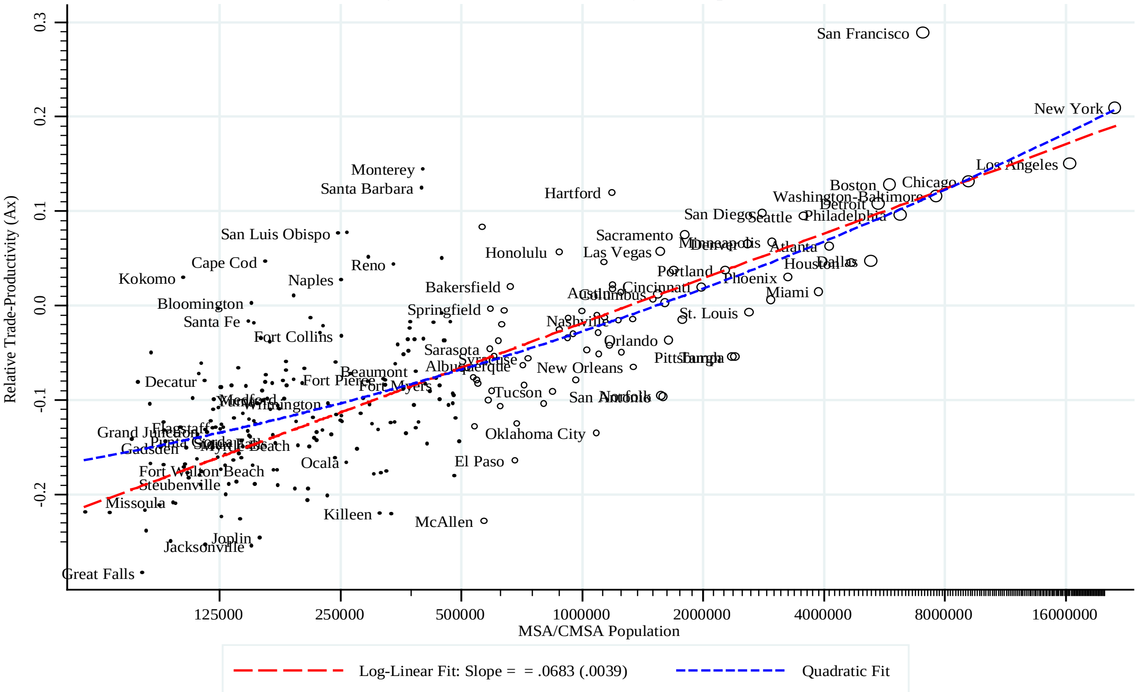
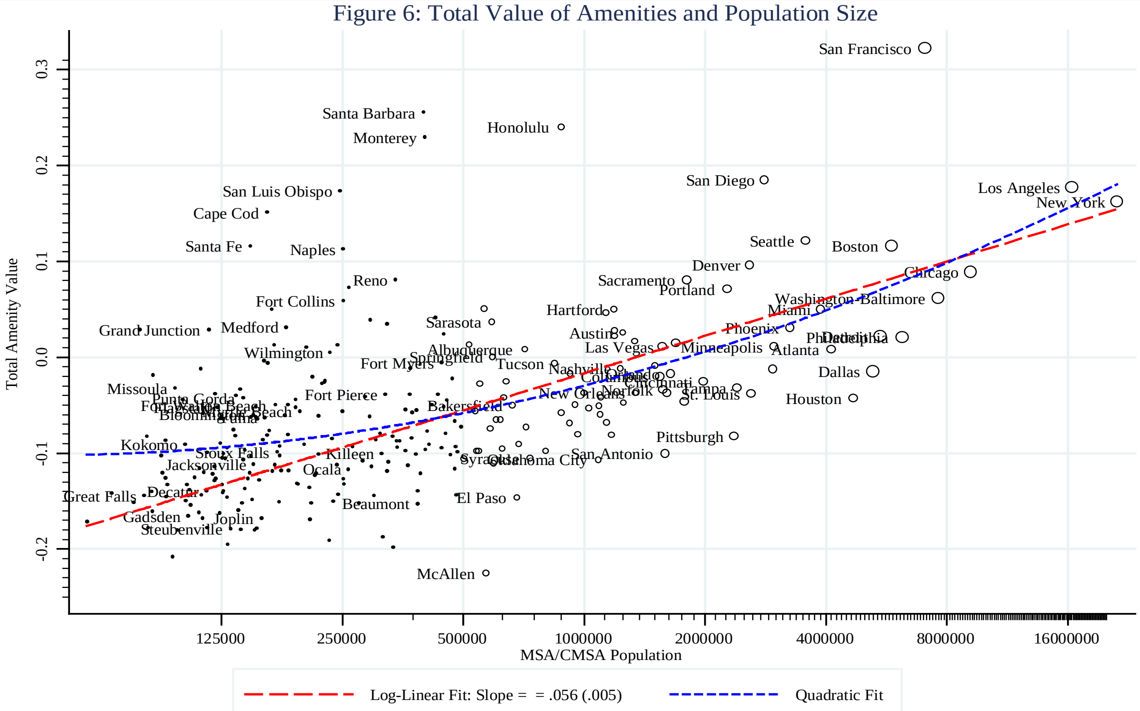


Figure 6: Total Value of Amenities and Population Size



Appendix

A Additional Tax Considerations and Details

A.1 Tax Deduction for Housing or other Non-Traded Goods

Tax deductions are applied to the consumption of home goods at the rate $\delta \in [0,1]$, so that the tax payment is given by $\tau(m - \delta py)$. With the deduction, the mobility condition becomes

$$\begin{aligned} \hat{Q}^j &= (1-\delta\tau')s_y\hat{p}^j - (1-\tau')s_w\hat{w}^j \\ &= s_y\hat{p}^j - s_w\hat{w}^j + \frac{d\tau^j}{m}, \end{aligned}$$

where the tax differential is given by $d\tau^j/m = \tau'(s_w\hat{w}^j - \delta s_y p^j)$. This differential can be solved by noting

$$\begin{aligned} s_w\hat{w}^j &= s_w\hat{w}^j_* + \frac{\lambda_L}{\lambda_N}\frac{d\tau^j}{m} \\ s_y\hat{p}^j &= s_y\hat{p}^j_* - \left(1 - \frac{\lambda_L}{\lambda_N}\right)\frac{d\tau^j}{m}, \end{aligned}$$

substituting these conditions into the tax differential formula, solving recursively:

$$\begin{aligned} \frac{d\tau^j}{m} &= \tau' s_w\hat{w}^j_* - \delta\tau' s_y\hat{p}^j_* + \tau'\left[\delta + (1-\delta)\frac{\lambda_L}{\lambda_N}\right] \\ &= \tau'\frac{s_w\hat{w}^j_* - \delta s_y\hat{p}^j_*}{1 - \tau'\left[\delta + (1-\delta)\lambda_L/\lambda_N\right]}. \end{aligned}$$

The tax multiplier now includes a second mechanism: higher prices lead to greater deductions, lowering taxes, and increasing prices further. It also softens the wage component of the multiplier, by softening higher living costs. Thus, the tax multiplier is increasing in δ, and attains a maximum value of $1/(1-\tau')$ when $\delta = 1$. Substituting in $\hat{w}^j_*$ and $\hat{p}^j_*$ from (7b) and (7c) with $\tau' = 0$, gives the tax differential in terms of the attributes:

$$\frac{d\tau^j}{m} = \tau'\frac{1}{1-\tau'\left[\delta + (1-\delta)\lambda_L/\lambda_N\right]}\left[(1-\delta)\left(\frac{1-\lambda_L}{\lambda_N}s_x\hat{A}^j_X - \frac{\lambda_L}{\lambda_N}s_y A^j_Y\right) - \frac{(1-\delta)\lambda_L + \delta\lambda_N}{\lambda_N}\hat{Q}^j\right].$$

This equation demonstrates that the deduction reduces the dependence of taxes on productivity and increases the implicit subsidy for quality-of-life. This formula can be substituted back into the above equations to determine the full capitalization effects with the deduction in place, enriching the equations in (7):

$$s_R\hat{r}^j = \frac{1}{1-\tau'\left[\delta+(1-\delta)\lambda_L/\lambda_N\right]}\left\{\hat{Q}^j + \left[1-\tau'\left(\delta+\frac{1-\delta}{\lambda_N}\right)\right]s_x\hat{A}_X^j + (1-\tau'\delta)\,s_y A_Y^j\right\}$$
$$s_w\hat{w}^j = \frac{1}{1-\tau'\left[\delta+(1-\delta)\lambda_L/\lambda_N\right]}\frac{1}{\lambda_N}\left[-\lambda_L\hat{Q}^j + (1-\lambda_L)\left(1-\tau'\delta\right)s_x\hat{A}_X^j - \lambda_L\left(1-\tau'\delta\right)s_y\hat{A}_Y^j\right]$$
$$s_y\hat{p}^j = \frac{1}{1-\tau'\left[\delta+(1-\delta)\lambda_L/\lambda_N\right]}\frac{1}{\lambda_N}\left\{(\lambda_N-\lambda_L)\,\hat{Q}^j + (1-\tau')(1-\lambda_L)s_x\hat{A}_X^j - (1-\tau')\lambda_L s_y\hat{A}_Y^j\right\}$$

With all three prices, quality-of-life is affected only by the multiplier, meaning it is capitalized more strongly with higher δ. It is fairly easy to show that higher δ lowers the overall impact of taxes on productivity capitalization for all of the effects.

Finally, the full value of amenities may be measured by $\hat{\Omega}^j = s_r\hat{r}^j + \tau' s_w\hat{w}^j - \delta\tau' s_y\hat{p}^j$, when land values are available, or by

$$\hat{\Omega}^j = \frac{1}{1-\lambda_L}\left\{\left[1-(1-\lambda_L)\delta\tau'\right]s_y\hat{p}^j + \left[\tau'\left(1-\lambda_L\right)-\left(1-\lambda_N\right)\right]s_w\hat{w}^j\right\} + \frac{1}{1-\lambda_L}s_y\hat{A}_Y^j,$$

when they are not. Relative to (8), this expression puts less weight on housing costs.

A.2 State Taxes

The tax differential with state taxes is computed by including an additional component based on wages and prices relative to the state average, as if state tax revenues are redistributed lump-sum to households within the state. This produces the augmented formula

$$\frac{d\tau^j}{m} = \tau'\left(s_w\hat{w}^j - \delta\tau' s_y\hat{p}^j\right) + \tau_S'[s_w(\hat{w}^j-\hat{w}^S) - \delta_S s_y(\hat{p}^j-\hat{p}^S)], \tag{A.1}$$

where τ_S' and δ_S are are marginal tax and deduction rates at the state-level, net of federal deductions, and $\hat{w}^S$ and $\hat{p}^S$ are the differentials for state S as a whole relative to the entire country.

B Parameterization

B.1 Economic Parameter Choices

The parameterization used here is the same as in Albouy (2009), although I review it below. Because of accounting identities mentioned above, only six parameters are free, but choosing these requires reconciling slightly conflicting sources.

Starting with income shares, Krueger (1999) makes the case that the labor share, s_w is close to 75 percent. In practice, this reflects the previous literature that weights the wage differential by labor income, rather than household income. Albouy (2008) argues this number applies to a representative household, so higher-income households, with more income from capital, receive greater weight. It also averages in retirees and others on fixed or transfer income (e.g. students). The share is also consistent with data in the Survey of Consumer Finances. Theoretically, the use of s_w in (4a) implies that if a households moves, their wage may change, but not the flow income from previous savings.

Poterba (1998) estimates that the share of income from corporate capital is 12 percent, and thus income from mobile capital, s_I should be higher, and is taken as 15 percent. This leaves 10 percent for land s_R. This is the same as in Shapiro (2006) and roughly consistent with estimates in Keiper et al. (1961) and Case (2007).[28]

Turning to expenditure shares, Shapiro (2006), Albouy (2008), Moretti (2013) and find that housing costs can also be used to approximate non-housing cost differences across cities. The cost-of-living differential is $s_y \hat{p}^j$, where $\hat{p}^j$ is equal to the housing-cost differential and s_y is the expenditure share on housing plus an additional term to capture how a one-percent increase in housing costs predicts a $b = 0.26$-percent increase in non-housing costs. In the Consumer Expenditure Survey (CEX), the share of income spent on shelter and utilities, s_{hous}, is 0.22, although the share of income spent on other goods, s_{oth}, is 0.56, with the remaining 0.22 spent on taxes or saved (Bureau of Labor Statistics 2002). Thus, the coefficient on housing costs is equal to $s_y = s_{hous} + s_{oth} b = 0.22 + 0.56 \times 0.26 = 36$ percent. This leaves s_x at 64 percent.[29]

I choose the cost-shares to be consistent with the expenditure and income shares above. I use a value of 2.5 percent for θ_L here. Beeson and Eberts (1989) use a value of 0.027, while Rappaport (2008a, 2008b) uses a value of 0.016. Valentinyi and Herrendorff (2008) estimate the land share of tradables at 4 percent, but their definition of tradables makes this an upper bound.

Following Carliner (2003) and Case (2007), I use a cost-share of land in home-goods, taken as housing, ϕ_L, at 23.3 percent: this is slightly above values reported in McDonald (1981), Roback (1982), and Thorsnes (1997), in order to take into account for secular increase in land cost-shares over time, seen in Davis and Palumbo (2007). Together the cost and expenditure shares imply that s_R is 10 percent, consistent with other income shares, and that λ_L is 17 percent. This seems reasonable as the remaining 83 percent of land for home goods includes all residential land, and most land used for commerce, roads, and government.[30]

The one remaining choice determines the cost-shares of labor and capital in both production sectors. As separate information on ϕ_K and θ_K is unavailable, I set both cost-shares of capital to be equal at 15 percent to be consistent with s_I. Accounting identities then determine that θ_N is 82.5 percent, ϕ_N is 62 percent, and λ_N is 70.4 percent.

[28] The values Keiper et al. (1961) reports were at a historical low: that total land value was found to be about 1.1 times GDP. A rate of return of 9 percent would justify using $s_R = 0.10$. Case (2007), ignoring agriculture, estimates the value of land to be $5.6 trillion in 2000 when personal income was $8.35 trillion, implying a smaller share.

[29] Utility costs account for one fifth of s_{hous}, which means that without them this parameter would be roughly 0.18. As shown below, taking out utility costs would be largely offset by larger differentials in housing costs, $\hat{p}^j$.

[30] These proportions are roughly consistent with other studies. In the base calibration of the model, 51 percent of land is devoted to actual housing, 32 percent is for non-housing home goods, and 17 percent is for traded goods, including those purchased by the federal government. Keiper et al. (1961) find that about 52.5 of land value is in residential uses, a 22.9 percent in industry, 20.9 percent in agriculture. Case (2007), ignoring agriculture, finds that in 2000 residential real estate accounted for 76.6 percent of land value, while commercial real estate accounted for the remaining 23.4 percent. Appendix D.2, there may be advantages to modeling housing and non-housing home goods, separately, but there is little additional information on non-housing goods to calibrate this model better. My suspicion is that non-housing home goods are less land-intensive and more labor-intensive than housing goods. Accounting for this would likely lower the implied share of total income going to land.

B.2 Choice of Tax Parameters

The federal marginal tax rate on wage income is determined by adding together federal marginal income tax rate and the effective marginal payroll tax rate. TAXSIM gives an average marginal federal income tax rate of 25.1 percent in 2000. In 2000, Social Security (OASDI) and Medicare (HI) tax rates were 12.4 and 2.9 percent on employer and employee combined. Estimates from Boskin et al. (1987, table 4) show that the marginal benefit from future returns from OASDI taxes is fairly low, generally no more than 50 percent, although only 85 percent of wage earnings are subject to the OASDI cap. HI taxes emulate a pure tax (Congressional Budget Office 2005). These facts suggest adding 37.5 percent of the Social Security tax and all of the Medicare tax to the federal income tax rate, adding 8.2 percent. The employer-half of the payroll tax (4.1 percent) has to be added to observed wage levels to produce gross wage levels. Overall, this puts an overall federal tax rate, τ' , of 33.3-percent on gross wages, although only 29.2 percent on observed wages.

Determining the federal deduction level requires taking into account the fact that many households do not itemize deductions. According to the Statistics on Income, although only 33 percent of tax returns itemize, they account for 67 percent of reported Adjusted Gross Income (AGI). Since the income-weighted share is what matters, 67 percent is multiplied by the effective tax reduction given in TAXSIM, in 2000 of 21.6 percent. Thus, on average these deductions reduce the effective price of eligible goods by 14.5 percent. Since eligible goods only include housing, this deduction applies to only 59 percent of home goods. Multiplying 14.5 percent by 59 percent, gives an effective price reduction of 8.6 percent for home goods. Divided by a federal tax rate of 33.3 percent, this produces a federal deduction level of 25.7 percent.

State income tax rates from 2000 are taken from TAXSIM, which, per dollar, fall at an average marginal rate of 4.5 percent. State sales tax data in 2000 are taken from the Tax Policy Center, originally supplied by the Federation of Tax Administrators. The average state sales tax rate is 5.2 percent. Sales tax rates are reduced by 10 percent to accommodate untaxed goods and services other than food or housing (Feenberg et al. 1997), and by another 8 percent in states that exempt food. Overall state taxes raise the marginal tax rate on wage differences within-state by an average of 5.9 percentage points, from zero points in Alaska to 8.8 points in Minnesota.

State-level deductions for housing expenditures, explicit in income taxes, and implicit in sales taxes, should also be included. At the state level, deductions for income taxes are calculated in an equivalent way using TAXSIM data. Furthermore, all housing expenditures are deducted from the sales tax. Overall this produces an average effective deduction level of $\delta = 0.291$.

B.3 Validity of First-Order Approximations

Technically, the first-order approximation works best in a Cobb-Douglas economy, where elasticities of substitution are one, productivity is not factor biased, and quality-of-life is not, similarly, "consumption biased."

B.3.1 Quadratic Approximations

The inferred land rent from equation (5) comes from a first-order approximation around the national average. This poses a problem if the cost-shares of land or labor vary substantially across cities due to variations in factor prices. I address this by taking a second-order approximation of equation (3) around the national average, and rearranging it to solve for the inaccuracy of the first-order approximation:

$$\hat{p} - \phi_L \hat{r}^j - \phi_N \hat{w}^j + \hat{A}_Y^j = \frac{1}{2}\phi_N \phi_L \left(1 - \sigma_Y^{NL}\right)\left(\hat{w}^j - \hat{r}^j\right)^2 + \frac{1}{2}\phi_K \left[\phi_N \left(1 - \sigma_Y^{NK}\right)\left(\hat{w}^j\right)^2 + \phi_L \left(1 - \sigma_Y^{LK}\right)\left(\hat{r}^j\right)^2\right]. \quad \text{(A.2)}$$

σ_Y^{NL} is the (Allen-Uzawa) partial elasticity of substitution between labor and land, with other partial elasticities similarly defined. The first term on the right-hand side captures the substitution between labor and land, and the second, between capital - which has a constant price - and the other two factors.

If $\hat{A}_Y^j = 0$, then (A.2) may provide quadratic estimates of land-rent differentials, $\hat{r}^j$, in terms of $\hat{p}^j$ and $\hat{w}^j$. If the elasticities of substitution are less than one, as is likely, then the cost-share of land increases with land rents. Since the land-share effect depends inversely on the cost-share of land, the quadratic approximation of $\hat{r}^j$ is concave in $\hat{p}^j$, as the land-share effect decreases with $\hat{r}^j$. At the central point where $\hat{p}^j = \hat{w}^j = 0$, the quadratic and linear approximations formulas are tangent, and thus the concave quadratic approximation lies below the linear approximation, with the difference increasing in the square of $\hat{p}^j$. Therefore, the linear estimates overstate land-rent differences for $\hat{p}^j > 0$, and understate differences for $\hat{p}^j < 0$. Additionally, the cost-share of labor increases with $\hat{w}^j$ and decreases with $\hat{r}^j$, causing the need for additional adjustments for the labor-cost effect.

Figure A1 graphs inferred land rents based on a second-order approximation, where $\sigma_Y^{NL} = \sigma_Y^{KL} = \sigma_Y^{NK} = 0.67$, against those already estimated off of the first-order approximation.(Appendix table A1 reports the numerical values)[31] The estimates from the quadratic formula differ most from the linear estimates where housing costs are furthest from zero. Yet, even at these extremes, they differ by less than 20 percent.[32]

Another expression could be used for trade-productivity. However, we know little about the substitutability between land and other inputs in traded-production. Many studies conclude that the elasticity of substitiution between labor and capital overall is close to one.

B.3.2 Local Heterogeneity in the Income Share and Tax Rates

Even in such an economy, the term on wages $(1 - \tau')s_w$ will not be constant as wage levels change.[33] Taking the model literally, where non-labor income is fixed the change in $s_w^j = w^j/m^j$ is

[31] These substitution elasticities are based on estimates in McDonald (1981) and Thorsnes (1997).

[32] There are three partial (Allen-Uzawa) elasticities of substitution in production for each combination of two factors, where $\sigma_Y^{LN} \equiv \left(\partial^2 c_Y / \partial w \partial r\right) / \left(\partial c_Y / \partial w \cdot \partial c_Y / \partial r\right)$ is the partial elasticity of substitution between labor and land in the production of Y, etc. Approximation of the cost-share is

$$\phi_L^j = \bar{\phi}_L \left\{1 + \left[\bar{\phi}_N \left(1 - \sigma_Y^{NL}\right) + \bar{\phi}_K \left(1 - \sigma_Y^{LK}\right)\right]\hat{r}^j - \bar{\phi}_N \left(1 - \sigma_Y^{NL}\right)\hat{w}^j\right\}$$

where the $\bar{\phi}$ terms are used to represent average cost shares in the economy. In the case where $\hat{w}^j = 0$ and $\sigma_Y^{LK} = \sigma_Y^{NL} = \sigma_Y$, then (A.2) can be arreanged to show $\hat{r}^j = \hat{p}^j/\bar{\phi}_L - \left(1 - \bar{\phi}_L\right)\left(1 - \sigma_Y\right)\left(\hat{r}^j\right)^2$. The second term describes how the quadratic approximation is below the linear approximation when $\hat{r}^j \neq 0$.

[33] The term pre-multiplying $\hat{w}^j$ is not constant unless $\frac{1-\tau'(m^j)}{1-\tau(m^j)/m} = c\frac{m^j}{m^j - I - R}$,where c is a constant. If the tax system is progressive and $\tau'(m^j) > \tau(m^j)/m$, then this condition cannot be met for all values of m^j.

$\hat{s}_w^j = \hat{w} - \hat{m} = (1 - s_w)\hat{w}^j$. A second-order approximation then uses $s_w\hat{w}^j + (1/2)(1 - s_w)(\hat{w}^j)^2 = s_w\hat{w}^j[1 - (1/2)(1 - s_w\hat{w}^j)]$ in place of $s_w\hat{w}^j$. Incorporating changes in federal tax rates involves multipying the $(1 - \tau')\, s_w\hat{w}^j$ term by $[1 - (1/2)(1 - s_w(1 - \varepsilon_{(1-\tau'),m})\hat{w}^j]$, where $\varepsilon_{(1-\tau'),m}$ is the elasticity of the net-of-tax rate with respect to income. From data in Piketty and Saez (2007), I estimate a value of $\varepsilon_{(1-\tau'),m} = -0.1$. Parameterized, the second-order adjustment replaces $\hat{w}^j$ with $(1 - 0.0875\hat{w}^j)\,\hat{w}^j$. Because $(\hat{w}^j)^2$ is typically small – its standard deviation is 0.017 – this adjustment has almost no effect on the estimates: $\hat{Q}^j$ using the second-order adjustment is almost identical to the original, with a correlation of over 0.999.

To consider this issue further, I use Census to data to calculate the ratio of wage and salary income to total household income by metro area. The average ratio 0.78, and the standard deviation is 0.034 when population weighted. A simple regression on the wage differential and the fraction of the population over 65 ($over65^j$) explains 88-percent of the variation.

$$s_w^j = 0.75 + \underset{(0.01)}{0.05}\hat{w}^j - \underset{(0.04)}{1.03}over65^j + e^j, R^2 = 0.88, var(e^j) = 0.012$$

The coefficient on wages is positive, as predicted, but well below the predicted value of 0.25. Measurement issues aside, this result may be reconciled with the model if moves across cities are infrequent, and savings rates are uniform across cities. The underlying assumption that non-labor income should not change when a household moves remains sensible. The coefficient on those over 65 highlights the need to average in those outside of the labor force. Indeed, it would be interesting to examine how cities with a greater fraction of retirees and others outisde of the labor force have a smaller traded sector relative to the home sector. Using the actual shares to estimate $\hat{Q}^j$ still results in very similar estimates, with a correlation coefficient of 0.999.

C Data and Estimation

C.1 Wages and Housing-Cost Differentials

Wage and housing-price data come from the United States Census data from the 2000 Integrated Public-Use Microdata Series (IPUMS), from Ruggles et al. (2004).

To estimate inter-urban wage differentials, $\hat{w}^j$, I use the logarithm of hourly wages from full-time workers, ages 25 to 55. These differentials should control for skill differences across workers to provide an analogue to the representative worker in the model and isolate the effect of a city on a worker's wage. Thus, I regress log wages on city-indicators (μ_w^j) and on extensive controls (X_{wi}^j) in the equation $\ln w_i^j = X_{wi}^j\beta_w + \mu_w^j + \varepsilon_{wi}^j$, and use the estimates of μ_w^j for the wage differentials. Identifying these differentials requires that workers do not sort across cities according to their unobserved skills. [34] An overstated wage differential for a city biases trade-productivity upwards and quality of life downwards. Below is a list of the controls used in the wage equation:

- 12 indicators of educational attainment;

[34] This assumption may not hold completely, but as argued in Albouy (2008), sorting may be less of an issue than commonly presumed for three major reasons. First, the variance in wages across metros in observable skills is relatively small. Second, different types of labor, according to education, are paid remarkably similar premia across cities. Third, dropping individuals that currently reside in a metropolitan area away from their state of birth changes the wage differentials by very little.

- a quartic in potential experience, and potential experience interacted with years of education;
- 9 indicators of industry at the one-digit level (1950 classification);
- 9 indicators of employment at the one-digit level (1950 classification);
- 4 indicators of marital status (married, divorced, widowed, separated);
- an indicator for veteran status, and veteran status interacted with age;
- 5 indicators of minority status (Black, Hispanic, Asian, Native American, and other);
- an indicator of immigrant status, years since immigration, and immigrant status interacted with black, Hispanic, Asian, and other; and
- 2 indicators for English proficiency (none or poor).

All covariates are interacted with gender.

I first run the regression using census-person weights. From the regressions, I calculate a predicted wage is using the individual characteristics, not the MSAs, to form a new weight equal to the predicted wage multiplied by the census-person weight. Economically, these income-adjusted weights are more relevant since workers' influence on prices is determined by their endowment and income share (see Section D.1 below). The new weights are then used in a second regression, which is used to calculate the city-wage differentials from the MSA indicator variables. In practice, this weighting procedure has only a small effect on the estimated wage differentials.

To estimate housing-cost, $\hat{p}^j$, I use both housing values and gross rents, with utilities, to calculate a flow cost. Following previous studies, I calculate comparable imputed rents for owned units by multiplying reported housing values by a rate of 7.85 percent (Peiser and Smith 1985) and adding this to utility costs.[35] To avoid measurement error from imperfect recall or rent control, the sample includes only units that were acquired in the last ten years. I then regress housing costs on flexible controls (X_{pi}^j) – interacted with renter-status – in the equation $\ln p_i^j = X_{pi}^j \beta_p + \mu_p^j + \varepsilon_{pi}^j$, and use the estimates of μ_p^j for the housing-cost differentials. Proper identification of housing-cost differences requires that average unobserved housing quality does not vary systematically across cities. An overstated housing-cost differential biases both trade-productivity and quality of life upwards.[36] Below is a list of the controls used in the housing-cost regression:

- 9 indicators for number of units in structure (1-family home, attached; 1-family house, detached; 2-family building; 3-4 family building; 5-9 family building, 10-19 family building; 20-49 family building; 50+ family building; mobile home or trailer);

[35]Based on an analysis of owner-occupied units, it appears that housing-cost differentials would be, on average, 20 percent larger if utility costs are excluded. In the mobility condition, this would be largely offset by using a value of s_y to exclude utilities that would be 20 percent smaller. In the housing-cost equation, it would suggest that including utilities should require using a smaller value of ϕ_L since utilities are likely to be less land-intensive than housing. However, the value of ϕ_L already appears to be somewhat low relative to recent studies.

[36]This issue may not be grave as Malpezzi et al. (1998) determine that housing-cost indices derived from the Census in this way perform as well or better than most other indices.

- 9 indicators for the number of rooms, 5 indicators for the number of bedrooms, number of rooms interacted with number of bedrooms, and the number of household members per room;
- 2 indicators for lot size;
- 7 indicators for when the building was built;
- 2 indicators for complete plumbing and kitchen facilities;
- an indicator for commercial use; and
- an indicator for condominium status (owned units only).

All of these variables are interacted with tenure, i.e. renter status. Therefore the owner-occupied user-cost rate of 7.85 percent only matters in how it used to incorporate utility costs.

I first run a regression of housing values on housing characteristics and MSA indicator variables using only owner-occupied units, weighting by census-housing weights. From this regression, I calculate a new value-adjusted weight by multiplying the census-housing weights by the predicted value from this first regression using housing characteristics alone. Economically, these weights reflect the number of efficiency units of housing that observation provides. I then run a second regression with these new weights for all units, rented and owner-occupied, on the housing characteristics fully interacted with tenure, along with the MSA indicators, which are not interacted. I take the house-price differentials from the MSA indicator variables in this second regression. As with the wage differentials, this adjusted weighting method has only a small impact on the measured price differentials.

Wage and housing-cost differences predicted by characteristics across metro areas, i.e., $\bar{X}^j_{wi}\beta_w$ and $\bar{X}^j_{pi}\beta_p$, where $\bar{X}^j_{wi}$ and $\bar{X}^j_{pi}$ are the characteristic averages by metro, are plotted in Figure A1 using the same scale as in Figure 1. These estimates suggest that observable differences in worker and housing quality seem to be small relative to differences in wage levels and housing costs. From that, one may infer that unobservable differences in worker and housing quality may also be small.

C.2 Adjustment for Heterogeneity in Housing User Costs

For owner-occupied housing units, the above methodology uses the same user-cost rate across cities. User costs may vary locally, however, due to several factors. To account for this, for these differences, I apply the user-cost formula as formulated by Poterba and Sinai (2008). For itemizers, this user cost is given by

$$UC = [1 - (\tau_D\lambda + \tau_Y(1-\lambda))]\, r_T + (1-\tau_Y)\,\beta - \tau_D\lambda\,(r_M - r_T) + d + (1 - \tau_D - k)\,\tau_p - \pi$$

where r_T is the risk-free interest rate, r_M is the mortgage interest rate, β is a housing-specific risk premium, d are maintenance and depreciation costs, π is the capital gain, τ_Y is the marginal income tax rate applied to investment income, λ is the share of the home financed with debt, τ_D is the marginal income tax rate applying to deductions, τ_p is the property tax rate, and k is the fraction of property taxes "refunded" in the form of local benefits.

My parameterization follows that of Poterba and Sinai (2008), making as many adjustments as possible to handle local heterogeneity.

- **Capital gains** π. Capital gains reduce the user cost of housing. Because capital gains can vary substantially across areas, this is potentially the most important adjustment, and also the most challenging to incorporate them in practice. For instance, it is not completely clear whether to use to use actualized or expected gains, and how to account for mean reversion. A common practice is to use long averages: I do so for regional housing price changes. Using Census and American Community Survey (ACS) data, I geocoded a comparable geography of metro areas, and calculated housing-price differentials for 1980 and 2010 (whereb 2010 is actually the ACS from 2007-11), using the methodology described in section C.1. The annualize relative price changes over this 30-year period exhibit a standard deviation of 0.9 percent.[37] To these I add a national (real) growth rate of 1 percent, based on relative housing-cost appreciaiton reported in the the BEA.

- **Local differences in mortgage rates** r_M: I take mortgage rates by state from in the from the Federal Housing Finance Agency. These are converted into real interest rates using an inflation rate of 2.5 percent. The average effective rate was 5.5 percent, with a standard deviation of 0.3 percent.

- **Marginal income tax rate applied to investment income:** τ_Y is the combined rate from federal and state taxes, provided by TAXSIM. The federal rate alone is 23.8 percent, and the state tax rates averages 4.4 percent, with a standard deviation of 2.4 percent.

- **Marginal income tax rate applied to deductions:** τ_D is the combined rate from federal and state taxes, provided by TAXSIM. The federal rate alone is 19.9 percent. The state average is only 1.6 percent, with a standard deviation of 2.6 percent.

- **Local property tax rate** τ_P. There are no excellent national sources of this data, and so I follow the common standard of taking the ratio of property tax payments to the reported value of housing in the Census. The average of this number is 0.55 percent with a standard deviation of 0.25 percent. These costs need to be discounted because property taxes are partly a benefit tax making them fees for local public services. This is accounted for by setting $k = 0.25$.

- **Risk premium** β. Lacking regional data on variation in the risk premium, I take the standard value of 2 percent.

- **The opportunity cost of funds** r_T is taken as constant at 4.5 percent.

- **Maintenance and depreciation**.d. To my knowledge, no one has has estimated regional differences in these numbers. For now I use a standard value of 2.5 percent everywhere.

- **Fraction of mortgage financed by debt,** λ.Following national averages, the loan-to-value ratio is taken at 52.4 percent for itemizers and 32.4 percent for non-itemizers.

- **Fraction itemizing returns** Among home owners I account for state level differences in itemization rates based on the IRS Statitics On Income (SOI), For consistency, accounted

[37] Using shorter averages would lead to somewhat larger variation, but it seems like this would be less accurate, and still not make a very important difference in the final user-cost numbers.

for the fact that as itemizers have a much higher share of income, and so I renormalized the values to have a mean value of 0.67. The mean user cost for itemizers I get is 6.84 percent, with a standard deviation of 0.9 percent. For non-itemizers, the user-cost formula produces a higher number of 8.18 percent with a standard deviation of 0.97 percent. Across both groups, the mean rate is 7.32 percent.

- **Fraction renting** These user cost-differences apply only to homeowners. I was able to account for local differences accounting for the fraction of households who rent. he average number of home-owners I had in the sample is 68.7 percent, with a standard deviation of 8.1 percent. The average is a bit high, as renters from group quarters and other such arrangements are dropped from the sample.

The difference between the original housing-cost indices and those that are locally adjusted is illustrated in Figure A3. Except at the lower end, adjusting for regional differences in user costs makes little difference: the correlation coefficient is 0.993 between the original and adjusted differentials.

C.3 Amenity Data

All climate and geographic data are calculated at the public-use microdata area (PUMA) and averaged up to the metropolitan level, weighted by population. Population density is measured at the census tract level, and also population-averaged.

Heating and cooling degree days (Annual) Degree day data are used to estimate amounts of energy required to maintain comfortable indoor temperature levels. Daily values are computed from each days mean temperature (max + min/2). Daily heating degree days are equal to $\max\{0, 65 - meantemp\}$ and daily cooling degree days are $\max\{0, meantemp - 65\}$. Annual degree days are the sum of daily degree days over the year. The data here refer to averages from 1970 to 2000 (National Climactic Data Center 2008).

Sunshine Average percentage of possible. The total time that sunshine reaches the surface of the earth is expressed as the percentage of the maximum amount possible from sunrise to sunset with clear sky conditions. (National Climactic Data Center 2008).

Average slope (percent) The average slope of the land in the metropolitan area. Coded by author using GSI software.

Coastal proximity Equal to one over the distance in miles to the nearest coastline. Coded by author using GSI software.

Violent crimes (per capita) These consist of the average of the four z-scores (standard deviations) for aggravated assaults, robbery, forcible rape, and murder (*City and County Data Book 2000*).

Property crimes (per capita) These consist of the average of the four z-scores (standard deviations) for aggravated burglary, larceny, motor theft, and arson (*City and County Data 2000)*

Air quality index (Median) An AQI value is calculated for each pollutant in an area (ground-level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide). The highest AQI value for the individual pollutants is the AQI value for that day. An AQI over 300 is considered hazardous; under 50, good; values in between correspond to moderate, unhealthy, and very unhealthy (Environmental Protection Agency, 2008).

Bars and restaurants Number of establishments classified as eating and drinking places (NAICS 722) in *County Business Patterns 2000*.

Arts and Culture Index from *Places Rated Almanac* (Savageau 1999). Based on a ranking of cities, it ranges from 100 (New York, NY) to 0 (Houma, LA).

D Additional Theoretical Details (Not for Publication)

D.1 Multiple Household Types

For simplicity, ignore federal taxes and assume there are two types of fully mobile households, referred to as "a" and "b." The most interesting case is when some members of each type live in every city. The mobility conditions for each type are

$$e_a(p, w_a, u; Q_a) = 0$$
$$e_b(p, w_b, u; Q_b) = 0$$

I generalize the two zero-profit conditions with unit-cost functions that have factor-specific productivity components.

$$c_X(w_a/A_{Xa}, w_b/A_{Xb}, r/A_{XL}, \bar{\imath}/A_{XL}) = 1$$
$$c_Y(w_a/A_{Ya}, w_b/A_{Yb}, r/A_{YL}, \bar{\imath}/A_{YK}) = p$$

The terms A_{Xa} and A_{Xb} give the relative productivity of each worker type in the city. Log-linearizing these equations:

$$s_{ya}\hat{p} - s_{wa}\hat{w}_a = \hat{Q}_a$$
$$s_{yb}\hat{p} - s_{wb}\hat{w}_b = \hat{Q}_b$$
$$\theta_{Na}\hat{w}_a + \theta_{Nb}\hat{w}_b + \theta_L\hat{r} = \hat{A}_X$$
$$\phi_{Na}\hat{w}_a + \phi_{Nb}\hat{w}_b + \phi_L\hat{r} = \hat{A}_Y$$

where θ denotes the cost-shares of each factor, and $\theta_a\hat{A}_{Xa} + \theta_b\hat{A}_{Xb} + \theta_L\hat{A}_{XL} + \theta_K\hat{A}_{XK} \equiv \hat{A}_X$ and $\phi_a\hat{A}_{Ya} + \phi_b\hat{A}_{Yb} + \phi_L\hat{A}_{YL} + \phi_K\hat{A}_{YK} \equiv \hat{A}_Y$. The additivity of these effects proves that differences in productivity have the same first-order effects on prices regardless of the factor they augment directly when weighted by the cost-share of that factor.[38]

[38]This is more general than the models seen in Roback (1988) and Beeson (1991), who assume $s_{wa} = s_{wb} = 1$ and $\phi_L = 1$.

Let the share of total income accruing to type a worker be $\mu_a = N_a m_a / (N_a m_a + N_b m_b)$, with the other share $\mu_b = 1 - \mu_a$, and define the following income-weighted averages

$$s_y \equiv \mu_a s_{ya} + \mu_b s_{yb},\ s_x \equiv 1 - s_y,\ \varsigma_y \equiv \mu_a s_{ya} / s_y$$
$$\hat{Q} \equiv \mu_a \hat{Q}_a + \mu_b \hat{Q}_b,\ s_w \equiv \mu_a s_{wa} + \mu_b s_{wb},\ \hat{w} \equiv \mu_a \frac{s_{wa}}{s_w} \hat{w}_a + \mu_b \frac{s_{wb}}{s_w} \hat{w}_b$$
$$\lambda_a = \frac{s_x \theta_{Na}}{s_x \theta_{Na} + s_y \phi_{Na}},\ \lambda_b = \frac{s_x \theta_{Nb}}{s_x \theta_{Nb} + s_y \phi_{Nb}},\ \lambda_N \equiv \frac{1}{s_y} [s_{ya} \mu_a \lambda_a + s_{yb} \mu_b \lambda_b]$$

Then it is possible to show that the following capitalization formulas hold.

$$s_R \hat{r} = \hat{Q} + s_x \hat{A}_X + s_y \hat{A}_Y$$
$$s_w \hat{w} = -\frac{\lambda_L}{\lambda_N} \hat{Q} + \frac{1 - \lambda_L}{\lambda_N} s_x \hat{A}_X - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y + \left[\left(\frac{\lambda_a}{\lambda_N} - 1 \right) \mu_a \hat{Q}_a + \left(\frac{\lambda_b}{\lambda_N} - 1 \right) \mu_b \hat{Q}_b \right]$$
$$s_y \hat{p} = \frac{\lambda_N - \lambda_L}{\lambda_N} \hat{Q} + \frac{1 - \lambda_L}{\lambda_N} s_x \hat{A}_X - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y + \left[\left(\frac{\lambda_a}{\lambda_N} - 1 \right) \mu_a \hat{Q}_a + \left(\frac{\lambda_b}{\lambda_N} - 1 \right) \mu_b \hat{Q}_b \right]$$

Except for the terms in square brackets, "[]", these terms are otherwise identical to equations (7) without taxes. The bracketed term explains that wage and housing-cost differences increase in the quality-of-life of the labor type that is relatively more represented in the traded-good sector, or decreasing in the quality-of-life of the labor type more represented in the home-good sector. The wage of a-types resembles the average wage except that it is lower in places a-types prefer relative to b-types.

$$\left[\frac{s_y}{s_{ya}} \right] s_{wa} \hat{w}_a = -\frac{\lambda_L}{\lambda_N} \hat{Q} + \frac{1 - \lambda_L}{\lambda_N} s_x \hat{A}_X - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y + \left[\frac{\lambda_b}{\lambda_N} \left(\hat{Q} - \frac{s_y}{s_{ya}} \hat{Q}_a \right) \right]$$

The model assumes that both types of households live in each city. This assumption is easier to maintain if the type of labor they supply are imperfect substitutes in production.

Factor-specific productivity differences do have first-order effects on quantities in the model. For example, in the case where partial elasticities of substitution across factors within sectors are equal, the relative employment of a-types relative to b-types is

$$\hat{N}_a - \hat{N}_b = -\sigma_X (\hat{w}_a - \hat{w}_b) + (\sigma_X - 1) \left(\hat{A}_{Xa} - \hat{A}_{Xb} \right)$$

D.2 Multiple Home Goods

Suppose now that there is one type of household but two types of goods, 1 and 2, e.g., housing versus local services. Beeson and Eberts (1989) consider this situation but do not solve for it completely. The four equilibrium conditions, using obvious definitions, are written

$$\begin{aligned} e(p_1, p_2, u)/Q &= m \\ c_X(w, r, \bar{\imath})/A_X &= 1 \\ c_{Y1}(w, r, \bar{\imath})/A_{Y1} &= p_1 \\ c_{Y2}(w, r, \bar{\imath})/A_{Y2} &= p_2 \end{aligned}$$

Log-linearizing these equations produces

$$\begin{aligned} s_{y1}\hat{p}_1 + s_{y2}\hat{p}_2 - s_w\hat{w} &= \hat{Q} \\ \theta_N\hat{w} + \theta_L\hat{r} &= \hat{A}_X \\ \phi_{N1}\hat{w} + \phi_{L1}\hat{r} - \hat{p}_1 &= \hat{A}_{Y1} \\ \phi_{N2}\hat{w} + \phi_{L2}\hat{r} - \hat{p}_2 &= \hat{A}_{Y2} \end{aligned}$$

If we define an aggregate shares, prices, and home-productivity appropriately

$$\begin{aligned} s_y \equiv s_{y1} + s_{y2}.\ \phi_L \equiv \frac{s_{y1}}{s_y}\phi_{L1} + \frac{s_{y2}}{s_y}\phi_{L2} \\ \hat{p} \equiv \frac{s_{y1}}{s_y}\hat{p}_1 + \frac{s_{y2}}{s_y}\hat{p}_2,\ \hat{A}_Y \equiv \frac{s_{y1}}{s_y}\hat{A}_{Y1} + \frac{s_{y2}}{s_y}\hat{A}_{Y2}, \end{aligned}$$

then the main results generalize:

$$\begin{aligned} s_R\hat{r} &= \hat{Q} + s_x\hat{A}_X + s_y\hat{A}_Y \\ s_w\hat{w} &= -\frac{\lambda_L}{\lambda_N}\hat{Q} + \frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X - \frac{\lambda_L}{\lambda_N}s_y\hat{A}_Y \\ s_y\hat{p} &= \frac{\lambda_N - \lambda_L}{\lambda_N}\hat{Q} + \frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X - \frac{\lambda_L}{\lambda_N}s_y\hat{A}_Y \end{aligned}$$

Now a question is whether using a local price index based on only one home-good price, e.g. the one for residential housing, $\hat{p}_1$, may be biased relative to using a more balanced local price index, $\hat{p}$.[39] Weighted by the relevant total expenditure share, the bias is given by

$$\begin{aligned} s_y(\hat{p}_1 - \hat{p}) = &\frac{1}{\lambda_N}\left[\lambda_N\left(1-\lambda_L\right)\left(\phi_{L1}/\phi_L - 1\right) - \lambda_L\left(1-\lambda_N\right)\left(\phi_{N1}/\phi_N - 1\right)\right]\left(\hat{Q} + s_{y2}\hat{A}_{Y2}\right) \\ &+ \frac{1-\lambda_L}{\lambda_N}\left[\lambda_N\left(\phi_{L1}/\phi_L - 1\right) + \left(1-\lambda_N\right)\left(\phi_{N1}/\phi_N - 1\right)\right]s_x\hat{A}_X \\ &+ \left\{\frac{1}{\lambda_N}\left[\lambda_N\left(1-\lambda_L\right)\left(\phi_{L1}/\phi_L - 1\right) - \lambda_L\left(1-\lambda_N\right)\left(\phi_{N1}/\phi_N - 1\right)\right] - \left[\frac{s_y - s_{y1}}{s_{y1}}\right]\right\}s_{y1}\hat{A}_{Y1} \end{aligned}$$

[39] Without loss of generality, the capitalization into a specific home-good is determined by .$s_{y1}\hat{p}_1 = \left(\frac{\lambda_N-\lambda_L}{\lambda_N} - \left[\lambda_{L2} - \lambda_{N2}\frac{\lambda_L}{\lambda_N}\right]\right)\left(\hat{Q} + s_{y2}\hat{A}_{Y2}\right) + \left(\frac{1-\lambda_L}{\lambda_N} - \left[\lambda_{L2} + \lambda_{N2}\frac{1-\lambda_L}{\lambda_N}\right]\right)s_x\hat{A}_X + \left(-\frac{\lambda_L}{\lambda_N} - \left[\lambda_{L2} - \lambda_{N2}\frac{\lambda_L}{\lambda_N}\right]\right)s_{y1}\hat{A}_{Y1}$

If the cost structure of both home goods are the same, i.e., if $\phi_{L1} = \phi_L$ and $\phi_{N1} = \phi_N$, then this collapses to $-(s_y - s_{y1})\hat{A}_{Y1}$, i.e., the price index is only biased up in cities relatively productive in the first home good. When the first home good is more land intensive and less labor intensive than the second, i.e. if $\phi_{L1} > \phi_L$ and $\phi_{N1} < \phi_{N2}$ then an index based on the first home good will more strongly capitalize differences in $\hat{A}_X$. In this case, the first good capitalizes differences in $\hat{Q}$, $\hat{A}_{Y1}$, and $\hat{A}_{Y2}$ more strongly when $(1/\lambda_L - 1)(\phi_{L1}/\phi_L - 1) > (1/\lambda_N - 1)(\phi_{N1}/\phi_N - 1)$. This condition is expected to hold as λ_L is probably much smaller than λ_N. In the extreme case, where the second good has the same factor proportions as the traded good, i.e., $\phi_{L2} = \theta_L$ and $\phi_{N2} = \theta_N$, $\hat{p}_2 = \hat{A}_X - \hat{A}_{Y2}$, its price only capitalizes differences in its own productivity. Most capitalization occurs in the first good.

The distinction between home goods and traded goods is somewhat artificial, as most goods are a mixture of both. The key distinction being how land and labor-intensive the goods are. The broader the definition of home goods, the larger is the effective share s_y, but the closer the cost shares ϕ_L and ϕ_N are to θ_L and θ_N. The capitalization effects on land are unchanged so long as s_R remains the same. The capitalization of Q and A_Y will also be the same, so long as the ratio λ_L/λ_N remains constant. The only substantial change are for A_X in wages and prices: as the definition of home goods expands, $(1 - \lambda_L)/\lambda_N$ gets larger, increasing the capitalization of A_X.

APPENDIX TABLE A1: LIST OF METROPOLITAN AND NON-METROPOLITAN AREAS RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
San Francisco-Oakland-San Jose, CA	7,039,362	0.256	0.813	2.780	2.246	0.138	3	0.289	1	0.045	0.323	1
Santa Barbara-Santa Maria-Lompoc, CA	399,347	0.068	0.662	2.651	2.111	0.176	2	0.125	7	-0.010	0.255	2
Honolulu, HI	876,156	-0.010	0.605	2.620	2.069	0.204	1	0.057	22	-0.022	0.240	3
Salinas (Monterey-Carmel), CA	401,762	0.103	0.590	2.244	1.847	0.137	4	0.144	4	0.005	0.229	4
San Diego, CA	2,813,833	0.058	0.479	1.894	1.590	0.123	7	0.098	11	-0.004	0.185	5
Los Angeles-Riverside-Orange County, CA	16,373,645	0.129	0.450	1.573	1.369	0.081	14	0.150	3	0.020	0.177	6
San Luis Obispo-Atascadero-Paso Robles, CA	246,681	0.036	0.452	1.840	1.546	0.124	6	0.077	16	-0.011	0.173	7
New York, Northern New Jersey, Long Island, NY-NJ-CT-PA	21,199,864	0.209	0.411	1.184	1.077	0.029	51	0.209	2	0.044	0.163	8
Barnstable-Yarmouth (Cape Cod), MA	162,582	0.005	0.395	1.678	1.422	0.121	8	0.046	26	-0.017	0.151	9
Non-metro, HI	335,381	-0.029	0.332	1.504	1.285	0.126		0.013		-0.016	0.135	
Seattle-Tacoma-Bremerton, WA	3,554,760	0.078	0.308	1.103	0.992	0.061	22	0.095	13	0.011	0.121	10
Boston-Worcester-Lawrence, MA-NH-ME-CT	5,819,100	0.123	0.294	0.925	0.851	0.034	46	0.128	6	0.024	0.116	11
Santa Fe, NM	147,635	-0.060	0.290	1.408	1.206	0.127	5	-0.017	60	-0.025	0.116	12
Naples, FL	251,377	-0.004	0.286	1.239	1.087	0.095	11	0.027	34	-0.011	0.113	13
Denver-Boulder-Greeley, CO	2,581,506	0.051	0.240	0.888	0.812	0.054	26	0.066	19	0.008	0.097	14
Chicago-Gary-Kenosha, IL-IN-WI	9,157,540	0.136	0.224	0.585	0.558	0.005	80	0.131	5	0.030	0.089	15
Non-metro, RI	61,968	0.060	0.215	0.757	0.703	0.040		0.071		0.009	0.085	
Sacramento-Yolo, CA	1,796,857	0.067	0.206	0.699	0.653	0.033	48	0.075	17	0.011	0.081	16
Reno, NV	339,486	0.027	0.210	0.826	0.757	0.053	30	0.043	29	-0.002	0.081	17
Anchorage, AK	260,283	0.073	0.185	0.595	0.562	0.023	59	0.077	15	0.013	0.073	18
Portland-Salem, OR-WA	2,265,223	0.024	0.174	0.680	0.632	0.047	37	0.037	30	0.003	0.071	19
Washington-Baltimore, DC-MD-VA-WV	7,608,070	0.126	0.154	0.314	0.307	-0.013	122	0.116	9	0.030	0.062	20
Fort Collins-Loveland, CO	251,494	-0.061	0.150	0.808	0.730	0.079	16	-0.032	72	-0.022	0.059	21
Non-metro, CO	693,605	-0.137	0.137	0.962	0.843	0.112		-0.094		-0.044	0.052	
Stockton-Lodi, CA	563,598	0.088	0.126	0.296	0.289	-0.002	93	0.083	14	0.021	0.051	22
Hartford, CT	1,183,110	0.134	0.133	0.201	0.198	-0.026	155	0.120	8	0.030	0.050	23
Miami-Fort Lauderdale, FL	3,876,380	0.001	0.126	0.535	0.503	0.041	39	0.015	39	-0.003	0.050	24
Bellingham, WA	166,814	-0.065	0.127	0.726	0.660	0.074	17	-0.038	82	-0.023	0.050	25
Non-metro, CA	1,121,254	-0.040	0.134	0.686	0.630	0.059		-0.017		-0.021	0.048	
West Palm Beach-Boca Raton, FL	1,131,184	0.042	0.115	0.378	0.364	0.017	66	0.046	27	0.009	0.047	26
Non-metro, CT	148,665	0.083	0.119	0.285	0.279	-0.007		0.078		0.015	0.043	
Madison, WI	426,526	-0.038	0.110	0.574	0.533	0.053	28	-0.018	63	-0.016	0.042	27
New London-Norwich, CT-RI	293,566	0.050	0.110	0.332	0.321	0.006	79	0.051	23	0.006	0.039	28
Sarasota-Bradenton, FL	589,959	-0.071	0.094	0.595	0.548	0.066	19	-0.046	85	-0.023	0.037	29
Non-metro, MA	247,672	-0.068	0.108	0.652	0.597	0.063		-0.042		-0.029	0.036	
Non-metro, AK	366,649	0.035	0.090	0.292	0.283	0.012		0.037		0.006	0.035	
Eugene-Springfield, OR	322,959	-0.118	0.091	0.716	0.644	0.088	13	-0.084	127	-0.037	0.035	30
Medford-Ashland, OR	181,269	-0.136	0.084	0.736	0.658	0.095	12	-0.099	147	-0.042	0.031	31
Phoenix-Mesa, AZ	3,251,876	0.028	0.075	0.243	0.237	0.012	72	0.030	32	0.007	0.031	32
Corvalis, OR	78,153	-0.113	0.076	0.634	0.575	0.081	15	-0.081	122	-0.035	0.029	33
Grand Junction, CO	116,255	-0.180	0.079	0.833	0.731	0.114	9	-0.134	200	-0.055	0.029	34
Providence-Fall River-Warwick, RI-MA	1,188,613	0.018	0.073	0.262	0.255	0.014	69	0.022	35	0.002	0.028	35
Austin-San Marcos, TX	1,249,763	0.009	0.067	0.264	0.256	0.016	67	0.014	40	-0.001	0.026	36
Modesto, CA	446,997	0.056	0.059	0.098	0.098	-0.008	106	0.050	24	0.014	0.024	37
Detroit-Ann Arbor-Flint, MI	5,456,428	0.130	0.053	-0.130	-0.139	-0.047	215	0.108	10	0.035	0.022	38
Raleigh-Durham-Chapel Hill, NC	1,187,941	0.016	0.044	0.143	0.141	0.011	74	0.018	38	0.008	0.022	39
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	6,188,463	0.114	0.052	-0.090	-0.096	-0.040	192	0.096	12	0.030	0.021	40

APPENDIX TABLE A1: LIST OF METROPOLITAN AND NON-METROPOLITAN AREAS RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Salt Lake City-Ogden, UT	1,333,914	-0.024	0.038	0.226	0.219	0.026	55	-0.015	57	-0.006	0.017	41
Milwaukee-Racine, WI	1,689,572	0.043	0.032	0.018	0.017	-0.009	107	0.037	31	0.013	0.015	42
Colorado Springs, CO	516,929	-0.088	0.033	0.384	0.360	0.055	25	-0.066	103	-0.025	0.013	43
Portland, ME	243,537	-0.078	0.019	0.299	0.283	0.051	33	-0.060	97	-0.017	0.013	44
Burlington, VT	169,391	-0.107	0.021	0.386	0.359	0.065	20	-0.082	125	-0.026	0.013	45
Las Vegas, NV-AZ	1,563,282	0.068	0.029	-0.065	-0.067	-0.025	150	0.057	21	0.018	0.011	46
Minneapolis-St. Paul, MN-WI	2,968,806	0.082	0.020	-0.142	-0.149	-0.032	171	0.067	18	0.026	0.011	47
Chico-Paradise, CA	203,171	-0.090	0.043	0.432	0.402	0.053	29	-0.067	104	-0.033	0.010	48
Albuquerque, NM	712,738	-0.082	0.013	0.282	0.267	0.049	34	-0.064	100	-0.020	0.008	49
Atlanta, GA	4,112,198	0.078	0.014	-0.154	-0.161	-0.032	174	0.063	20	0.024	0.008	50
Wilmington, NC	233,450	-0.134	0.017	0.441	0.405	0.071	18	-0.104	155	-0.039	0.005	51
Springfield, MA	591,932	-0.006	0.009	0.055	0.055	0.002	87	-0.003	48	-0.005	0.000	52
Charlottesville, VA	159,576	-0.113	-0.003	0.300	0.281	0.054	27	-0.090	136	-0.034	-0.004	53
Fort Myers-Cape Coral, FL	440,888	-0.105	-0.014	0.228	0.215	0.049	36	-0.084	129	-0.028	-0.005	54
Non-metro, WA	994,967	-0.083	-0.014	0.170	0.162	0.037		-0.067		-0.022	-0.005	
Redding, CA	163,256	-0.094	0.001	0.263	0.248	0.041	38	-0.074	110	-0.032	-0.006	55
Tucson, AZ	843,746	-0.114	-0.010	0.268	0.252	0.052	31	-0.091	139	-0.033	-0.006	56
Non-metro, NV	250,521	0.008	-0.017	-0.097	-0.099	-0.011		0.005		0.002	-0.008	
Charlotte-Gastonia-Rock Hill, NC-SC	1,499,293	0.013	-0.033	-0.177	-0.182	-0.013	123	0.007	43	0.009	-0.008	57
Non-metro, NH	496,087	-0.100	-0.030	0.147	0.140	0.042		-0.082		-0.025	-0.010	
Non-metro, OR	919,033	-0.140	-0.024	0.284	0.264	0.062		-0.113		-0.039	-0.011	
Nashville, TN	1,231,311	-0.016	-0.030	-0.086	-0.086	-0.001	90	-0.016	59	-0.003	-0.011	58
Provo-Orem, UT	368,536	-0.056	-0.030	0.024	0.024	0.019	64	-0.048	87	-0.014	-0.011	59
Iowa City, IA	111,006	-0.087	-0.032	0.105	0.101	0.034	45	-0.072	109	-0.022	-0.012	60
Cleveland-Akron, OH	2,945,831	0.012	-0.032	-0.171	-0.176	-0.016	127	0.006	44	0.005	-0.012	61
Dallas-Fort Worth, TX	5,221,801	0.064	-0.037	-0.338	-0.360	-0.044	205	0.047	25	0.019	-0.014	62
Fresno, CA	922,516	-0.012	-0.039	-0.133	-0.135	-0.008	104	-0.014	56	-0.004	-0.017	63
Orlando, FL	1,644,561	-0.040	-0.046	-0.088	-0.088	0.006	78	-0.037	79	-0.008	-0.017	64
Pittsfield, MA	84,699	-0.058	-0.033	0.021	0.020	0.014	70	-0.050	89	-0.020	-0.018	65
Columbus, OH	1,540,157	0.023	-0.054	-0.296	-0.310	-0.028	159	0.013	41	0.009	-0.020	66
Merced, CA	210,554	-0.010	-0.048	-0.180	-0.184	-0.012	121	-0.013	55	-0.002	-0.020	67
Lancaster, PA	470,658	-0.015	-0.053	-0.188	-0.192	-0.011	117	-0.017	61	-0.003	-0.022	68
Green Bay, WI	226,778	-0.019	-0.064	-0.223	-0.229	-0.011	116	-0.022	66	-0.002	-0.025	69
Cincinnati-Hamilton, OH-KY-IN	1,979,202	0.035	-0.070	-0.394	-0.420	-0.038	186	0.020	37	0.014	-0.025	70
Allentown-Bethlehem-Easton, PA	637,958	0.002	-0.064	-0.280	-0.291	-0.022	141	-0.005	49	0.002	-0.026	71
Asheville, NC	225,965	-0.159	-0.060	0.181	0.167	0.058	23	-0.132	197	-0.044	-0.026	72
Yakima, WA	222,581	-0.027	-0.072	-0.236	-0.242	-0.009	108	-0.029	70	-0.004	-0.027	73
Charleston-North Charleston, SC	549,033	-0.095	-0.069	-0.036	-0.037	0.025	57	-0.082	123	-0.024	-0.028	74
Non-metro, VT	439,436	-0.197	-0.086	0.173	0.157	0.073		-0.165		-0.050	-0.032	
Tampa-St. Petersburg-Clearwater, FL	2,395,997	-0.057	-0.084	-0.204	-0.208	0.003	86	-0.054	94	-0.012	-0.032	75
Missoula, MT	95,802	-0.251	-0.090	0.306	0.271	0.101	10	-0.208	260	-0.063	-0.033	76
Yuba City, CA	139,149	-0.073	-0.074	-0.115	-0.116	0.009	76	-0.066	102	-0.022	-0.034	77
Norfolk-Virginia Beach-Newport News, VA-	1,569,541	-0.109	-0.081	-0.045	-0.047	0.027	53	-0.095	141	-0.029	-0.034	78
Non-metro, DE	156,638	-0.081	-0.088	-0.155	-0.157	0.010		-0.073		-0.021	-0.037	
New Orleans, LA	1,337,726	-0.070	-0.097	-0.224	-0.228	0.005	81	-0.065	101	-0.015	-0.037	79
Indianapolis, IN	1,607,486	0.017	-0.096	-0.459	-0.492	-0.039	189	0.003	45	0.009	-0.037	80
Richmond-Petersburg, VA	996,512	0.006	-0.098	-0.437	-0.466	-0.033	178	-0.006	50	0.006	-0.037	81

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		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
St. Louis, MO-IL	2,603,607	0.005	-0.104	-0.458	-0.489	-0.034	180	-0.007	51	0.008	-0.038	82
Bloomington, IN	120,563	-0.127	-0.090	-0.036	-0.038	0.032	49	-0.110	166	-0.035	-0.038	83
Fort Pierce-Port St. Lucie, FL	319,426	-0.085	-0.100	-0.197	-0.200	0.011	73	-0.078	113	-0.019	-0.039	84
Boise City, ID	432,345	-0.083	-0.109	-0.239	-0.243	0.010	75	-0.077	112	-0.015	-0.039	85
Visalia-Tulare-Porterville, CA	368,021	-0.032	-0.094	-0.315	-0.326	-0.016	130	-0.036	77	-0.008	-0.039	86
State College, PA	135,758	-0.139	-0.092	-0.010	-0.014	0.036	43	-0.120	173	-0.039	-0.040	87
Tallahassee, FL	284,539	-0.110	-0.106	-0.150	-0.152	0.022	61	-0.098	145	-0.026	-0.041	88
Harrisburg-Lebanon-Carlisle, PA	629,401	-0.011	-0.105	-0.420	-0.444	-0.029	162	-0.020	65	0.000	-0.042	89
Jacksonville, FL	1,100,491	-0.050	-0.110	-0.333	-0.345	-0.009	110	-0.051	90	-0.009	-0.042	90
Punta Gorda, FL	141,627	-0.167	-0.108	-0.006	-0.011	0.049	35	-0.143	212	-0.042	-0.043	91
Houston-Galveston-Brazoria, TX	4,669,571	0.073	-0.111	-0.675	-0.762	-0.072	267	0.045	28	0.025	-0.043	92
Richland-Kennewick-Pasco, WA	191,822	0.029	-0.117	-0.584	-0.640	-0.051	225	0.011	42	0.014	-0.044	93
Lawrence, KS	99,962	-0.148	-0.112	-0.070	-0.073	0.038	41	-0.129	190	-0.037	-0.045	94
Des Moines, IA	456,022	-0.030	-0.123	-0.444	-0.469	-0.022	140	-0.037	78	-0.001	-0.045	95
Kansas City, MO-KS	1,776,062	-0.001	-0.129	-0.547	-0.592	-0.037	184	-0.015	58	0.009	-0.046	96
Non-metro, MD	385,446	-0.033	-0.105	-0.360	-0.375	-0.022		-0.037		-0.010	-0.046	
Greensboro--Winston Salem--High Point, NC	1,251,509	-0.046	-0.126	-0.414	-0.435	-0.016	126	-0.049	88	-0.006	-0.047	97
Dayton-Springfield, OH	950,558	-0.021	-0.124	-0.475	-0.506	-0.030	164	-0.030	71	-0.002	-0.049	98
Bakersfield, CA	661,645	0.044	-0.132	-0.684	-0.767	-0.063	252	0.020	36	0.019	-0.050	99
Fort Walton Beach, FL	170,498	-0.204	-0.125	0.025	0.017	0.062	21	-0.174	241	-0.052	-0.050	100
Lafayette, IN	182,821	-0.070	-0.123	-0.336	-0.347	-0.006	98	-0.069	106	-0.016	-0.050	101
Spokane, WA	417,939	-0.097	-0.128	-0.281	-0.287	0.008	77	-0.090	138	-0.022	-0.050	102
Grand Rapids-Muskegon-Holland, MI	1,088,514	0.004	-0.122	-0.532	-0.575	-0.044	204	-0.010	53	0.003	-0.050	103
Bryan-College Station, TX	152,415	-0.138	-0.126	-0.162	-0.164	0.027	54	-0.122	176	-0.035	-0.051	104
Lansing-East Lansing, MI	447,728	0.006	-0.126	-0.557	-0.605	-0.046	211	-0.008	52	0.004	-0.052	105
Cedar Rapids, IA	191,701	-0.081	-0.137	-0.365	-0.378	-0.002	92	-0.078	115	-0.016	-0.052	106
Flagstaff, AZ-UT	122,366	-0.146	-0.128	-0.145	-0.147	0.030	50	-0.129	191	-0.038	-0.052	107
Louisville, KY-IN	1,025,598	-0.040	-0.138	-0.480	-0.510	-0.023	144	-0.047	86	-0.005	-0.053	108
Appleton-Oshkosh-Neenah, WI	358,365	-0.047	-0.138	-0.463	-0.489	-0.021	138	-0.052	91	-0.008	-0.054	109
York, PA	381,751	-0.026	-0.138	-0.518	-0.555	-0.032	175	-0.036	76	-0.003	-0.055	110
Columbia, SC	536,691	-0.076	-0.145	-0.410	-0.427	-0.007	99	-0.076	111	-0.015	-0.056	111
Lincoln, NE	250,291	-0.134	-0.150	-0.272	-0.277	0.022	62	-0.122	175	-0.029	-0.056	112
Myrtle Beach, SC	196,629	-0.169	-0.135	-0.116	-0.119	0.038	42	-0.148	217	-0.045	-0.057	113
Reading, PA	373,638	-0.002	-0.146	-0.618	-0.676	-0.046	210	-0.017	62	0.004	-0.057	114
Albany-Schenectady-Troy, NY	875,583	-0.014	-0.132	-0.526	-0.565	-0.041	198	-0.026	68	-0.005	-0.058	115
Sheboygan, WI	112,646	-0.058	-0.146	-0.465	-0.490	-0.019	133	-0.062	98	-0.011	-0.058	116
Rochester, NY	1,098,201	-0.018	-0.136	-0.532	-0.572	-0.041	195	-0.029	69	-0.006	-0.059	117
Bloomington-Normal, IL	150,433	0.024	-0.149	-0.705	-0.788	-0.061	248	0.003	46	0.011	-0.060	118
Champaign-Urbana, IL	179,669	-0.082	-0.142	-0.385	-0.400	-0.009	112	-0.080	119	-0.022	-0.060	119
Gainesville, FL	217,955	-0.148	-0.156	-0.262	-0.267	0.024	58	-0.134	201	-0.035	-0.061	120
Savannah, GA	293,000	-0.081	-0.151	-0.426	-0.445	-0.011	115	-0.080	120	-0.019	-0.062	121
Panama City, FL	148,217	-0.153	-0.159	-0.263	-0.267	0.026	56	-0.138	207	-0.036	-0.062	122
Janesville-Beloit, WI	152,307	-0.002	-0.164	-0.699	-0.775	-0.050	224	-0.019	64	0.007	-0.063	123
Yuma, AZ	160,026	-0.106	-0.158	-0.387	-0.401	0.002	88	-0.100	151	-0.024	-0.063	124
Rochester, MN	124,277	0.018	-0.164	-0.753	-0.848	-0.061	246	-0.003	47	0.012	-0.063	125
Athens, GA	153,444	-0.138	-0.153	-0.275	-0.281	0.016	68	-0.125	185	-0.037	-0.064	126
Dover, DE	126,697	-0.087	-0.158	-0.439	-0.458	-0.009	111	-0.086	133	-0.020	-0.064	127

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		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Baton Rouge, LA	602,894	-0.045	-0.169	-0.601	-0.649	-0.031	166	-0.053	92	-0.005	-0.065	128
Toledo, OH	618,203	-0.025	-0.164	-0.636	-0.694	-0.041	196	-0.037	81	-0.001	-0.065	129
Melbourne-Titusville-Palm Bay, FL	476,230	-0.108	-0.171	-0.434	-0.452	0.000	89	-0.104	154	-0.023	-0.066	130
Non-metro, AZ	603,632	-0.184	-0.163	-0.194	-0.197	0.037		-0.163		-0.048	-0.067	
Memphis, TN-AR-MS	1,135,614	0.008	-0.178	-0.784	-0.886	-0.060	242	-0.013	54	0.011	-0.068	131
Birmingham, AL	921,106	-0.019	-0.179	-0.716	-0.794	-0.047	212	-0.034	73	0.003	-0.069	132
Non-metro, UT	524,673	-0.134	-0.171	-0.366	-0.376	0.010		-0.124		-0.033	-0.069	
Omaha, NE-IA	716,998	-0.080	-0.195	-0.617	-0.663	-0.019	134	-0.084	128	-0.011	-0.072	133
Daytona Beach, FL	493,175	-0.157	-0.185	-0.362	-0.372	0.019	63	-0.144	213	-0.036	-0.073	134
Little Rock-North Little Rock, AR	583,845	-0.099	-0.197	-0.572	-0.609	-0.011	119	-0.100	150	-0.017	-0.075	135
Greenville, NC	133,798	-0.081	-0.195	-0.613	-0.658	-0.022	139	-0.085	131	-0.014	-0.076	136
Tuscaloosa, AL	164,875	-0.098	-0.195	-0.564	-0.599	-0.013	124	-0.099	146	-0.020	-0.077	137
Canton-Massillon, OH	406,934	-0.079	-0.191	-0.602	-0.646	-0.024	148	-0.083	126	-0.017	-0.077	138
Fayetteville-Springdale-Rogers, AR	311,121	-0.139	-0.206	-0.503	-0.526	0.005	82	-0.132	195	-0.029	-0.080	139
Kalamazoo-Battle Creek, MI	452,851	-0.020	-0.196	-0.783	-0.878	-0.056	234	-0.037	80	-0.002	-0.080	140
Greenville-Spartanburg-Anderson, SC	962,441	-0.071	-0.210	-0.706	-0.771	-0.031	165	-0.078	114	-0.010	-0.081	141
Elkhart-Goshen, IN	182,791	-0.047	-0.204	-0.744	-0.822	-0.043	202	-0.059	96	-0.006	-0.081	142
Buffalo-Niagara Falls, NY	1,170,111	-0.027	-0.190	-0.742	-0.824	-0.054	231	-0.042	84	-0.007	-0.081	143
Benton Harbor, MI	162,453	-0.076	-0.194	-0.623	-0.671	-0.029	163	-0.081	121	-0.019	-0.081	144
Columbia, MO	135,454	-0.180	-0.204	-0.380	-0.390	0.023	60	-0.164	230	-0.044	-0.082	145
Pittsburgh, PA	2,358,695	-0.041	-0.207	-0.773	-0.860	-0.047	217	-0.054	93	-0.005	-0.082	146
Cheyenne, WY	81,607	-0.246	-0.214	-0.240	-0.245	0.056	24	-0.217	263	-0.059	-0.083	147
Montgomery, AL	333,055	-0.129	-0.209	-0.542	-0.570	-0.003	95	-0.124	183	-0.029	-0.083	148
Rockford, IL	371,236	-0.002	-0.211	-0.897	-1.033	-0.069	262	-0.024	67	0.005	-0.084	149
Roanoke, VA	235,932	-0.106	-0.212	-0.616	-0.658	-0.017	131	-0.107	162	-0.024	-0.085	150
Fayetteville, NC	302,963	-0.198	-0.209	-0.351	-0.359	0.028	52	-0.178	246	-0.051	-0.086	151
Jackson, MI	158,422	-0.014	-0.212	-0.870	-0.993	-0.064	259	-0.034	74	0.001	-0.086	152
Lewiston-Auburn, ME	90,830	-0.125	-0.229	-0.639	-0.683	-0.008	101	-0.123	180	-0.023	-0.087	153
Hickory-Morganton-Lenoir, NC	341,851	-0.127	-0.220	-0.592	-0.629	-0.008	105	-0.124	181	-0.028	-0.087	154
Peoria-Pekin, IL	347,387	-0.022	-0.217	-0.869	-0.989	-0.061	247	-0.041	83	-0.001	-0.088	155
Glens Falls, NY	124,345	-0.110	-0.204	-0.573	-0.608	-0.020	136	-0.109	163	-0.033	-0.090	156
Non-metro, ME	808,317	-0.201	-0.229	-0.426	-0.439	0.027		-0.184		-0.048	-0.090	
Pensacola, FL	412,153	-0.154	-0.232	-0.573	-0.604	0.003	85	-0.146	216	-0.034	-0.091	157
Kokomo, IN	101,541	0.069	-0.237	-1.208	-1.531	-0.110	276	0.029	33	0.030	-0.091	158
Knoxville, TN	687,249	-0.127	-0.231	-0.642	-0.686	-0.011	120	-0.125	184	-0.027	-0.091	159
Springfield, IL	201,437	-0.074	-0.222	-0.749	-0.823	-0.039	187	-0.082	124	-0.016	-0.091	160
Non-metro, MT	596,684	-0.266	-0.239	-0.294	-0.301	0.059		-0.236		-0.062	-0.091	
Tyler, TX	174,706	-0.102	-0.234	-0.722	-0.786	-0.025	151	-0.106	160	-0.021	-0.093	161
South Bend, IN	265,559	-0.060	-0.235	-0.842	-0.945	-0.047	214	-0.072	108	-0.009	-0.093	162
Lexington, KY	479,198	-0.088	-0.241	-0.790	-0.872	-0.033	177	-0.095	142	-0.015	-0.094	163
Huntsville, AL	342,376	-0.045	-0.244	-0.921	-1.053	-0.055	232	-0.062	99	-0.002	-0.094	164
Jackson, MS	440,801	-0.092	-0.246	-0.801	-0.886	-0.031	170	-0.099	149	-0.015	-0.095	165
Billings, MT	129,352	-0.180	-0.252	-0.582	-0.612	0.013	71	-0.169	236	-0.037	-0.095	166
Scranton--Wilkes-Barre--Hazleton, PA	624,776	-0.103	-0.236	-0.728	-0.793	-0.027	157	-0.106	161	-0.022	-0.095	167
Saginaw-Bay City-Midland, MI	403,070	-0.012	-0.239	-0.990	-1.158	-0.074	270	-0.035	75	0.003	-0.096	168
Non-metro, FL	1,144,881	-0.178	-0.247	-0.569	-0.597	0.010		-0.167		-0.040	-0.097	
Rocky Mount, NC	143,026	-0.111	-0.246	-0.750	-0.819	-0.024	145	-0.114	168	-0.022	-0.097	169

APPENDIX TABLE A1: LIST OF METROPOLITAN AND NON-METROPOLITAN AREAS RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Davenport-Moline-Rock Island, IA-IL	359,062	-0.078	-0.245	-0.838	-0.936	-0.041	199	-0.088	135	-0.014	-0.098	170
Wichita, KS	545,220	-0.065	-0.257	-0.925	-1.052	-0.048	218	-0.079	116	-0.005	-0.098	171
Tulsa, OK	803,235	-0.096	-0.260	-0.849	-0.945	-0.032	172	-0.104	153	-0.013	-0.098	172
Mobile, AL	540,258	-0.129	-0.248	-0.709	-0.766	-0.016	128	-0.128	188	-0.027	-0.098	173
Non-metro, WY	345,642	-0.174	-0.256	-0.619	-0.655	0.007		-0.165		-0.037	-0.099	
Lakeland-Winter Haven, FL	483,924	-0.116	-0.254	-0.770	-0.842	-0.023	142	-0.119	172	-0.022	-0.099	174
Non-metro, ID	786,043	-0.186	-0.251	-0.565	-0.592	0.012		-0.174		-0.043	-0.099	
Sioux Falls, SD	172,412	-0.149	-0.258	-0.694	-0.745	-0.006	97	-0.146	215	-0.030	-0.099	175
Auburn-Opelika, AL	115,092	-0.132	-0.252	-0.716	-0.773	-0.015	125	-0.132	196	-0.028	-0.100	176
San Antonio, TX	1,592,383	-0.088	-0.254	-0.846	-0.943	-0.039	188	-0.097	143	-0.016	-0.100	177
Killeen-Temple, TX	312,952	-0.245	-0.249	-0.393	-0.404	0.040	40	-0.220	266	-0.061	-0.101	178
La Crosse, WI-MN	126,838	-0.126	-0.247	-0.713	-0.771	-0.020	135	-0.126	187	-0.029	-0.101	179
Amarillo, TX	217,858	-0.146	-0.253	-0.684	-0.734	-0.010	113	-0.142	211	-0.033	-0.101	180
Corpus Christi, TX	380,783	-0.099	-0.255	-0.820	-0.908	-0.034	179	-0.105	159	-0.019	-0.101	181
Chattanooga, TN-GA	465,161	-0.098	-0.258	-0.837	-0.930	-0.035	181	-0.105	158	-0.018	-0.102	182
Las Cruces, NM	174,682	-0.205	-0.261	-0.554	-0.579	0.019	65	-0.190	254	-0.047	-0.102	183
Rapid City, SD	88,565	-0.232	-0.266	-0.501	-0.520	0.033	47	-0.212	262	-0.052	-0.102	184
Eau Claire, WI	148,337	-0.118	-0.256	-0.772	-0.845	-0.026	154	-0.120	174	-0.026	-0.103	185
Wausau, WI	125,834	-0.074	-0.265	-0.934	-1.063	-0.049	222	-0.086	134	-0.011	-0.105	186
Non-metro, WI	1,723,367	-0.116	-0.260	-0.795	-0.873	-0.028		-0.120		-0.025	-0.105	
Syracuse, NY	732,117	-0.037	-0.251	-0.973	-1.127	-0.069	264	-0.056	95	-0.008	-0.105	187
Waterloo-Cedar Falls, IA	128,012	-0.127	-0.271	-0.813	-0.894	-0.023	143	-0.129	189	-0.024	-0.106	188
Fort Wayne, IN	502,141	-0.049	-0.268	-1.014	-1.180	-0.063	254	-0.067	105	-0.004	-0.106	189
Pueblo, CO	141,472	-0.168	-0.269	-0.689	-0.737	-0.003	94	-0.162	228	-0.038	-0.106	190
Oklahoma City, OK	1,083,346	-0.133	-0.278	-0.826	-0.909	-0.020	137	-0.135	202	-0.024	-0.107	191
Non-metro, MI	1,768,978	-0.102	-0.258	-0.826	-0.915	-0.038		-0.108		-0.024	-0.107	
Non-metro, NC	2,612,257	-0.150	-0.268	-0.736	-0.796	-0.013		-0.148		-0.034	-0.108	
Erie, PA	280,843	-0.108	-0.268	-0.854	-0.949	-0.035	182	-0.114	167	-0.023	-0.108	192
Springfield, MO	325,721	-0.185	-0.272	-0.658	-0.699	0.003	84	-0.175	242	-0.043	-0.109	193
Youngstown-Warren, OH	594,746	-0.077	-0.276	-0.970	-1.111	-0.052	227	-0.090	137	-0.013	-0.110	194
Jacksonville, NC	150,355	-0.286	-0.264	-0.344	-0.353	0.051	32	-0.254	275	-0.077	-0.111	195
Topeka, KS	169,871	-0.135	-0.286	-0.854	-0.944	-0.024	147	-0.137	206	-0.027	-0.112	196
Lubbock, TX	242,628	-0.166	-0.282	-0.750	-0.810	-0.009	109	-0.161	227	-0.037	-0.112	197
Biloxi-Gulfport-Pascagoula, MS	363,988	-0.132	-0.289	-0.875	-0.971	-0.026	156	-0.135	203	-0.025	-0.113	198
Evansville-Henderson, IN-KY	296,195	-0.093	-0.286	-0.970	-1.105	-0.047	213	-0.104	157	-0.017	-0.114	199
Williamsport, PA	120,044	-0.126	-0.282	-0.861	-0.955	-0.031	168	-0.130	192	-0.028	-0.114	200
Sherman-Denison, TX	110,595	-0.134	-0.291	-0.879	-0.976	-0.028	158	-0.137	205	-0.028	-0.115	201
Augusta-Aiken, GA-SC	477,441	-0.078	-0.294	-1.046	-1.216	-0.057	235	-0.093	140	-0.012	-0.116	202
Ocala, FL	258,916	-0.170	-0.298	-0.810	-0.883	-0.010	114	-0.166	232	-0.036	-0.117	203
Lake Charles, LA	183,577	-0.066	-0.303	-1.118	-1.324	-0.064	258	-0.085	130	-0.006	-0.118	204
Mansfield, OH	175,818	-0.099	-0.294	-0.988	-1.129	-0.048	219	-0.110	164	-0.019	-0.118	205
St. Cloud, MN	167,392	-0.100	-0.290	-0.969	-1.103	-0.048	220	-0.110	165	-0.022	-0.119	206
Macon, GA	322,549	-0.059	-0.299	-1.117	-1.326	-0.068	261	-0.079	117	-0.007	-0.119	207
Goldsboro, NC	113,329	-0.183	-0.297	-0.771	-0.833	-0.007	100	-0.176	243	-0.043	-0.120	208
Dubuque, IA	89,143	-0.148	-0.307	-0.909	-1.012	-0.024	146	-0.150	220	-0.029	-0.120	209
Monroe, LA	147,250	-0.126	-0.307	-0.966	-1.092	-0.036	183	-0.133	199	-0.024	-0.121	210
Lynchburg, VA	214,911	-0.137	-0.300	-0.911	-1.017	-0.031	169	-0.140	209	-0.030	-0.121	211

APPENDIX TABLE A1: LIST OF METROPOLITAN AND NON-METROPOLITAN AREAS RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Shreveport-Bossier City, LA	392,302	-0.115	-0.308	-1.004	-1.146	-0.042	201	-0.124	182	-0.021	-0.121	212
Muncie, IN	118,769	-0.114	-0.304	-0.989	-1.126	-0.043	203	-0.122	177	-0.023	-0.121	213
Non-metro, IN	1,690,582	-0.101	-0.306	-1.033	-1.190	-0.050		-0.113		-0.019	-0.122	
Non-metro, SC	1,205,050	-0.135	-0.311	-0.960	-1.082	-0.033		-0.140		-0.026	-0.122	
Non-metro, OH	2,139,364	-0.099	-0.306	-1.041	-1.202	-0.052		-0.111		-0.019	-0.123	
Waco, TX	213,517	-0.108	-0.311	-1.038	-1.195	-0.047	216	-0.118	171	-0.019	-0.123	214
Jackson, TN	107,377	-0.080	-0.322	-1.157	-1.377	-0.063	253	-0.098	144	-0.010	-0.125	215
Bangor, ME	90,864	-0.170	-0.324	-0.921	-1.023	-0.018	132	-0.169	235	-0.034	-0.126	216
Decatur, AL	145,867	-0.064	-0.326	-1.220	-1.480	-0.072	266	-0.085	132	-0.005	-0.126	217
Albany, GA	120,822	-0.082	-0.316	-1.129	-1.334	-0.063	255	-0.099	148	-0.014	-0.127	218
Charleston, WV	251,662	-0.103	-0.331	-1.133	-1.332	-0.052	226	-0.117	170	-0.014	-0.127	219
Non-metro, NM	783,991	-0.212	-0.324	-0.806	-0.872	0.002		-0.202		-0.046	-0.127	
Lima, OH	155,084	-0.087	-0.322	-1.139	-1.347	-0.062	251	-0.103	152	-0.015	-0.129	220
Sharon, PA	120,293	-0.147	-0.319	-0.963	-1.083	-0.033	176	-0.151	222	-0.033	-0.129	221
Non-metro, NY	1,503,399	-0.115	-0.304	-0.985	-1.121	-0.050		-0.123		-0.031	-0.129	
Laredo, TX	193,117	-0.200	-0.332	-0.870	-0.952	-0.008	103	-0.194	256	-0.045	-0.132	222
Binghamton, NY	252,320	-0.114	-0.313	-1.028	-1.179	-0.054	229	-0.123	179	-0.030	-0.133	223
Houma, LA	194,477	-0.110	-0.338	-1.146	-1.350	-0.054	230	-0.123	178	-0.018	-0.133	224
Owensboro, KY	91,545	-0.136	-0.338	-1.074	-1.236	-0.041	194	-0.144	214	-0.026	-0.133	225
St. Joseph, MO	102,490	-0.167	-0.335	-0.976	-1.096	-0.026	152	-0.168	234	-0.036	-0.133	226
Florence, SC	125,761	-0.120	-0.341	-1.131	-1.324	-0.049	223	-0.131	194	-0.020	-0.133	227
Non-metro, GA	2,519,789	-0.140	-0.330	-1.029	-1.173	-0.040		-0.146		-0.031	-0.134	
Non-metro, VA	1,550,447	-0.160	-0.334	-0.992	-1.118	-0.031		-0.162		-0.036	-0.135	
Clarksville-Hopkinsville, TN-KY	207,033	-0.214	-0.342	-0.877	-0.959	-0.004	96	-0.206	259	-0.049	-0.136	228
Florence, AL	142,950	-0.142	-0.348	-1.102	-1.275	-0.042	200	-0.149	218	-0.027	-0.137	229
San Angelo, TX	104,010	-0.177	-0.348	-1.006	-1.132	-0.025	149	-0.177	244	-0.038	-0.138	230
Abilene, TX	126,555	-0.235	-0.349	-0.848	-0.920	0.004	83	-0.223	268	-0.055	-0.139	231
Decatur, IL	114,706	-0.053	-0.349	-1.349	-1.699	-0.089	274	-0.080	118	-0.005	-0.140	232
Lafayette, LA	385,647	-0.116	-0.356	-1.207	-1.438	-0.057	236	-0.130	193	-0.019	-0.140	233
Victoria, TX	84,088	-0.083	-0.356	-1.299	-1.598	-0.074	269	-0.104	156	-0.010	-0.140	234
Alexandria, LA	126,337	-0.171	-0.358	-1.064	-1.213	-0.031	167	-0.173	239	-0.035	-0.142	235
Casper, WY	66,533	-0.228	-0.366	-0.941	-1.038	-0.002	91	-0.219	265	-0.048	-0.142	236
Duluth-Superior, MN-WI	243,815	-0.098	-0.356	-1.254	-1.519	-0.069	265	-0.116	169	-0.018	-0.143	237
Johnson City-Kingsport-Bristol, TN-VA	480,091	-0.179	-0.363	-1.064	-1.211	-0.028	160	-0.180	248	-0.037	-0.144	238
Hattiesburg, MS	111,674	-0.178	-0.364	-1.071	-1.221	-0.029	161	-0.180	247	-0.037	-0.144	239
Utica-Rome, NY	299,896	-0.112	-0.342	-1.159	-1.367	-0.064	257	-0.125	186	-0.028	-0.144	240
Great Falls, MT	80,357	-0.307	-0.373	-0.755	-0.801	0.036	44	-0.283	276	-0.069	-0.145	241
Elmira, NY	91,070	-0.120	-0.345	-1.148	-1.348	-0.061	245	-0.132	198	-0.031	-0.146	242
Altoona, PA	129,144	-0.150	-0.363	-1.142	-1.330	-0.045	207	-0.158	225	-0.032	-0.146	243
Non-metro, PA	1,889,525	-0.135	-0.364	-1.190	-1.405	-0.053		-0.145		-0.027	-0.146	
El Paso, TX	679,622	-0.158	-0.369	-1.148	-1.336	-0.041	197	-0.164	231	-0.031	-0.146	244
Terre Haute, IN	149,192	-0.125	-0.372	-1.251	-1.502	-0.060	244	-0.139	208	-0.023	-0.148	245
Cumberland, MD-WV	102,008	-0.167	-0.365	-1.102	-1.267	-0.040	191	-0.171	238	-0.039	-0.150	246
Non-metro, IA	1,600,191	-0.192	-0.381	-1.105	-1.264	-0.027		-0.192		-0.039	-0.150	
Non-metro, IL	1,877,585	-0.145	-0.369	-1.182	-1.389	-0.052		-0.154		-0.032	-0.150	
Odessa-Midland, TX	237,132	-0.121	-0.382	-1.304	-1.588	-0.063	256	-0.136	204	-0.020	-0.151	247
Fargo-Moorhead, ND-MN	174,367	-0.168	-0.382	-1.174	-1.370	-0.039	190	-0.174	240	-0.033	-0.151	248

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		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Non-metro, MN	1,456,119	-0.157	-0.367	-1.142	-1.327	-0.047		-0.163		-0.037	-0.151	
Pocatello, ID	75,565	-0.125	-0.396	-1.355	-1.669	-0.061	249	-0.141	210	-0.016	-0.152	249
Columbus, GA-AL	274,624	-0.140	-0.379	-1.237	-1.473	-0.055	233	-0.152	223	-0.029	-0.152	250
Wichita Falls, TX	140,518	-0.234	-0.383	-0.995	-1.106	-0.008	102	-0.226	269	-0.053	-0.152	251
Longview-Marshall, TX	208,780	-0.136	-0.386	-1.280	-1.542	-0.057	237	-0.149	219	-0.025	-0.152	252
Beaumont-Port Arthur, TX	385,090	-0.035	-0.390	-1.574	-2.147	-0.108	275	-0.070	107	0.005	-0.153	253
Sumter, SC	104,646	-0.178	-0.388	-1.170	-1.361	-0.037	185	-0.182	249	-0.037	-0.154	254
Non-metro, TN	1,827,139	-0.185	-0.403	-1.219	-1.430	-0.038		-0.189		-0.037	-0.159	
Dothan, AL	137,916	-0.181	-0.404	-1.232	-1.450	-0.04	193	-0.186	250	-0.037	-0.160	255
Pine Bluff, AR	84,278	-0.156	-0.416	-1.353	-1.651	-0.053	228	-0.168	233	-0.025	-0.161	256
Danville, VA	110,156	-0.151	-0.403	-1.312	-1.586	-0.057	239	-0.163	229	-0.030	-0.162	257
Sioux City, IA-NE	124,130	-0.147	-0.417	-1.385	-1.708	-0.06	243	-0.161	226	-0.024	-0.162	258
Gadsden, AL	103,459	-0.133	-0.421	-1.440	-1.810	-0.069	263	-0.15	221	-0.021	-0.165	259
Anniston, AL	112,249	-0.183	-0.424	-1.314	-1.576	-0.046	209	-0.19	253	-0.036	-0.168	260
Joplin, MO	157,322	-0.254	-0.417	-1.086	-1.223	-0.011	118	-0.246	272	-0.059	-0.168	261
Fort Smith, AR-OK	207,290	-0.187	-0.433	-1.343	-1.620	-0.045	206	-0.194	255	-0.034	-0.169	262
Enid, OK	57,813	-0.218	-0.435	-1.267	-1.490	-0.032	173	-0.219	264	-0.045	-0.172	263
Non-metro, LA	1,098,766	-0.167	-0.435	-1.406	-1.733	-0.058		-0.178		-0.031	-0.172	
Non-metro, TX	3,159,940	-0.200	-0.442	-1.341	-1.611	-0.043		-0.206		-0.041	-0.175	
Non-metro, WV	1,042,776	-0.205	-0.445	-1.345	-1.614	-0.042		-0.21		-0.042	-0.176	
Non-metro, SD	493,867	-0.291	-0.457	-1.157	-1.310	0.001		-0.279		-0.062	-0.178	
Jonesboro, AR	82,148	-0.240	-0.452	-1.277	-1.498	-0.026	153	-0.238	271	-0.050	-0.178	264
Lawton, OK	114,996	-0.260	-0.448	-1.204	-1.384	-0.016	129	-0.253	274	-0.058	-0.178	265
Wheeling, WV-OH	153,172	-0.178	-0.448	-1.430	-1.767	-0.058	240	-0.189	251	-0.035	-0.178	266
Steubenville-Weirton, OH-WV	132,008	-0.178	-0.448	-1.429	-1.766	-0.058	241	-0.189	252	-0.036	-0.179	267
Jamestown, NY	139,750	-0.140	-0.430	-1.459	-1.840	-0.079	273	-0.157	224	-0.034	-0.180	268
Non-metro, AR	1,352,381	-0.238	-0.457	-1.306	-1.541	-0.028		-0.237		-0.049	-0.180	
Non-metro, KY	2,068,667	-0.182	-0.456	-1.456	-1.810	-0.057		-0.193		-0.035	-0.180	
Grand Forks, ND-MN	97,478	-0.204	-0.455	-1.387	-1.683	-0.046	208	-0.21	261	-0.042	-0.180	269
Parkersburg-Marietta, WV-OH	151,237	-0.153	-0.457	-1.537	-1.975	-0.072	268	-0.17	237	-0.027	-0.180	270
Non-metro, MO	1,800,410	-0.256	-0.456	-1.248	-1.449	-0.023		-0.251		-0.059	-0.183	
Non-metro, NE	811,425	-0.261	-0.464	-1.271	-1.481	-0.021		-0.256		-0.057	-0.184	
Huntington-Ashland, WV-KY-OH	315,538	-0.160	-0.477	-1.603	-2.098	-0.074	271	-0.177	245	-0.027	-0.188	271
Non-metro, KS	1,167,355	-0.240	-0.469	-1.351	-1.611	-0.035		-0.24		-0.053	-0.188	
Non-metro, AL	1,338,141	-0.174	-0.477	-1.568	-2.019	-0.067		-0.189		-0.031	-0.188	
Johnstown, PA	232,621	-0.190	-0.476	-1.519	-1.917	-0.062	250	-0.201	258	-0.039	-0.191	272
Texarkana, TX-Texarkana, AR	129,749	-0.185	-0.498	-1.625	-2.124	-0.068	260	-0.2	257	-0.033	-0.196	273
Non-metro, OK	1,352,292	-0.255	-0.496	-1.424	-1.720	-0.034		-0.255		-0.054	-0.197	
Brownsville-Harlingen-San Benito, TX	335,227	-0.211	-0.502	-1.570	-1.998	-0.057	238	-0.221	267	-0.041	-0.198	274
Non-metro, MS	1,820,996	-0.202	-0.517	-1.660	-2.180	-0.066		-0.215		-0.037	-0.203	
Bismarck, ND	94,719	-0.244	-0.532	-1.610	-2.052	-0.048	221	-0.25	273	-0.047	-0.208	275
Non-metro, ND	358,234	-0.260	-0.532	-1.565	-1.959	-0.041		-0.262		-0.052	-0.208	
McAllen-Edinburg-Mission, TX	569,463	-0.212	-0.570	-1.861	-2.641	-0.079	272	-0.228	270	-0.039	-0.225	276

APPENDIX TABLE A2: LIST OF STATES RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity		Federal Tax Differential	Total Amenity Values	
State Name	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank		Value	Rank
Hawaii	1,211,537	-0.015	0.530	2.311	1.852	0.182	1	0.045	10	-0.02	0.211	1
California	33,871,648	0.126	0.458	1.615	1.360	0.085	2	0.148	3	0.019	0.18	2
New Jersey	8,414,350	0.189	0.336	0.919	0.832	0.012	18	0.186	1	0.039	0.131	3
Connecticut	3,405,565	0.165	0.278	0.737	0.678	0.006	20	0.160	2	0.034	0.108	4
Massachusetts	6,349,097	0.094	0.251	0.816	0.749	0.034	9	0.101	5	0.017	0.098	5
New York	18,976,457	0.120	0.199	0.524	0.416	0.003	22	0.116	4	0.025	0.077	6
Washington	5,894,121	0.026	0.181	0.706	0.631	0.046	7	0.040	12	0.001	0.072	7
Colorado	4,301,261	-0.016	0.172	0.781	0.705	0.065	4	0.006	16	-0.01	0.069	8
New Hampshire	1,235,786	0.033	0.164	0.613	0.566	0.037	8	0.044	11	0.004	0.065	9
District of Columbia	572,059	0.126	0.154	0.314	0.307	-0.015	.	0.116	.	0.028	0.059	.
Alaska	626,932	0.050	0.130	0.418	0.399	0.016	15	0.054	8	0.009	0.051	10
Maryland	5,296,486	0.110	0.126	0.239	0.229	-0.016	29	0.101	6	0.025	0.049	11
Oregon	3,421,399	-0.045	0.106	0.579	0.534	0.058	5	-0.024	20	-0.015	0.043	12
Rhode Island	1,048,319	0.021	0.082	0.294	0.283	0.016	16	0.026	15	0.003	0.032	13
Illinois	12,419,293	0.065	0.063	0.091	0.025	-0.013	26	0.058	7	0.015	0.024	14
Nevada	1,998,257	0.054	0.054	0.082	0.069	-0.010	25	0.048	9	0.012	0.021	15
Arizona	5,130,632	-0.027	0.019	0.158	0.150	0.021	13	-0.019	17	-0.008	0.008	16
Delaware	783,600	0.043	-0.010	-0.159	-0.167	-0.025	33	0.033	14	0.011	-0.005	17
Utah	2,233,169	-0.055	-0.023	0.053	0.046	0.021	12	-0.046	26	-0.014	-0.008	18
Florida	15,982,378	-0.060	-0.036	0.013	-0.009	0.020	14	-0.051	27	-0.015	-0.013	19
Vermont	608,827	-0.172	-0.056	0.232	0.213	0.071	3	-0.142	39	-0.043	-0.02	20
Michigan	9,938,444	0.051	-0.061	-0.402	-0.444	-0.047	49	0.034	13	0.015	-0.025	21
Virginia	7,078,515	-0.035	-0.085	-0.268	-0.313	-0.010	24	-0.036	23	-0.006	-0.033	22
Wisconsin	5,363,675	-0.035	-0.099	-0.328	-0.371	-0.014	28	-0.038	24	-0.006	-0.039	23
New Mexico	1,819,046	-0.148	-0.136	-0.176	-0.229	0.032	10	-0.132	36	-0.034	-0.052	24
Minnesota	4,919,479	-0.009	-0.134	-0.548	-0.629	-0.039	43	-0.021	18	0.002	-0.053	25
Pennsylvania	12,281,054	-0.011	-0.135	-0.549	-0.623	-0.039	41	-0.023	19	0.001	-0.054	26
North Carolina	8,049,313	-0.084	-0.141	-0.373	-0.403	-0.003	23	-0.081	29	-0.017	-0.055	27
Ohio	11,353,140	-0.024	-0.143	-0.548	-0.614	-0.035	39	-0.034	22	-0.002	-0.057	28
Georgia	8,186,453	-0.021	-0.145	-0.562	-0.637	-0.037	40	-0.032	21	-0.001	-0.057	29
Maine	1,274,923	-0.160	-0.171	-0.294	-0.318	0.027	11	-0.145	41	-0.036	-0.066	30
Indiana	6,080,485	-0.031	-0.168	-0.633	-0.730	-0.039	42	-0.043	25	-0.003	-0.066	31
Texas	20,851,820	-0.041	-0.203	-0.754	-0.891	-0.045	46	-0.054	28	-0.005	-0.08	32
Idaho	1,293,953	-0.148	-0.212	-0.502	-0.538	0.007	19	-0.139	38	-0.032	-0.082	33
South Carolina	4,012,012	-0.100	-0.214	-0.640	-0.713	-0.018	30	-0.102	30	-0.019	-0.083	34
Montana	902,195	-0.256	-0.237	-0.313	-0.330	0.055	6	-0.227	48	-0.059	-0.09	35
Missouri	5,595,211	-0.106	-0.247	-0.766	-0.859	-0.026	34	-0.111	32	-0.02	-0.097	36
Tennessee	5,689,283	-0.101	-0.249	-0.787	-0.899	-0.029	36	-0.107	31	-0.019	-0.097	37
Wyoming	493,782	-0.193	-0.264	-0.599	-0.639	0.014	17	-0.181	46	-0.042	-0.102	38
Louisiana	4,468,976	-0.104	-0.264	-0.844	-0.990	-0.032	37	-0.111	33	-0.019	-0.103	39
Iowa	2,926,324	-0.140	-0.293	-0.870	-0.986	-0.024	32	-0.142	40	-0.027	-0.114	40
Kansas	2,688,418	-0.132	-0.312	-0.975	-1.131	-0.034	38	-0.137	37	-0.025	-0.122	41
Nebraska	1,711,263	-0.174	-0.319	-0.886	-1.007	-0.014	27	-0.172	43	-0.035	-0.124	42
Alabama	4,447,100	-0.114	-0.318	-1.051	-1.264	-0.046	48	-0.124	34	-0.02	-0.125	43
Kentucky	4,041,769	-0.121	-0.326	-1.066	-1.286	-0.045	45	-0.130	35	-0.021	-0.128	44
Arkansas	2,673,400	-0.185	-0.364	-1.050	-1.223	-0.023	31	-0.185	47	-0.037	-0.142	45
Oklahoma	3,450,654	-0.178	-0.369	-1.091	-1.269	-0.029	35	-0.181	45	-0.035	-0.144	46
South Dakota	754,844	-0.252	-0.389	-0.974	-1.088	0.003	21	-0.240	50	-0.053	-0.151	47
West Virginia	1,808,344	-0.161	-0.392	-1.239	-1.511	-0.045	47	-0.169	42	-0.03	-0.154	48
Mississippi	2,844,658	-0.167	-0.427	-1.370	-1.738	-0.054	50	-0.178	44	-0.03	-0.167	49
North Dakota	642,200	-0.234	-0.495	-1.478	-1.831	-0.041	44	-0.238	49	-0.046	-0.193	50

TABLE A3: THE RELATIONSHIP BETWEEN SPECIFIC AMENITIES AND HOUSING COSTS, WAGES, QUALITY OF LIFE, PRODUCTIVITY, LAND RENTS, FEDERAL TAXES, TOTAL AMENITY VALUES, METRO POPULATION, COLLEGE SHARE, AND WRLURI WITH CLIMATE AND GEOGRAPHY VARIABLES ONLY (NOT FOR PUBLICATION)

			Observables		Amenity Type		Capitalization Into		Total	Logarithm	Share of	
	Mean	Standard Deviation	Housing Cost	Wage	Quality of Life	Trade Productivity	Local Land Rents	Federal Tax Payment	Amenity Value	of Metro Populatoin	Adults with College	WRLURI Index
			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Minus Heating-Degree Days	-4.38	2.15	0.075***	0.034***	0.008*	0.035***	0.023***	0.008***	0.030***	0.362***	0.009	0.011
(1000s)			(0.018)	(0.010)	(0.004)	(0.009)	(0.006)	(0.002)	(0.007)	(0.122)	(0.006)	(0.065)
Minus Cooling-Degree Days	-1.28	0.89	0.142***	0.038**	0.027***	0.045**	0.051***	0.005	0.056***	0.430	0.009	-0.141
(1000s)			(0.037)	(0.019)	(0.007)	(0.018)	(0.012)	(0.004)	(0.015)	(0.277)	(0.016)	(0.155)
Sunshine	0.60	0.08	1.617***	0.486***	0.284***	0.557***	0.559***	0.081***	0.640***	3.079*	0.101	4.135***
(percent possible)			(0.243)	(0.128)	(0.046)	(0.123)	(0.078)	(0.030)	(0.097)	(1.615)	(0.095)	(1.028)
Inverse Distance to Coast	0.04	0.04	0.128***	0.051***	0.016***	0.054***	0.041***	0.009***	0.050***	0.378***	0.016***	0.398***
(Ocean or Great Lake)			(0.018)	(0.009)	(0.002)	(0.009)	(0.005)	(0.002)	(0.007)	(0.123)	(0.005)	(0.053)
Average Slope of Land	1.68	1.59	0.006	-0.015***	0.009***	-0.011***	0.007**	-0.005***	0.002	-0.170***	-0.004	0.071*
(percent)			(0.008)	(0.004)	(0.002)	(0.004)	(0.003)	(0.001)	(0.003)	(0.046)	(0.003)	(0.040)
Latitude	37.76	4.86	0.029***	0.018***	0.001	0.018***	0.007***	0.004***	0.012***	0.134***	0.007**	0.092***
(degrees)			(0.008)	(0.005)	(0.002)	(0.004)	(0.003)	(0.001)	(0.003)	(0.049)	(0.003)	(0.032)
Constant			-1.054***	-0.554***	-0.076	-0.551***	-0.299***	-0.130***	-0.429***	11.612***	0.066	-4.578***
			(0.299)	(0.184)	(0.067)	(0.171)	(0.095)	(0.045)	(0.120)	(1.966)	(0.121)	(1.427)
R-squared			0.71	0.56	0.67	0.60	0.73	0.47	0.70	0.34	0.19	0.46

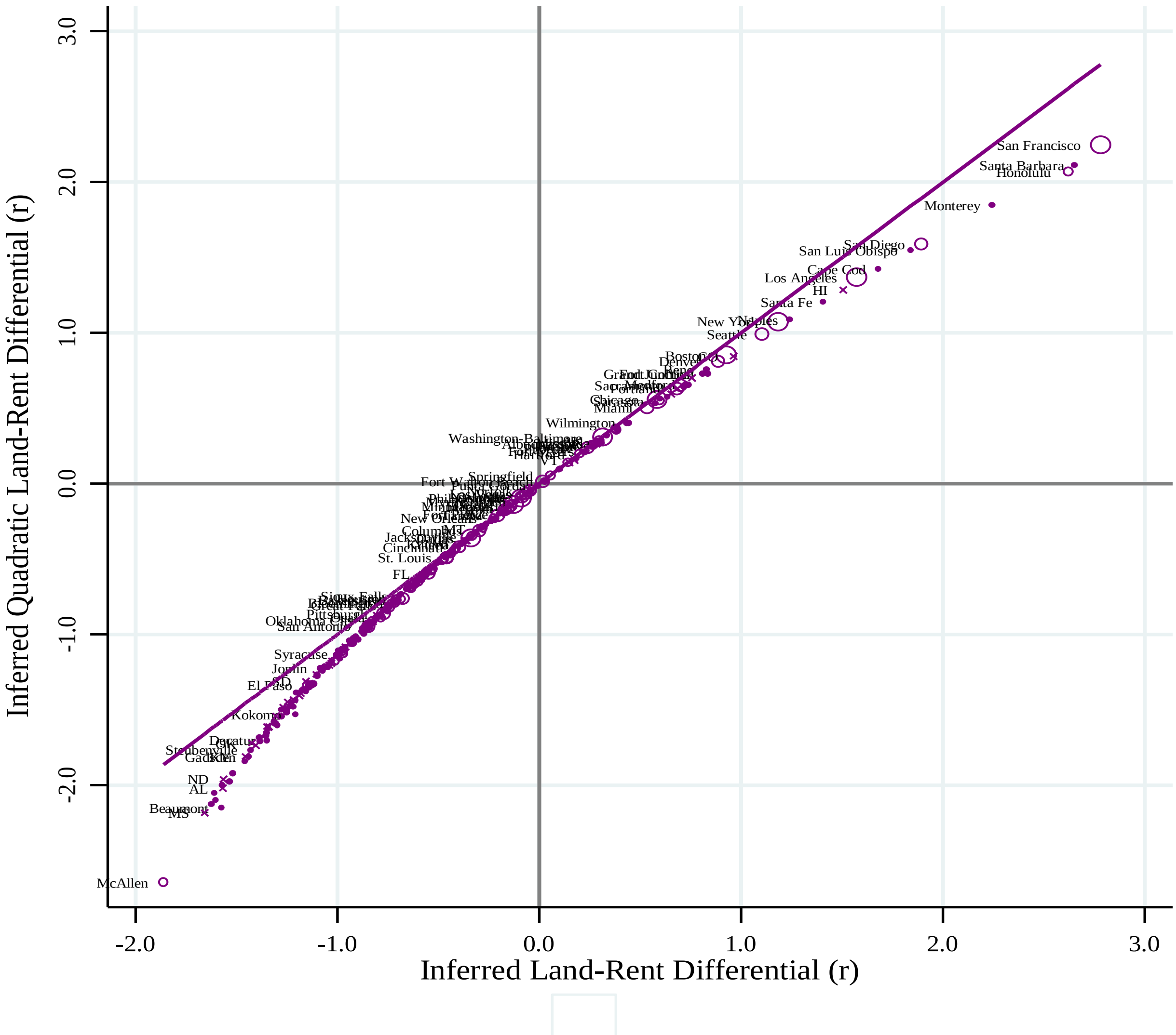
218 observations with complete data. Robust standard errors shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. Regressions weighted by the sum of individuals in a city, each according to their predicted income in an average city. Amenity variables are described in Section 4.1.

TABLE A4: THE RELATIONSHIP BETWEEN SPECIFIC AMENITIES AND HOUSING COSTS, WAGES, QUALITY OF LIFE, PRODUCTIVITY, LAND RENTS, FEDERAL TAXES, AND TOTAL AMENITY VALUES WITH EXTENDED REGRESSOR LIST (NOT FOR PUBLICATON)

			Observables		Amenity Type		Capitalization Into		Total
	Mean	Standard Deviation	Housing Cost (1)	Wage (2)	Quality of Life (3)	Trade Productivity (4)	Local Land Rents (5)	Federal Tax Payment (6)	Amenity Value (7)
Logarithm of Population	14.63	1.32	0.097***	0.061***	0.001	0.059***	0.025***	0.014***	0.039***
			(0.014)	(0.007)	(0.004)	(0.007)	(0.005)	(0.002)	(0.006)
Percent of Population College Graduates	0.26	0.07	1.188***	0.304**	0.241***	0.368***	0.426***	0.051	0.476***
			(0.248)	(0.128)	(0.072)	(0.118)	(0.093)	(0.033)	(0.099)
Whartron Residential Land-Use Regulatory Index (WRLURI)	0.05	0.93	-0.008	-0.005	0.000	-0.005	-0.002	-0.001	-0.003
			(0.012)	(0.006)	(0.004)	(0.005)	(0.005)	(0.002)	(0.005)
Minus Heating-Degree Days (1000s)	-4.38	2.15	0.042***	0.002	0.013***	0.006	0.017***	0.000	0.017***
			(0.009)	(0.006)	(0.003)	(0.005)	(0.004)	(0.001)	(0.004)
Minus Cooling-Degree Days (1000s)	-1.28	0.89	0.138***	0.027*	0.031***	0.036***	0.051***	0.003	0.054***
			(0.018)	(0.014)	(0.007)	(0.012)	(0.007)	(0.004)	(0.007)
Sunshine (percent possible)	0.60	0.08	1.184***	0.306***	0.235***	0.369***	0.423***	0.048**	0.471***
			(0.127)	(0.092)	(0.044)	(0.080)	(0.047)	(0.024)	(0.051)
Inverse Distance to Coast (Ocean or Great Lake)	0.04	0.04	0.047***	0.013***	0.008***	0.016***	0.017***	0.001	0.018***
			(0.009)	(0.005)	(0.003)	(0.004)	(0.003)	(0.001)	(0.003)
Average Slope of Land (percent)	1.68	1.59	0.017**	(0.003)	0.007***	(0.001)	0.008***	-0.002**	0.006**
			(0.007)	(0.003)	(0.002)	(0.003)	(0.003)	(0.001)	(0.003)
Latitude (degrees)	37.76	4.86	0.006	0.004	0.000	0.004	0.001	0.001	0.002
			(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
Percent African-American	0.12	0.95	-0.185	0.055	-0.091**	0.024	-0.094	0.019	-0.075
			(0.164)	(0.080)	(0.045)	(0.074)	(0.060)	(0.019)	(0.064)
Percent Hispanic	0.09	0.11	0.151	0.002	0.041	0.018	0.064	-0.012	0.052
			(0.196)	(0.070)	(0.045)	(0.072)	(0.071)	(0.014)	(0.077)
Percent Over 65	0.12	0.03	0.199	-0.082	0.112	-0.044	0.108	-0.024	0.084
			(0.572)	(0.325)	(0.184)	(0.290)	(0.218)	(0.082)	(0.227)
Percent Under 18	0.28	0.02	-0.836	-0.086	-0.216	-0.157	-0.335	0.018	-0.317
			(0.647)	(0.361)	(0.228)	(0.316)	(0.259)	(0.093)	(0.258)
Restaurants and Bars per capita	0.17	0.28	0.065	-0.023	0.033***	-0.011	0.034*	-0.009*	0.025
			(0.049)	(0.020)	(0.012)	(0.019)	(0.018)	(0.005)	(0.020)
Places Rated Arts & Culture Index	0.80	0.26	-0.04	-0.037	0.004	-0.033	-0.007	-0.01	-0.017
			(0.056)	(0.032)	(0.017)	(0.029)	(0.021)	(0.008)	(0.022)
Median Air Quality Index	-0.49	0.13	0.271***	0.084	0.048**	0.095*	0.093***	0.016	0.109***
			(0.078)	(0.055)	(0.022)	(0.049)	(0.026)	(0.014)	(0.031)
Violent Crimes Index	0.00	0.68	-0.029	0.010	-0.015***	0.005	-0.015**	0.003	-0.012
			(0.019)	(0.009)	(0.006)	(0.008)	(0.007)	(0.002)	(0.008)
Property Crimes Index	0.00	0.75	-0.007	-0.010	0.002	-0.009	0.000	-0.003	-0.003
			(0.013)	(0.009)	(0.004)	(0.008)	(0.004)	(0.002)	(0.005)
Constant			-1.832***	-1.035***	-0.095	-1.014***	-0.500***	-0.243***	-0.744***
			(0.355)	(0.168)	(0.108)	(0.154)	(0.137)	(0.043)	(0.141)
R-squared			0.93	0.87	0.84	0.90	0.92	0.82	0.93

282 observations with complete data. Robust standard errors shown in parentheses. * p<0.1, ** p<0.05, *** p<0.01. Regressions weighted by the sum of individuals in a city, each according to their predicted income in an average city. Amenity variables are described in Section 4.1.

Figure A2: Land Rents Inferred with Quadratic vs Linear Approximation



Quadratic inferred land rents based on calibration: phiL =0.2333, phiN =0.6167, sigmaY =.6667

Figure A2: Compositional Wage and Housing Costs across Areas: 2000

Using the same scale as figure 1 for comparison

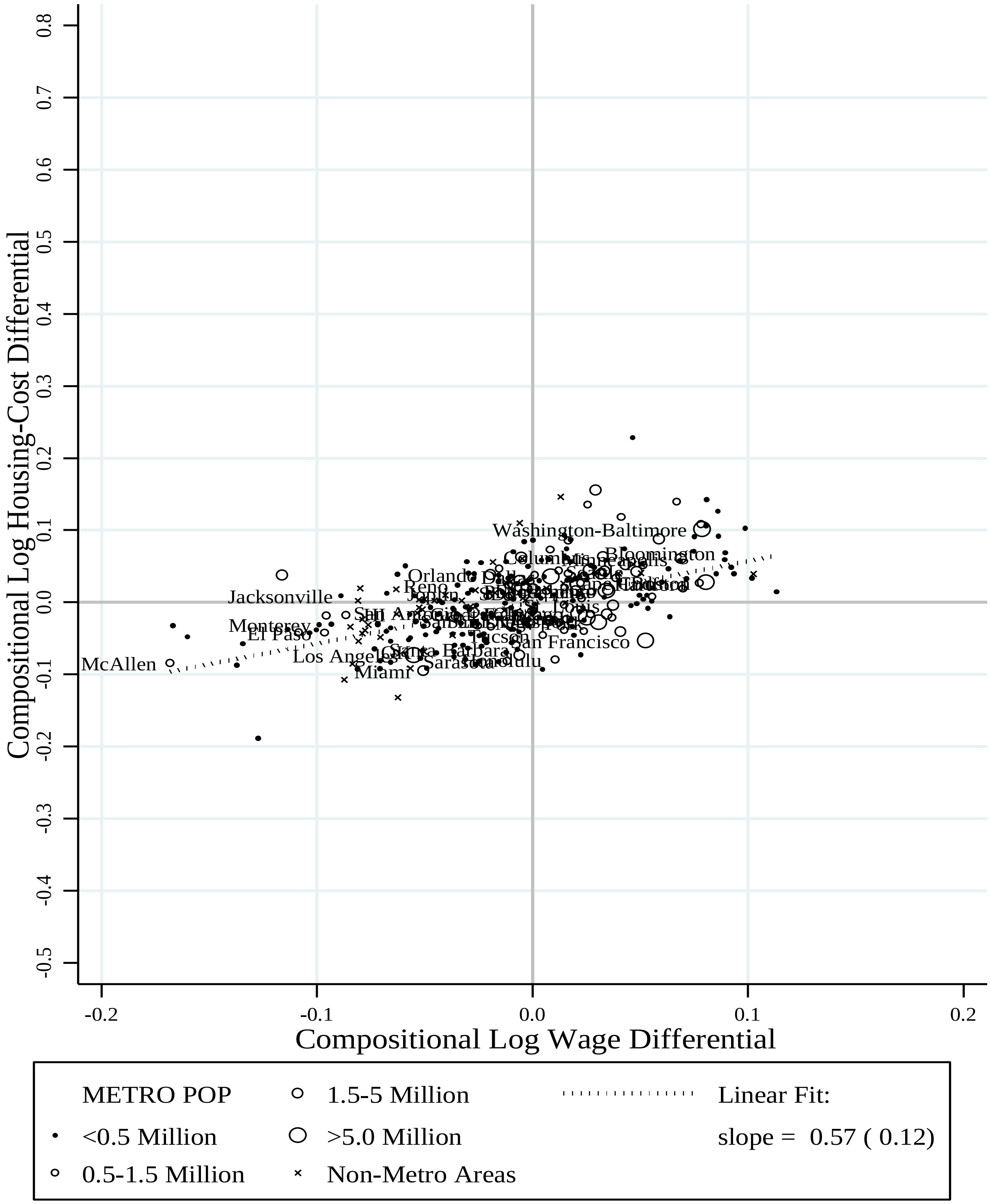


Figure A3: Housing Costs with Local User-Cost Adjustments, 2000