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WHAT ARE CITIES WORTH? LAND RENTS, LOCAL PRODUCTIVITY, AND THE CAPITALIZATION OF AMENITY VALUES

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ABSTRACT

Estimates of local land rents and firm productivity from wage and housing-cost data should incorporate parameters from the housing production function. Across cities, differences in amenity values are capitalized into the sum of local land values and federal-tax payments. Improved modeling is used to predict how amenities affect wages and housing costs, estimate quality-of-life and firm-productivity differences across U.S. cities, and revise estimates of the value of public-infrastructure investments. Private land values vary mainly from quality-of-life differences, while social land values vary mainly from firm-productivity differences. Highly valuable cities are typically coastal, temperate, sunny, and have large or well-educated populations.

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1 Introduction

David Ricardo (1817) first explained how productivity differences in the "original and indestructible powers of the soil" are fully capitalized into differences in land rents across sites. George (1879), Tiebout (1956), Arnott and Stiglitz (1979), and others extended this insight to explain how the economic value of all local site characteristics, from weather to local taxes – broadly termed "amenities" – are capitalized into land rents. Amenities come in two kinds, although some are a mixture of both: consumption amenities increase household welfare, raising quality of life, and production amenities lower firm costs, raising productivity. Estimates of amenity values based on land-rent differences are used to measure the incidence of taxes, the benefits of government spending, the costs of pollution, and other important economic prices.

The values of local amenities are also reflected in prices other than land rents, such as housing costs, as housing services are produced from local land and other inputs. Across cities, values are also reflected in local wages, as firms pay less in areas with consumption amenities and more in places with production amenities. Using duality theory, Roback (1982) elegantly demonstrates the dependence of wages, land rents, and housing costs on local amenity values in a three equation model where labor and capital are mobile in a general equilibrium setting. However, in application, she and other researchers have relied exclusively on a simplified two-equation model, which equates housing directly with land. The richer, three-equation model – where the third equation models the production of housing from land and other factors – has never been applied empirically, despite being much more realistic.[1]

While data for housing costs are readily available, data on land rents are notoriously rare.[2] As demonstrated below, three issues have to be considered when land rents, or the value of amenities

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[1] For instance, a comprehensive review of the quality-of-life literature in Gyourko et al. (1999), makes extensive use of the Roback framework, but makes no mention of this third equation.

[2] Davis and Polumbo (2007) try to infer the costs of land rents across metropolitan areas by subtracting construction costs, obtained from R.S. Means, from observed housing data. While insightful, this methodology implicitly assumes that there are no other costs, such as expenditures to overcome regulatory burdens, to producing housing other than construction and land costs, and that housing productivity does not vary across metropolitan area. Rappaport (2008) uses a 3-equation model, similar to the one here without taxation, but only to simulate the effect of productivity differences on population density across cities.

that affect them, are estimated from housing-cost data. First, the cost-share of land in housing services is less than one and the share of income spent on housing services is greater than the share of income received from residential land. Thus, a 10-percent difference in local housing costs between two cities does not correspond to a 10-percent difference in land rents. Second, non-land input costs, such as labor, vary across cities and should be subtracted from housing values before using the remaining value to infer the value of land. Third, because of differences in the natural and regulatory environments, the housing production sector in different cities may vary in efficiency, so that land rents may be overestimated in cities with relatively inefficient housing sectors.[3]

These three issues reappear in measures of local firm productivity from the two-equation model, seen in Beeson and Eberts (1989), Rauch (1993), Dekle and Eaton (1999), Rudd (2000), Gabriel and Rosenthal (2004), Glaeser and Saiz (2004), Shapiro (2006), and Deitz and Abel (2008).[4] Local firm productivity is measured through the cost of local factors, such as land and labor, as only highly productive firms can be profitable in cities with high factor costs, assuming a competitive equilibrium with mobile firms and trade across cities. However, by using housing costs as a direct measure of land costs, the productivity estimates in these studies put too much weight on wages and too little weight on housing costs when determining the costs of local factors, and may be biased upwards in cities where housing-productivity is low. The model presented here not only helps eliminate these problems, but also considers the effect of productivity differences in housing production, as these affect wages and housing costs very differently than productivity differences in the production of goods tradable across cities.

The three-equation model predicts how consumption and production amenities affect wages, housing costs, and land rents differently. Because of its realism, the model may be calibrated to the U.S. economy to provide new and exact predictions of these effects — an exercise the two-

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[3] Roback does note that "In general, the housing price gradient will not capture the full valuation of the amenities. An adjustment for the differences in wages must be included." (p.1266) To my knowledge, this adjustment has not been applied empirically. Rudd (2000) separates housing costs from land rents, but housing costs are divided into land, utilities, and structures.

[4] Tabuchi and Yoshida (2000) use actual data on land rents, although this is later conflated with housing services.

equation model is not amenable to. Although land-rent differences are not typically observed, they fully capitalize differences in the value of all amenities when federal tax distortions are absent. It is estimated that only a quarter of the value of consumption amenities is reflected through lower wages, with the rest reflected in higher housing costs, or costs-of-living more generally. Amenities that lower the production costs of goods tradable across cities are reflected in higher wages and housing costs, and these may capitalize over 100 percent of their value. In contrast, amenities that lower the production costs of goods not tradable across cities are reflected in lower wages and housing costs, which negatively capitalize a portion of their value..

Interestingly, federal income taxes break the fundamental insight that land-rent differences should fully capitalize differences in amenity values. As demonstrated in Albouy (2008a), amenities that raise wages also raise federal income tax liabilities. As a result, production amenities for traded goods are effectively taxed and their values are undercapitalized into local land rents; consumption amenities and production amenities for non-traded goods are effectively subsidized and their values are overcapitalized. Thus, federal taxes create a wedge between the economic value of an amenity and the value that is capitalized into local land rents, with the difference equal to the federal fiscal externality generated by that amenity. The effect of an amenity on federal tax revenues needs to be added to its effect on local land rents in order to determine the amenity's full social value. Hence, the full value of a city's amenities, which reflects its land's social value, depends not only on its land rents, which reflects its land's private value, but also on its local wage level. Since production amenities raise wages while consumption amenities lower them, the former are effectively taxed, while the latter are effectively subsidized.

The importance of these theoretical insights is illustrated in three empirical applications. The first revises estimates from Haughwout (2002) of the value of public infrastructure in central cities, based on the two-equation Roback model. Based on the model here, revised estimates are 147 percent larger than Haughwout's original estimates, and raise the possibility that the marginal benefits of public infrastructure may indeed exceed their marginal costs.

The second application estimates inter-city differences in land rents, firm-productivity, quality-of-life, federal-tax burdens, and total amenity values across cities in the United States using wage and housing-cost data from the 2000 Census, assuming that there are no differences in housing-productivity.[5] An appealing feature of these calculations is that they are visible through graphs. The standard deviation in the value of consumption amenities across cities is 5.1 percent of income, which is less than the standard deviation in the value of production amenities of 8.4 percent of income. However, because federal taxes reduce the impact of production amenities on land rents, these vary more because of consumption amenities.

The third, more exploratory, application examines the cross-sectional relationship between individual amenities and estimates of firm productivity, land rents, federal tax burdens, and other measures from the second application. Productivity increases with city size and education levels, in line with the estimates found in Rosenthal and Strange (2004) and Moretti (2004). A new, thought-provoking, result is that productivity is strongly correlated with sunniness and proximity to a coast, while it is negatively correlated with hot climate, even controlling for latitude. Although estimates of land rents and firm-productivity may be biased upwards in cities with low local housing-productivity, an index of residential land-use regulations is not significantly correlated with these measures. Households are effectively taxed for living in sunny or coastal cities, or cities with a large or well-educated population. Accordingly, the value of these amenities are not fully capitalized into land rents. Meanwhile, life in hot and rural areas is effectively subsidized.

2 Model Set-up

To explain how prices vary with amenity levels across cities, I adapt the three-equation general equilibrium model of Roback (1980, 1982), where the less-known third equation models the production of goods that are not traded across cities. Federal income taxes are also included, as in Albouy (2008a). The national economy is closed and contains many cities, indexed by j, which trade with each other and share a homogenous population of mobile households. These households

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[5] Quality-of-life and federal tax differences across cities are examined in much greater depth in Albouy (2008a, 2008b); land-rent, firm-productivity, and total-amenity-value differences are emphasized here.

consume a numeraire traded good, x, and a non-traded "home" good, y, with local price, p^j. In application, the local price of home goods is equated with the local cost of housing services.[6]

Cities differ in three attributes: quality of life, Q^j, which raises household utility; the level of productivity in the traded-good sector, A_X^j, or "trade-productivity," and the level of productivity in the home-good sector, A_Y^j, or "home-productivity." All of these attributes depend on a vector of city amenities, $\mathbf{Z}^j = (Z_1^j, ..., Z_K^j)$, natural or artificial, according to some unknown functions $Q^j = \widetilde{Q}(\mathbf{Z}^j)$, $A_X^j = \widetilde{A_X}(\mathbf{Z}^j)$, and $A_Y^j = \widetilde{A_Y}(\mathbf{Z}^j)$. For a consumption amenity, e.g. safety or clement weather, $\partial\tilde{Q}/\partial Z_k > 0$; for a trade-production amenity, e.g. navigable water or agglomeration economies, $\partial\widetilde{A_X}/\partial Z_k > 0$; for a home-production amenity, e.g. flat geography or the absence of land-use restrictions, $\partial\widetilde{A_Y}/\partial Z_k > 0$. It is also a possible that a single amenity affects more than one attribute, or affects an attribute negatively. The use of this notation provides an accounting system that isolates the different effects of an amenity, depending on how it is valued separately by households, traded-good firms, and home-good firms.

It is worth noting that amenities may be endogenous to quantities in the model, and that this poses different problems when measuring values than when using comparative statics to predict the effect of an amenity change. For example, an increase in population, N^j, may lead to greater pollution, lowering Q^j. If a city were to receive a theme-park, improving Q, this would raise N, raising pollution, and indirectly decreasing Q. The value of the theme-park could be measured empirically by controlling for pollution, although the value when accounting for pollution externalities should not control for pollution. Both direct and indirect of amenities have to be taken into account when using comparative statics to determine the causal effect of an amenity on the attributes and prices in a city.

Firms produce traded and home goods out of land, capital, and labor. Within a city, factors are mobile and receive the same payment in either sector. Land, L, is fixed in supply in each city at L^j, and is paid a city-specific price r^j. Capital, K, is fully mobile and is paid the price $\bar{\imath}$ everywhere. The supply of capital in each city is denoted K^j, with the national level of capital fixed at K_{TOT},

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[6] Non-housing goods are considered to be a composite commodity of traded goods and non-housing home goods. Multiple home-good types are considered in Appendix A.4.

thus $\sum_j K^j = K_{TOT}$. 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. The total number of worker-households is fixed at N_{TOT}, so $\sum_j N^j = N_{TOT}$. Households own identical diversified portfolios of land and capital, which pay an income $R = \frac{1}{N_{TOT}} \sum_j r^j L^j$ from land and $I = \bar{\imath} \frac{K_{TOT}}{N_{TOT}}$, from capital. Total income, $m^j \equiv R + I + w^j$, varies across cities only as wages vary. Out of this income households pay a federal income tax of $\tau(m)$, which is redistributed in uniform lump-sum payments. Deductions and state taxes are discussed further in Albouy (2008a).[7]

Household preferences are modeled by a utility function $U(x, y; Q)$, that is quasi-concave over x and y, and increasing in Q. The expenditure function for a worker in city j is $e(p^j, u; Q^j) \equiv \min_{x,y}\{x + p^j y : U(x, y; Q^j) \geq u\}$. Q is assumed to enter neutrally into the utility function and is normalized so that $e(p^j, u; Q^j) = e(p^j, u)/Q^j$, where $e(p^j, u) \equiv e(p^j, u; 1)$. Since households are fully mobile, their utility must be the same across all inhabited cities, so that higher prices or lower quality-of-life must be compensated with greater after-tax income:

$$e(p^j, \bar{u})/Q^j = m^j - \tau(m^j) \tag{1}$$

where $\bar{u}$ is the level of utility attained nationally by all households.[8]

Operating under perfect competition, firms produce traded and home goods according to the functions $X^j = F_X^j(L_X^j, N_X^j, K_X^j; A_X^j)$ and $Y^j = F_Y(L_Y^j, N_Y^j, K_Y^j; A_Y^j)$, where F_X and F_Y are concave and exhibit constant returns to scale. All factors are fully employed: $L_X^j + L_Y^j = L^j$, $N_X^j + N_Y^j = N^j$, and $K_X^j + K_Y^j = K^j$. Unit cost in the traded-good sector is $c_X(r^j, w^j, \bar{\imath}; A_X^j) \equiv \min_{L,N,K}\{r^j L + w^j N + \bar{\imath} K : A_X^j F(L, N, K) = 1\}$. For simplicity, let $c_X(r^j, w^j, \bar{\imath}; A_X^j) =$

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[7] In general results are robust to elastic labor and land supply so long as the new units supplied are equivalent to the old units (Roback 1980). Furthermore, results do not change signicantly with international capital flows or if federal tax revenues are used to purchase tradable goods.

[8] The model generalizes easily to a case 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 A.3 discusses how the model's predictions are affected with multiple household types with different preferences and labor skills.

$c_X(r^j, w^j, \bar{\imath})/A_X^j$ where $c(r, w, i) \equiv c(r, w, i; 1)$.[9] A symmetric definition holds for the unit costs in the home-good sector, c_Y. As markets are competitive, firms make zero profits in equilibrium, so that for given output prices, more productive cities must pay higher rents and wages to achieve zero profits. Thus in equilibrium, the following conditions hold in all cities:

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

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

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, as is likely, that home goods are more cost-intensive in land relative to labor than traded goods, both absolutely, $\phi_L^j \geq \theta_L^j$, and relative to labor, $\phi_L^j/\phi_N^j \geq \theta_L^j/\theta_N^j$, implying that $\lambda_L^j \leq \lambda_N^j$.

3 The Relationship between Wages, Rents, Productivity, and Housing Costs

3.1 Prices and Amenities in Equilibrium

To analyze the effect of city attributes on prices, assume that the three attributes, Q, A_X, and A_Y may be treated as continuous variables. The equilibrium conditions (1), (2), and (3) implicitly define the prices w^j,r^j, and p^j as a function of Q^j, A_X^j, and A_Y^j. These conditions may be log-

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[9] As shown in Appendix A.3 Non-Hicks-neutral productivity differences have similar impacts on relative prices across cities, but not on relative quantities.

linearized to express a particular city's price differentials in terms of its city-attribute differentials, each relative to the national average. These differentials are expressed in logarithms so that, for any variable z, $\hat{z}^j = \ln z^j - \ln \bar{z} \cong \left(z^j - \bar{z}\right)/\bar{z}$, approximates the percent difference in city j of z relative to the geometric average $\bar{z}$. Letting E be the expectations operator over cities, then $E[\hat{z}^j] = 0$.

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

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

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

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

These equations are first-order approximations around a nationally-representative city and so the share values are national averages. Equation (4a) measures local quality-of-life, $\hat{Q}^j$, 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, $\hat{p}^j$. Stated in reverse, cities are inferred to have low home-productivity if the price of home goods is high relative to the local input costs. Together, these equilibrium conditions state that the relative value of a city's amenities is measured by the implicit willingness-to-pay of households and firms for all of the city's amenities.

With accurate data on wage, housing-cost, and land-rent differences across cities, as well as knowledge of the economic parameters at the national level, the system of equations (4) can be solved for $\hat{Q}^j, \hat{A}_X^j$, and $\hat{A}_Y^j$. Without data on land rents, $\hat{r}^j$, quality-of-life, $\hat{Q}^j$, can still be calculated, but trade-productivity, $\hat{A}_X^j$, and home-productivity, $\hat{A}_Y^j$, cannot be separately identified. A linear restriction on the relationship between the three unobservables – land-rents, trade-productivity, and home-productivity – must be imposed to measure these variables.

3.2 Inferring Land Rents

3.2.1 Linear Estimates

As land rents are typically unobserved it is worth considering how land-rent differences may be inferred from wage and housing-cost differences. Solving equation (4c) for $\hat{r}^j$, the land-rent differential is given by

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

Analyzing this formula, land-rent differentials differ from housing-cost differentials because of three effects:

Land-share effect: For given wages, the land-rent differential is $1/\phi_L$ times the home-good price differential, as land costs make up only a fraction, ϕ_L, of total home-good prices.

Labor-cost effect: In high-wage areas, the labor-cost component of the home-good price, $\phi_N \hat{w}^j$, needs to be subtracted, as it is not part of the land cost.

Home-productivity effect: Home-good prices in cities with high home productivity understate the cost of local factors. Therefore, land rent in a city with higher home-productivity is greater than in a city with lower home-productivity with the same observed wage and home-good price. This effect is the most difficult to account for since home-productivity is unobserved.

Because home-productivity cannot be observed, land-rent differentials are estimated here by assuming that there are no home-productivity differences across cities, i.e. $\hat{A}_X^j = 0$, for all j. This assumption causes land rents to be overestimated in cities with low home-productivity. In previous studies, where researchers have equated housing with land, they have implicitly assumed that $\phi_L = 1$, $\phi_N = 0$, and $\hat{A}_Y^j = 0$ for all j; the current model imposes no such restrictions, but retains them as a special case.

3.2.2 Quadratic Estimates

The inferred land rent from equation (5) is based on 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. This can be addressed by taking a second-order approximation of equation (3) around the national average, and rearranging to solve for the inaccuracy of the first-order approximation:

$$\begin{aligned}\hat{p} - \phi_L \hat{r}^j - \phi_N \hat{w}^j + \hat{A}_Y^j = {} & \frac{1}{2}\phi_N \phi_L \left(1 - \sigma_Y^{NL}\right)\left(\hat{w}^j - \hat{r}^j\right)^2 \\ & + \frac{1}{2}\phi_K \left[\phi_N \left(1 - \sigma_Y^{NK}\right)\left(\hat{w}^j\right)^2 + \phi_L \left(1 - \sigma_Y^{LK}\right)\left(\hat{r}^j\right)^2\right] \qquad (6)\end{aligned}$$

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 using (6) to solve for $\hat{r}^j$ in terms of $\hat{p}^j$ and $\hat{w}^j$ produces a quadratic estimate of land-rent differentials. 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 then 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, 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. As seen below in Figure 3 (and Appendix Figure A1), plausible quadratic estimates are not very different from the linear estimates, and thus for theoretical simplicity first-order approximations are used in the analysis below.[10]

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[10] There are three partial (Allen-Uzawa) elasticities of substitution in production for each combination of two factors,

3.3 Inferring Trade-Productivity

With land-rent data, trade-productivity differences can be measured directly from (4b). Without land-rent data, trade-productivity differences can be obtained from wage and home-good prices by substituting (5) into (4b):

$$\hat{A}_X^j = \frac{\theta_L}{\phi_L}\hat{p}^j + \left(\theta_N - \phi_N \frac{\theta_L}{\phi_L}\right)\hat{w}^j + \frac{\theta_L}{\phi_L}\hat{A}_Y^j \tag{7}$$

This formula differs from the previously-used formula for trade-productivity in the two-equation model, which imposes $\hat{A}_X^j = \theta_L \hat{p}^j + \theta_N \hat{w}^j$, because of the same three effects that cause home-good prices and land rents to differ:

Land-share effect Home-good price differentials are weighted by θ_L/ϕ_L, which is greater than θ_L, since housing-cost differentials understate land-rent differentials, holding wages constant.

Labor-cost effect Wage differentials are weighed by $(\theta_N - \phi_N\theta_L/\phi_L)$, which is less than θ_N, to account for the fact that higher wages lead to higher housing costs. Failing to make this adjustment double-counts the labor-costs included in the home-good price differential, $\hat{p}^j$.

Home-productivity effect In cities with high home-productivity, home-good prices understate the cost of local land, so that trade-productivity estimates are also understated.

The last effect implies that, when only wages and home-good prices are observed, low home-productivity may be confused for high trade-productivity, as both are positively associated with wages and home-good prices. The magnitude of this effect depends on the cost-share of land in the traded-sector relative to that in the home-sector, θ_L/ϕ_L.

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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 given by

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

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 (6) can be rearreanged 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 when $\hat{r}^j \neq 0$.

To cement intuition, it is helpful to consider two extreme cases between which the correct measure lies. In the first case, traded goods are made without land, i.e. $\theta_L = 0$, and so trade-productivity is proportional to the wage level, $\hat{A}_X^j = \theta_N \hat{w}^j$. This case, commonly assumed, appears to be reasonable as θ_L in modern production is small. But according to (7) it is the ratio θ_L/ϕ_L that matters, and this ratio may be much larger than θ_L if ϕ_L is close to zero. Also, the variation in $\hat{p}^j$ is often large relative to the variation in $\hat{w}^j$, meaning it may give substantial information about $\hat{A}_X^j$. In the second case, the cost shares in both sectors are the same, i.e. $\theta_L = \phi_L$, and $\theta_N = \phi_N$, in which case trade-productivity is given by $\hat{A}_X^j = \hat{p}^j + \hat{A}_Y^j$. Holding home-productivity constant, trade-productivity can be inferred directly from home-good prices since these exactly reflect the input costs of traded-good firms. At the same time, differences in home-productivity have a strong confounding effect on measures of trade-productivity, since the latter are measured only from home-good prices.

4 The Capitalization of Amenity Values

4.1 Capitalization without Federal Income Taxes

The effects of differences in quality of life, trade-productivity, and home-productivity on local land rents, home-good prices, and wages are determined by inverting the system of equations (4). For greater comparability across equations, each differential is multiplied by its share of income, so that the equations are expressed as the change in land, labor, and home-good values relative to total income. To begin, assume that there is no federal income tax, setting $\tau' = 0$, so that the inversion yields

$$s_R \hat{r}_0^j = \frac{l^j dr^j}{m} = \hat{Q}^j + s_x \hat{A}_X^j + s_y \hat{A}_Y^j \equiv \hat{\Omega}^j \tag{8a}$$

$$s_w \hat{w}_0^j = \frac{dw^j}{m} = -\frac{\lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N} s_x \hat{A}_X^j - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y^j \tag{8b}$$

$$s_y \hat{p}_0^j = \frac{y^j dp^j}{m} = \frac{\lambda_N - \lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N} s_x \hat{A}_X^j - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y^j \tag{8c}$$

where the subscript "0" is used to denote price differentials in the absence of federal taxes and $l^j = L^j/N^j$ is the land-to-labor ratio. Equation (8a) is obtained by summing up (4a), s_x times (4b), and s_y times (4c), and simplifying, which reveals that the $\hat{w}^j$ and $\hat{p}^j$ terms sum to zero; it expresses the classic result that differences in land values completely capture the value of amenity differences, denoted $\hat{\Omega}^j$, reflected in quality of life, trade-productivity, and home-productivity, each properly weighted to express their contribution to welfare.[11]

By the zero-profit condition for traded-good firms, (4b), wage differences compensate firms for rent differences, as well as trade-productivity differences, by $\hat{w}_0^j = -(\theta_L/\theta_N)\hat{r}_0^j + \hat{A}_X^j/\theta_N = [(1/\lambda_N)s_x\hat{A}_X^j - (\lambda_L/\lambda_N)\hat{\Omega}^j]/s_w$, leading to (8b). Thus wages rise with trade-productivity and fall with quality-of-life and home-productivity. Since traded-goods are relatively labor-intensive, $\lambda_N > \lambda_L$, wage decreases undercapitalize the value of consumption and home-production amenities. Wage increases may overcapitalize the value of trade-production amenities if the fraction of land in home goods, $1 - \lambda_L$, is greater than λ_N.[12]

By the mobility condition (4a), with $\tau' = 0$, home-good price differences compensate for wage differences, as well as quality-of-life differences, according to, $s_y\hat{p}_0 = s_w\hat{w}_0^j + \hat{Q}^j = (1/\lambda_N)s_x\hat{A}_X^j + \hat{Q}^j - (\lambda_L/\lambda_N)\hat{\Omega}^j$, leading to (8c). It implies that consumption amenities are under-capitalized into local home-good values, while trade-production amenities may be overcapitalzed. Furthermore, home-good prices negatively capitalize the value of home-production amenities, but only partially.[13]

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[11] The linearized version of (8a) is $L^j dr^j = N^j dQ^j + X^j dA_X^j + p^j Y^j dA_Y^j = N^j d\Omega^j$. $L^j dr^j$ is the change in land value, $N^j dQ^j$ is the improvemnt in quality-of-life across the resident population, $X^j dA_X^j$ is the decrease in costs in local production of tradables, and $p^j Y^j dA_Y^j$ is the decrease in costs of the local production of non-tradables.

[12] Note that $1/\lambda_N = 1/[1-(1-\lambda_N)] = \sum_k^\infty (1-\lambda_N)^k$, expresses a multiplier effect accounts for the feedback effect of higher land rents on wages through the local labor market, similar to Tolley (1974). A rise in land-values by $\hat{r}^j$, directly raises home-good prices by $\phi_L\hat{r}^j$, raising overall cost-of-living by $s_y\phi_L\hat{r}^j$. To compensate households, firms raise wages by $1/s_w$ times this amount, $(s_y/s_w)\,\phi_L\hat{r}^j$, raising home-good prices indirectly by $\phi_N\,(s_y/s_w)\,\phi_L\hat{r}^j = (1-\lambda_N)\,\phi_L\hat{r}^j$, and leading to further feedback effects.

[13] Roback (1982, p. 1265) reports a linear analogue to equation (8c) 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 non-traded prices is ambiguous, although this is not true if non-traded goods are relatively land intensive, an assumption which could be used to support Roback's assumption that the determinant in equation 9 (Δ^*) is greater than zero.

4.2 Accounting for Federal Taxes

Introducing federal taxes on labor income, setting $\tau' > 0$, changes the capitalization formulas so that differences in land rents no longer fully reflect differences in amenity values. The mobility condition (4a) can be rewritten as $s_w\hat{w}^j - s_y\hat{p}^j = \tau' s_w\hat{w}^j - \hat{Q}^j$, which states that differences in pre-tax real incomes higher federal taxes or lower quality of life. It is useful to express this federal tax differential, $d\tau^j/m \equiv \tau' s_w\hat{w}^j$, as a fraction of total income, as it has an effect identical to $-\hat{Q}^j$. Differences in federal tax burdens are driven by differences in local wage levels, which are driven by differences in amenities. Since positive federal tax differentials enter the mobility condition in the same way as negative quality-of-life differentials, the wage differential in the presence of federal taxes, $\hat{w}^j$, can be determined as a function of the wage differential without federal taxes, $\hat{w}_0^j$, by substituting into (8b):

$$s_w\hat{w}^j = s_w\hat{w}_0^j + \frac{\lambda_L}{\lambda_N}\overbrace{\tau' s_w\hat{w}^j}^{d\tau^j/m} = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}s_w\hat{w}_0^j \tag{9}$$

Wage differentials with federal taxation are a multiple of wage differentials in the absence of federal taxes. Thus, as federal taxes are higher in cities with higher wages according to equation (8b), they are higher in cities with higher trade-productivity, lower quality-of-life, and lower home-productivity:

$$\frac{d\tau^j}{m} = \tau' s_w\hat{w}^j = \tau'\frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}\left(-\frac{\lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X^j - \frac{\lambda_L}{\lambda_N}s_y\hat{A}_Y^j\right) \tag{10}$$

Dividing equation (10) by τ' gives the counterpart to (8b) with federal taxes: the capitalization of any amenity into wages is merely augmented by the factor $1/\left(1-\tau'\lambda_L/\lambda_N\right) > 1$.

With the observation that positive federal tax differentials are capitalized into prices like negative quality-of-life differentials, substituting (10) into (8a) describes how amenities are capitalized into land values under federal taxation.

$$s_R\hat{r}^j = s_R\hat{r}_0^j - \frac{d\tau^j}{m} = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}\left[\hat{Q}^j + \left(1-\frac{1}{\lambda_N}\tau'\right)s_x\hat{A}_X^j + s_y\hat{A}_Y^j\right] \tag{11a}$$

The second equality implies that consumption and home-production amenities are capitalized by more than their value, as these lead to lower federal taxes, while trade-production amenities are capitalized by less than their value, as these lead to higher federal taxes.[14] Capitalization into home-good prices is then given by

$$s_y\hat{p}^j = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}\left[\frac{\lambda_N-\lambda_L}{\lambda_N}\hat{Q}^j + (1-\tau')\frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X^j - (1-\tau')\frac{\lambda_L}{\lambda_N}s_y\hat{A}_Y^j\right] \tag{12}$$

With federal taxes, home goods capitalize the value of consumption amenities by a greater amount and production amenities by a lesser amount.

4.3 The Total Value of Amenities

Rearranging the first equality of (11a) we can write that differences in the total economic value of amenities, $\hat{\Omega}^j$, equals the value captured by local land rents, $s_R\hat{r}^j$, plus the value captured by federal-tax payments, $d\tau^j/m$:

$$\hat{\Omega}^j = s_R\hat{r}^j + \frac{d\tau^j}{m} = s_R\hat{r}^j + \tau' s_w\hat{w}^j \tag{13}$$

Thus, federal taxes introduce a wedge between the value of amenities capitalized into land rents, and the total economic value of those amenities. The effect of an amenity on federal tax revenues, which appears through wages, needs to be added to its effect on land rents in order to obtain the full economic value of that amenity.

When land rents need to be inferred through wages and housing costs, the empirical counterpart

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[14] The tax system is further complicated by the presence of deductions in the tax code for owner-occupied housing, as well as state taxes, which exhibit a federal-like component in so far as wages vary within states. These further complications are incorporated, but not discussed, as their effects are fairly small – Albouy (2008a) contains further details.

of (13) can be obtained by substituting in (5) to obtain an expression for $\hat{\Omega}^j$:

$$\hat{\Omega}^j = \frac{s_R}{\phi_L}\hat{p}^j + \left(\tau' s_w - \frac{s_R \phi_N}{\phi_L}\right)\hat{w}^j + \frac{s_R}{\phi_L}\hat{A}_Y^j = \frac{1}{1-\lambda_L}\left\{s_y(\hat{p}^j + \hat{A}_Y^j) + \left[\tau'(1-\lambda_L) + \lambda_N - 1\right] s_w \hat{w}^j\right\} \tag{14}$$

Unlike the rent-differential equation, (5), it is theoretically unclear whether wage-levels should enter positively or negatively into the total-value estimate as the negative labor-cost effect is countered by a positive federal-tax effect.

5 Applying the Model

5.1 Calibration

The above model may be applied empirically by calibrating the parameter values of the model based on expenditure and cost share data at the national level. Because of various accounting identities, there are only six free parameters to choose, although doing so requires reconciling various, somewhat conflicting, sources.

Looking first at income shares, Krueger (1999) makes the case that s_w is close to 75 percent. Poterba (1998) estimates that the share of income from corporate capital is 12 percent, and thus s_I should be higher, and is taken as 15 percent. This leaves 10 percent for s_R, which is roughly consistent with estimates in Keiper et al. (1961) and Case (2007). [15]

Turning next to expenditure shares, Albouy (2008a), Moretti (2008), and Shapiro (2006) find that housing costs can also be used to approximate non-housing cost differences across cities. The cost-of-living differential is given by $s_y\hat{p}^j$, where $\hat{p}^j$ is equal to the housing-cost differential and s_y is equal to 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},

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[15] .The values Keiper reports were at a historical low. Keiper et al. (1961) find 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.

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 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.

The remaining choices for the cost shares are chosen to be consistent with the expenditure and income shares. θ_L appears to be small: Beeson and Eberts (1986) use a value of 0.027, while Rappaport (2008) uses a smaller value of 0.016. Valentinyi and Herrendorff (2008) estimate the land share of tradeables at 4 percent, although their definition of tradeables differs from the definition here. A value of 2.5 percent is used here. Following Carliner (2003) and Case (2007), the cost-share of land in home-goods, taken as housing costs, ϕ_L, is taken at 23.3 percent: this is slightly above values reported in McDonald (1981), Roback (1982), and Thorsnes (1997) to take into account an increase in land-cost shares over time seen in Davis and Palumbo (2007). Together with the expenditure shares, these cost shares imply that λ_L is 17 percent and s_R is 10 percent, which is consistent with the above choices. This appears reasonable since the remaining 83 percent for home goods includes all residential land and a significant portion of commercial land.[16]

The last choice simultaneously determines the cost shares of labor and capital in the two production sectors. As separate information on ϕ_K and θ_K, is unavailable, both cost-shares of capital are set equal to 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.

5.2 Predicted Capitalization Effects

The parameter values calibrated for the model may be substituted directly into the capitalization formulas in section 4 to demonstrate how prices should capitalize amenity differences across cities

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[16] 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.

in the U.S. economy. Table 1 reports how an increase in quality of life, trade-productivity, or home-productivity equivalent to a one-percent income should affect land rents, wages, housing costs, federal taxes and total amenity values, measured as a percent of total income. The coefficients in Table A ignore federal taxes, as in (8), while the coefficients in B take into account relevant federal and state taxes and deductions, corresponding to the results in (10), (11a), (12), with minor adjustments to account for the tax deductibility of some housing expenditures (Albouy, 2008b).

In the tax-free numbers, land rents reflect dollar-for-dollar the economic value of amenities, regardless of whether they affect households or firms. Three quarters of the value of quality-of-life differences are capitalized into higher home-good prices, with the remaining quarter reflected in local wages. Wages and home-good prices overcapitalize the value of trade-production amenities by almost 20 percent. The value of home-production amenities is negatively capitalized into wages and home-good prices, with a one-percent increase in A_Y reducing p by 0.23 percent.

The differences in the coefficients in Panel A and in Panel B are due to federal taxes. The incidence of federal taxes on cities may be understood by observing how attributes affect the tax differential. Most interestingly, trade-production amenities are effectively taxed at a rate of 42 percent, since these have a powerful effect on wages. As a result, land rents capitalize only 58 percent, and home-good prices 87 percent of the value of these amenities, while wages capitalize an even higher 129 percent to compensate for the higher taxes. On the other hand, consumption amenities are subsidized at a rate of 10 percent, and home-production amenities at a rate of 8 percent, which is captured in higher land rents and mainly in higher home-good prices. These effects are small since these amenities have only a weak effect on wages.

5.3 Reassessing the Value of Public Infrastructure

Haughwout (2002) applies the two-equation model to estimate the marginal benefit of public capital investments using housing-cost and wage data from 1971 to 1992 for a sample of 36 large US cities. This public capital stock includes roads, parks, sewer systems, and public buildings, and by the year 2000 has a replacement value of $428 billion, according to the perpetual inventory technique described in Haughwout and Inman (1996). Haughwout finds that public infrastructure has a positive value, but that on the margin this benefit is less than its cost. Furthermore, Haughwout determines that public infrastructure benefits households more than firms. A problem with this method is that it equates housing values with land values: the estimated effect of public infrastructure on housing values in percentage terms is multiplied by a measure of average land values, to determine how public infrastructure is capitalized into land values. This procedure ignores the land-share, labor-cost, and federal-tax effects discussed above.

Haughwout's estimates of the effect of public infrastructure on housing costs and wages are presented in columns 1 and 2 of Table 2. The estimates in panel A depend on regression specifications which control for natural amenities, such as weather, as well as local taxes and services; the less precise estimates in panel B control for state and year effects. The estimated total values per dollar of public infrastructure inferred from the housing effects are in column (5), with columns (3) and (4) separating the values for households and firms using the wage effect. The estimates in Panel A from Haughwout's model find that public infrastructure investments are worth 60 cents per dollar on the margin, with 39 cents going to households and 21 cents going to firms. The estimates in Panel B find a total value of only 30 cents, with a 39 cent gain to households, and a 9 cent loss to firms.

The revised estimates of the value of public infrastructure use Haughwout's housing-cost and wage effects, but recalculate the values based on the calibrated model here, rather than the calibration implicit in his model.[17] The revised total value estimates are larger than the originals by 147 percent: in Panel A the marginal value of a dollar of public infrastructure is \$1.48, passing the cost-benefit test (assuming the marginal cost of public funds is less than \$1.48), while in Panel B, the

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[17] The revised model is benchmarked to the Haughwout estimates by assuming that the share of income from wages, s_w, in both models is equal to 75 percent. Using other information from Haughwout's estimates (available upon request), the implicit calibration in his model can be inferred as $s_y = 0.124, s_R = 0.173$, $\theta_L = 0.055, \theta_N = 0.856$, $\phi_L = 1$, and $\tau' = 0$. Total income (Nm) is equal to the wage bill \$51,960 million divided by $s_w = 0.75$, to \$69,280 million. Taking a value $s_w < 0.75$, in the Haughwout calibration leads to a larger total income and larger inferred values in the revised estimates. If the shares of income from land are set equal, so that $s_R = 0.1$ in Haughwout's model, would produce a total income value of \$119, 965 million, creating estimates that are 72 percent higher. In order to to be conservative and since land values are likely to be a larger source of income in central cities this other estimate is not presented.

estimate is \$0.74, falling short of the \$1 benchmark, albeit not in a statistically significant sense. These difference from the original estimates is due primarily to correcting for the land-share effect. The correction from the labor-cost effect is fairly small, as public infrastructure has little effect on wages. In both revised estimates it appears that most of the benefits accrue to households, with the change from the original estimates driven by an increase in the home-good expenditure share, s_y. In sum, public infrastructure investments appear to improve welfare significantly mainly by improving quality of life, rather than raising firm productivity. Thus the effects on taxable income are small, and the government will not recoup most of its investments. It should be noted that these value estimates may be a lower bound, as they do not include any spillover effects which may benefit jurisdictions outside of the central cities where the public infrastructure is located.[18]

6 Differences across U.S. Cities

In this application, the relative value of every American city's entire bundle of amenities is estimated using wage and housing-cost data. This value is decomposed into productivity and quality-of-life components, as well as the values appropriated locally by land and federally by taxes.

6.1 Data and the Estimation of Wage and Housing-Cost Differentials

Wage and housing-cost differentials are estimated using the 5 percent sample of Census data from the 2000 Integrated Public Use Microdata Series (IPUMS). Cities are defined at the Metropolitan Statistical Area (MSA) level using 1999 OMB definitions. Consolidated MSAs are treated as a single city (e.g. San Francisco includes Oakland and San Jose), as well as all non-metropolitan areas within each state. This classification produces a total of 290 areas of which 241 are actual metropolitan areas and 49 are non-metropolitan areas of states. More details are provided in Appendix B. The 5 percent Census sample is used in its entirety, guaranteeing the precision of

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[18] This effect is especially true locally, as local wages do not rise. Also note that because home-productivity effects are unobserved, it is hard to know how these bias the estimates. If public infrastructure improves home-productivity, which seems likely, then the revised estimates are too low.

the wage and price and differentials: the average city has 14,199 wage and 11,119 housing-cost observations; the smallest city has 1,093 wage and 817 housing-price observations.

Inter-urban wage differentials, w^j, are calculated from the logarithm of hourly wages for full-time workers, ages 25 to 55. These differentials control for skill differences across workers to provide an analogue to the representative worker in the model. Thus, log wages are regressed on city-indicators (μ_j^w) and on extensive controls (X_{ij}^w) — each fully interacted with gender — for education, experience, race, occupation, industry, and veteran, marital, and immigrant status, in an equation of the form $\ln w_{ij} = X_{ij}^w \beta^w + \mu_j^w + \varepsilon_{ij}^w$. The estimates μ_j^w are used as the wage differential, and are interpreted as the causal effect of city characteristics on a worker's wage. Identifying these differentials requires that workers do not sort across cities according to their unobserved skills. This assumption may not hold completely: Glaeser and Maré (2001) argue that up to one third of the urban-rural wage gap could be due to selection, suggesting that at least two thirds of wage differentials are valid, although this issue deserves greater investigation. At the same time, it is possible that the estimates could be too small, as some control variables, such as occupation or industry, could depend on where the worker locates. An overstated wage differential will bias productivity upwards and quality of life downwards.

Both housing values and gross rents, including utilities, are used to calculate housing costs. Following previous studies, imputed rents are converted from housing values using a discount rate of 7.85 percent (Peiser and Smith 1985), with utility costs added, to make the imputed rents comparable to gross rents. To avoid measurement error from imperfect recall or rent control, the sample includes only units that were acquired in the last ten years. Housing-cost differentials are calculated in a manner similar to wage differentials, using a regression of housing costs on flexible controls (Y_i^j) – interacted with renter-status – for size, rooms, acreage, commercial use, kitchen and plumbing facilities, type and age of building, and the number of residents per room. This regression takes the form: $\ln p_i^j = Y_i^j \beta^p + \nu^j + \varepsilon_i^j$. The coefficients ν^j are used as housing-cost differentials. Proper identification of housing-cost differences requires that average unobserved housing quality does not vary systematically across cities. An overstated price differential will bias both productivity and quality of life upwards.[19]

Data on amenities are taken from various sources. Amenities may be divided into two categories. The first are natural site-specific characteristics such as climate and geography, which are considered to be exogenous to a city's inhabitants. These include inches of precipitation, heating degree days and cooling degree days per year (*City and County Databook 2000*), sunshine out of the fraction possible (National Oceanic and Atmospheric Association 2008), and whether a metropolitan area is adjacent to a major coast (Atlantic, Pacific, Gulf or Great Lake). The second category of amenities are those that depend on a city's inhabitants. Only three types of artificial "amenities" are included here. The first two, population and the share of population with college degrees, are not standard amenities, per se, but are rather fundamental determinants of amenities. The third, is the Wharton Residential Land-Use Regulatory Index, or WRLURI, provided by Gyourko et al. (2007), which is used to control for housing-productivity differences.

6.2 Estimating Land-Rent, Quality-of-Life, and Firm-Productivity Differences

6.2.1 Comparison with Previous Research

Land rents, trade-productivity, and quality-of-life differentials are estimated from wage and housing-cost differentials using equations (5) (4a), (7), (14), calibrated with the parameters chosen in Section 5.1, yielding the following relationships, for what I term the "adjusted model:"

$$\begin{aligned}
\hat{r}^j &= 4.29\hat{p}^j - 2.76\hat{w}^j \ (+4.29\hat{A}_Y^j) \\
\hat{Q}^j &= 0.35\hat{p}^j - 0.51\hat{w}^j \\
\hat{A}_X^j &= 0.11\hat{p}^j + 0.79\hat{w}^j \ (+0.11\hat{A}_Y^j) \\
\hat{\Omega}^j &= 0.42\hat{p}^j - 0.01\hat{w}^j \ (+0.42\hat{A}^j)
\end{aligned}$$

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[19] 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.

The terms in parentheses correspond to the bias that results from not having identified home-productivity. Places with high home-productivity have their land rents and trade-productivity biased downwards, although the downward bias is much more severe in the inference of land rents.[20]

These relationships differ substantially from those typical of the previous literature (e.g. Beeson and Eberts, 1989), using the simpler two-equation model, which I term the "unadjusted model." This model effectively sets $\phi_L = 1$, $\phi_N = 0$, and $\hat{A}_X^j = 0$, $\tau' = 0$, and typically $s_w = 1$ and $s_y = 0.25$, leading to the following formulae:

$$\begin{aligned}\hat{r}^j &= \hat{p}^j \\ \hat{Q}^j &= 0.25\hat{p}^j - \hat{w}^j \\ \hat{A}_X^j &= 0.025\hat{p}^j + 0.825\hat{w}^j\end{aligned}$$

Note, that this characterization does not obey the income identities in the model here, as it assumes that land and capital income are paid to non-resident owners. Thus there is no direct analogue to $\hat{\Omega}^j$, although as a fraction of resident income this could be calculated as $0.27\hat{p}^j$.

The differences between the two estimation procedures can be explained in a graph of wages and housing costs by solving for the curves that have average land rents, quality-of-life, and firm-productivity. This produces an iso-rent curve across cities with average rent, a mobility condition for households across cities with average quality-of-life, and a zero-profit condition for firms across cities with average firm-productivity. These curves are graphed for the adjusted model in Figure 1A and for the unadjusted model in Figure 1B.

In the adjusted model the slope of the iso-rent curve is positive, accounting for the labor-cost effect. Thus, cities with the same housing costs should have higher land rents in low-wage cities than in high-wage cities. The land-share effect is illustrated with the second, thinner, iso-rent curve, which corresponds to a rent-differential of 0.25: in the unadjusted model, the higher iso-rent

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[20] Note that the inclusion of state taxes in the actual calculations cause some deviations from these simplified formulas, which are regression-derived approximations.

curve intercepts the housing-cost axis at 0.25, while in the adjusted model, it intercepts the axis at 0.0575.

The mobility condition is upward sloping as this reflects the rate at which housing costs must increase as wage levels increase to keep the households indifferent between cities. As explained in Albouy (2008b), the slope in the adjusted model is smaller as it accounts for federal taxes, differences in the cost-of-living outside of housing, and non-labor income sources.

The slope of the zero-profit condition is downward sloping as it graphs the rate at which housing costs, proxying for land costs, must fall with local wage levels in order for firms to break even. The adjusted model has a lesser slope since the land-share and labor-cost effect imply that land rents drop more rapidly with falling housing costs and rising labor costs than actual housing costs.

Note that an iso-value curve, tracing out the points where cities have the same total amenity value can also be drawn, although in both models the curve is remarkably flat. This is true by assumption in the unadjusted model, but by coincidence in the adjusted model, as the labor-cost effect and the federal-tax effect in (14) are of opposite and almost equal size according to the calibration. Interestingly, if land rents were on the vertical axis instead of housing costs, the iso-value curve would unequivocally be downward sloping in the adjusted model for $\tau' > 0$.

6.2.2 Graphing Differences across Cities

A graph of wage and housing cost differences across U.S. metropolitan areas, complete with these adjusted curves, is presented in Figure 2. This figure presents the key data in the estimation of land rents, quality-of-life, trade-productivity, and total amenity values. It also displays the curves presented in Figure 1A to make the calculation of those quantities more transparent.

The average iso-rent curve separates the high-rent cities above it from the low-rent cities below it. A city's inferred land-rent differential is proportional to its distance from this curve. These land-rent differentials are graphed in Figure 3, which also graphs a line for how the inferred land rents change with housing costs if wages are held constant at the national average. For a given housing-cost differential, the vertical distance to this line represents the land-share effect and the vertical distance from this line to a city marker represents the labor-cost effect. Empirically, the land-share effect is more important for inferring land rents than the labor-cost effect. Because housing costs and wages are positively correlated, the labor-cost effect tends to flatten the observed land-rent/housing-cost gradient.

Figure 3B graphs the quadratic land-rent estimates (numerical values are given in Appendix Table A) using the formula in (6), assuming $\sigma_Y^{NL} = \sigma_Y^{KL} = \sigma_Y^{NK} = 0.67$.[21] The figure also graphs a curve showing how inferred land rents change with housing costs, holding wages at the national average, accounting for the land-share effect. As explained in section 3.2.2, the quadratic estimates differ most from the linear estimates where housing costs are furthest from zero. Yet, even at these extremes, they differ by only 20 percent. While arguably more accurate, these quadratic estimates are generally similar to the linear estimates.

Quality-of-life and trade-productivity estimates are graphed in Figure 4. Their estimation can be understood graphically through a change in coordinate systems, where the average mobility condition and the average zero-profit condition in Figure 2, in the space of wages and housing costs, give the axes to the new coordinate system in Figure 4, in the space of productivity and quality-of-life. Since quality-of-life is constant across the average mobility condition, and trade-productivity increases with the distance rightward along this curve, it corresponds to the horizontal axis for trade-productivity. Since trade-productivity is constant across the average zero-profit condition, and quality-of-life is increasing with the distance upwards along this curve, it corresponds to the vertical axis for quality-of-life. The average iso-rent and iso-value curves also pass through this change of coordinates, with their downward slope illustrating how rents and values increase with both quality-of-life and trade-productivity.

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[21] These substitution elasticities are based off of estimates in McDonald (1981) and Thorsnes (1997). A graph showing the iso-rent curves for different rent values in both the linear and quadratic case is shown in Appendix Figure A.

6.3 The Most Productive and Valuable Cities

Table 3 lists the estimated wage, housing-cost, land-rent, quality-of-life, trade-productivity, federal-tax, and total-amenity-value differentials for a selected list of the largest and most valuable cities, as measured by the total amenity value. The same quantities are also reported by Census region and city size, as measured by population, ranked by the total value of their amenities. A complete list of these quantities for all cities and non-metro areas of states, are given in Appendix Table A; these quantities are shown aggregated by state in Appendix Table B.

According to these results, the metropolitan area with the most valuable land in the United States is the San Francisco Bay Area, as it combines the fourth highest quality-of-life with the first highest trade-productivity. This is followed by a number of smaller, resort-like, but economically vibrant cities such as Santa Barbara, Honolulu, and San Diego, and the large coastal powerhouses of New York, Los Angeles, Boston, Seattle, and Chicago (counting the Great Lakes as a coast). Note that by putting more weight on housing costs, the trade-productivity estimate for Los Angeles is higher than that for Detroit, even though the latter has higher nominal wage levels.

Further down the list are smaller cities in less crowded areas such as West Virginia, Mississippi, and North and South Dakota. The estimates suggest that an acre of land in San Francisco is 230 times more valuable than an acre in McAllen, TX, which has the lowest land value of all cities, and that an acre in the most valuable state, Hawaii, is worth 24 times an acre in the least valuable state, North Dakota.

6.4 Explaining the Variation of Prices across Cities

Based on the theoretical model, the observed or inferred variation in housing costs, wages, and land rents can be derived from the inferred variation in quality of life and firm productivity. For example, using equation (8a), variation in total amenity values can be decomposed as

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

From this formula it is possible to infer whether variance in total amenity values is due primarily to quality-of-life or productivity differences. This is assessed by comparing the two variance terms alone, since if the variation of either quality-of-life or firm productivity is eliminated, the covariance term collapses to zero. Note that this analysis takes these amenity values as fixed, and is therefore more useful for measurement purposes than for determining how an exogenous change in the amenity distribution will change the distribution of land rents. The latter may be subject to feedback effects, such as population flows. For instance, a higher quality-of-life in a city will attract a greater number of people, which should increase trade productivity through agglomeration economies.[22]

Results of the decomposition are given in Table 4. Panel A, which accounts for the effect of federal taxes, reflects the existing situation. It reveals that while both quality-of-life and productivity each play large roles in determining land rents, quality-of-life differences are slightly more important than productivity differences. On the other hand, productivity differences are a more important determinant of value differences across cities. This is seen in Figure 4, which is scaled so that a one-centimeter increase in quality-of-life has the same impact as a one-centimeter increase in productivity: population-weighted, the spread of cities along the horizontal axis, measuring quality-of-life, is greater than along the vertical axis, measuring quality of life. Thus, if federal tax revenues are added back in to local land values to determine the total amenity value of cities, productive amenities are a greater source of value differences across cities than consumption amenities.

Using a similar decomposition reveals that wages are driven almost entirely by productivity differences. Closely mimicking total value differences, housing-cost differences are influenced by both quality-of-life and home-productivity differences, but are influenced more by productivity differences. Panel B presents a counterfactual distribution of rents, wages, and housing-costs if federal taxes were made geographically neutral, but amenities across areas remained fixed. It

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[22] This decomposition is different than the one in Beeson and Eberts (1989) and Deitz and Abel (2008), who decompose each differentials into its productivity and quality-of-life component. Such a decomposition is hard to interpret since each component may have a different sign. For instance, 116 percent of San Francisco's wage differential of 0.21 is explained by its higher productivity and -16 percent is explained by its higher quality of life.

shows that productivity differences would become even more important in the determination of land rents and housing costs.[23]

6.5 The Relationship with Observed Amenities

The last empirical exercise considers the relationship between the observed amenities described at the end of Section 6.1, and the measured differentials. This exercise involves running a series of regressions of these differentials on the amenity vector. First consider a series of regressions of wages and housing costs on a vector of amenities $(Z_1^j, ...Z_K^j)$:

$$\hat{p}^j = \sum_k Z_k^j \pi_{kp} + \varepsilon_p^j,\ \hat{w}^j = \sum_k Z_k^j \pi_{kw} + \varepsilon_w^j$$

Next, consider regressing quality-of-life and firm productivity on the same vector of amenities:

$$\hat{Q}^j = \sum_k Z_k^j \pi_{kQ} + \varepsilon_p^j,\ \hat{A}_X^j - \hat{A}_Y^j \frac{\theta_L}{\phi_L} = \sum_k Z_k^j \pi_{kA} + \varepsilon_A^j$$

The second-term on the right-hand side of the productivity equation $-\hat{A}_Y^j \theta_L / \phi_L$ accounts for the fact that trade-productivity estimates may contain home-productivity effects. This motivates using the Wharton Residential Land-Use Regulatory Index in the amenity vector. Similarly, local land values, federal revenues, and total amenity values can then be regressed on the amenities

$$\hat{r}^j - \hat{A}_Y^j \frac{1}{\phi_L} = \sum_k Z_k^j \pi_{kR} + \varepsilon_R^j,\ \frac{d\tau^j}{m} = \sum_k Z_k^j \pi_{k\tau} + \varepsilon_\tau^j$$

The second term on the right-hand side of the land-rent equation $-\hat{A}_Y^j / \phi_L$, accounts for the potential bias in measured land rents due to home-productivity. Finally, there is a regression for total

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[23] While the decomposition tells us that productive amenities are more important in determinig wages and housing costs, while consumption amenities are more important in determing land rents, it is not clear from the analysis which is more important in affecting household location choice. If consumption amenites are predominant, it can be said that in general "jobs follow people," while if production amenities are predominant, then "people follow jobs." Analysis from Appendix A.2 suggests that both consumption and production amenities are important, although it is difficult ascertain precisely given limitations of the model in dealing with quantities.

amenity value

$$\hat{\Omega}^j - \hat{A}_Y^j \frac{s_R}{\phi_L} = \sum_k Z_k^j \pi_{\Omega R} + \varepsilon_\Omega^j$$

which includes a similar bias component. The coefficient $\pi_{\Omega T}$ gives the full economic value of a one-unit increase in amenity k.

Because of the many empirical caveats – including omitted variable bias, simultaneity, multicollinearity, and small sample problems – this exercise is not expected to produce well-identified, conclusive results. Rather, it serves to illustrate how the estimates are interrelated, and to aid further analysis.[24] Nevertheless, the results are provocative and somewhat consistent with the previous research.

The relationships between trade-productivity and total amenity value with population size are graphed in Figures 5 and 6. Controlling for other amenities in Table 5, the elasticities of wages, firm-productivity, and economic value with respect to population size are 5.3, 4.9, and 2.8 percent, respectively, consistent with those surveyed in Rosenthal and Strange (2004) and Melo et al. (2009). Furthermore, greater population size does not appear to come at the expense of lower quality of life.

Both productivity and quality of life appear to be positively impacted by the share of the population with a college degree: a ten percent increase in the college share (2.3 standard deviations), leads to a 6.2-percent increase in productivity, similar to the findings in Moretti (2004) based on more rigorous methods. The corresponding number for quality of life is 4.3 percent. In terms of overall value, high human capital in a city appears to contribute as much to quality of life as it does to productivity, reinforcing findings in Shapiro (2006) based on instrumental-variable estimates in a growth model.

The coefficient on the regulatory land-use index is potentially interesting, as it should put a specific number on the cost of land-use regulation. In practice, this variable has positive coefficients in the productivity and land-rent regression, as predicted, but it is not significant in either

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[24] Since all of these equations involve the same regressors, there are no efficiency gains to estimating them simultaneously through a system of seemingly unrelated regressions (SUR), and therefore they are simply estimated using ordinary least squares (OLS).

regression. This suggests that differences in home-productivity are not seriously biasing these estimates, although these cursory estimates may deserve further probing.

Also novel are the estimated relationships between the natural amenity variables and productivity. These results show that sunshine and proximity to a coast may have substantial effects on firm productivity. The effect of a coast might be explained through lower transportation costs and the benefits of being a transshipment center. The effects of sunshine are striking — recall that heat enters separately. The reasons for this effect could be biological, although it deserves further examination. Hot summers, as measured through cooling-degree days appears to be bad for productivity, perhaps lending credence to a theory at least as old as Montesquieu (1752) that heat may inhibit the ability of humans to work. This has been reinforced in recent engineering studies that indoor as well as outdoor workers are substantially less productive at temperatures barely above room temperature (Engineering News Record, 2008). Nevertheless, how this estimate can be so large in the presence of modern air-conditioning raises questions about its validity. Yet the estimate is robust to including various other controls, such as latitude.

Overall, population size, education level, sunshine, and proximity to an ocean coast all appear to be beneficial to both households and firms, and thus have very high economic values. While cold winters, expressed through heating-degree days, are bad for households, overall the degree-day measures suggest that making a warm day one-degree hotter is worse for the economy than making a cool day one-degree colder. If these results are truly accurate and robust, then this finding could reflect serious welfare consequences for the United States if climate change causes summers to become hotter. Households may also lose welfare if they are exposed to lower levels of sunshine if they move North to escape rising temperatures.

How the total value of amenity differences across cities is distributed between local land rents and federal tax payments is also interesting. In general, larger federal revenues are collected in areas with greater trade-productive amenities. Thus, the federal government effectively taxes households for living in a city that is large, well-educated, sunny, or near the coast, while at the same time it effectively subsidizes life in hot places. Failure to include the value of amenities collected in federal revenues would lead to underestimates of the total value of productive amenities. The most important of these "amenities" is city size: high population levels are so heavily taxed that it is possible for cities to be too small, rather than too large, contrary to previous findings (e.g. Fenge and Meier, 2001).

7 Conclusion

This research establishes that land rents and local productivity may indeed be inferred from local housing and labor costs if the cost-structure in the housing and tradeables market is known, and if local-housing productivity is not an important confounding factor. These inferred land rents should be combined with federal tax revenue estimates when determining the total value of a city's amenities. This total includes the value to firms, which results in higher income, and the value to households, which does not. The techniques outlined above not only help to determine the private and social value of an area's land, but also provide a more complete framework to value the benefits of social investments, such as in public infrastructure or greenhouse-gas abatement. The techniques also make it clear that obtaining data on actual land rents would help to make amenity-value estimates more accurate, and make it possible to distinguish amenities that lower the production-costs of goods traded across cities from amenities that raise the production-costs of goods that are not.

Not only can this model be used to improve valuation techniques for amenities, but it also provides a basis for several avenues of further thought. The observation that city amenities lead to fiscal externalities through federal tax payments raises the need to consider other externalities that occur across cities. For instance, Glaeser and Kahn (2008) find that there are large differences in the amount of carbon that cities produce: cities that produce less carbon per capita are of greater value to society than those that produce more, although this value is not priced into local land rents. Second, the analysis raises issues about how the population is distributed optimally across space: it appears that social welfare would rise if the effective supply of land could be increased in the most valuable areas. This might be accomplished by streamlining land-use regulations in coastal cities, particularly in California, where amenities are abundant, federal tax revenues are high, and carbon emissions are low. Finally, the static spatial model of local labor markets developed here may help to develop a theoretical foundation for an even richer dynamic model to understand how household location decisions respond to changes in employment and consumption opportunities over time.

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TABLE 1: PREDICTED EFFECT OF AMENITIES ON THE VALUE OF LAND RENTS, WAGES, AND HOME-GOOD PRICES, WITH AND WITHOUT FEDERAL

	Normalized Percent Increase in Value from a One-Percent Increase in Amenity Type		
Amenity Type	Quality of Life (1)	Trade Productivity (2)	Home Productivity (3)
Panel A: Federal Taxes Geographically Neutral			
Land Rents	1.00	1.00	1.00
Wages	-0.23	1.19	-0.23
Home-Good Prices	0.77	1.19	-0.23
Panel B: With Federal Income Taxes			
Land Rents	1.10	0.58	1.08
Wages	-0.25	1.29	-0.25
Home-Good Prices	0.85	0.87	-0.17
Federal Tax Payment	-0.10	0.42	-0.08

TABLE 2: ESTIMATES OF PUBLIC INFRASTRUCTURE VALUES USING THE ORIGINAL TWO-EQUATION MODEL AND THE REVISED THREE-EQUATION MODEL

Effect of a 1 Std. Dev. Increase in Public Infrastructure on			Value per Dollar of Public Infrastructure			
Housing Costs (1)	Wages (2)	Valuation Procedure	Household Quality of Life (3)	Trade Productivity (4)	Total Value (5)	Federal Taxes (6)
Panel A: Cross-Sectional Estimates with Controls						
		Original	0.39	0.21	0.60	
0.23	0.003		(0.06)	(0.04)	(0.07)	
(0.02)	(0.002)					
		Revised	1.22	0.26	1.48	0.01
			(0.18)	(0.04)	(0.18)	(0.01)
Panel B: With City and Year Effects						
		Original	0.39	-0.09	0.30	
0.12	-0.016		(0.10)	(0.10)	(0.15)	
(0.05)	(0.009)					
		Revised	0.74	0.00	0.74	-0.06
			(0.14)	(0.11)	(0.18)	(0.03)

Values taken from rows 2 and 4 in Table 4 of Haughwout (2002).which give the highest and lowest estimates of the value of public infrastructure. The figures in this table give the value of $4,640 million increase in public infrastructure; to normalize this to the value of a dollar of public infrastructure, all of the estimates are divided by this figure. Column 4 reports what percentage of infrastructure investments is returned in federal taxes and is not capitalized into land values. The revised calibration is benchmarked to the Haughwout (2002) calibration by assuming that the income share of wages is 75 percent in both calibrations.

TABLE 3: 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	0.27	0.75	2.48	0.13	0.29	0.07	0.32
Santa Barbara, CA	399,347	0.11	0.67	2.55	0.18	0.16	0.02	0.28
Salinas, CA	401,762	0.09	0.53	2.05	0.14	0.13	0.02	0.22
Honolulu, HI	876,156	-0.01	0.49	2.13	0.18	0.05	0.00	0.21
San Diego, CA	2,813,833	0.06	0.44	1.72	0.12	0.10	0.01	0.18
New York, NY	21,199,865	0.22	0.42	1.24	0.04	0.21	0.05	0.18
Los Angeles, CA	16,373,645	0.13	0.40	1.36	0.07	0.14	0.03	0.17
Boston, MA	5,819,100	0.14	0.35	1.12	0.05	0.14	0.03	0.15
Seattle, WA	3,554,760	0.08	0.28	0.97	0.06	0.09	0.02	0.12
Chicago, IL	9,157,540	0.14	0.22	0.57	0.01	0.13	0.04	0.09
Denver, CO	2,581,506	0.05	0.20	0.74	0.05	0.06	0.01	0.09
Portland, OR	2,265,223	0.03	0.17	0.63	0.05	0.04	0.01	0.07
Washington, DC	7,608,070	0.13	0.17	0.35	-0.01	0.12	0.03	0.07
Miami, FL	3,876,380	-0.01	0.13	0.57	0.05	0.01	0.00	0.06
Phoenix, AZ	3,251,876	0.03	0.10	0.33	0.02	0.03	0.01	0.04
Detroit, MI	5,456,428	0.14	0.09	0.02	-0.04	0.11	0.04	0.04
Philadelphia, PA	6,188,463	0.12	0.07	-0.02	-0.04	0.10	0.03	0.03
Minneapolis, MN	2,968,806	0.09	0.06	0.00	-0.02	0.07	0.03	0.03
Atlanta, GA	4,112,198	0.08	0.02	-0.15	-0.03	0.06	0.02	0.01
Dallas, TX	5,221,801	0.07	0.01	-0.15	-0.03	0.06	0.02	0.00
Cleveland, OH	2,945,831	0.01	-0.04	-0.19	-0.02	0.00	0.00	-0.01
Tampa, FL	2,395,997	-0.06	-0.05	-0.07	0.01	-0.05	-0.01	-0.02
Houston, TX	4,669,571	0.07	-0.08	-0.52	-0.06	0.05	0.02	-0.03
St. Louis, MO	2,603,607	0.01	-0.09	-0.42	-0.03	-0.01	0.00	-0.04
Pittsburgh, PA	2,358,695	-0.04	-0.17	-0.63	-0.04	-0.05	-0.01	-0.07
Census Division								
Pacific	45,042,272	0.10	0.36	1.28	0.08	0.12	0.02	0.15
New England	13,928,540	0.07	0.18	0.58	0.03	0.07	0.02	0.07
Middle Atlantic	39,668,438	0.08	0.11	0.25	0.00	0.07	0.02	0.04
Mountain	18,174,904	-0.05	0.02	0.20	0.03	-0.04	-0.01	0.01
South Atlantic	51,778,682	-0.03	-0.06	-0.17	0.00	-0.03	-0.01	-0.02
East North Central	45,145,135	0.00	-0.09	-0.40	-0.03	-0.01	0.00	-0.04
West South Central	31,440,101	-0.08	-0.21	-0.68	-0.03	-0.08	-0.02	-0.09
West North Central	19,224,096	-0.11	-0.25	-0.78	-0.03	-0.11	-0.03	-0.10
East South Central	17,019,738	-0.12	-0.30	-0.96	-0.04	-0.12	-0.03	-0.12
MSA Population								
MSA, Pop > 5 Million	81,606,427	0.16	0.32	0.95	0.03	0.16	0.04	0.14
MSA, Pop 1.5-4.9 Million	55,543,090	0.03	0.05	0.13	0.00	0.03	0.01	0.02
MSA, Pop 0.5-1.4 Million	40,499,870	-0.03	-0.07	-0.22	-0.01	-0.03	-0.01	-0.03
MSA, Pop < 0.5 Million	36,417,747	-0.09	-0.15	-0.41	-0.01	-0.08	-0.02	-0.06
Non-MSA areas	67,354,772	-0.14	-0.28	-0.83	-0.03	-0.14	-0.04	-0.12
United States	281,421,906	0.13	0.29	0.94	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 price differentials based on the average logarithm of rents and housing prices for units moved in within the last 10 years. Adjusted differentials are city-fixed effects from individual level regressions on extended sets of worker and housing covariates.

TABLE 4: VARIANCE DECOMPOSTION OF QUALITY-OF-LIFE AND 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	0.883	0.362	0.264	0.373
Wages	0.018	0.016	1.148	-0.165
Housing Costs	0.085	0.173	0.480	0.347
Tax Differential	0.001	0.023	1.166	-0.198
Total Value	0.015	0.179	0.472	0.350
Panel B: Federal Taxes Geographically Neutral				
Land Rents	1.486	0.179	0.472	0.350
Wages	0.016	0.016	1.146	-0.162
Housing Costs	0.126	0.097	0.611	0.293
Tax Differential	0.000			
Total Value	0.015	0.179	0.472	0.350

TABLE 5: THE RELATIONSHIP BETWEEN SPECIFIC 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)	Economic Value (7)
Logarithm of Population	14.85	1.36	0.066***	0.053***	-0.004	0.049***	0.014***	0.014***	0.028***
			(0.013)	(0.005)	(0.003)	(0.005)	(0.005)	(0.001)	(0.005)
Percent of Population College Graduates	0.19	0.04	1.926***	0.522***	0.437***	0.618***	0.681***	0.152***	0.833***
			(0.517)	(0.200)	(0.128)	(0.203)	(0.183)	(0.056)	(0.222)
Whartron Residential Land-Use Regulatory Index (WRLURI)	0.31	0.84	0.011	0.001	0.003	0.002	0.005	-0.001	0.004
			(0.013)	(0.006)	(0.005)	(0.005)	(0.005)	(0.002)	(0.006)
Heating-Degree Days (1000s)	4.24	2.02	-0.035***	0.000	-0.012***	-0.003	-0.015***	0.001	-0.015***
			(0.012)	(0.006)	(0.003)	(0.006)	(0.004)	(0.002)	(0.005)
Cooling-Degree Days (1000s)	1.32	0.93	-0.139***	-0.032***	-0.032***	-0.040***	-0.051***	-0.007**	-0.057***
			(0.026)	(0.012)	(0.006)	(0.012)	(0.009)	(0.003)	(0.011)
Sunshine (percent possible)	0.61	0.09	1.128***	0.234***	0.277***	0.306***	0.419***	0.054**	0.473***
			(0.203)	(0.085)	(0.067)	(0.079)	(0.080)	(0.022)	(0.085)
Precipitation (10s of inches)	3.90	1.32	0.003	0.004	-0.001	0.003	0.000	0.001	0.002
			(0.013)	(0.004)	(0.004)	(0.004)	(0.005)	(0.001)	(0.006)
Close to Coast (Ocean or Great Lake)	0.60	0.49	0.123***	0.015	0.035***	0.025**	0.049***	0.002	0.050***
			(0.024)	(0.011)	(0.008)	(0.010)	(0.009)	(0.003)	(0.010)
Constant			-1.684***	-0.955***	-0.112	-0.934***	-0.457***	-0.253***	-0.710***
			(0.295)	(0.088)	(0.083)	(0.092)	(0.113)	(0.022)	(0.122)
R-squared			0.89	0.85	0.73	0.88	0.86	0.84	0.89
Number of Observations			204	204	204	204	204	204	204

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.

Figure 1A: Adjusted Model
(This Research)

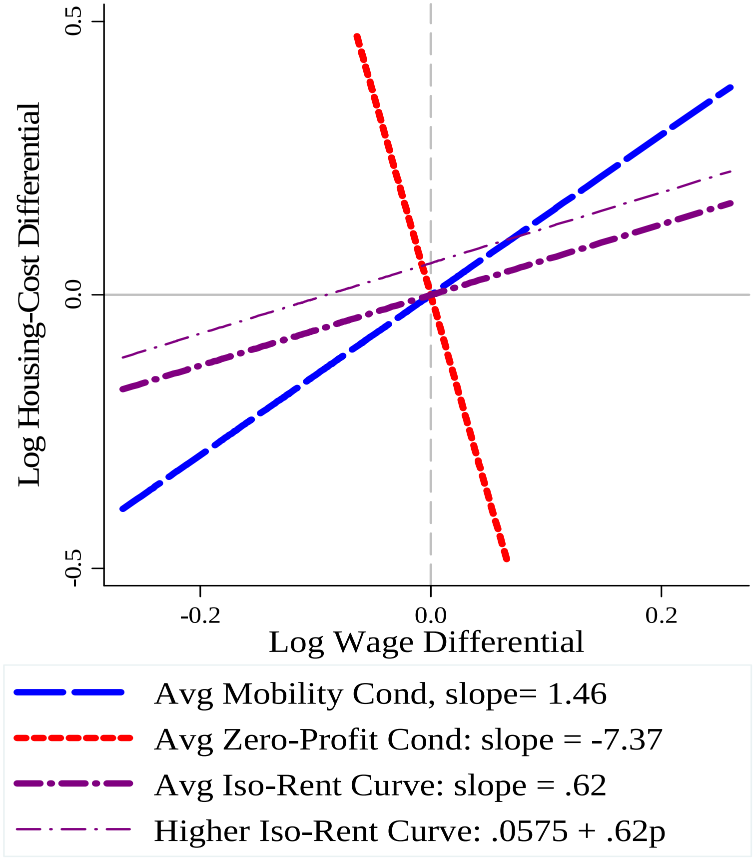


Figure 1B: Unadjusted Model
(Previous Literature)

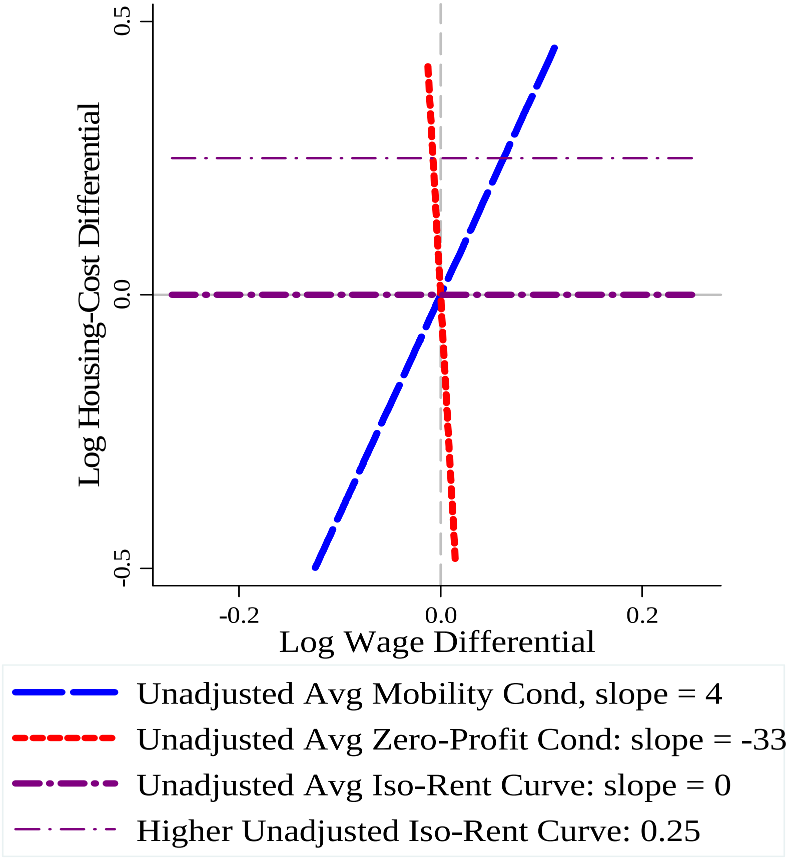


Figure 2: Housing Costs versus Wage Levels across Metro Areas, 2000

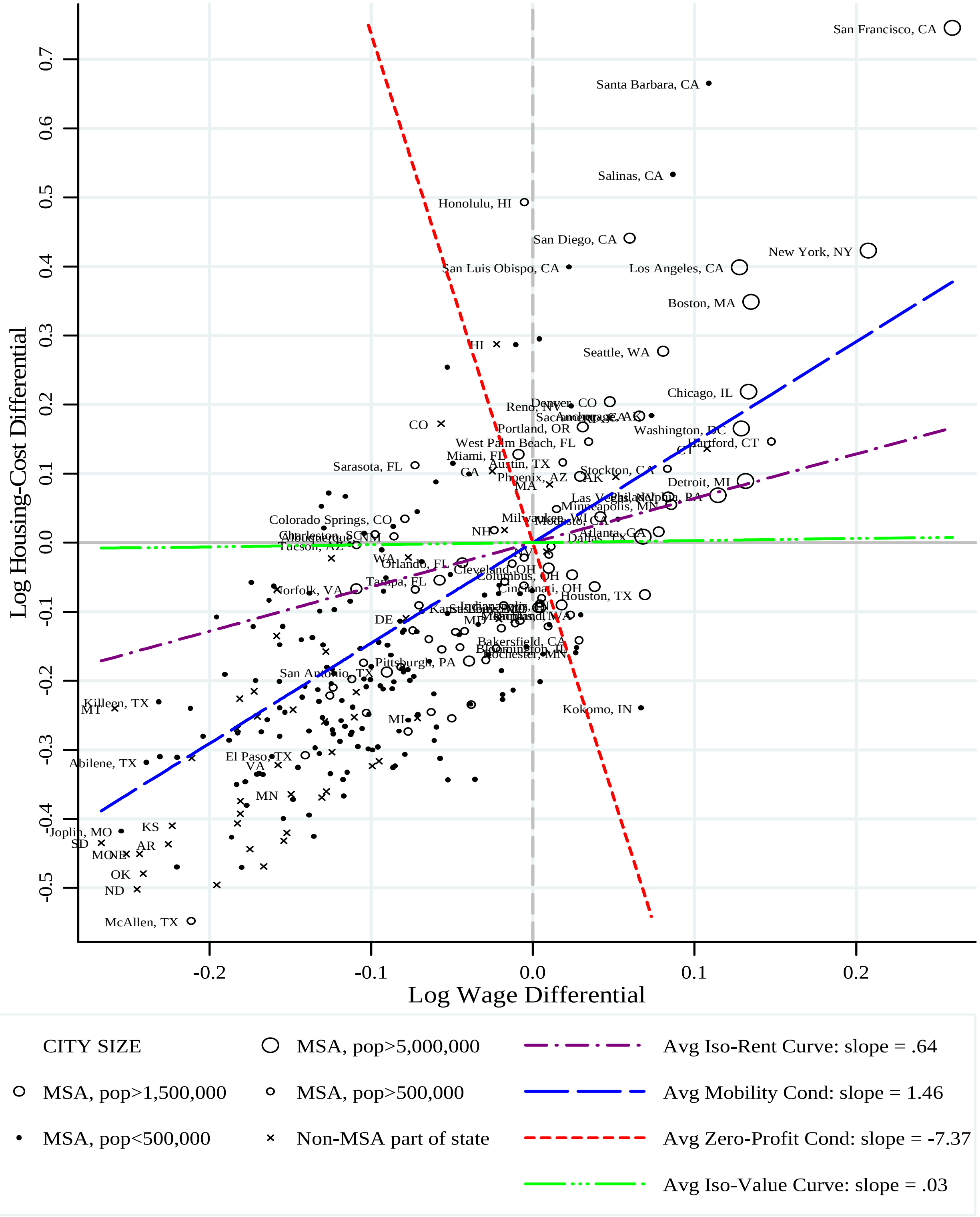


Figure 3: Housing Costs and Inferred Land Rents

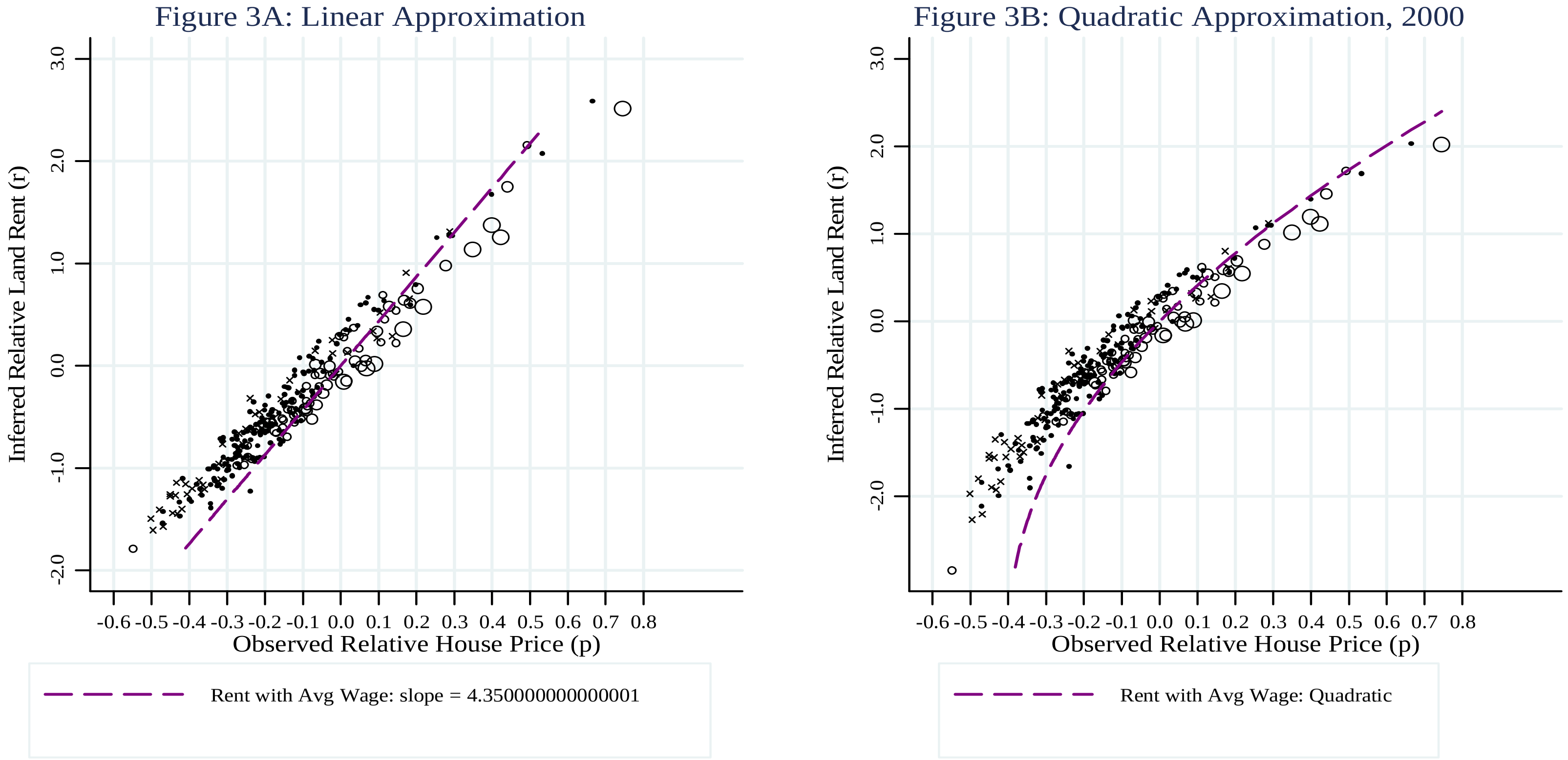


Figure 3A: Linear Approximation

Figure 3B: Quadratic Approximation, 2000

Inferred land rents based on calibration: phiL =.23, phiN =.62, sigmaY = 1.0

Inferred land rents based on calibration: phiL =.23, phiN =.62, sigmaY =.62

Figure 4: Estimated Productivity and Quality of Life, 2000

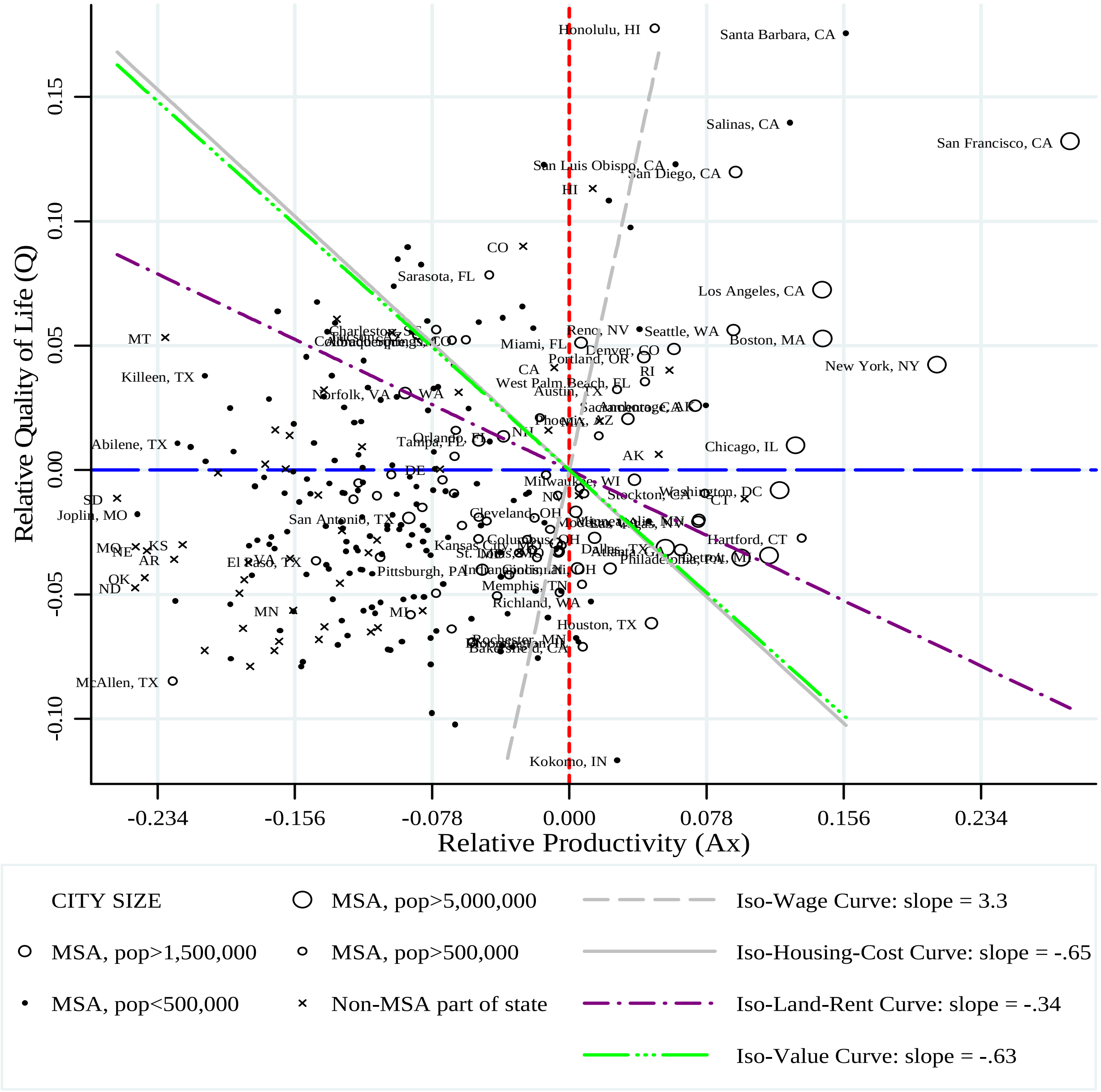


Figure 5: Productivity and Population Size

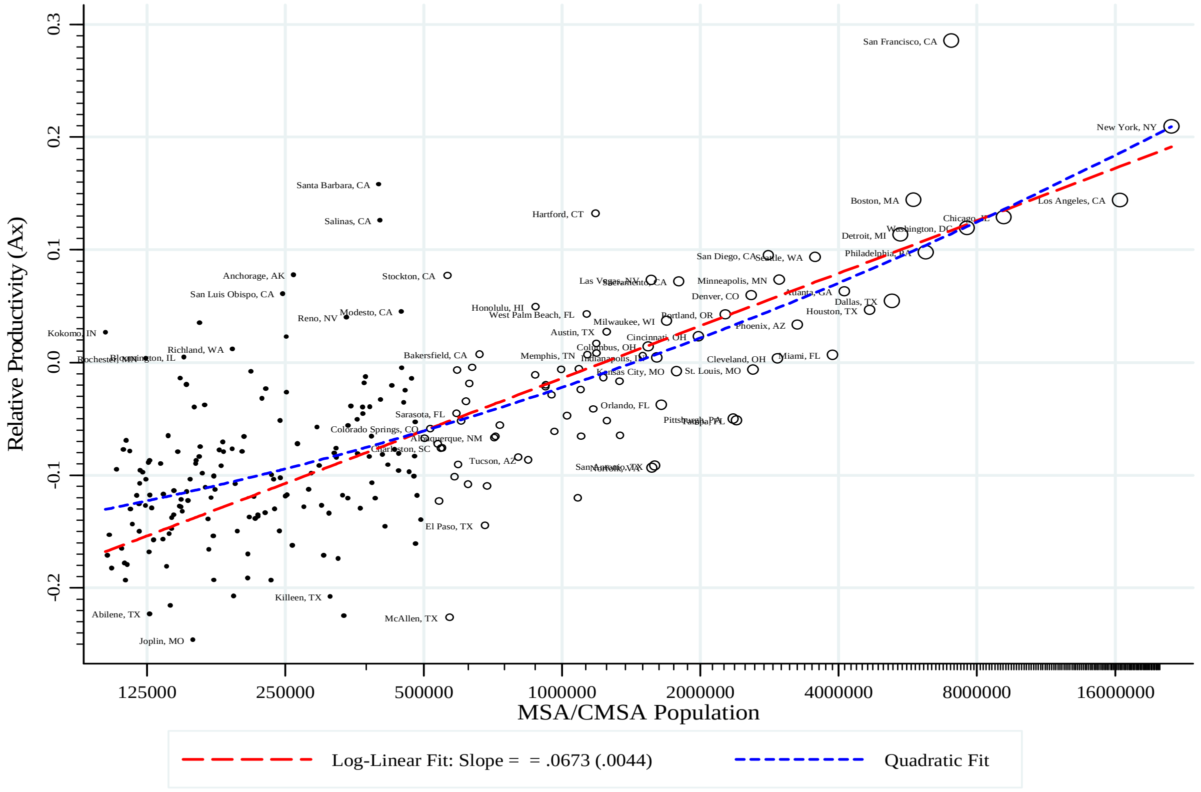
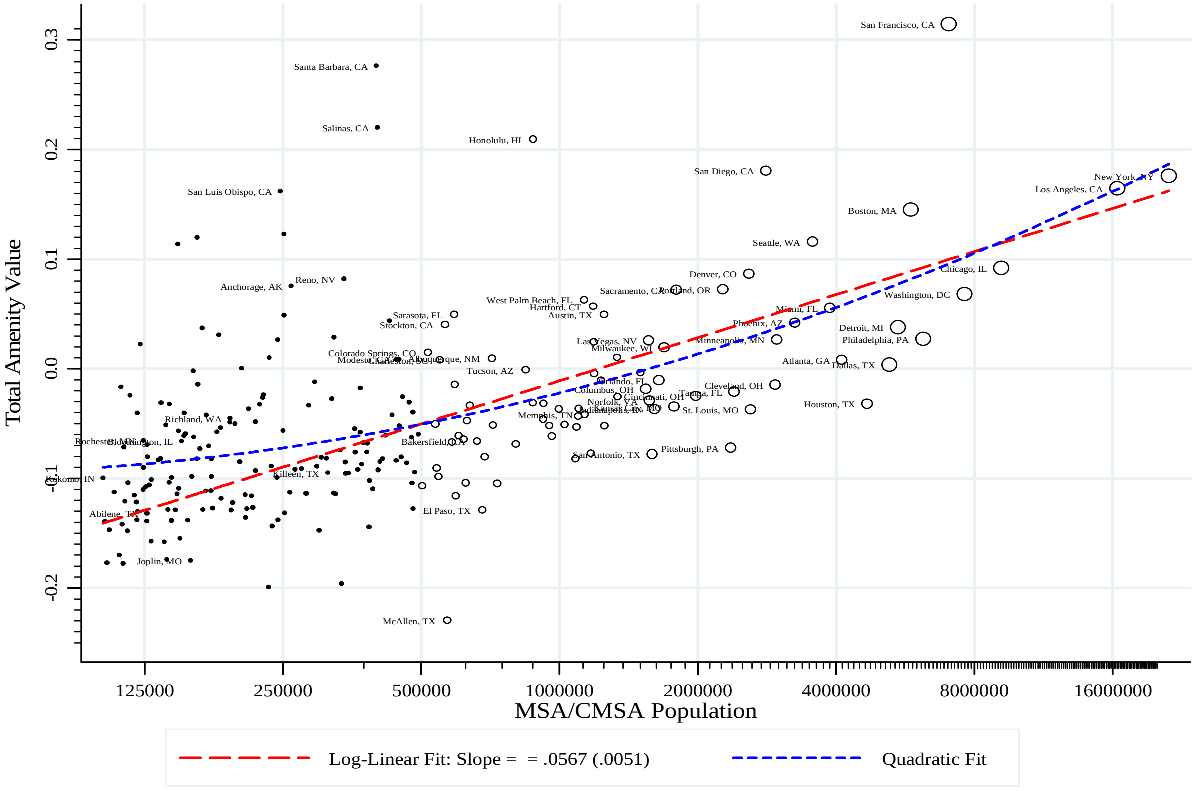


Figure 6: Total Value of Amenities and Population Size



Appendix

A Additional Theoretical Details

A.1 System of Equations

The entire system consists of fourteen equations in fourteen unknowns, with three exogenous parameters: Q, A_X, and, A_Y, with superscripts j supressed. The first three equations (1), (2), and (3) determine the prices of land, labor, and the home good, r, w and p. With these prices given, the budget constraint and the consumption tangency condition determine the consumption quantities x and y,

$$x + py = w + R + I - \tau(w) \tag{A.1}$$

$$(\partial U/\partial y) / (\partial U/\partial x) = p \tag{A.2}$$

where$R$ and I are given. Changes in output (X, Y), employment (N_X, N_Y, N), capital (K_X, K_Y), and land use (L_X, L_Y) are determined by nine equations in the production sector: six statements of Shepard's Lemma

$$\partial c_X/\partial w = N_X/X,\ \partial c_X/\partial r = L_X/X,\ \partial c_X/\partial i = K_X/X \tag{A.3}$$

$$\partial N_Y/\partial w = N_Y/Y,\ \partial c_Y/\partial r = L_Y/Y,\ \partial c_Y/\partial i = K_Y/Y \tag{A.4}$$

and three equations for total population, the land constraint, and total home-good production per capita

$$N_X + N_Y = N \tag{A.5}$$

$$L_X + L_Y = L \tag{A.6}$$

$$Y = yN \tag{A.7}$$

A.2 Quantity Changes

A.2.1 Consumption

The budget constraint (A.1) and tangency condition (A.2) can be log-linearized to yield

$$s_x\hat{x} + s_y(\hat{p} + \hat{y}) = s_w\hat{w} - \frac{d\tau}{m} \tag{A.8}$$

$$\hat{x} - \hat{y} = \sigma_D\hat{p} \tag{A.9}$$

Subtracting (4a) from (A.8), $s_x\hat{x} + s_y\hat{y} = -\hat{Q}$ and substituting in (A.9) yields

$$\hat{y} = -s_x\sigma_D\hat{p} - \hat{Q} \tag{A.10}$$

In the simple case without taxes $\hat{p}_y = \frac{1}{s_y}\left(\frac{\lambda_N-\lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X^j\right)$ and so we can see that home-good consumption is decreasing in both productivity and quality of life.

$$\hat{y} = -\frac{s_x}{s_y}\frac{1-\lambda_L}{\lambda_N}\sigma_D s_x\hat{A}_X^j - \left(\frac{s_x}{s_y}\frac{\lambda_N-\lambda_L}{\lambda_N}\sigma_D + 1\right)\hat{Q}$$

A.2.2 Production

In the production sector, differentiating and log-linearizing the Shepard's Lemma conditions (A.3) and (A.4) gives six equations of the following form

$$\hat{N}_X = \hat{X} - \hat{A}_X + \theta_L\sigma_X^{LN}\left(\hat{r}-\hat{w}\right) + \theta_K\sigma_X^{NK}\left(\hat{\imath}-\hat{w}\right) \tag{A.11}$$

These expressions make use of partial (Allen-Uzawa) elasticities of substitution. Each sector has three partial (Allen-Uzawa) elasticities of substitution in production for each combination of two factors, where $\sigma_X^{LN} \equiv \left(\partial^2 c/\partial w\partial r\right)/\left(\partial c/\partial w\cdot\partial c/\partial r\right)$ is the partial elasticity of substitution between labor and land in the production of X, etc. Because productivity differences are Hicks-neutral, they do not affect these elasticities of substitution. Log-linearizing the constraints (A.5), (A.6), and (A.7)

$$\begin{aligned}
\lambda_N\hat{N}_X + (1-\lambda_N)\hat{N}_Y &= \hat{N}\\
\lambda_L\hat{L}_X + (1-\lambda_L)\hat{L}_Y &= 0\\
\hat{N} + \hat{y} &= \hat{Y}
\end{aligned}$$

Substituting in (4b), (4c), and (A.10), setting $\hat{A}_Y = 0$, and rearranging gives a system of nine equations in nine unknowns. If partial elasticities within sectors are equal, $\sigma_Y^{NL} = \sigma_Y^{LK} = \sigma_Y^{NK} = \sigma_Y$, as in CES production, then these equations taken on the matrix form below:

$$\begin{bmatrix}
1 & 0 & 0 & -1 & 0 & 0 & 0 & 0 & 0\\
0 & 1 & 0 & -1 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 1 & -1 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 1 & 0 & 0 & -1 & 0\\
0 & 0 & 0 & 0 & 0 & 1 & 0 & -1 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 1 & -1 & 0\\
\lambda_N & 0 & 0 & 0 & 1-\lambda_N & 0 & 0 & 0 & -1\\
0 & \lambda_L & 0 & 0 & 0 & 1-\lambda_L & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -1
\end{bmatrix}
\begin{bmatrix}
\hat{N}_X\\ \hat{L}_X\\ \hat{K}_X\\ \hat{X}\\ \hat{N}_Y\\ \hat{L}_Y\\ \hat{K}_Y\\ \hat{Y}\\ \hat{N}
\end{bmatrix}
=
\begin{bmatrix}
\left(\sigma_X-1\right)\hat{A}_X - \sigma_X\hat{w}\\
\left(\sigma_X-1\right)\hat{A}_X - \sigma_X\hat{r}\\
\left(\sigma_X-1\right)\hat{A}_X\\
\sigma_Y\left(\hat{p}-\hat{w}\right)\\
\sigma_Y\left(\hat{p}-\hat{r}\right)\\
\sigma_Y\hat{p}\\
0\\
0\\
-s_x\sigma_D\hat{p} - \hat{Q}
\end{bmatrix}$$

The quantities on the right-hand side of the equation are already derived from the observed data. The solution for $\hat{N}$ is given by

$$\hat{N} = \frac{1}{s_R}\left\{\lambda_L\sigma_X\left(\hat{r}-\hat{w}\right) + \sigma_Y\left[\lambda_L\frac{1-\lambda_N}{\lambda_N}\left(\hat{p}-\hat{w}\right) + \left(1-\lambda_L\right)\left(\hat{p}-\hat{r}\right)\right] + \frac{\lambda_N-\lambda_L}{\lambda_N}\left(\sigma_D s_x\hat{p} + \hat{Q}\right)\right\}$$

Note that $\hat{p}, \hat{w}$, and $\hat{r}$, are determined by $\hat{Q}$, and $\hat{A}$, according to the capitalization formulas in Section 4.

According to the calibrated model where $\sigma_Y = \sigma_X = 0.667$, the numerical solution to this equation is simply.

$$\hat{N} = 1.82\hat{Q} + 1.36\hat{A}_X$$

According to Table 3, the standard deviations of $\hat{Q}$ and $\hat{A}_X$ are 0.051 and 0.131: multiplied by the respective coefficients in the equation produces 0.094 and 0.179. This suggests that both quality of life and productivity are important determinants of population location decisions, although productivity appear to be slightly more important. However, these predictions cannot be taken too literally given the that the model's predictions for quantity differences are quite sensitive to its assumptions, such as fixed land supply. Furthermore, quality of life may and productivity most certainly depends on the population size of a city.

A.3 Multiple Household Types

Assume there are two types of fully mobile households, referred to as "a" and "b," and that some members of each type lives in every city. The mobility conditions for each type of household are

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

The two zero-profit conditions are generalized 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 is used to denote 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.[25]

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[25] 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 $\mu_a = N_a m_a / \left(N_a m_a + N_b m_b\right)$, with the other share $\mu_b = 1 - \mu_a$, and define the following income-weighted averages

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

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

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

Except for the terms in square brackets, "[]", these terms are otherwise identical to equations (8a), (8b), (8c). 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

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

A.4 Multiple Home Goods

Suppose now that there is one type of household but two types of goods, 1 and 2, such as residential housing and local services. 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 one using only one home-good price, e.g. the one for residential housing, may be biased.[26] The bias is then given by

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

If $\phi_{L1} = \phi_L$ and $\phi_{N1} = \phi_N$, then this collapses to $-s_y\hat{A}_{Y!}$.

B Data and Estimation

United States Census data from the 2000 Integrated Public-Use Microdata Series (IPUMS), from Ruggles et al. (2004), are used to calculate wage and housing price differentials. The wage differentials are calculated for workers ages 25 to 55, who report working at least 30 hours a week, 26 weeks a year. The MSA assigned to a worker is determined by their place of residence, rather

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[26] The capitalization into a specific home-good is.$s_{y1}\hat{p}_1 = \left(\frac{\lambda_N-\lambda_L}{\lambda_N} - \left[\lambda_{L2} - \lambda_{N2}\frac{\lambda_L}{\lambda_N}\right]\right)\left(\hat{Q} + s_{y2}\hat{A}_{Y2}\right) + \left(\frac{1-\lambda_L}{\lambda_N} - \left[\lambda_{L2} + \lambda_{N2}\frac{1-\lambda_L}{\lambda_N}\right]\right)s_x\hat{A}_X + \left(-\frac{\lambda_L}{\lambda_N} - \left[\lambda_{L2} - \lambda_{N2}\frac{\lambda_L}{\lambda_N}\right]\right)s_{y1}\hat{A}_{Y1}$

than their place of work. The wage differential of an MSA is found by regressing log hourly wages on individual covariates and indicators for which MSA a worker lives in, using the coefficients on these MSA indicators. The covariates consist of

- 12 indicators of educational attainment;
- 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;
- 2 indicators for English proficiency (none or poor).

All covariates are interacted with gender.

This regression is first run using census-person weights. From the regressions a predicted wage is calculated using individual characteristics alone, controlling for MSA, to form a new weight equal to the predicted wage times the census-person weight. These new income-adjusted weights are needed since workers need to be weighted by their income share. 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.

Housing price differentials are calculated using the logarithm reported gross rents and housing values. Only housing units moved into within the last 10 years are included in the sample to ensure that the price data are fairly accurate. The differential housing price of an MSA is calculated in a manner similar to wages, except using a regression of the actual or imputed rent on a set of covariates at the unit level. The covariates for the adjusted differential are

- 9 indicators of building size;
- 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;

- an indicator for condominium status (owned units only).

A regression of housing values on housing characteristics and MSA indicator variables is first run using only owner-occupied units, weighting by census-housing weights. A new value-adjusted weight is calculated by multiplying the census-housing weights by the predicted value from this first regression using housing characteristics alone, controlling for MSA. A second regression is run using 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. The house-price differentials are taken 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.

TABLE A: 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 CMSA	7,039,362	0.260	0.746	2.478	2.037	0.132	4	0.285	1	0.067	0.315	1
Santa Barbara--Santa Maria--Lompoc, CA MSA	399,347	0.109	0.665	2.550	2.054	0.176	2	0.157	3	0.022	0.277	2
Salinas, CA MSA	401,762	0.087	0.533	2.046	1.704	0.140	3	0.126	8	0.016	0.220	3
Honolulu, HI MSA	876,156	-0.005	0.493	2.127	1.739	0.178	1	0.049	23	-0.003	0.209	4
San Diego, CA MSA	2,813,833	0.060	0.441	1.724	1.467	0.120	7	0.095	12	0.008	0.181	5
New York--Northern New Jersey--Long Island, NY--NJ--CT--PA CMSA	21,199,865	0.208	0.423	1.239	1.114	0.042	39	0.209	2	0.052	0.176	6
Los Angeles--Riverside--Orange County, CA CMSA	16,373,645	0.128	0.399	1.355	1.199	0.073	15	0.144	5	0.029	0.165	7
San Luis Obispo--Atascadero--Paso Robles, CA MSA	246,681	0.022	0.399	1.650	1.404	0.123	5	0.060	20	-0.003	0.162	8
Boston--Worcester--Lawrence, MA--NH--ME--CT CMSA	5,819,100	0.135	0.349	1.122	1.013	0.053	30	0.144	4	0.033	0.145	9
Naples, FL MSA	251,377	-0.010	0.287	1.257	1.100	0.108	8	0.023	35	-0.003	0.123	10
non-metropolitan areas, HI	335,651	-0.022	0.287	1.294	1.126	0.114		0.013		-0.007	0.122	
Barnstable--Yarmouth, MA MSA	162,582	0.004	0.295	1.254	1.100	0.098	9	0.035	30	-0.006	0.120	11
Seattle--Tacoma--Bremerton, WA CMSA	3,554,760	0.081	0.277	0.966	0.880	0.056	26	0.093	13	0.020	0.116	12
Santa Fe, NM MSA	147,635	-0.053	0.254	1.235	1.074	0.123	6	-0.014	60	-0.010	0.114	13
Chicago--Gary--Kenosha, IL--IN--WI CMSA	9,157,540	0.133	0.219	0.568	0.540	0.010	70	0.129	7	0.035	0.092	14
Denver--Boulder--Greeley, CO CMSA	2,581,506	0.048	0.204	0.743	0.689	0.049	34	0.060	21	0.013	0.087	15
Reno, NV MSA	339,486	0.024	0.198	0.783	0.721	0.057	24	0.040	28	0.004	0.082	16
non-metropolitan areas, RI	258,023	0.047	0.181	0.645	0.604	0.040		0.057		0.012	0.077	
Anchorage, AK MSA	260,283	0.073	0.184	0.586	0.553	0.026	53	0.078	14	0.017	0.076	17
non-metropolitan areas, CO	924,086	-0.057	0.172	0.896	0.803	0.090		-0.026		-0.016	0.073	
Portland--Salem, OR--WA CMSA	2,265,223	0.031	0.167	0.631	0.590	0.045	36	0.042	27	0.009	0.073	18
Sacramento--Yolo, CA CMSA	1,796,857	0.066	0.183	0.603	0.568	0.026	52	0.072	18	0.012	0.072	19
Washington--Baltimore, DC--MD--VA--WV CMSA	7,608,070	0.129	0.165	0.351	0.339	-0.008	98	0.120	9	0.033	0.068	20
West Palm Beach--Boca Raton, FL MSA	1,131,184	0.035	0.146	0.531	0.502	0.035	42	0.043	26	0.010	0.063	21
Hartford, CT MSA	1,183,110	0.148	0.146	0.219	0.212	-0.028	148	0.132	6	0.035	0.057	22
Miami--Fort Lauderdale, FL CMSA	3,876,380	-0.009	0.128	0.571	0.534	0.051	33	0.007	42	-0.002	0.056	23
non-metropolitan areas, CT	1,350,818	0.108	0.136	0.286	0.278	-0.012		0.100		0.023	0.052	
Austin--San Marcos, TX MSA	1,249,763	0.019	0.116	0.447	0.425	0.032	46	0.027	33	0.005	0.050	24
Sarasota--Bradenton, FL MSA	589,959	-0.073	0.112	0.681	0.620	0.079	13	-0.045	85	-0.019	0.049	25
Fort Collins--Loveland, CO MSA	251,494	-0.049	0.115	0.628	0.578	0.066	17	-0.027	71	-0.014	0.049	26
Madison, WI MSA	426,526	-0.039	0.099	0.535	0.498	0.057	23	-0.021	66	-0.010	0.044	27
Phoenix--Mesa, AZ MSA	3,251,876	0.029	0.096	0.330	0.319	0.021	59	0.033	31	0.009	0.042	28
Stockton--Lodi, CA MSA	563,598	0.083	0.107	0.228	0.223	-0.009	100	0.077	15	0.018	0.040	29
non-metropolitan areas, AK	367,124	0.051	0.095	0.267	0.260	0.006		0.051		0.012	0.039	
Detroit--Ann Arbor--Flint, MI CMSA	5,456,428	0.132	0.089	0.019	0.013	-0.035	174	0.114	10	0.036	0.038	30
Bellingham, WA MSA	166,814	-0.060	0.088	0.543	0.503	0.061	19	-0.038	78	-0.017	0.037	31
non-metropolitan areas, CA	1,249,739	-0.025	0.103	0.513	0.480	0.041		-0.009		-0.015	0.036	
Medford--Ashland, OR MSA	181,269	-0.126	0.072	0.658	0.591	0.090	10	-0.092	142	-0.035	0.031	32
non-metropolitan areas, MA	569,691	0.010	0.084	0.333	0.321	0.020		0.017		-0.002	0.031	
Eugene--Springfield, OR MSA	322,959	-0.116	0.067	0.607	0.550	0.083	12	-0.084	131	-0.032	0.029	33
Philadelphia--Wilmington--Atlantic City, PA--NJ--DE--MD CMSA	6,188,463	0.115	0.068	-0.024	-0.030	-0.035	176	0.098	11	0.030	0.027	34
Minneapolis--St. Paul, MN--WI MSA	2,968,806	0.086	0.055	-0.003	-0.005	-0.020	126	0.074	16	0.027	0.027	35
Portland, ME MSA	243,537	-0.071	0.045	0.390	0.365	0.060	21	-0.052	91	-0.012	0.027	36
Las Vegas, NV--AZ MSA	1,563,282	0.084	0.066	0.052	0.050	-0.021	129	0.073	17	0.021	0.026	37
Raleigh--Durham--Chapel Hill, NC MSA	1,187,941	0.015	0.049	0.167	0.164	0.014	64	0.017	36	0.008	0.024	38
Flagstaff, AZ--UT MSA	122,366	-0.131	0.053	0.587	0.530	0.085	11	-0.098	148	-0.036	0.023	39
Milwaukee--Racine, WI CMSA	1,689,572	0.042	0.038	0.046	0.045	-0.004	88	0.037	29	0.015	0.020	40

TABLE A: 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
Colorado Springs, CO MSA	516,929	-0.079	0.035	0.367	0.344	0.053	31	-0.059	97	-0.022	0.015	41
Salt Lake City--Ogden, UT MSA	1,333,914	-0.024	0.018	0.144	0.140	0.021	58	-0.017	61	-0.004	0.010	42
Wilmington, NC MSA	233,450	-0.129	0.021	0.449	0.410	0.074	14	-0.100	151	-0.035	0.010	43
Albuquerque, NM MSA	712,738	-0.086	0.009	0.276	0.260	0.052	32	-0.067	105	-0.018	0.010	44
Modesto, CA MSA	446,997	0.053	0.034	-0.001	-0.002	-0.020	125	0.045	25	0.009	0.009	45
Fort Myers--Cape Coral, FL MSA	440,888	-0.104	0.014	0.347	0.322	0.060	20	-0.081	125	-0.026	0.008	46
non-metropolitan areas, NH	1,011,597	-0.018	0.018	0.127	0.124	0.016		-0.012		-0.004	0.008	
Atlanta, GA MSA	4,112,198	0.078	0.016	-0.148	-0.156	-0.032	164	0.063	19	0.023	0.008	47
Charleston--North Charleston, SC MSA	549,033	-0.098	0.012	0.321	0.300	0.056	25	-0.076	113	-0.024	0.008	48
Dallas--Fort Worth, TX CMSA	5,221,801	0.068	0.009	-0.152	-0.159	-0.031	160	0.055	22	0.019	0.004	49
Chico--Paradise, CA MSA	203,171	-0.086	0.024	0.340	0.318	0.043	38	-0.066	104	-0.033	0.001	50
Tucson, AZ MSA	843,746	-0.109	-0.003	0.287	0.267	0.054	29	-0.087	132	-0.030	-0.001	51
Charlottesville, VA MSA	159,576	-0.113	-0.003	0.301	0.279	0.056	28	-0.090	137	-0.032	-0.002	52
Charlotte--Gastonia--Rock Hill, NC--SC MSA	1,499,293	0.010	-0.018	-0.104	-0.106	-0.007	95	0.006	43	0.007	-0.004	53
Providence--Fall River--Warwick, RI--MA MSA	1,188,613	0.011	-0.006	-0.055	-0.055	-0.009	107	0.008	39	0.001	-0.004	54
non-metropolitan areas, NV	285,196	0.008	-0.013	-0.079	-0.080	-0.010		0.005		0.001	-0.007	
non-metropolitan areas, WA	1,063,531	-0.077	-0.021	0.121	0.115	0.031		-0.063		-0.021	-0.009	
non-metropolitan areas, OR	1,194,699	-0.125	-0.023	0.248	0.229	0.055		-0.101		-0.034	-0.009	
Orlando, FL MSA	1,644,561	-0.044	-0.029	-0.004	-0.005	0.014	65	-0.038	77	-0.010	-0.010	55
Nashville, TN MSA	1,231,311	-0.013	-0.030	-0.095	-0.096	-0.002	83	-0.013	58	-0.001	-0.011	56
Savannah, GA MSA	293,000	-0.069	-0.028	0.072	0.068	0.025	56	-0.057	96	-0.019	-0.012	57
Redding, CA MSA	163,256	-0.093	-0.010	0.213	0.201	0.034	43	-0.075	111	-0.035	-0.014	58
Springfield, MA MSA	591,932	-0.005	-0.022	-0.078	-0.079	-0.010	111	-0.007	53	-0.007	-0.014	59
Cleveland--Akron, OH CMSA	2,945,831	0.010	-0.037	-0.185	-0.190	-0.017	118	0.004	47	0.004	-0.014	60
Iowa City, IA MSA	111,006	-0.091	-0.051	0.033	0.030	0.033	45	-0.077	117	-0.020	-0.017	61
Provo--Orem, UT MSA	368,536	-0.051	-0.046	-0.057	-0.058	0.012	67	-0.045	84	-0.012	-0.017	62
Columbus, OH MSA	1,540,157	0.024	-0.047	-0.268	-0.279	-0.027	147	0.014	37	0.008	-0.018	63
Tampa--St. Petersburg--Clearwater, FL MSA	2,395,997	-0.058	-0.054	-0.074	-0.075	0.012	66	-0.051	89	-0.014	-0.021	64
non-metropolitan areas, VT	608,387	-0.158	-0.068	0.146	0.131	0.061		-0.132		-0.038	-0.024	
Green Bay, WI MSA	226,778	-0.021	-0.062	-0.208	-0.213	-0.009	101	-0.023	68	-0.003	-0.024	65
Grand Junction, CO MSA	116,255	-0.174	-0.058	0.235	0.210	0.068	16	-0.144	205	-0.048	-0.024	66
Cincinnati--Hamilton, OH--KY--IN CMSA	1,979,202	0.038	-0.064	-0.379	-0.404	-0.040	181	0.023	34	0.013	-0.025	67
New Orleans, LA MSA	1,337,726	-0.073	-0.068	-0.090	-0.091	0.016	63	-0.065	99	-0.016	-0.025	68
Des Moines, IA MSA	456,022	-0.021	-0.074	-0.258	-0.266	-0.010	110	-0.025	70	0.000	-0.026	69
Asheville, NC MSA	225,965	-0.160	-0.063	0.174	0.156	0.059	22	-0.133	195	-0.043	-0.026	70
Fort Pierce--Port St. Lucie, FL MSA	319,426	-0.092	-0.070	-0.046	-0.048	0.024	57	-0.080	123	-0.023	-0.027	71
Norfolk--Virginia Beach--Newport News, VA--NC MSA	1,569,541	-0.109	-0.067	0.014	0.010	0.031	47	-0.093	143	-0.030	-0.029	72
Lancaster, PA MSA	470,658	-0.008	-0.074	-0.294	-0.306	-0.021	130	-0.014	59	-0.001	-0.030	73
State College, PA MSA	135,758	-0.138	-0.073	0.069	0.060	0.044	37	-0.117	169	-0.038	-0.031	74
Albany--Schenectady--Troy, NY MSA	875,583	-0.005	-0.062	-0.251	-0.259	-0.024	140	-0.011	56	-0.006	-0.031	75
Fresno, CA MSA	922,516	-0.017	-0.057	-0.196	-0.201	-0.019	122	-0.020	65	-0.012	-0.032	76
Houston--Galveston--Brazoria, TX CMSA	4,669,571	0.069	-0.075	-0.515	-0.566	-0.062	216	0.047	24	0.020	-0.032	77
Punta Gorda, FL MSA	141,627	-0.163	-0.084	0.092	0.079	0.056	27	-0.138	201	-0.042	-0.032	78
Yakima, WA MSA	222,581	-0.030	-0.076	-0.244	-0.251	-0.012	114	-0.032	73	-0.008	-0.032	79
Allentown--Bethlehem--Easton, PA MSA	637,958	0.005	-0.081	-0.361	-0.380	-0.030	158	-0.004	48	0.003	-0.033	80
Tallahassee, FL MSA	284,539	-0.113	-0.085	-0.052	-0.056	0.030	49	-0.098	150	-0.028	-0.033	81
Kansas City, MO--KS MSA	1,776,062	0.003	-0.094	-0.412	-0.437	-0.030	154	-0.007	54	0.007	-0.035	82

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Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Jacksonville, FL MSA	1,100,491	-0.070	-0.091	-0.194	-0.198	0.006	75	-0.065	102	-0.017	-0.036	83
Merced, CA MSA	210,554	0.000	-0.070	-0.298	-0.310	-0.032	161	-0.008	55	-0.007	-0.037	84
Richmond--Petersburg, VA MSA	996,512	0.004	-0.088	-0.390	-0.412	-0.033	169	-0.006	51	0.002	-0.037	85
Indianapolis, IN MSA	1,607,486	0.018	-0.090	-0.436	-0.465	-0.040	180	0.005	45	0.007	-0.037	86
St. Louis, MO--IL MSA	2,603,607	0.005	-0.094	-0.417	-0.442	-0.033	170	-0.006	52	0.005	-0.037	87
Lexington, KY MSA	479,198	-0.053	-0.103	-0.294	-0.304	-0.006	92	-0.053	93	-0.010	-0.039	88
Bryan--College Station, TX MSA	152,415	-0.132	-0.099	-0.061	-0.066	0.033	44	-0.115	168	-0.034	-0.040	89
Bloomington, IN MSA	120,563	-0.123	-0.097	-0.077	-0.081	0.028	51	-0.107	160	-0.033	-0.040	90
Memphis, TN--AR--MS MSA	1,135,614	0.023	-0.105	-0.513	-0.555	-0.046	193	0.007	41	0.010	-0.042	91
Boise City, ID MSA	432,345	-0.082	-0.114	-0.260	-0.267	0.007	73	-0.077	116	-0.016	-0.042	92
Fort Walton Beach, FL MSA	170,498	-0.196	-0.108	0.079	0.062	0.064	18	-0.166	221	-0.050	-0.042	93
Rochester, NY MSA	1,098,201	-0.018	-0.091	-0.339	-0.354	-0.028	150	-0.024	69	-0.009	-0.043	94
Richland--Kennewick--Pasco, WA MSA	191,822	0.030	-0.105	-0.530	-0.577	-0.053	204	0.012	38	0.008	-0.045	95
Birmingham, AL MSA	921,106	-0.011	-0.117	-0.470	-0.501	-0.032	163	-0.021	67	0.001	-0.046	96
non-metropolitan areas, DE	158,149	-0.078	-0.110	-0.252	-0.259	0.000		-0.074		-0.022	-0.047	
Harrisburg--Lebanon--Carlisle, PA MSA	629,401	-0.008	-0.114	-0.465	-0.495	-0.035	177	-0.018	63	-0.001	-0.047	97
Gainesville, FL MSA	217,955	-0.155	-0.121	-0.093	-0.099	0.038	40	-0.135	198	-0.039	-0.048	98
Cedar Rapids, IA MSA	191,701	-0.080	-0.127	-0.324	-0.335	0.000	80	-0.076	115	-0.016	-0.049	99
Myrtle Beach, SC MSA	196,629	-0.173	-0.121	-0.042	-0.052	0.046	35	-0.150	211	-0.046	-0.050	100
Columbia, SC MSA	536,691	-0.074	-0.127	-0.339	-0.352	-0.004	87	-0.072	110	-0.016	-0.050	101
Louisville, KY--IN MSA	1,025,598	-0.042	-0.128	-0.433	-0.457	-0.021	127	-0.047	86	-0.007	-0.051	102
Yuba City, CA MSA	139,149	-0.069	-0.100	-0.239	-0.245	-0.010	108	-0.065	100	-0.027	-0.051	103
non-metropolitan areas, MD	666,998	-0.021	-0.111	-0.416	-0.439	-0.033		-0.028		-0.010	-0.051	
Omaha, NE--IA MSA	716,998	-0.064	-0.140	-0.421	-0.442	-0.009	106	-0.066	103	-0.009	-0.051	104
Dayton--Springfield, OH MSA	950,558	-0.019	-0.124	-0.478	-0.509	-0.033	171	-0.029	72	-0.004	-0.052	105
Lansing--East Lansing, MI MSA	447,728	0.010	-0.119	-0.538	-0.583	-0.049	195	-0.005	49	0.002	-0.052	106
Greensboro--Winston-Salem--High Point, NC MSA	1,251,509	-0.048	-0.130	-0.423	-0.445	-0.019	123	-0.052	90	-0.010	-0.052	107
Grand Rapids--Muskegon--Holland, MI MSA	1,088,514	0.010	-0.121	-0.547	-0.593	-0.049	196	-0.006	50	0.002	-0.053	108
Lafayette, IN MSA	182,821	-0.072	-0.129	-0.354	-0.368	-0.009	99	-0.070	108	-0.018	-0.054	109
Appleton--Oshkosh--Neenah, WI MSA	358,365	-0.046	-0.133	-0.446	-0.470	-0.022	134	-0.050	88	-0.010	-0.055	110
Lincoln, NE MSA	250,291	-0.130	-0.148	-0.276	-0.285	0.019	60	-0.118	175	-0.029	-0.056	111
Panama City, FL MSA	148,217	-0.143	-0.141	-0.207	-0.214	0.025	54	-0.128	189	-0.036	-0.057	112
non-metropolitan areas, AZ	942,343	-0.159	-0.135	-0.140	-0.147	0.032		-0.140		-0.043	-0.057	
Champaign--Urbana, IL MSA	179,669	-0.080	-0.130	-0.333	-0.345	-0.008	96	-0.077	118	-0.024	-0.058	113
Visalia--Tulare--Porterville, CA MSA	368,021	-0.034	-0.118	-0.414	-0.435	-0.033	168	-0.039	82	-0.017	-0.058	114
Athens, GA MSA	153,444	-0.136	-0.137	-0.212	-0.218	0.019	61	-0.122	182	-0.038	-0.059	115
Daytona Beach, FL MSA	493,175	-0.157	-0.148	-0.202	-0.209	0.030	48	-0.140	204	-0.039	-0.060	116
Spokane, WA MSA	417,939	-0.095	-0.144	-0.355	-0.368	-0.003	84	-0.091	139	-0.025	-0.061	117
Baton Rouge, LA MSA	602,894	-0.045	-0.152	-0.525	-0.561	-0.028	149	-0.052	92	-0.008	-0.061	118
Janesville--Beloit, WI MSA	152,307	-0.004	-0.151	-0.636	-0.698	-0.049	194	-0.019	64	0.003	-0.061	119
Greenville--Spartanburg--Anderson, SC MSA	962,441	-0.056	-0.155	-0.507	-0.539	-0.022	133	-0.061	98	-0.011	-0.061	120
Yuma, AZ MSA	160,026	-0.090	-0.149	-0.388	-0.404	-0.007	94	-0.087	134	-0.023	-0.062	121
Melbourne--Titusville--Palm Bay, FL MSA	476,230	-0.107	-0.153	-0.362	-0.376	0.002	78	-0.101	153	-0.026	-0.062	122
Toledo, OH MSA	618,203	-0.023	-0.153	-0.594	-0.644	-0.042	189	-0.034	75	-0.005	-0.064	123
Rochester, MN MSA	124,277	0.027	-0.159	-0.756	-0.855	-0.068	222	0.004	46	0.010	-0.065	124
Bakersfield, CA MSA	661,645	0.029	-0.141	-0.685	-0.765	-0.071	228	0.008	40	0.003	-0.066	125
Bloomington--Normal, IL MSA	150,433	0.027	-0.152	-0.726	-0.817	-0.069	225	0.005	44	0.007	-0.066	126

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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-metropolitan areas, UT	531,967	-0.128	-0.158	-0.322	-0.333	0.010		-0.118		-0.034	-0.066	
Little Rock--North Little Rock, AR MSA	583,845	-0.105	-0.174	-0.457	-0.479	-0.002	82	-0.101	154	-0.021	-0.067	127
Reading, PA MSA	373,638	0.006	-0.161	-0.709	-0.790	-0.060	213	-0.012	57	0.004	-0.067	128
York, PA MSA	381,751	-0.027	-0.162	-0.621	-0.675	-0.043	191	-0.039	80	-0.006	-0.068	129
Tulsa, OK MSA	803,235	-0.082	-0.180	-0.546	-0.581	-0.015	117	-0.084	130	-0.014	-0.069	130
Dover, DE MSA	126,697	-0.088	-0.163	-0.455	-0.478	-0.014	116	-0.087	133	-0.024	-0.069	131
Sioux Falls, SD MSA	172,412	-0.127	-0.181	-0.422	-0.441	0.006	74	-0.120	177	-0.028	-0.071	132
Sheboygan, WI MSA	112,646	-0.064	-0.172	-0.560	-0.600	-0.027	146	-0.069	107	-0.015	-0.071	133
Pittsburgh, PA MSA	2,358,695	-0.039	-0.172	-0.627	-0.681	-0.040	185	-0.050	87	-0.009	-0.072	134
Tuscaloosa, AL MSA	164,875	-0.100	-0.180	-0.494	-0.521	-0.010	109	-0.098	149	-0.023	-0.073	135
Montgomery, AL MSA	333,055	-0.124	-0.183	-0.443	-0.463	0.001	79	-0.118	172	-0.030	-0.074	136
Corpus Christi, TX MSA	380,783	-0.081	-0.182	-0.558	-0.596	-0.022	135	-0.083	129	-0.020	-0.076	137
Davenport--Moline--Rock Island, IA--IL MSA	359,062	-0.077	-0.184	-0.575	-0.615	-0.024	141	-0.081	124	-0.018	-0.076	138
Buffalo--Niagara Falls, NY MSA	1,170,111	-0.029	-0.170	-0.648	-0.708	-0.051	198	-0.041	83	-0.012	-0.077	139
San Antonio, TX MSA	1,592,383	-0.090	-0.187	-0.553	-0.589	-0.019	124	-0.091	141	-0.022	-0.078	140
La Crosse, WI--MN MSA	126,838	-0.123	-0.190	-0.473	-0.497	-0.005	89	-0.117	171	-0.033	-0.080	141
Knoxville, TN MSA	687,249	-0.112	-0.197	-0.537	-0.569	-0.010	112	-0.109	163	-0.027	-0.080	142
Kalamazoo--Battle Creek, MI MSA	452,851	-0.019	-0.186	-0.742	-0.826	-0.058	211	-0.035	76	-0.006	-0.080	143
Fayetteville, NC MSA	302,963	-0.191	-0.191	-0.291	-0.303	0.029	50	-0.171	225	-0.052	-0.081	144
Fayetteville--Springdale--Rogers, AR MSA	311,121	-0.141	-0.208	-0.502	-0.529	0.004	76	-0.134	196	-0.031	-0.082	145
Columbia, MO MSA	135,454	-0.171	-0.200	-0.381	-0.397	0.019	62	-0.157	215	-0.044	-0.082	146
Pensacola, FL MSA	412,153	-0.157	-0.201	-0.428	-0.447	0.011	68	-0.145	207	-0.039	-0.082	147
Oklahoma City, OK MSA	1,083,346	-0.123	-0.210	-0.558	-0.593	-0.005	90	-0.120	178	-0.026	-0.082	148
Benton Harbor, MI MSA	162,453	-0.080	-0.187	-0.582	-0.624	-0.029	152	-0.083	128	-0.024	-0.082	149
Tyler, TX MSA	174,706	-0.100	-0.198	-0.573	-0.611	-0.018	120	-0.101	152	-0.025	-0.082	150
Greenville, NC MSA	133,798	-0.086	-0.202	-0.627	-0.675	-0.026	143	-0.089	136	-0.021	-0.083	151
Jackson, MS MSA	440,801	-0.093	-0.212	-0.654	-0.707	-0.022	131	-0.096	146	-0.018	-0.084	152
Canton--Massillon, OH MSA	406,934	-0.076	-0.199	-0.644	-0.697	-0.032	165	-0.081	126	-0.020	-0.085	153
Springfield, IL MSA	201,437	-0.074	-0.194	-0.628	-0.678	-0.034	173	-0.079	122	-0.022	-0.085	154
Hickory--Morganton--Lenoir, NC MSA	341,851	-0.125	-0.204	-0.531	-0.562	-0.008	97	-0.120	180	-0.032	-0.085	155
Chattanooga, TN--GA MSA	465,161	-0.094	-0.207	-0.627	-0.675	-0.024	139	-0.097	147	-0.023	-0.086	156
Rockford, IL MSA	371,236	0.005	-0.202	-0.877	-1.007	-0.076	233	-0.018	62	0.001	-0.087	157
non-metropolitan areas, FL	1,222,532	-0.173	-0.215	-0.445	-0.466	0.014		-0.159		-0.043	-0.088	
Roanoke, VA MSA	235,932	-0.103	-0.209	-0.609	-0.653	-0.022	132	-0.104	158	-0.028	-0.089	158
Evansville--Henderson, IN--KY MSA	296,195	-0.087	-0.212	-0.667	-0.724	-0.030	157	-0.091	140	-0.022	-0.089	159
Glens Falls, NY MSA	124,345	-0.104	-0.197	-0.558	-0.593	-0.024	138	-0.104	157	-0.034	-0.090	160
Mobile, AL MSA	540,258	-0.125	-0.221	-0.602	-0.643	-0.012	113	-0.123	183	-0.030	-0.090	161
non-metropolitan areas, ME	1,033,664	-0.181	-0.226	-0.468	-0.491	0.016		-0.167		-0.044	-0.091	
Columbus, GA--AL MSA	274,624	-0.133	-0.213	-0.545	-0.578	-0.009	104	-0.128	188	-0.037	-0.091	162
South Bend, IN MSA	265,559	-0.061	-0.219	-0.770	-0.854	-0.046	192	-0.072	109	-0.015	-0.092	163
Biloxi--Gulfport--Pascagoula, MS MSA	363,988	-0.132	-0.230	-0.620	-0.664	-0.009	103	-0.129	191	-0.030	-0.092	164
Saginaw--Bay City--Midland, MI MSA	403,070	-0.012	-0.214	-0.882	-1.009	-0.071	229	-0.032	74	-0.004	-0.092	165
Amarillo, TX MSA	217,858	-0.143	-0.224	-0.565	-0.600	-0.005	91	-0.137	199	-0.036	-0.093	166
non-metropolitan areas, MT	774,080	-0.259	-0.240	-0.313	-0.333	0.054		-0.230		-0.062	-0.094	
Lakeland--Winter Haven, FL MSA	483,924	-0.118	-0.229	-0.654	-0.705	-0.019	121	-0.118	174	-0.029	-0.094	167
Killeen--Temple, TX MSA	312,952	-0.231	-0.231	-0.348	-0.367	0.038	41	-0.207	236	-0.060	-0.095	168
Peoria--Pekin, IL MSA	347,387	-0.019	-0.220	-0.891	-1.020	-0.071	227	-0.038	79	-0.006	-0.095	169

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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
Huntsville, AL MSA	342,376	-0.039	-0.234	-0.897	-1.022	-0.060	214	-0.056	95	-0.006	-0.096	170
Jackson, MI MSA	158,422	-0.019	-0.227	-0.923	-1.063	-0.073	232	-0.039	81	-0.006	-0.098	171
non-metropolitan areas, NY	1,744,930	-0.109	-0.217	-0.626	-0.672	-0.028		-0.109		-0.036	-0.098	
Wichita, KS MSA	545,220	-0.063	-0.245	-0.878	-0.992	-0.050	197	-0.076	114	-0.010	-0.098	172
Las Cruces, NM MSA	174,682	-0.212	-0.240	-0.442	-0.465	0.025	55	-0.193	234	-0.054	-0.098	173
Lubbock, TX MSA	242,628	-0.157	-0.239	-0.592	-0.631	-0.004	86	-0.149	209	-0.040	-0.099	174
Rocky Mount, NC MSA	143,026	-0.111	-0.238	-0.713	-0.776	-0.027	144	-0.113	167	-0.028	-0.099	175
Kokomo, IN MSA	101,541	0.067	-0.239	-1.210	-1.534	-0.117	241	0.027	32	0.021	-0.100	176
Billings, MT MSA	129,352	-0.164	-0.256	-0.645	-0.692	0.000	81	-0.157	217	-0.036	-0.101	177
non-metropolitan areas, NC	2,632,956	-0.148	-0.242	-0.627	-0.671	-0.010		-0.143		-0.039	-0.101	
Lafayette, LA MSA	385,647	-0.101	-0.249	-0.785	-0.866	-0.034	172	-0.107	159	-0.023	-0.102	178
non-metropolitan areas, ID	863,855	-0.170	-0.252	-0.608	-0.648	0.001		-0.161		-0.042	-0.103	
Pueblo, CO MSA	141,472	-0.153	-0.246	-0.629	-0.673	-0.009	105	-0.147	208	-0.041	-0.104	179
Auburn--Opelika, AL MSA	115,092	-0.130	-0.253	-0.726	-0.790	-0.021	128	-0.130	193	-0.031	-0.104	180
Augusta--Aiken, GA--SC MSA	477,441	-0.071	-0.249	-0.869	-0.979	-0.051	200	-0.083	127	-0.017	-0.104	181
Scranton--Wilkes-Barre--Hazleton, PA MSA	624,776	-0.103	-0.247	-0.772	-0.850	-0.035	175	-0.108	162	-0.027	-0.104	182
Syracuse, NY MSA	732,117	-0.038	-0.235	-0.900	-1.027	-0.069	223	-0.055	94	-0.014	-0.104	183
Waterloo--Cedar Falls, IA MSA	128,012	-0.128	-0.261	-0.767	-0.840	-0.023	137	-0.129	190	-0.029	-0.106	184
non-metropolitan areas, WI	1,866,585	-0.111	-0.253	-0.777	-0.855	-0.033		-0.114		-0.029	-0.106	
Fort Wayne, IN MSA	502,141	-0.050	-0.255	-0.953	-1.096	-0.064	217	-0.067	106	-0.011	-0.107	185
non-metropolitan areas, SC	1,616,255	-0.129	-0.259	-0.753	-0.823	-0.024		-0.130		-0.032	-0.107	
Wausau, WI MSA	125,834	-0.077	-0.257	-0.889	-1.003	-0.051	199	-0.088	135	-0.019	-0.108	186
non-metropolitan areas, WY	493,849	-0.183	-0.270	-0.651	-0.698	0.002		-0.173		-0.043	-0.108	
Eau Claire, WI MSA	148,337	-0.119	-0.258	-0.777	-0.854	-0.031	159	-0.121	181	-0.031	-0.109	187
Shreveport--Bossier City, LA MSA	392,302	-0.116	-0.266	-0.820	-0.907	-0.033	166	-0.120	179	-0.027	-0.109	188
Sioux City, IA--NE MSA	124,130	-0.124	-0.271	-0.819	-0.906	-0.029	153	-0.127	186	-0.028	-0.110	189
non-metropolitan areas, MI	2,178,963	-0.071	-0.254	-0.892	-1.008	-0.057		-0.084		-0.021	-0.110	
Fargo--Moorhead, ND--MN MSA	174,367	-0.157	-0.280	-0.768	-0.839	-0.013	115	-0.154	214	-0.034	-0.111	190
Topeka, KS MSA	169,871	-0.138	-0.273	-0.787	-0.864	-0.023	136	-0.139	203	-0.033	-0.111	191
Jackson, TN MSA	107,377	-0.083	-0.273	-0.942	-1.072	-0.052	202	-0.095	144	-0.018	-0.113	192
Ocala, FL MSA	258,916	-0.168	-0.274	-0.710	-0.768	-0.009	102	-0.162	219	-0.042	-0.113	193
Macon, GA MSA	322,549	-0.060	-0.267	-0.981	-1.132	-0.065	219	-0.076	112	-0.015	-0.113	194
Erie, PA MSA	280,843	-0.106	-0.269	-0.862	-0.962	-0.042	187	-0.112	165	-0.027	-0.114	195
Monroe, LA MSA	147,250	-0.123	-0.277	-0.846	-0.939	-0.033	167	-0.127	187	-0.029	-0.114	196
Springfield, MO MSA	325,721	-0.182	-0.276	-0.677	-0.729	-0.003	85	-0.174	226	-0.046	-0.114	197
Clarksville--Hopkinsville, TN--KY MSA	207,033	-0.204	-0.281	-0.638	-0.683	0.007	72	-0.191	231	-0.051	-0.115	198
Muncie, IN MSA	118,769	-0.112	-0.275	-0.868	-0.969	-0.040	184	-0.118	173	-0.029	-0.115	199
Youngstown--Warren, OH MSA	594,746	-0.077	-0.274	-0.959	-1.097	-0.058	212	-0.090	138	-0.020	-0.116	200
Waco, TX MSA	213,517	-0.113	-0.278	-0.881	-0.986	-0.040	183	-0.119	176	-0.028	-0.116	201
Lake Charles, LA MSA	183,577	-0.061	-0.287	-1.060	-1.242	-0.068	221	-0.079	121	-0.012	-0.118	202
Goldsboro, NC MSA	113,329	-0.188	-0.286	-0.707	-0.764	-0.006	93	-0.179	228	-0.050	-0.121	203
Williamsport, PA MSA	120,044	-0.119	-0.288	-0.904	-1.014	-0.042	186	-0.125	184	-0.031	-0.122	204
Houma, LA MSA	194,477	-0.096	-0.296	-1.003	-1.152	-0.053	205	-0.107	161	-0.022	-0.122	205
Lynchburg, VA MSA	214,911	-0.135	-0.297	-0.902	-1.010	-0.038	179	-0.138	202	-0.036	-0.126	206
Mansfield, OH MSA	175,818	-0.102	-0.299	-1.000	-1.147	-0.055	207	-0.112	166	-0.027	-0.127	207
Longview--Marshall, TX MSA	208,780	-0.132	-0.306	-0.945	-1.066	-0.040	182	-0.137	200	-0.033	-0.127	208
Johnson City--Kingsport--Bristol, TN--VA MSA	480,091	-0.161	-0.310	-0.881	-0.979	-0.025	142	-0.160	218	-0.039	-0.127	209

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Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
St. Cloud, MN MSA	167,392	-0.099	-0.300	-1.012	-1.164	-0.058	210	-0.110	164	-0.027	-0.128	210
Wichita Falls, TX MSA	140,518	-0.231	-0.310	-0.691	-0.745	0.009	71	-0.215	237	-0.059	-0.128	211
Decatur, AL MSA	145,867	-0.057	-0.313	-1.181	-1.423	-0.078	236	-0.079	120	-0.011	-0.129	212
El Paso, TX MSA	679,622	-0.141	-0.308	-0.931	-1.046	-0.036	178	-0.144	206	-0.036	-0.129	213
non-metropolitan areas, NM	783,050	-0.211	-0.312	-0.755	-0.820	-0.001		-0.200		-0.053	-0.129	
Laredo, TX MSA	193,117	-0.220	-0.311	-0.724	-0.783	0.004	77	-0.207	235	-0.056	-0.129	214
non-metropolitan areas, GA	2,744,802	-0.124	-0.303	-0.956	-1.083	-0.046		-0.131		-0.034	-0.129	
Albany, GA MSA	120,822	-0.079	-0.307	-1.097	-1.289	-0.069	224	-0.095	145	-0.020	-0.130	215
Binghamton, NY MSA	252,320	-0.108	-0.295	-0.967	-1.100	-0.057	208	-0.117	170	-0.035	-0.131	216
Abilene, TX MSA	126,555	-0.239	-0.318	-0.702	-0.758	0.011	69	-0.223	238	-0.062	-0.132	217
non-metropolitan areas, IN	1,791,003	-0.095	-0.317	-1.093	-1.280	-0.063		-0.109		-0.024	-0.133	
Fort Smith, AR--OK MSA	207,290	-0.169	-0.334	-0.965	-1.086	-0.027	145	-0.170	223	-0.039	-0.135	218
non-metropolitan areas, VA	1,640,567	-0.158	-0.322	-0.944	-1.062	-0.035		-0.159		-0.043	-0.137	
non-metropolitan areas, OH	2,548,986	-0.099	-0.323	-1.112	-1.305	-0.065		-0.113		-0.026	-0.137	
Sharon, PA MSA	120,293	-0.145	-0.326	-0.994	-1.130	-0.042	188	-0.150	210	-0.038	-0.138	219
Duluth--Superior, MN--WI MSA	243,815	-0.085	-0.323	-1.151	-1.367	-0.073	231	-0.102	155	-0.023	-0.138	220
Lima, OH MSA	155,084	-0.087	-0.326	-1.157	-1.376	-0.072	230	-0.103	156	-0.023	-0.138	221
Florence, AL MSA	142,950	-0.125	-0.335	-1.088	-1.264	-0.052	201	-0.135	197	-0.029	-0.138	222
Alexandria, LA MSA	126,337	-0.167	-0.336	-0.978	-1.104	-0.032	162	-0.168	222	-0.041	-0.139	223
St. Joseph, MO MSA	102,490	-0.171	-0.335	-0.965	-1.087	-0.030	155	-0.171	224	-0.043	-0.139	224
Hattiesburg, MS MSA	111,674	-0.178	-0.346	-0.993	-1.123	-0.028	151	-0.178	227	-0.043	-0.142	225
Odessa--Midland, TX MSA	237,132	-0.117	-0.343	-1.146	-1.350	-0.061	215	-0.129	192	-0.029	-0.143	226
Beaumont--Port Arthur, TX MSA	385,090	-0.036	-0.343	-1.370	-1.747	-0.102	240	-0.065	101	-0.007	-0.144	227
Sumter, SC MSA	104,646	-0.183	-0.350	-0.994	-1.123	-0.030	156	-0.182	230	-0.047	-0.147	228
Utica--Rome, NY MSA	299,896	-0.115	-0.333	-1.108	-1.296	-0.067	220	-0.126	185	-0.037	-0.147	229
Decatur, IL MSA	114,706	-0.052	-0.344	-1.327	-1.663	-0.098	239	-0.078	119	-0.015	-0.148	230
non-metropolitan areas, PA	2,023,193	-0.128	-0.360	-1.191	-1.414	-0.063		-0.139		-0.033	-0.152	
non-metropolitan areas, IA	1,863,270	-0.181	-0.374	-1.104	-1.274	-0.037		-0.183		-0.044	-0.154	
Terre Haute, IN MSA	149,192	-0.117	-0.367	-1.249	-1.506	-0.070	226	-0.132	194	-0.030	-0.155	231
non-metropolitan areas, MN	1,565,030	-0.150	-0.365	-1.149	-1.345	-0.056		-0.157		-0.042	-0.157	
Altoona, PA MSA	129,144	-0.148	-0.372	-1.184	-1.397	-0.057	209	-0.157	216	-0.039	-0.157	232
Dothan, AL MSA	137,916	-0.177	-0.381	-1.142	-1.328	-0.042	190	-0.181	229	-0.044	-0.158	233
non-metropolitan areas, IL	2,202,549	-0.131	-0.369	-1.220	-1.457	-0.068		-0.143		-0.037	-0.159	
non-metropolitan areas, TN	2,123,330	-0.181	-0.393	-1.182	-1.386	-0.044		-0.185		-0.044	-0.162	
non-metropolitan areas, TX	4,030,376	-0.183	-0.407	-1.237	-1.467	-0.049		-0.188		-0.046	-0.170	
Danville, VA MSA	110,156	-0.154	-0.400	-1.286	-1.550	-0.065	218	-0.165	220	-0.041	-0.170	234
non-metropolitan areas, KS	1,366,517	-0.223	-0.410	-1.141	-1.317	-0.030		-0.220		-0.057	-0.171	
Jamestown, NY MSA	139,750	-0.138	-0.395	-1.309	-1.592	-0.077	235	-0.152	212	-0.043	-0.174	235
non-metropolitan areas, LA	1,415,540	-0.152	-0.420	-1.380	-1.704	-0.069		-0.165		-0.037	-0.175	
Joplin, MO MSA	157,322	-0.254	-0.418	-1.087	-1.240	-0.018	119	-0.246	241	-0.066	-0.175	236
non-metropolitan areas, SD	629,811	-0.267	-0.435	-1.125	-1.290	-0.011		-0.257		-0.063	-0.176	
Gadsden, AL MSA	103,459	-0.135	-0.426	-1.449	-1.831	-0.079	237	-0.152	213	-0.032	-0.177	237
Anniston, AL MSA	112,249	-0.186	-0.427	-1.314	-1.584	-0.054	206	-0.193	233	-0.046	-0.177	238
non-metropolitan areas, AR	1,607,993	-0.226	-0.437	-1.249	-1.474	-0.036		-0.225		-0.055	-0.180	
non-metropolitan areas, KY	2,828,647	-0.154	-0.432	-1.426	-1.781	-0.073		-0.168		-0.038	-0.180	
non-metropolitan areas, WV	1,809,034	-0.175	-0.444	-1.419	-1.760	-0.064		-0.186		-0.041	-0.183	
non-metropolitan areas, NE	878,760	-0.243	-0.451	-1.259	-1.485	-0.032		-0.240		-0.060	-0.186	

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

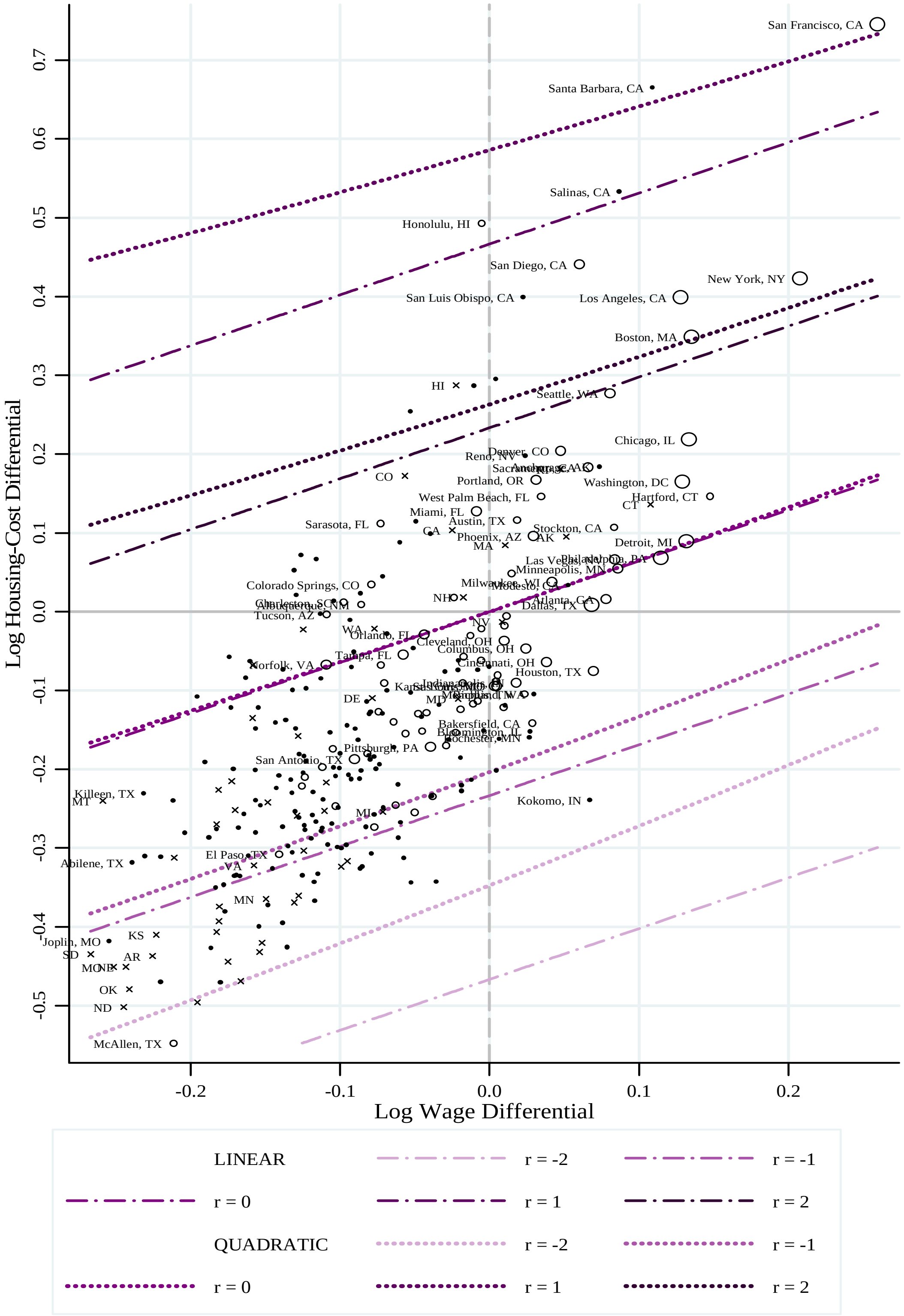
		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
non-metropolitan areas, MO	1,798,819	-0.251	-0.451	-1.237	-1.450	-0.031		-0.247		-0.065	-0.189	
non-metropolitan areas, AL	1,504,381	-0.166	-0.469	-1.550	-1.999	-0.079		-0.182		-0.040	-0.195	
Brownsville--Harlingen--San Benito, TX MSA	335,227	-0.220	-0.470	-1.404	-1.717	-0.053	203	-0.224	239	-0.056	-0.196	239
non-metropolitan areas, OK	1,862,951	-0.241	-0.479	-1.387	-1.684	-0.043		-0.242		-0.059	-0.198	
Johnstown, PA MSA	232,621	-0.180	-0.470	-1.518	-1.931	-0.076	234	-0.193	232	-0.047	-0.199	240
non-metropolitan areas, ND	521,239	-0.245	-0.502	-1.474	-1.826	-0.047		-0.247		-0.058	-0.205	
non-metropolitan areas, MS	1,869,256	-0.196	-0.496	-1.585	-2.049	-0.073		-0.208		-0.047	-0.205	
McAllen--Edinburg--Mission, TX MSA	569,463	-0.211	-0.548	-1.764	-2.417	-0.085	238	-0.226	240	-0.053	-0.229	241

Populations in non-metropolitan areas are approximate.

TABLE B: LIST OF STATES RANKED BY TOTAL AMENITY VALUE

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
State Name	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Hawaii	1,211,717	-0.010	0.431	1.877	1.555	0.159	1	0.038	10	-0.004	0.183	1
California	33,884,660	0.134	0.435	1.493	1.271	0.083	2	0.152	2	0.031	0.18	2
New Jersey	8,416,753	0.189	0.350	0.980	0.880	0.023	12	0.186	1	0.044	0.142	3
Massachusetts	6,353,449	0.103	0.277	0.901	0.815	0.043	7	0.111	4	0.024	0.114	4
Connecticut	3,408,068	0.153	0.244	0.624	0.574	0.005	19	0.147	3	0.036	0.099	5
Washington	5,894,780	0.030	0.165	0.625	0.565	0.043	8	0.042	9	0.007	0.069	6
New York	18,976,061	0.093	0.166	0.454	0.355	0.009	17	0.091	6	0.022	0.067	7
Colorado	4,300,832	-0.007	0.157	0.693	0.634	0.060	4	0.011	15	-0.002	0.067	8
District of Columbia	571,753	0.129	0.165	0.351	0.339	-0.011		0.120		0.031	0.066	
Alaska	626,187	0.059	0.127	0.382	0.366	0.013	16	0.060	7	0.014	0.052	9
Maryland	5,299,635	0.109	0.129	0.250	0.237	-0.013	27	0.100	5	0.026	0.051	10
Oregon	3,424,928	-0.042	0.089	0.497	0.461	0.054	5	-0.023	19	-0.011	0.039	11
Nevada	2,000,306	0.061	0.079	0.170	0.156	-0.005	23	0.056	8	0.014	0.031	12
New Hampshire	1,234,816	0.003	0.062	0.258	0.241	0.021	14	0.009	16	0	0.026	13
Rhode island	1,048,463	0.022	0.048	0.148	0.135	0.006	18	0.022	13	0.005	0.02	14
Arizona	5,133,711	-0.030	0.036	0.238	0.225	0.029	10	-0.020	18	-0.007	0.016	15
Illinois	12,417,190	0.045	0.013	-0.069	-0.158	-0.020	29	0.037	11	0.011	0.004	16
Delaware	783,216	0.046	-0.002	-0.137	-0.146	-0.026	32	0.036	12	0.011	-0.002	17
Florida	15,986,890	-0.065	-0.019	0.098	0.077	0.028	11	-0.053	26	-0.016	-0.006	18
Utah	2,230,835	-0.061	-0.047	-0.034	-0.040	0.016	15	-0.053	27	-0.015	-0.018	19
Virginia	7,080,588	-0.016	-0.051	-0.173	-0.214	-0.009	25	-0.018	17	-0.004	-0.021	20
Vermont	608,387	-0.158	-0.068	0.146	0.131	0.061	3	-0.132	37	-0.038	-0.024	21
Michigan	9,935,711	0.033	-0.080	-0.436	-0.493	-0.046	46	0.018	14	0.008	-0.035	22
New Mexico	1,818,615	-0.144	-0.119	-0.114	-0.165	0.035	9	-0.126	36	-0.034	-0.046	23
North Carolina	8,047,735	-0.073	-0.115	-0.290	-0.313	-0.002	22	-0.070	29	-0.017	-0.046	24
Georgia	8,186,187	-0.015	-0.125	-0.495	-0.554	-0.036	39	-0.026	20	-0.003	-0.053	25
Wisconsin	5,357,182	-0.054	-0.133	-0.419	-0.468	-0.018	28	-0.057	28	-0.013	-0.055	26
Minnesota	4,912,048	-0.024	-0.147	-0.565	-0.661	-0.039	42	-0.035	21	-0.005	-0.062	27
Ohio	11,353,531	-0.024	-0.148	-0.566	-0.637	-0.039	41	-0.035	22	-0.005	-0.062	28
Texas	20,848,171	-0.034	-0.155	-0.571	-0.664	-0.037	40	-0.044	24	-0.008	-0.065	29
Pennsylvania	12,275,624	-0.027	-0.161	-0.616	-0.706	-0.043	44	-0.039	23	-0.006	-0.068	30
South Carolina	4,013,644	-0.099	-0.177	-0.485	-0.531	-0.010	26	-0.097	30	-0.023	-0.072	31
Maine	1,275,357	-0.166	-0.188	-0.347	-0.371	0.022	13	-0.151	41	-0.04	-0.074	32
Indiana	6,081,521	-0.039	-0.185	-0.683	-0.792	-0.045	45	-0.051	25	-0.009	-0.077	33
Idaho	1,294,016	-0.143	-0.209	-0.500	-0.531	0.003	20	-0.135	38	-0.034	-0.084	34
Montana	902,740	-0.246	-0.242	-0.356	-0.380	0.047	6	-0.221	48	-0.059	-0.095	35
Tennessee	5,688,335	-0.100	-0.231	-0.713	-0.811	-0.028	35	-0.104	31	-0.023	-0.095	36
Missouri	5,595,490	-0.110	-0.245	-0.746	-0.844	-0.028	33	-0.113	33	-0.026	-0.1	37
Louisiana	4,469,586	-0.105	-0.251	-0.787	-0.929	-0.033	37	-0.110	32	-0.024	-0.103	38
Wyoming	493,849	-0.183	-0.270	-0.651	-0.698	0.002	21	-0.173	43	-0.043	-0.108	39
Iowa	2,923,345	-0.146	-0.300	-0.883	-1.008	-0.028	34	-0.148	40	-0.034	-0.123	40
Kansas	2,687,110	-0.138	-0.301	-0.910	-1.035	-0.033	38	-0.141	39	-0.032	-0.123	41
Alabama	4,446,543	-0.112	-0.309	-1.014	-1.231	-0.050	47	-0.121	34	-0.026	-0.127	42
Kentucky	4,040,856	-0.110	-0.321	-1.072	-1.312	-0.055	48	-0.122	35	-0.025	-0.133	43
Nebraska	1,709,804	-0.181	-0.329	-0.911	-1.054	-0.020	30	-0.178	44	-0.043	-0.134	44
Arkansas	2,672,286	-0.186	-0.346	-0.968	-1.118	-0.023	31	-0.184	45	-0.044	-0.141	45
Oklahoma	3,450,058	-0.186	-0.365	-1.051	-1.242	-0.030	36	-0.186	47	-0.044	-0.149	46
South Dakota	753,887	-0.249	-0.402	-1.033	-1.179	-0.009	24	-0.239	50	-0.059	-0.162	47
Mississippi	2,844,004	-0.164	-0.403	-1.275	-1.602	-0.055	49	-0.172	42	-0.038	-0.166	48
West Virginia	1,809,034	-0.175	-0.444	-1.419	-1.760	-0.064	50	-0.186	46	-0.041	-0.183	49
North Dakota	642,412	-0.230	-0.464	-1.354	-1.658	-0.041	43	-0.231	49	-0.054	-0.189	50

Figure A1: Linear versus Quadratic Inference of Land-Rent Differentials



Iso-rent curves based on calibration: phiL =.233333, phiN =.62, sigmaY =.66667