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ABSTRACT

Estimates of local land rents and firm productivity from wage and housing-cost data require incorporating 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 upgrade estimates of public-infrastructure values. Private land values vary mainly from quality-of-life differences, while social land (or total-amenity) values vary mainly from firm-productivity differences. The most valuable cities are generally coastal, sunny, and have large or well-educated populations.

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1 Introduction

David Ricardo (1817) firs explained how productivity differences in the "original and indestructible powers of the soil" are capitalized into land rents across sites. This insight was extended by George (1879), Tiebout (1956), Oates (1969), Arnott and Stiglitz (1979), and others to explain how the economic value of all local site characteristics, from climate to property taxes – broadly termed "amenities" – may be fully reflecte in the value of land. 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 fir costs, raising productivity. Estimates of amenity values based on land-rent differences are used to measure the incidence of taxes, the benefit of government spending, the costs of pollution, and other important economic prices.

The values of local amenities are also reflecte in the prices of goods other than land, such as housing, which is produced from land and other inputs. Across cities, values are reflecte in local wages, as firm may pay less in areas with consumption amenities and more in places with production amenities. Using duality theory, Roback (1982) 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, the third equation of this model, relating housing costs to local wage and land rents, has been ignored in applications, which have relied exclusively on a less realistic two-equation model that equates housing with land.[1] One reason for this is that data on land rents are rare, while data for housing costs are readily available.[2]

This paper demonstrates the importance of modeling the relationship between housing and land costs for valuing amenities across cities, taking into account three main phenomena. First, the cost-share of land in housing services is less than one, so that a 10-percent difference in local housing

[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) 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 the suburban sample of houses is representative, that housing productivity does not vary across metropolitan areas, and that there are no other costs, such as expenditures to overcome regulatory burdens, to producing housing other than construction and land costs. 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.

costs between two cities does not correspond to a 10-percent difference in land rents. Second, housing costs may be influence by from input prices other than land, such as labor. Third, natural and regulatory environments may cause housing production to vary in efficien y across cities, so that housing costs may be high relative to land values in cities with inefficien housing sectors.[3]

These issues arise in measures of local fir productivity – 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 Chen and Rosenthal (2008) – based on local factor costs.[4] In a competitive equilibrium with mobile firm that trade nationally, only cities with productive firm can maintain high factor costs. But in the two-equation model, these productivity estimates put too much weight on wages and too little on housing costs, and may be biased upwards where housing-productivity is low. Furthermore, without land-rent data, productivity improvements in the housing sector may be confused for productivity declines in the tradable sector.

The three-equation model neatly predicts how consumption and production amenities affect wages, housing costs, and land rents. 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-equation model is not amenable to. The calibrated model predicts that only a quarter of the value of consumption amenities is reflecte through lower wages, with the rest reflecte in higher housing costs. Amenities that lower the cost of tradable production may be overcapitalized into higher wages and housing costs, while amenities that lower the cost of housing production are reflecte in higher land rents but lower wages and housing costs.

An additional insight presented here – which builds upon Albouy (2009) – is that federal income taxes alter the close relationship between amenity values and private land values. Amenities that raise wages indirectly raise federal income tax liabilities. As a result, the social value of land and its amenities is understated by private land values in cities where wages are high. An amenity's

[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) but hte discussion ends there. 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 conflate with housing services.

full social value is determined by its effect on local land rents and federal tax revenues together: the latter exert a positive fisca externality on other areas. Because of how they influenc wages, production amenities for traded goods are effectively taxed and their values are undercapitalized into local land rents, while consumption amenities and production amenities for non-traded goods are effectively subsidized and their values are overcapitalized.

The theoretical insights from the expanded model are illustrated in three empirical applications. The firs revises estimates of the value of public infrastructure from Haughwout (2002) using the two-equation model. Improved estimates are over double Haughwout's originals, and raise the possibility that the marginal benefit of public infrastructure may exceed their marginal costs.

The second application estimates inter-metropolitan differences in land rents, firm-produc ivity, quality-of-life, and total amenity values – along with previously estimated differences in quality of life and federal-tax burdens – in the United States using Census data on wages and housing costs.[5] The relationships between these measures is interpreted clearly and appealingly through graphs. The unavailability of land-rent data is dealt with by assuming, unrealistically, that housing productivity is constant across cities. According to the calibration, this assumption should not heavily bias measures of productivity in the tradable sector, although it fails to capture land-rent variation due to housing productivity. Across cities, the standard deviations in the value of consumption and production amenities are 4.6 and 8.4 percent of income, respectfully. Yet, because of federal taxes, consumption amenities have a greater influenc on the distribution of land rents.

The third, more exploratory, application examines the cross-sectional relationship between individual amenities and measures from the second application. Tradable productivity increases with city size and education levels, in line with the estimates in the literature, and is strongly correlated with sunniness and proximity to a coast, but negatively correlated with hot climates. An index of residential land-use regulations is not significantl related to productivity. Households are effectively taxed for living in cities that are sunny, coastal, large, or well-educated. Amenities in these cities are under-valued by land rents, while hot, rural areas are over-valued.

[5] Quality-of-life and federal tax differences across cities are examined in much greater depth in Albouy (2008, 2009); land-rent, firm-product vity, and total-amenity-value measures are reported for the firs time here.

2 Model Set-up

To explain how prices vary with amenity levels across cities, I use the three-equation general equilibrium model of Albouy (2009), which adds federal taxes to the three-equation Roback (1980, 1982) model. 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 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 general 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. fla geography or the absence of land-use restrictions, $\partial\widetilde{A_Y}/\partial Z_k > 0$. It is possible that a single amenity affects more than one attribute, or affects an attribute negatively.

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 fi ed in supply in each city at L^j, and is paid a city-specifi price r^j. Capital, K, is fully mobile and is paid the price $\bar{\imath}$ everywhere. The supply of capital in each city is K^j, with the national level of capital fi ed at K_{TOT}, 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 fi ed at N^{TOT}, so $\sum_j N^j = N^{TOT}$. Households own identical diversifie 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, $m^j \equiv$

[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 C.5.

$R + I + w^j$, 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 in Appendix C.[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 $e(p^j, u; Q^j) \equiv \min_{x,y}\{x + p^j y : U(x, y; Q^j) \geq u\}$. Assume Q enters 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, firm 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 $c_X(r^j, w^j, \bar{\imath}; A_X^j) = c_X(r^j, w^j, \bar{\imath})/A_X^j$ where $c(r, w, i) \equiv c(r, w, i; 1)$.[9] A symmetric definitio holds for the unit costs in the home-good sector, c_Y. As markets are competitive, firm make zero profit in equilibrium, so that for given output prices, more productive cities must pay higher rents and wages to achieve

[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 fl ws 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 fi ed 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 sufficientl large subset of mobile marginal households (Gyourko and Tracy 1989). Appendix C.4 discusses how the model's predictions are affected with multiple household types with different preferences and labor skills.

[9] As shown in Appendix C.4 Non-Hicks-neutral productivity differences have similar impacts on relative prices across cities, but not on relative quantities.

zero profits Thus in equilibrium, the following conditions hold in all cities:

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

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

In the simplifie two-equation Roback-model, the last equation is reduced to $r^j = p^j$.

For households, denote the share of gross expenditures spent on traded goods and home goods as $s_x^j \equiv x^j/m^j$ and $s_y^j \equiv p^j y^j/m^j$; denote the shares of income received from land, labor, and capital income as $s_R^j \equiv R/m^j$, $s_w^j \equiv w^j/m^j$, and $s_I^j \equiv I/m^j$. For firms denote the cost shares of land, labor, and capital in the traded-good sector as $\theta_L^j \equiv r^j L_X^j/X^j$, $\theta_N^j \equiv w^j N_X^j/X^j$ and $\theta_K^j \equiv \bar{\imath} K_X^j/X^j$; denote equivalent cost shares in the home-good sector as ϕ_L^j, ϕ_N^j, and ϕ_K^j. Finally, denote the shares of land, labor and, capital used to produce traded goods as $\lambda_L^j \equiv L_X^j/L^j$, $\lambda_N^j \equiv N_X^j/N^j$, and $\lambda_K^j \equiv K_X^j/K^j$. Assume home goods are more cost-intensive in land relative to labor than traded goods, both absolutely, $\phi_L^j \geq \theta_L^j$, and relatively, $\phi_L^j/\phi_N^j \geq \theta_L^j/\theta_N^j$, implying $\lambda_L^j \leq \lambda_N^j$.

3 Relating Rents, Wages, Housing Costs, and Productivity

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 are continuous variables. The equilibrium conditions (1), (2), and (3) implicitly defin 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-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, $\hat{z}^j = \ln z^j - \ln \bar{z} \cong (z^j - \bar{z})/\bar{z}$, 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-orde 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), emphasized here, 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 firm 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, $\hat{Q}^j$, is still identified but trade-productivity, $\hat{A}_X^j$, and home-productivity, $\hat{A}_Y^j$, are not identifie separately without a restriction on them, land rents, or the relationship between these three variables.

Amenities may be endogenous, but this poses different problems for measurement than for the prediction of general-equilibrium effects. For example, say that increasing the population, N^j, leads to pollution, lowering Q^j. If a city receives a theme-park, improving Q, this will attract migrants, raising N and indirectly lowering Q through pollution. Yet, price data alone may be used to measure the value of the theme-park by controlling for pollution or population, as wells as to measure the overall quality of life, regardless of the endogenous population effects.

3.2 Inferring Land Rents

As land rents are typically unobserved it is worth considering how land-rent differences may be inferred from wage and housing-cost differences. Solving (4c) for the land-rent differential:

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

Thus, land-rent differentials differ from housing-cost differentials through 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. Holding other prices constant, cities with greater home-productivity have higher rents.

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. $\hat{A}_Y^j = 0$, for all j. This assumption causes land rents to be overestimated in cities with low home-productivity. Previous studies that equate housing with land implicitly assume $\phi_L = 1$, $\phi_N = 0$, and $\hat{A}_Y^j = 0$ for all j.[10]

3.3 Inferring Productivity

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

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

[10] Estimates based on a quadratic approximation of (3), using partial elasticities of substitution, are presented in Appendix B, although this refinemen matters little in application.

This differs from the formula in previous studies, $\hat{A}_X^j = \theta_L \hat{p}^j + \theta_N \hat{w}^j$, through the same effects:

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

Labor-cost effect Wage differentials are weighted 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 $\hat{p}^j$.

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.[11]

4 The Capitalization of Amenity Values into Prices

4.1 Capitalization without Federal Income Taxes

The effects of 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). To make it easier to compare equations, each differential is multiplied by its share of income, so that the equations

[11] To cement intuition, it is helpful to consider two extreme cases between which the correct measure lies. In the firs case, traded goods are made without land, i.e. $\theta_L = 0$, and so trade-productivity is given by the wage level alone, $\hat{A}_X^j = \theta_N \hat{w}^j$. This case, commonly assumed, appears to be reasonable as θ_L in modern production is small. But the variation in $\hat{p}^j$, and more fundamentally $\hat{r}^j$, may be large relative to the variation in $\hat{w}^j$, so that it provies substantial additional information about $\hat{A}_X^j$. Furthermore, with housing costs in equation (6), it is the ratio θ_L/ϕ_L that matters, and this ratio may be much larger than θ_L if ϕ_L is small. 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 is given by home-good prices since they reflec the input costs of traded-good firm exactly. But then, trade-productivity differences are perfectly confounded by home-productivity, which lowers home-good prices in the same proportion that trade-productivity raises them.

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

$$s_R \hat{r}_0^j = \frac{l^j dr^j}{m} = \hat{Q}^j + s_x \hat{A}_X^j + s_y \hat{A}_Y^j \equiv \hat{\Omega}^j \tag{7a}$$

$$s_w \hat{w}_0^j = \frac{dw^j}{m} = -\frac{\lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N} s_x \hat{A}_X^j - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y^j \tag{7b}$$

$$s_y \hat{p}_0^j = \frac{y^j dp^j}{m} = \frac{\lambda_N - \lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N} s_x \hat{A}_X^j - \frac{\lambda_L}{\lambda_N} s_y \hat{A}_Y^j \tag{7c}$$

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 (7a) is obtained by summing up (4a), s_x times (4b), and s_y times (4c), and simplifying, causing the terms multiplying $\hat{w}^j$ and $\hat{p}^j$ to equal zero. This equation expresses the canonical result that land values completely capture the value of amenity differences, denoted $\hat{\Omega}^j$, reflecte in quality of life, trade-productivity, and home-productivity, each weighted by its contribution to household welfare.[12]

By the zero-profi condition for traded-good firms (4b), wage differences compensate firm for rent and 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 (7b). Thus, wages rise with trade-productivity but fall with quality-of-life and home-productivity. With traded-goods relatively labor-intensive, $\lambda_N > \lambda_L$, wages negatively capitalize the value of consumption and home-production amenities by less than 100 percent. Wage positively capitalize the value of trade-production amenities by over 100 percent if the fraction of land in home goods, $1 - \lambda_L$, is greater than λ_N.[13]

By the mobility condition (4a), home-good price differences compensate for wage and quality-

[12]The linearized version of (7a) 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.

These expressions differ from the ones in Albouy (2009) because the are expressed in terms of the differential value relative to all income, and use factor fractions, λ, rather than cost shares, θ and ϕ.

[13]The term $1/\lambda_N = 1/[1-(1-\lambda_N)] = \sum_k^\infty (1-\lambda_N)^k$, expresses a multiplier effect, accounting 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, firm 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.

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 (7c). Hence, consumption amenities are undercapitalized into local home-good values, while trade-production amenities may be overcapitalized. Home-good prices *negatively,* albeit partially, capitalize the value of home-production amenities.[14]

4.2 Accounting for Federal Taxes

Federal taxes on labor income change the capitalization process so that land rents no longer fully reflec amenity values. Rewriting the mobility condition (4a) as $s_w\hat{w}^j - s_y\hat{p}^j = \tau' s_w\hat{w}^j - \hat{Q}^j$ states that differences in pre-tax real incomes compensate for higher federal taxes or lower quality of life. Expressing the federal tax differential, $d\tau^j/m \equiv \tau' s_w\hat{w}^j$, as a fraction of total income, it has an effect identical to $-\hat{Q}^j$. Federal tax differentials are driven by local wages, which depend on amenities. Wage differentials with taxes, $\hat{w}^j$, are a multiple of those without taxes, $\hat{w}_0^j$, as seen by using the fact that federal tax burdens are like a consumption disamenity in equation (7b):

$$s_w\hat{w}^j = s_w\hat{w}_0^j + \frac{\lambda_L}{\lambda_N}\overbrace{\tau' s_w\hat{w}^j}^{d\tau^j/m} = \frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}s_w\hat{w}_0^j \tag{8}$$

Thus, as federal taxes are higher in cities with higher wages according to equation (7b), they are higher in cities with higher trade-productivity, lower quality-of-life, and lower home-productivity:

$$\frac{d\tau^j}{m} = \tau' s_w\hat{w}^j = \tau'\frac{1}{1-\frac{\lambda_L}{\lambda_N}\tau'}\overbrace{\left(-\frac{\lambda_L}{\lambda_N}\hat{Q}^j + \frac{1-\lambda_L}{\lambda_N}s_x\hat{A}_X^j - \frac{\lambda_L}{\lambda_N}s_y\hat{A}_Y^j\right)}^{s_w\hat{w}_0^j} \tag{9}$$

Dividing (9) by τ' gives the counterpart to (7b) with taxes: the capitalization of any amenity into wages is simply augmented by the factor $1/\left(1-\tau'\lambda_L/\lambda_N\right) > 1$.

Since higher federal taxes are capitalized into prices in the same way as lower quality of life,

[14]Roback (1982, p. 1265) reports a linear analogue to equation (7c) 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.

substituting (9) into (7a) describes how amenities are capitalized into land values with taxes:

$$s_R \hat{r}^j = s_R \hat{r}_0^j - \frac{d\tau^j}{m} = \frac{1}{1 - \frac{\lambda_L}{\lambda_N}\tau'} \left[\hat{Q}^j + \left(1 - \frac{1}{\lambda_N}\tau'\right) s_x \hat{A}_X^j + s_y \hat{A}_Y^j \right] \tag{10}$$

The last expression implies that consumption and home-production amenities are capitalized by more than their value, as they lower federal taxes, while trade-production amenities are capitalized less, as they raise federal taxes. Capitalization into home-good prices is then

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

Federal taxes increase how much home goods capitalize consumption amenities and decrease how much they capitalize production amenities.[15]

4.3 The Total Value of Amenities

Rearranging the firs equality of (10), differences in the total 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, $d\tau^j/m$:

$$\hat{\Omega}^j = s_R \hat{r}^j + \frac{d\tau^j}{m} = s_R \hat{r}^j + \tau' s_w \hat{w}^j \tag{12}$$

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 through wages must be added to its effect on land rents to obtain its full value.

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

[15] The tax system is complicated by deductions for owner-occupied housing and state taxes, which exhibit a federal-like component in so far as wages vary within states. These complications are incorporated, but not discussed, as they are lengthy while their effects are generally small – Appendix C and Albouy (2009) contain more detail.

of (12) can be obtained by substituting in (5) to obtain an expression for $\hat{\Omega}^j$:

$$\hat{\Omega}^j = \frac{s_R}{\phi_L}\hat{p}^j + \left(\tau' s_w - \frac{s_R \phi_N}{\phi_L}\right)\hat{w}^j + \frac{s_R}{\phi_L}\hat{A}_Y^j = \frac{1}{1-\lambda_L}\left\{ s_y(\hat{p}^j + \hat{A}_Y^j) + \left[\tau'\left(1-\lambda_L\right) - \left(1-\lambda_N\right)\right] s_w \hat{w}^j \right\} \tag{13}$$

Unlike in (5), it is theoretically ambiguous whether wage-levels enter negatively into (13) as the negative labor-cost effect, $-\left(1-\lambda_N\right)$, is countered by a positive federal-tax effect, $\tau'\left(1-\lambda_L\right)$.

5 Applying the Model

5.1 Calibration

The theoretical model may be applied by calibrating the parameter values at the national level. Because of accounting identities, only six parameters are free, but choosing these requires reconciling slightly conflictin sources.

Starting with 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).[16]

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

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

$s_y = s_{hous} + s_{oth} b = 0.22 + 0.56 \times 0.26 = 36$ percent. This leaves s_x at 64 percent.

The cost shares are chosen to be consistent with the expenditure and income shares above. θ_L appears small: Beeson and Eberts (1986) use a value of 0.027, while Rappaport (2008) uses a value of 0.016. Valentinyi and Herrendorff (2008) estimate the land share of tradeables at 4 percent, although their definitio of tradeables differs from the one here. A value of 2.5 percent for θ_L is used here. Following Carliner (2003) and Case (2007), the cost-share of land in home-goods, taken as housing, 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 the cost and expenditure shares imply λ_L is 17 percent and s_R is 10 percent, consistently. This appears reasonable since the remaining 83 percent of land for home goods includes all residential land and much commercial land.[17] The one remaining choice determines the cost shares of labor and capital in both production sectors. As separate information on ϕ_K and θ_K, is unavailable, 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.[18]

The federal tax rate is set at 33.3 percent. Details on this tax rate, as well as the rates chosen for state taxes and housing deductions are discussed in Appendix C.3.

5.2 Predicted Capitalization Effects

With the calibrated parameter values, the capitalization formulas in section 4 predict exactly how amenity values are capitalized into local prices. Table 1 reports how a one-dollar increase in the

[17]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) fin 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, find 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.

[18]The cost shares of $\phi_L = 0.233$ and $\phi_N = 0.62$ are very close and statistically indistinguishable from preliminary cost-function estimates of (4c) in Albouy and Ehrlich (2010) using land-value data from CoStar and housing-cost and construction-wage data from the American Community Survey in a limited cross-section of U.S. metro areas for the years 2006 to 2008.

local value of quality of life, trade-productivity, or home-productivity affects the value of local land rents, wages, housing costs, federal taxes or total amenities. The coefficient in Table A ignore federal taxes, as in (7), while the coefficient in B account for THEM, as in (9), (10), (11), and in addition, state taxes and the deductibility of housing expenditures.

In the tax-free numbers, land rents reflec dollar-for-dollar the economic value of amenities whether they affect households or firms Three quarters of quality-of-life values are capitalized into higher home-good prices, with the remaining quarter reflecte in lower local wages. Wages and home-good prices overcapitalize the value of trade-production amenities by 19 percent. Home-production amenities worth one dollar lower the costs of labor and home goods by 23 cents.

In Panel B, the incidence of federal taxes on cities may be understood by observing how amenities affect the tax differential. Most importantly, trade-production amenities are effectively taxed at a rate of 37 percent, since these have a powerful effect on wages. As a result, land rents capitalize only 63 percent, and home-good prices, 91 percent, of the value of production amenities, while wages capitalize a higher 128 percent to compensate for the greater tax burden. On the other hand, consumption amenities are subsidized at a rate of 19 percent, and home-production amenities at a rate of 8 percent, which is captured in higher land rents and home-good prices.[19]

5.3 Reassessing the Value of Public Infrastructure

Haughwout (2002) estimates the marginal benefi 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 for these cities 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). His method equates housing values with land values: the estimated effect of public infrastructure on housing values, measured in percentage terms, is multiplied by average land values to determine the infrastructure's value. This method ignores the land-share,

[19] Tax deductions increase the subsidization of consumption amenities since these raise the cost of housing, and with it the value of the deduction. Deductions reduce the subsidization of home-production amenities, since these decrease housing costs and the value of the deduction.

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 regression estimates in panel A are based on repeated cross-sections that control for natural amenities, including climate, and local taxes and services; the less precise estimates in panel B control for state and year effects. The inferred values of a dollar of public infrastructure are in column 5, with columns 3 and 4 separating the values for households and fir s. In Panel A, public infrastructure is valued at 60 cents per dollar of cost, with 39 cents going to households and 21 cents going to firms The values in Panel B is only 30 cents on the dollar, representing 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 regression estimates, but recalculate the values using the richer calibrated model here.[20] The revised values are larger than the originals by 128 percent: in Panel A the marginal value of a dollar of public infrastructure is \$1.37, which may passes a cost-benefi test if the marginal cost of public funds is sufficientl low. In Panel B, the estimate is \$0.68, still falling short of even the \$1 benchmark, albeit not statistically at a significan level. The revised value estimates are higher mainly from correcting for the land-share effect; the labor-cost effect is small as public infrastructure has little effect on wages, and hence also on federal tax revenues. In the revised estimates, most of the benefit accrue to households. The reported estimates may be too low, as they ignore spillover effects to jurisdictions outside of where the infrastructure is located.[21]

[20]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, this produces a total income value of \$119, 965 million, creating revised estimates that are an additional 72 percent higher. To be conservative, and since land values are likely to be a larger source of income in central cities, these higher values are not presented.

[21]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.

6 Valuing Amenities across U.S. Cities

6.1 Data and Wage and Housing-Cost Differentials

Wage and housing-cost differentials are estimated with the 5 percent sample of Census data from the 2000 Integrated Public Use Microdata Series (IPUMS). Cities are define 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 classificatio 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 D. The entire 5 percent Census sample, guaranteeing that the wage and price differentials are precise: the average metro has 14,199 wage and 11,119 housing-cost observations; the smallest 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. 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 the equation $\ln w_{ij} = X_{ij}^w \beta^w + \mu_j^w + \varepsilon_{ij}^w$. Estimates of μ_j^w are used as the wage differentials, 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 for a city will bias trade-productivity upwards and quality of life downwards.

Both housing values and gross rents, including utility costs, 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 fl xible 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 coefficient ν^j are used as housing-cost differentials. Proper identificatio of housing-cost differences requires that average unobserved housing quality does not vary systematically across cities. An overstated price differential will bias both trade-productivity and quality of life upwards.[22]

Amenity data are taken from various sources, and may be divided into two categories. The firs involves natural site-specifi 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 involves amenities that depend on a city's inhabitants. Only three types of artificia "amenities" are included here. The firs 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.

[22] 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.

6.2 Land-Rent, Productivity, and Total-Value Measures

Land-rent, trade-productivity, and quality-of-life differentials are inferred from observed wage and housing-cost differentials using equations (5) (4a), (6), (13), calibrated with the parameters from Section 5.1, and adjusted further for housing deductions and average state taxes.[23] This yields the following numerical relationships for what is termed the "adjusted" model:

$$\hat{r}^j = 4.29\hat{p}^j - 2.75\hat{w}^j \ (+4.29\hat{A}_Y^j) \tag{14a}$$

$$\hat{Q}^j = 0.32\hat{p}^j - 0.49\hat{w}^j \tag{14b}$$

$$\hat{A}_X^j = 0.11\hat{p}^j + 0.79\hat{w}^j \ (+0.11\hat{A}_Y^j) \tag{14c}$$

$$\hat{\Omega}^j = 0.39\hat{p}^j + 0.01\hat{w}^j \ (+0.39\hat{A}^j) \tag{14d}$$

The terms in parentheses give the bias that results from not identifying home-productivity differences, a result of not having independent data on land rents. Places with high home-productivity have their inferred land rents and trade-productivity biased downwards, although numerically the bias is more severe with rents. The total amenity values are biased mainly by omitting home-productivity, but offer a fairly good estimate of the combined value of other amenities.

The relationships in 14 differ substantially from those typical of the previous literature (e.g. Beeson and Eberts, 1989), based on the two-equation, or "unadjusted," model, which 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 formulae:

$$\hat{r}^j = \hat{p}^j \tag{15a}$$

$$\hat{Q}^j = 0.25\hat{p}^j - \hat{w}^j \tag{15b}$$

$$\hat{A}_X^j = 0.025\hat{p}^j + 0.825\hat{w}^j \tag{15c}$$

[23] The actual formulas are more complex and differ by state. The simplifie formulas presented are close approximations based on regression estimates.

This unadjusted does not obey the standard income identities, as it assumes that land and capital income are paid to non-resident owners. Thus, there is no clear analogue to $\hat{\Omega}^j$, although the value of amenities as a fraction of resident income is $0.27\hat{p}^j$.

The two numerical models are illustrated using graphs in Figures 1A and 1B, with wages and housing costs on the axes. Each draws an iso-rent curve across cities with average rent, a mobility condition across cities with average quality of life, and a zero-profi condition across cities with average productivity.

In the adjusted model the slope of the iso-rent curve is positive, illustrating the labor-cost effect, as higher wage levels increase the cost of housing. The land-share effect is illustrated with the second, thinner, iso-rent curve, corresponding to a rent-differential of 0.25: in the unadjusted model, this curve intercepts the housing-cost axis at 0.25; in the adjusted model, it intercepts the axis at 0.0575.

The mobility condition slopes upward at the rate at which housing costs must increase as wage levels increase to keep households indifferent. As explained in Albouy (2008), the slope in the adjusted model is flatte to account for federal taxes, non-housing costs, and non-labor income.

The slope of the zero-profi 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 firm to break even. The adjusted model has a flatte slope since the land-share and labor-cost effects make inferred land rents drop more rapidly than housing costs.

Iso-value curves, 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 (13) are of opposite and almost equal size in the calibration.[24]

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

[24] If land rents are put on the vertical axis instead of housing costs, the labor-cost effect would disappear and the iso-value curve would unambiguously slope downward for $\tau' > 0$.

in Figure 1A to make the calculation of these values 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 far more important for inferring land rents than the labor-cost effect. With wages and housing costs positively correlated, the labor-cost effect tends to f atten the observed land-rent/housing-cost gradient.

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

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. The values are also reported by Census region and city population size. A list of all cities and non-metro areas of states is in Appendix Table A1; aggregate state values are in Appendix Table

A2.

The most valuable metropolis in the United States is the San Francisco Bay Area, as it combines the fourth highest quality-of-life with the very highest trade-productivity. This is followed by a number of smaller, resort-like, but economically vibrant cities, including 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 68 times more valuable than an acre in McAllen, TX, which has the lowest land value of all cities, and that an urban acre in the most valuable state, Hawaii, is worth 24 times an urban acre in the least valuable state, North Dakota.

6.4 The Variation of Prices and Amenities across Cities

Variation in housing costs, wages, and land rents across cities ultimately stem from variation in quality of life and fir productivity. For example, using (7a), that variation in total amenity values can be decomposed as

$$var(\hat{\Omega}^j) = var(\hat{Q}^j) + s_x^2 var(\hat{A}_X^j) + 2s_x cov(\hat{Q}^j, \hat{A}_X^j) \tag{16}$$

From this formula, one can assess whether the variance in total amenity values is due primarily to quality-of-life or productivity differences, an issue of considerable interest. This is done by comparing the two variance terms, since if the variance of either attribute is set to zero, the covariance term also collapses to zero. This analysis takes the attributes as fi ed, and is therefore better for measurement purposes than for determining how an exogenous change in the amenity distribution would change land rents. Such a change could be subject to feedback effects from population fl ws and the like, as discussed above. For instance, a higher quality-of-life will attract workers, who may increase trade-productivity through greater agglomeration economies.[25]

Results of the decomposition are in Table 4. Panel A, which accounts for the effect of federal taxes, is meant to reflec reality. It reveals that while both quality of life and productivity each play large roles in determining land rents, quality-of-life is slightly more important. On the other hand, productivity variation is clearly more important in determining overall values. This is seen in Figure 4, which is scaled so that quality-of-life and productivity differences of equal distance have equal value: 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. A similar decomposition reveals that wage variation – and with it, tax variation – is driven almost entirely by productivity. Housing-cost differences are influence somewhat by quality-of-life, but much more by productivity.

Panel B presents a counter-factual distribution of rents, wages, and housing-costs if federal taxes were made geographically neutral, but amenities across areas remained fi ed. It shows that productivity differences would become even more important in the determination of land rents and housing costs.[26]

6.5 Relationship between Measures and Observed Amenities

The last empirical exercise considers the relationship between amenity measures and the measured differentials. This involves running several regressions, beginning with regressions of wages and

[25] 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.

[26] 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 difficul ascertain precisely given limitations of the model in dealing with quantities.

housing costs on a vector of amenities $(Z_1^j, ...Z_K^j)$:

$$\hat{p}^j = \sum_k Z_k^j \pi_{kp} + \varepsilon_p^j, \ \hat{w}^j = \sum_k Z_k^j \pi_{kw} + \varepsilon_w^j \tag{17}$$

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

$$\hat{Q}^j = \sum_k Z_k^j \pi_{kQ} + \varepsilon_p^j, \ \hat{A}_X^j - \hat{A}_Y^j \frac{\theta_L}{\phi_L} = \sum_k Z_k^j \pi_{kA} + \varepsilon_A^j \tag{18}$$

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 a residential land-use regulation variable as a control. Similarly, local land values, federal revenues, and total amenity values can then be regressed on the amenities

$$\hat{r}^j - \hat{A}_Y^j \frac{1}{\phi_L} = \sum_k Z_k^j \pi_{kR} + \varepsilon_R^j, \ \frac{d\tau^j}{m} = \sum_k Z_k^j \pi_{k\tau} + \varepsilon_\tau^j \tag{19}$$

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, for total amenity values

$$\hat{\Omega}^j - \hat{A}_Y^j \frac{s_R}{\phi_L} = \sum_k Z_k^j \pi_{\Omega R} + \varepsilon_\Omega^j \tag{20}$$

which includes a similar bias component. The coefficien $\pi_{\Omega\tau}$ gives the full economic value of a one-unit increase in amenity k.[27]

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. Nevertheless, the amenity variables explain a large fraction of the observed variation

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

and the results are stimulating.

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-product vity, and economic value with respect to population size are 5.3, 4.9, and 2.7 percent, respectively, consistent with those surveyed in Rosenthal and Strange (2004) and Melo et al. (2009). Furthermore, greater population size is only mildly associated with a 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 finding in Moretti (2004), based on more rigorous methods. The corresponding number for quality of life is 3.8 percent. High human-capital levels appear to contribute as much to quality of life as they do to productivity, reinforcing finding in Shapiro (2006) based on instrumental-variable estimates in a panel of cities.

The coefficien on the regulatory land-use index in the productivity regression is small and insignificant suggesting that home-productivity differences are not seriously biasing estimates.

Also novel are the estimated relationships between the natural amenity variables and productivity, which show that sunshine and coastal proximity may have substantial effects on fir productivity. The coastal effect may be explained through lower transportation costs. The effects of sunshine are striking and could be biological, although this speculation deserves further examination. Hot summers, as measured through cooling-degree days, appears to be bad for productivity, perhaps lending credence to Montesquieu (1752) old theory that heat inhibits 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). Yet, the magnitude of this estimate in the presence of modern, inexpensive, air-conditioning raises questions about the estimate's validity, although it is robust to the latitude control shown.

Overall, population size, education level, sunshine, and coastal proximity appear to be benefi cial 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.[28]

The distribution of amenity value differences between local land rents and federal-tax payments is 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 cities that are large, well-educated, sunny, or near the coast, while it subsidizes life in hot places. The adjustment for federal taxes is particularly important for human capital and city size. High population levels are so heavily taxed that cities may to be too small, rather than too large, contrary to many theoretical arguments (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, especially if local-housing productivity is not an important confounding factor. Inferred local land rents may be combined with federal tax revenue estimates to determine the full value of a city's amenities. This includes amenities to firms which raise incomes, and amenities to households, which do not. The richer accounting provides a fuller and more accurate technique to value social investments, such as in infrastructure. Furthermore, actual data on land rents would make amenity-value estimates more accurate, and help distinguish amenities help produce tradeable goods from ones that help produce non-tradeables.

The analysis above raises several further thoughts. First, cities may exhibit cross-city externalities other than through federal taxes. For instance, Glaeser and Kahn (2008) fin that cities differ largely in the carbon they emit: cities that emit less carbon per capita are of greater value to society,

[28] Using more geographically disaggregated data, Albouy et al. (2010) fin that the effects of climate on productivity are not robust to controlling for state fi ed effects. Admittedly, state controls do eliminate much of the climate variation available in the data. The impact of climate on quality of life impacts is quite robust to many controls. Estimates of these impacts, and related measures of welfare costs from climate chnage are explored in this paper.

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 where amenities are abundant, federal tax payments are high, and carbon emissions are low. Finally, the static spatial model of local labor markets here may help to develop a foundation for a dynamic model for how household location decisions may 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

	Increase in Value from a One-Dollar Increase in Amenity Value		
Amenity Type	Quality of Life	Trade Productivity	Home Productivity
	(1)	(2)	(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	1.19	0.63	1.07
Wages	-0.27	1.28	-0.24
Home-Good Prices	0.92	0.91	-0.17
Federal Tax Payment	-0.19	0.37	-0.07

Panel A is based on formulas (7a), (7b), and (7c) using $s_R = 0.10$, $s_w = 0.75$, $s_x = 0.64$, $s_y = 0.36$, $\lambda_L = 0.17$, $\lambda_N = 0.704$. Panel B is based on formulas (9), (10), and (11) with $\tau' = 0.333$, but also accounts for average state taxes and deductions for housing.

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	1.10	0.26	1.37	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	0.68	0.00	0.68	-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	0.26	0.75	2.48	0.11	0.29	0.05	0.30
Santa Barbara, CA	399,347	0.11	0.67	2.56	0.16	0.16	0.00	0.26
Salinas, CA	401,762	0.09	0.53	2.05	0.13	0.13	0.00	0.21
Honolulu, HI	876,156	-0.01	0.49	2.13	0.17	0.05	-0.02	0.20
San Diego, CA	2,813,833	0.06	0.44	1.72	0.11	0.10	0.00	0.17
New York, NY	21,199,865	0.21	0.42	1.24	0.03	0.21	0.04	0.17
Los Angeles, CA	16,373,645	0.13	0.40	1.36	0.07	0.14	0.02	0.16
Boston, MA	5,819,100	0.14	0.35	1.12	0.05	0.15	0.03	0.14
Seattle, WA	3,554,760	0.08	0.28	0.97	0.05	0.09	0.01	0.11
Chicago, IL	9,157,540	0.14	0.22	0.56	0.00	0.13	0.03	0.09
Denver, CO	2,581,506	0.05	0.20	0.75	0.05	0.06	0.01	0.08
Portland, OR	2,265,223	0.03	0.17	0.63	0.04	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	-0.01	0.05
Phoenix, AZ	3,251,876	0.03	0.10	0.33	0.02	0.04	0.01	0.04
Detroit, MI	5,456,428	0.13	0.09	0.02	-0.04	0.12	0.04	0.04
Philadelphia, PA	6,188,463	0.12	0.07	-0.03	-0.04	0.10	0.03	0.03
Minneapolis, MN	2,968,806	0.09	0.06	-0.01	-0.02	0.08	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	-0.16	-0.03	0.06	0.02	0.00
Cleveland, OH	2,945,831	0.01	-0.04	-0.19	-0.02	0.01	0.01	-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	0.01	-0.04
Pittsburgh, PA	2,358,695	-0.04	-0.17	-0.64	-0.04	-0.05	-0.01	-0.07
Census Division								
Pacific	45,042,272	0.10	0.36	1.28	0.07	0.12	0.02	0.14
New England	13,928,540	0.07	0.18	0.59	0.02	0.07	0.01	0.07
Middle Atlantic	39,668,438	0.08	0.11	0.25	-0.01	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	-0.07	-0.21	-0.68	-0.03	-0.08	-0.01	-0.08
West North Central	19,224,096	-0.11	-0.25	-0.78	-0.03	-0.12	-0.02	-0.10
East South Central	17,019,738	-0.12	-0.30	-0.96	-0.04	-0.12	-0.02	-0.12
MSA Population								
MSA, Pop > 5 Million	81,606,427	0.16	0.32	0.95	0.03	0.16	0.03	0.13
MSA, Pop 1.5-4.9 Million	55,543,090	0.03	0.05	0.12	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	-0.02	-0.14	-0.03	-0.11
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	0.884	0.334	0.317	0.349
Wages	0.018	0.015	1.123	-0.138
Housing Costs	0.085	0.160	0.529	0.311
Tax Differential	0.001	0.093	1.267	-0.367
Total Value	0.013	0.158	0.532	0.310
Panel B: Federal Taxes Geographically Neutral				
Land Rents	1.333	0.158	0.532	0.310
Wages	0.016	0.012	1.112	-0.123
Housing Costs	0.117	0.083	0.666	0.251
Tax Differential	0.000	.	.	.
Total Value	0.013	0.158	0.532	0.310

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	Wage	Quality of Life	Trade Productivity	Local Land Rents	Federal Tax Payment	Economic Value
			(1)	(2)	(3)	(4)	(5)	(6)	(7)
Logarithm of Population	14.85	1.36	0.067***	0.053***	-0.005*	0.049***	0.014***	0.013***	0.027***
			(0.012)	(0.004)	(0.003)	(0.005)	(0.004)	(0.001)	(0.005)
Percent of Population College Graduates	0.19	0.04	1.931***	0.523***	0.375***	0.620***	0.683***	0.088*	0.772***
			(0.509)	(0.194)	(0.115)	(0.197)	(0.182)	(0.046)	(0.204)
Whartron Residential Land-Use Regulatory Index (WRLURI)	0.31	0.84	0.005	-0.002	0.002	-0.001	0.003	-0.001	0.002
			(0.013)	(0.006)	(0.004)	(0.005)	(0.005)	(0.002)	(0.005)
Heating-Degree Days (1000s)	4.24	2.02	-0.050***	-0.006	-0.013***	-0.010	-0.020***	0.000	-0.020***
			(0.012)	(0.009)	(0.003)	(0.008)	(0.004)	(0.002)	(0.005)
Cooling-Degree Days (1000s)	1.32	0.93	-0.120***	-0.022*	-0.027***	-0.031**	-0.045***	-0.001	-0.047***
			(0.025)	(0.013)	(0.006)	(0.012)	(0.008)	(0.003)	(0.010)
Sunshine (percent possible)	0.61	0.09	1.150***	0.237***	0.257***	0.311***	0.427***	0.028	0.456***
			(0.201)	(0.087)	(0.061)	(0.081)	(0.079)	(0.022)	(0.078)
Precipitation (10s of inches)	3.90	1.32	0.005	0.004	-0.001	0.004	0.001	0.001	0.002
			(0.013)	(0.004)	(0.004)	(0.004)	(0.005)	(0.001)	(0.005)
Latitude (degrees)	37.70	4.90	0.010***	0.005	0.001	0.005	0.003**	0.001	0.004***
			(0.004)	(0.004)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)
Close to Coast (Ocean or Great Lake)	0.60	0.49	0.123	0.015	0.031	0.025	0.049	-0.001	0.047
			(0.023)	(0.011)	(0.007)	(0.010)	(0.009)	(0.003)	(0.009)
Constant			-2.058	-1.128	-0.117	-1.111	-0.572	-0.256	-0.828
			(0.338)	(0.129)	(0.093)	(0.124)	(0.130)	(0.031)	(0.130)
R-squared			0.89	0.85	0.71	0.88	0.86	0.79	0.89

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

Figure 1A: Adjusted Model

(This Research)

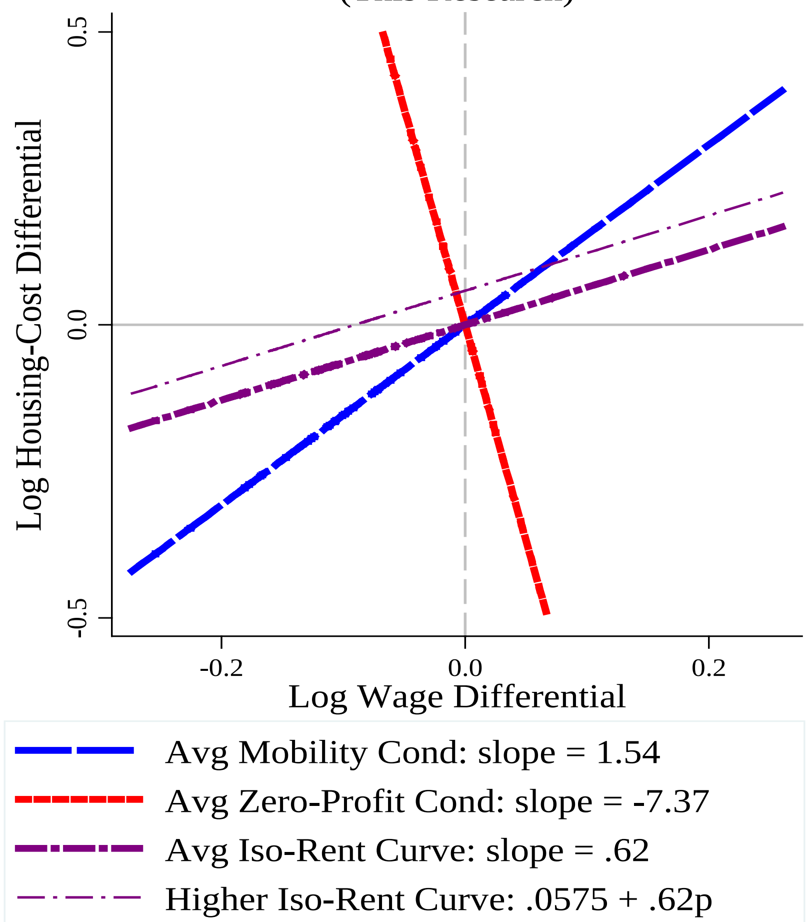


Figure 1B: Unadjusted Model

(Previous Literature)

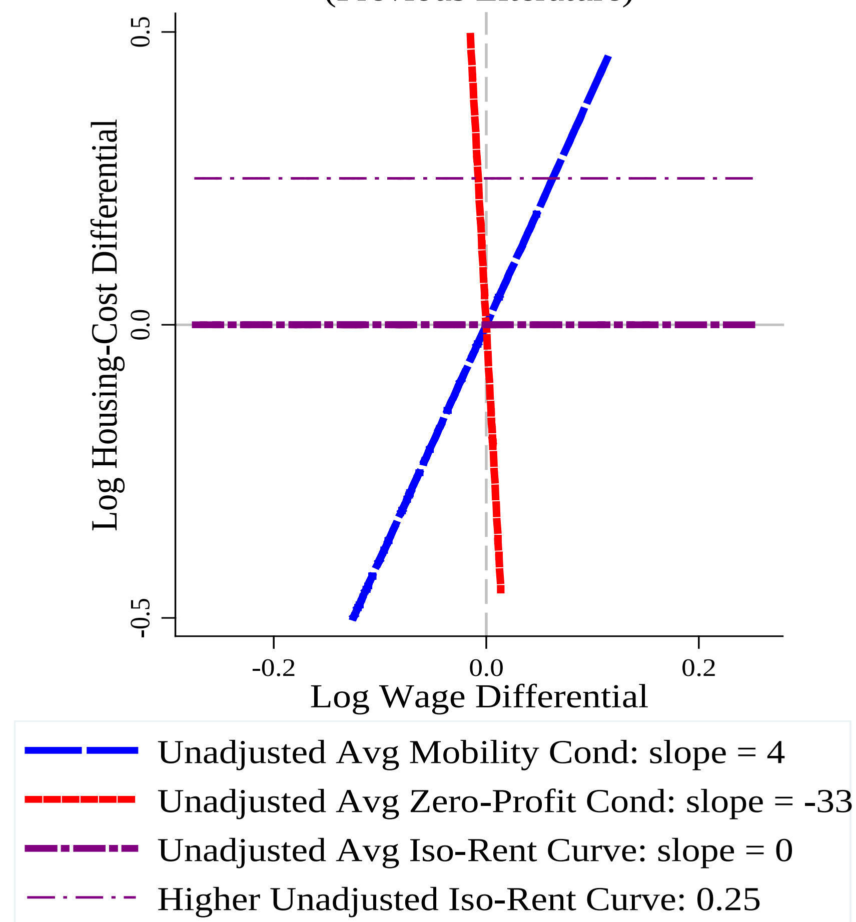


Figure 2: Housing Costs versus Wage Levels across Metro Areas, 2000

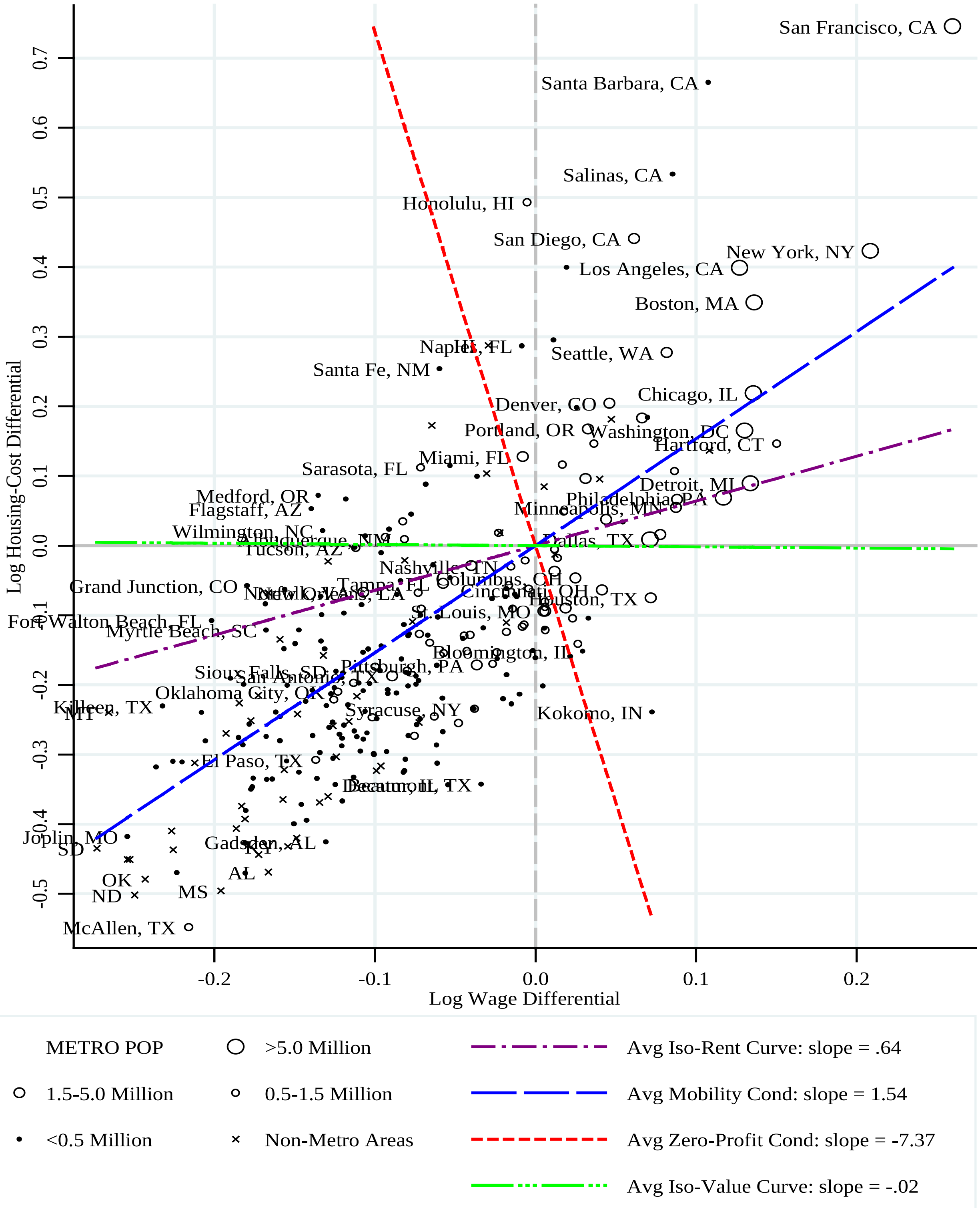
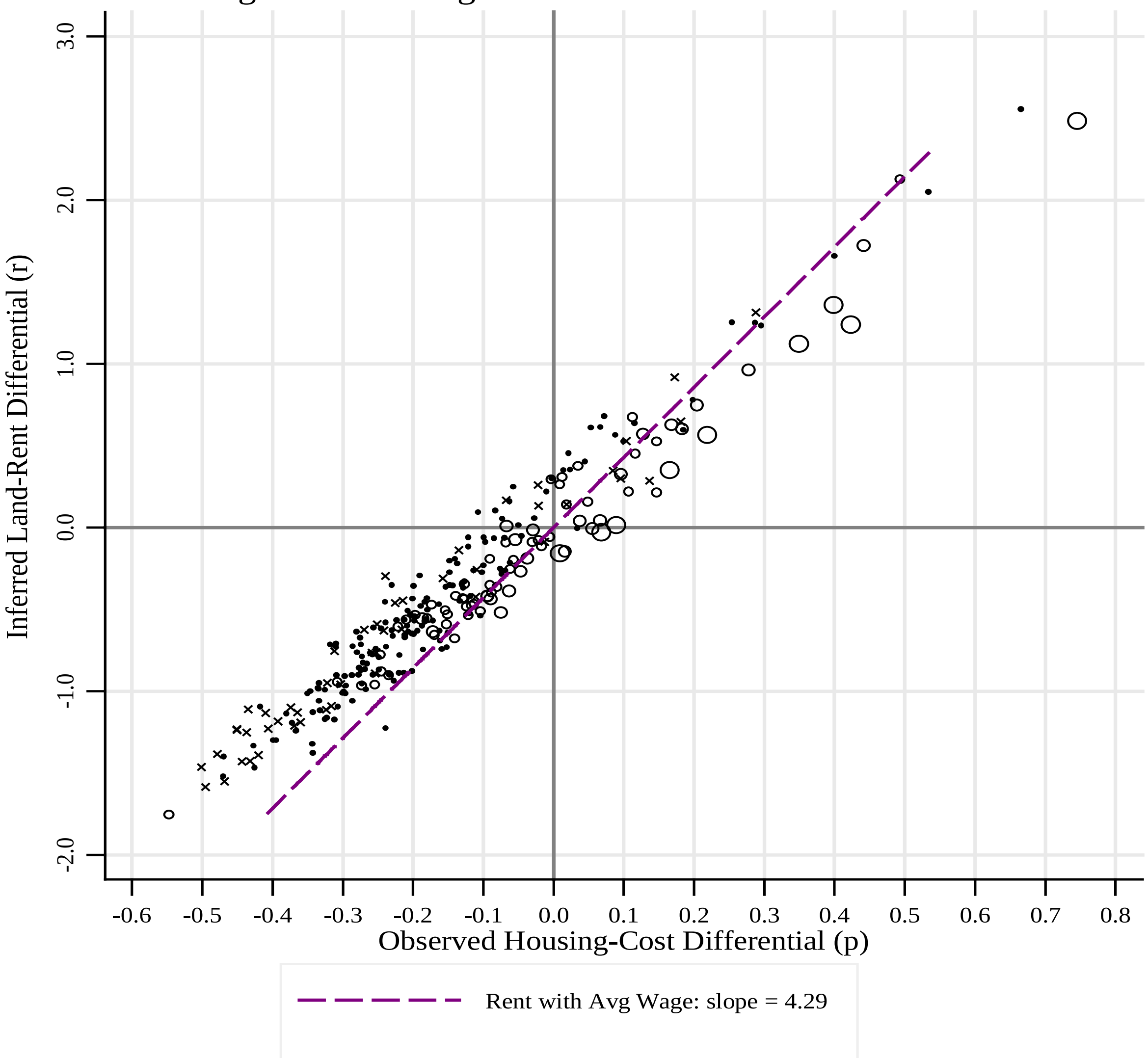


Figure 3: Housing Costs and Inferred Land Rents



Inferred land rents based on calibration: phiL =.233333, phiN =.616667, sigmaY = 1.0

Figure 4: Estimated Productivity and Quality of Life, 2000

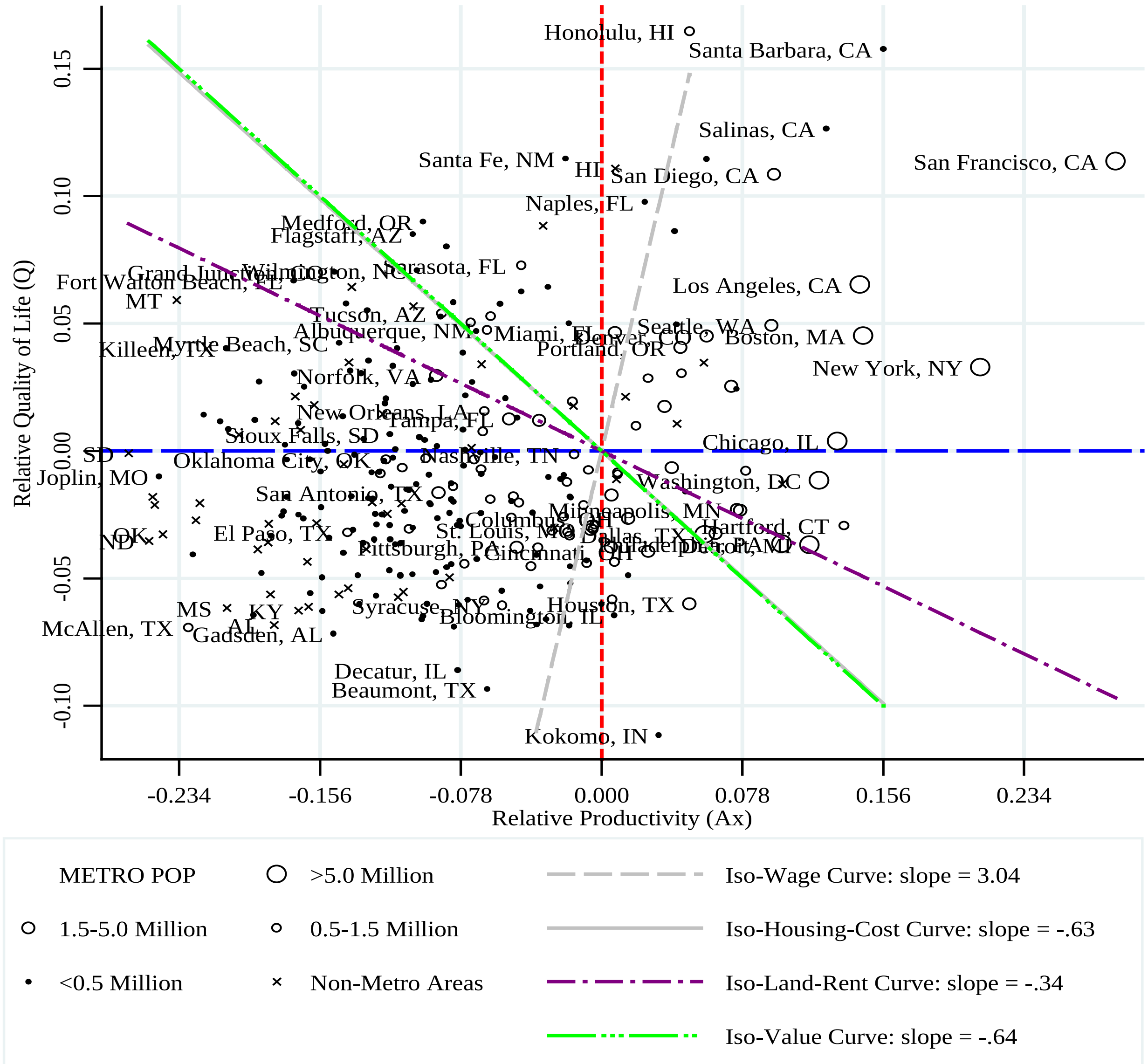


Figure 5: Productivity and Population Size

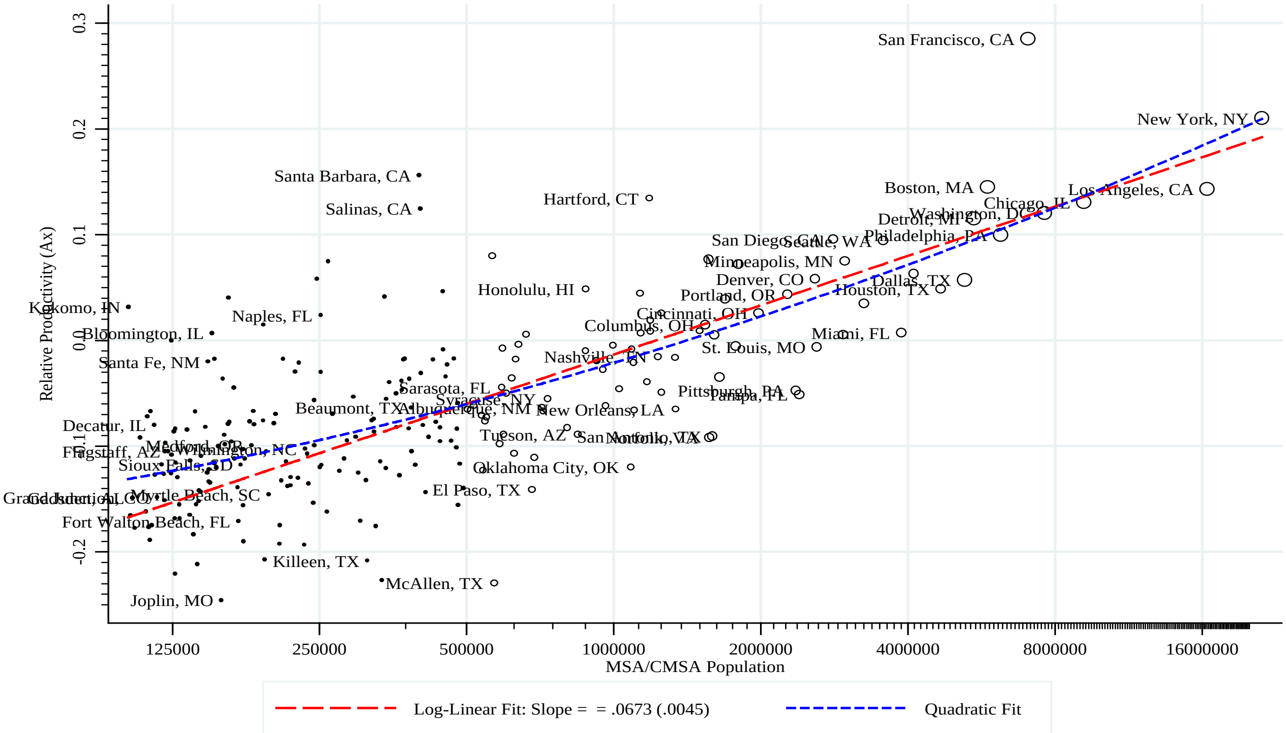
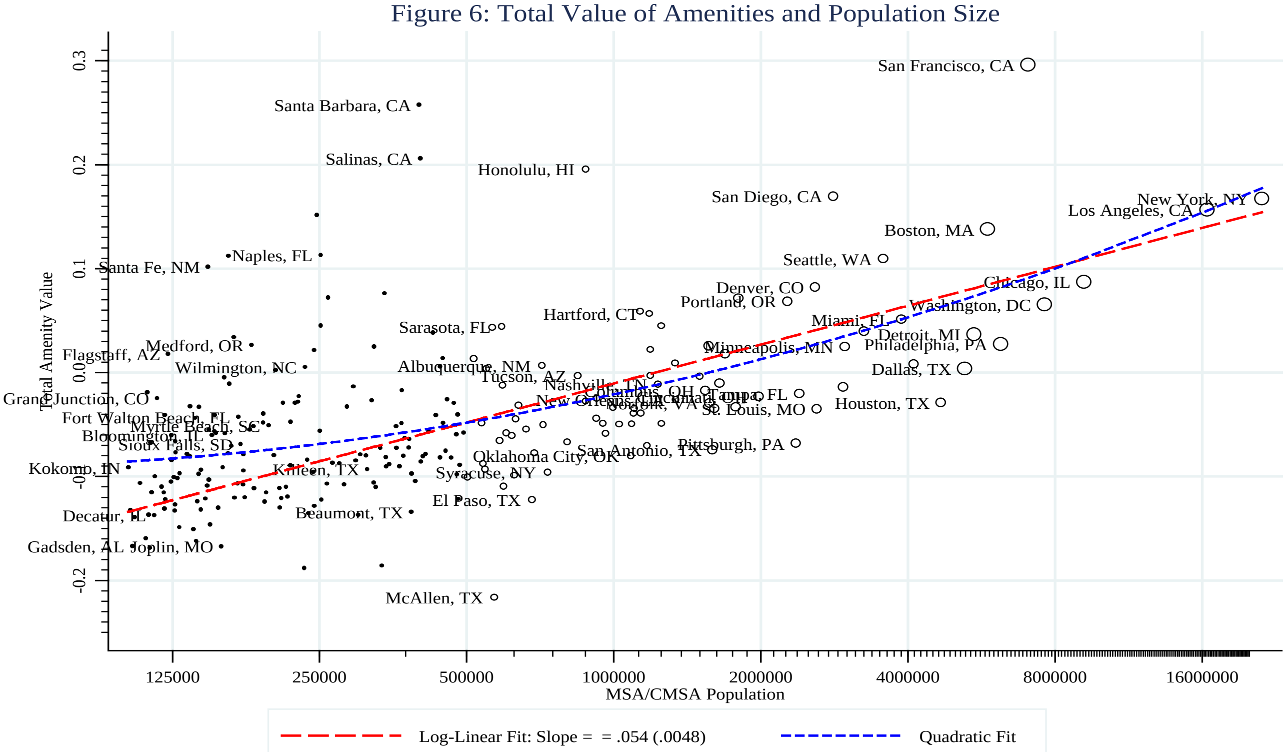


Figure 6: Total Value of Amenities and Population Size



Appendix - Not for Publication

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 firs 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

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

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

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.

$$\hat{N} = 1.90\hat{Q} + 1.39\hat{A}_X$$

According to Table 3, the standard deviations of $\hat{Q}$ and $\hat{A}_X$ are 0.046 and 0.131: multiplied by the respective coefficient in the equation produces 0.087 and 0.183. This suggests that both quality of life and productivity are important determinants of population location decisions, although productivity appear to be somewhat 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 fi ed land supply. Furthermore, productivity certainly depends on the population size of a city, as may quality of life.

B Quadratic Land-Rent Estimates

The inferred land rent from equation (5) is based on a first-orde 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-orde approximation:

$$\hat{p} - \phi_L \hat{r}^j - \phi_N \hat{w}^j + \hat{A}_Y^j = \frac{1}{2}\phi_N \phi_L \left(1 - \sigma_Y^{NL}\right)\left(\hat{w}^j - \hat{r}^j\right)^2 + \frac{1}{2}\phi_K \left[\phi_N \left(1 - \sigma_Y^{NK}\right)\left(\hat{w}^j\right)^2 + \phi_L \left(1 - \sigma_Y^{LK}\right)\left(\hat{r}^j\right)^2\right] \tag{A.12}$$

σ_Y^{NL} is the (Allen-Uzawa) partial elasticity of substitution between labor and land, with other partial elasticities similarly defined The firs 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 (A.12) 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.

Appendix Figure A1 illustrates a number of iso-rent curves in both the linear case and the quadratic case, where $\sigma_Y^{NL} = \sigma_Y^{KL} = \sigma_Y^{NK} = 0.67$.[29] Figure A2 graphs the quadratic land-rent

[29] These substitution elasticities are based off of estimates in McDonald (1981) and Thorsnes (1997). These estimates are also consistent with preliminary estimates in Albouy and Ehrlich (2010).

estimates (numerical values are given in Appendix Table A1) using the formula in (A.12) The figur 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. 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.[30]

C Additional Tax Issues

C.1 Deduction

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

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

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

$$\begin{aligned} s_w\hat{w}^j &= s_w\hat{w}_0^j + \frac{\lambda_L}{\lambda_N}\frac{d\tau^j}{m} \\ s_y\hat{p}^j &= s_y\hat{p}_0^j - \left(1 - \frac{\lambda_L}{\lambda_N}\right)\frac{d\tau^j}{m} \end{aligned}$$

and substituting them into the tax differential formula, and solving recursively,

$$\begin{aligned} \frac{d\tau^j}{m} &= \tau' s_w\hat{w}_0^j - \delta\tau' s_y\hat{p}_0^j + \tau'\left[\delta + (1-\delta)\frac{\lambda_L}{\lambda_N}\right] \\ &= \tau'\frac{s_w\hat{w}_0^j - \delta s_y\hat{p}_0^j}{1-\tau'\left[\delta + (1-\delta)\lambda_L/\lambda_N\right]} \end{aligned}$$

Substituting in (7b) and (7c) gives the tax differential in terms of amenities.

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

[30] There are three partial (Allen-Uzawa) elasticities of substitution in production for each combination of two factors, where $\sigma_Y^{LN} \equiv \left(\partial^2 c_Y/\partial w \partial r\right)/\left(\partial c_Y/\partial w \cdot \partial c_Y/\partial r\right)$ is the partial elasticity of substitution between labor and land in the production of Y, etc. Approximation of the cost share is 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 (A.12) 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 $\hat{r}^j \neq 0$.

We can see that the deduction reduces the dependence of taxes on productivity differences and increases the implicit subsidy for quality-of-life advantages.

C.2 State Taxes

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

$$\frac{d\tau^j}{m} = \tau' \left(s_w \hat{w}^j - \delta \tau' s_y \hat{p}^j \right) + \tau'_S [s_w(\hat{w}^j - \hat{w}^S) - \delta_S s_y (\hat{p}^j - \hat{p}^S)] \tag{A.13}$$

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

C.3 Calibration of Tax Parameters

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

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

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

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

C.4 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-profi conditions are generalized with unit-cost functions that have factor-specifi 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-orde effects on prices regardless of the factor they augment directly when weighted by the cost-share of that factor.[31]

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

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

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

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

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

Except for the terms in square brackets, "[]", these terms are otherwise identical to equations (7a), (7b), (7c). 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-specifi productivity differences do have first-orde effects on quantities in the model. For example, in the case where partial elasticities of substitution across factors within sectors are equal, the relative employment of a-types relative to b-types is

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

C.5 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.

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

Log-linearizing these equations produces

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

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

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

then the main results generalize:

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

Now a question is whether one using only one home-good price, e.g. the one for residential housing, may be biased.[32] The bias is then given by

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

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

D 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 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 coefficient 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)

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

- 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 proficien y (none or poor).

All covariates are interacted with gender.

This regression is firs 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 firs 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 firs 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.

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

Full Name of Metropolitan Area	Population	Adjusted Differentials: Wages	Adjusted Differentials: Housing Costs	Land Rents: Linear	Land Rents: Quadratic	Quality of Life: Value	Quality of Life: Rank	Trade-Productivity: Value	Trade-Productivity: Rank	Federal Tax Differential	Total Amenity Values: Value	Total Amenity Values: Rank
San Francisco--Oakland--San Jose, CA CMSA	7,039,362	0.260	0.746	2.482	2.039	0.114	6	0.285	1	0.048	0.296	1
Santa Barbara--Santa Maria--Lompoc, CA MSA	399,347	0.108	0.665	2.556	2.058	0.158	2	0.156	3	0.002	0.258	2
Salinas-Monterey-Carmel, CA MSA	401,762	0.085	0.533	2.052	1.708	0.126	3	0.125	8	0.001	0.206	3
Honolulu, HI MSA	876,156	-0.005	0.493	2.127	1.739	0.165	1	0.049	23	-0.017	0.196	4
San Diego, CA MSA	2,813,833	0.061	0.441	1.722	1.466	0.108	7	0.096	12	-0.002	0.170	5
New York--Northern New Jersey--Long Island, NY--NJ--CT--PA CMSA	21,199,864	0.209	0.423	1.239	1.115	0.033	43	0.210	2	0.043	0.167	6
Los Angeles--Riverside--Orange County, CA CMSA	16,373,645	0.127	0.399	1.360	1.202	0.065	17	0.143	5	0.021	0.157	7
San Luis Obispo--Atascadero--Paso Robles, CA MSA	246,681	0.019	0.400	1.659	1.411	0.115	5	0.058	21	-0.014	0.152	8
Boston--Worcester--Lawrence, MA--NH--ME--CT CMSA	5,819,100	0.136	0.349	1.122	1.013	0.045	34	0.145	4	0.026	0.138	9
non-metropolitan areas, HI	335,651	-0.029	0.288	1.314	1.140	0.111		0.008		-0.016	0.116	
Naples, FL MSA	251,377	-0.009	0.287	1.253	1.097	0.098	8	0.024	35	-0.012	0.113	10
Barnstable--Yarmouth, MA MSA	162,582	0.011	0.295	1.235	1.087	0.086	10	0.040	29	-0.011	0.112	11
Seattle--Tacoma--Bremerton, WA CMSA	3,554,760	0.082	0.277	0.965	0.879	0.049	30	0.094	13	0.013	0.110	12
Santa Fe, NM MSA	147,635	-0.060	0.254	1.254	1.088	0.115	4	-0.020	67	-0.024	0.102	13
Chicago--Gary--Kenosha, IL--IN--WI CMSA	9,157,540	0.136	0.219	0.564	0.536	0.004	80	0.131	7	0.031	0.087	14
Denver--Boulder--Greeley, CO CMSA	2,581,506	0.046	0.204	0.749	0.694	0.045	35	0.058	20	0.007	0.082	15
Reno, NV MSA	339,486	0.026	0.198	0.779	0.717	0.050	29	0.042	28	-0.002	0.076	16
Anchorage, AK MSA	260,283	0.070	0.184	0.598	0.564	0.024	56	0.075	17	0.012	0.072	17
Sacramento--Yolo, CA CMSA	1,796,857	0.066	0.183	0.603	0.568	0.025	54	0.072	18	0.011	0.071	18
non-metropolitan areas, RI	258,023	0.047	0.181	0.647	0.606	0.035		0.057		0.006	0.071	
Portland--Salem, OR--WA CMSA	2,265,223	0.033	0.167	0.628	0.588	0.041	37	0.044	27	0.006	0.069	19
non-metropolitan areas, CO	924,086	-0.065	0.173	0.918	0.819	0.088		-0.033		-0.024	0.068	
Washington--Baltimore, DC--MD--VA--WV CMSA	7,608,070	0.130	0.165	0.350	0.339	-0.012	116	0.120	9	0.031	0.066	20
West Palm Beach--Boca Raton, FL MSA	1,131,184	0.036	0.146	0.527	0.499	0.030	46	0.044	26	0.006	0.059	21
Hartford, CT MSA	1,183,110	0.150	0.147	0.215	0.208	-0.029	164	0.134	6	0.035	0.057	22
Miami--Fort Lauderdale, FL CMSA	3,876,380	-0.008	0.128	0.570	0.533	0.046	33	0.007	41	-0.006	0.051	23
non-metropolitan areas, CT	1,350,818	0.108	0.136	0.287	0.279	-0.013		0.100		0.022	0.051	
Fort Collins--Loveland, CO MSA	251,494	-0.053	0.115	0.639	0.587	0.064	18	-0.030	73	-0.019	0.045	24
Austin--San Marcos, TX MSA	1,249,763	0.017	0.116	0.453	0.431	0.029	49	0.026	34	0.000	0.045	25
Sarasota--Bradenton, FL MSA	589,959	-0.072	0.112	0.677	0.617	0.073	13	-0.045	83	-0.023	0.044	26
Stockton--Lodi, CA MSA	563,598	0.087	0.107	0.221	0.216	-0.008	103	0.080	14	0.021	0.043	27
Phoenix--Mesa, AZ MSA	3,251,876	0.031	0.096	0.327	0.316	0.018	62	0.035	31	0.007	0.040	28
Madison, WI MSA	426,526	-0.036	0.099	0.527	0.491	0.050	28	-0.018	64	-0.014	0.038	29
non-metropolitan areas, AK	367,124	0.040	0.096	0.300	0.291	0.011		0.042		0.007	0.037	
Detroit--Ann Arbor--Flint, MI CMSA	5,456,428	0.134	0.089	0.015	0.009	-0.037	186	0.115	10	0.036	0.037	30
non-metropolitan areas, CA	1,249,739	-0.030	0.104	0.528	0.493	0.044		-0.013		-0.017	0.036	
Bellingham, WA MSA	166,814	-0.068	0.088	0.566	0.522	0.063	19	-0.045	84	-0.023	0.034	31
non-metropolitan areas, MA	569,691	0.005	0.085	0.348	0.334	0.021		0.013		-0.005	0.030	
Philadelphia--Wilmington--Atlantic City, PA--NJ--DE--MD CMSA	6,188,463	0.117	0.068	-0.028	-0.034	-0.036	184	0.100	11	0.030	0.027	32
Medford--Ashland, OR MSA	181,269	-0.135	0.072	0.681	0.610	0.090	9	-0.099	150	-0.042	0.027	33
Las Vegas, NV--AZ MSA	1,563,282	0.088	0.066	0.042	0.040	-0.023	144	0.077	15	0.022	0.026	34
Eugene--Springfield, OR MSA	322,959	-0.118	0.067	0.612	0.554	0.080	12	-0.086	134	-0.036	0.025	35
Minneapolis--St. Paul, MN--WI MSA	2,968,806	0.088	0.055	-0.005	-0.008	-0.023	143	0.075	16	0.026	0.025	36
Raleigh--Durham--Chapel Hill, NC MSA	1,187,941	0.018	0.049	0.160	0.158	0.010	72	0.019	36	0.006	0.022	37
Portland, ME MSA	243,537	-0.077	0.045	0.406	0.379	0.058	22	-0.056	95	-0.019	0.022	38
Milwaukee--Racine, WI CMSA	1,689,572	0.044	0.038	0.041	0.040	-0.007	100	0.039	30	0.014	0.018	39
Flagstaff, AZ--UT MSA	122,366	-0.140	0.053	0.611	0.549	0.085	11	-0.105	157	-0.043	0.018	40

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

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Modesto, CA MSA	446,997	0.054	0.034	-0.004	-0.005	-0.016	124	0.047	25	0.014	0.014	41
Colorado Springs, CO MSA	516,929	-0.083	0.035	0.376	0.352	0.053	25	-0.062	97	-0.024	0.013	42
Salt Lake City--Ogden, UT MSA	1,333,914	-0.023	0.018	0.142	0.139	0.019	60	-0.016	57	-0.005	0.009	43
Atlanta, GA MSA	4,112,198	0.078	0.016	-0.146	-0.153	-0.032	175	0.063	19	0.023	0.008	44
non-metropolitan areas, NH	1,011,597	-0.022	0.018	0.140	0.137	0.018		-0.016		-0.006	0.008	
Albuquerque, NM MSA	712,738	-0.082	0.009	0.264	0.250	0.048	31	-0.064	100	-0.020	0.007	45
Fort Myers--Cape Coral, FL MSA	440,888	-0.106	0.014	0.351	0.326	0.058	20	-0.082	127	-0.029	0.006	46
Wilmington, NC MSA	233,450	-0.133	0.021	0.457	0.416	0.071	14	-0.102	154	-0.040	0.005	47
Charleston--North Charleston, SC MSA	549,033	-0.094	0.012	0.310	0.290	0.050	27	-0.073	112	-0.027	0.004	48
Dallas--Fort Worth, TX CMSA	5,221,801	0.071	0.009	-0.158	-0.166	-0.033	176	0.057	22	0.020	0.004	49
Chico--Paradise, CA MSA	203,171	-0.091	0.024	0.353	0.329	0.047	32	-0.070	109	-0.033	0.002	50
Providence--Fall River--Warwick, RI--MA MSA	1,188,613	0.012	-0.005	-0.055	-0.056	-0.008	106	0.009	40	0.003	-0.003	51
Tucson, AZ MSA	843,746	-0.112	-0.003	0.294	0.273	0.054	24	-0.089	135	-0.032	-0.003	52
Charlotte--Gastonia--Rock Hill, NC--SC MSA	1,499,293	0.014	-0.018	-0.113	-0.115	-0.009	110	0.009	39	0.008	-0.003	53
Charlottesville, VA MSA	159,576	-0.113	-0.003	0.299	0.277	0.053	26	-0.089	137	-0.034	-0.004	54
non-metropolitan areas, NV	285,196	0.012	-0.013	-0.088	-0.089	-0.011		0.008		0.003	-0.006	
non-metropolitan areas, WA	1,063,531	-0.082	-0.021	0.133	0.127	0.034		-0.067		-0.022	-0.009	
non-metropolitan areas, OR	1,194,699	-0.129	-0.022	0.260	0.239	0.057		-0.105		-0.036	-0.010	
Orlando, FL MSA	1,644,561	-0.040	-0.029	-0.014	-0.014	0.012	69	-0.035	76	-0.009	-0.010	55
Redding, CA MSA	163,256	-0.096	-0.010	0.220	0.207	0.039	40	-0.077	119	-0.033	-0.011	56
Nashville, TN MSA	1,231,311	-0.015	-0.030	-0.088	-0.089	-0.001	88	-0.015	56	-0.002	-0.011	57
Springfield, MA MSA	591,932	-0.006	-0.022	-0.075	-0.075	-0.007	102	-0.007	52	-0.005	-0.012	58
Savannah, GA MSA	293,000	-0.064	-0.027	0.058	0.055	0.021	58	-0.053	92	-0.019	-0.013	59
Cleveland--Akron, OH CMSA	2,945,831	0.012	-0.037	-0.190	-0.195	-0.017	126	0.005	45	0.005	-0.014	60
Provo--Orem, UT MSA	368,536	-0.053	-0.046	-0.051	-0.052	0.013	66	-0.047	86	-0.012	-0.017	61
Columbus, OH MSA	1,540,157	0.025	-0.046	-0.268	-0.280	-0.027	158	0.015	38	0.010	-0.017	62
Iowa City, IA MSA	111,006	-0.084	-0.051	0.014	0.011	0.027	52	-0.072	111	-0.020	-0.019	63
Tampa--St. Petersburg--Clearwater, FL MSA	2,395,997	-0.058	-0.054	-0.074	-0.075	0.013	67	-0.051	91	-0.013	-0.020	64
Green Bay, WI MSA	226,778	-0.018	-0.062	-0.214	-0.220	-0.009	112	-0.021	69	-0.001	-0.023	65
Cincinnati--Hamilton, OH--KY--IN CMSA	1,979,202	0.041	-0.064	-0.387	-0.413	-0.039	190	0.026	33	0.016	-0.023	66
non-metropolitan areas, VT	608,387	-0.166	-0.068	0.167	0.149	0.064		-0.139		-0.041	-0.024	
Fresno, CA MSA	922,516	-0.017	-0.057	-0.198	-0.203	-0.012	117	-0.019	66	-0.005	-0.025	67
Grand Junction, CO MSA	116,255	-0.180	-0.057	0.249	0.222	0.070	15	-0.148	208	-0.049	-0.025	68
Des Moines, IA MSA	456,022	-0.019	-0.074	-0.264	-0.272	-0.011	115	-0.023	70	0.001	-0.026	69
New Orleans, LA MSA	1,337,726	-0.073	-0.068	-0.089	-0.090	0.016	63	-0.065	101	-0.017	-0.026	70
Fort Pierce--Port St. Lucie, FL MSA	319,426	-0.086	-0.070	-0.063	-0.065	0.022	57	-0.076	114	-0.020	-0.027	71
Albany--Schenectady--Troy, NY MSA	875,583	-0.004	-0.062	-0.253	-0.262	-0.021	141	-0.010	55	-0.002	-0.028	72
Asheville, NC MSA	225,965	-0.156	-0.063	0.161	0.144	0.055	23	-0.130	193	-0.044	-0.028	73
Houston--Galveston--Brazoria, TX CMSA	4,669,571	0.072	-0.075	-0.520	-0.572	-0.060	221	0.049	24	0.023	-0.029	74
Yakima, WA MSA	222,581	-0.027	-0.076	-0.251	-0.258	-0.010	114	-0.030	72	-0.004	-0.029	75
Norfolk--Virginia Beach--Newport News, VA--NC MSA	1,569,541	-0.107	-0.067	0.008	0.004	0.030	48	-0.092	141	-0.030	-0.029	76
Merced, CA MSA	210,554	-0.013	-0.070	-0.263	-0.272	-0.018	129	-0.018	61	-0.003	-0.029	77
Lancaster, PA MSA	470,658	-0.012	-0.074	-0.283	-0.294	-0.018	131	-0.017	58	-0.001	-0.029	78
Allentown--Bethlehem--Easton, PA MSA	637,958	0.006	-0.080	-0.361	-0.380	-0.029	161	-0.004	48	0.005	-0.031	79
State College, PA MSA	135,758	-0.134	-0.073	0.055	0.047	0.040	38	-0.113	168	-0.038	-0.032	80
Tallahassee, FL MSA	284,539	-0.108	-0.085	-0.065	-0.068	0.028	50	-0.095	143	-0.026	-0.033	81
Punta Gorda, FL MSA	141,627	-0.168	-0.083	0.105	0.090	0.058	21	-0.142	204	-0.043	-0.033	82

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

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Kansas City, MO--KS MSA	1,776,062	0.006	-0.094	-0.419	-0.445	-0.030	166	-0.005	50	0.009	-0.033	83
Richmond--Petersburg, VA MSA	996,512	0.006	-0.088	-0.394	-0.416	-0.031	169	-0.005	49	0.006	-0.034	84
Indianapolis, IN MSA	1,607,486	0.019	-0.090	-0.437	-0.467	-0.038	187	0.005	46	0.009	-0.034	85
Jacksonville, FL MSA	1,100,491	-0.071	-0.091	-0.192	-0.196	0.008	75	-0.066	103	-0.015	-0.035	86
St. Louis, MO--IL MSA	2,603,607	0.005	-0.094	-0.416	-0.442	-0.031	170	-0.006	51	0.007	-0.035	87
Memphis, TN--AR--MS MSA	1,135,614	0.023	-0.104	-0.511	-0.553	-0.044	196	0.007	42	0.012	-0.039	88
Rochester, NY MSA	1,098,201	-0.014	-0.091	-0.349	-0.365	-0.026	154	-0.021	68	-0.004	-0.039	89
Richland--Kennewick--Pasco, WA MSA	191,822	0.033	-0.104	-0.538	-0.586	-0.049	209	0.015	37	0.014	-0.039	90
Lexington, KY MSA	479,198	-0.061	-0.102	-0.272	-0.279	-0.002	90	-0.059	96	-0.013	-0.040	91
Bryan--College Station, TX MSA	152,415	-0.133	-0.099	-0.059	-0.064	0.033	42	-0.116	172	-0.035	-0.041	92
Bloomington, IN MSA	120,563	-0.119	-0.097	-0.087	-0.091	0.026	53	-0.105	156	-0.032	-0.041	93
Boise City, ID MSA	432,345	-0.082	-0.114	-0.261	-0.268	0.008	74	-0.077	118	-0.015	-0.041	94
Fort Walton Beach, FL MSA	170,498	-0.202	-0.108	0.094	0.075	0.067	16	-0.171	224	-0.052	-0.043	95
Yuba City, CA MSA	139,149	-0.072	-0.100	-0.230	-0.236	-0.001	87	-0.067	107	-0.021	-0.044	96
Birmingham, AL MSA	921,106	-0.008	-0.117	-0.477	-0.509	-0.032	173	-0.019	65	0.004	-0.044	97
Harrisburg--Lebanon--Carlisle, PA MSA	629,401	-0.007	-0.113	-0.466	-0.497	-0.033	177	-0.018	62	0.002	-0.045	98
non-metropolitan areas, DE	158,149	-0.077	-0.109	-0.258	-0.264	0.001		-0.072		-0.019	-0.045	
non-metropolitan areas, MD	666,998	-0.018	-0.111	-0.424	-0.448	-0.030		-0.026		-0.005	-0.047	
Gainesville, FL MSA	217,955	-0.147	-0.121	-0.114	-0.120	0.035	41	-0.129	191	-0.036	-0.047	99
Cedar Rapids, IA MSA	191,701	-0.079	-0.127	-0.326	-0.337	0.000	85	-0.076	115	-0.015	-0.048	100
Lansing--East Lansing, MI MSA	447,728	0.005	-0.119	-0.524	-0.565	-0.043	195	-0.008	54	0.004	-0.048	101
Columbia, SC MSA	536,691	-0.072	-0.127	-0.345	-0.357	-0.003	94	-0.071	110	-0.014	-0.049	102
Visalia--Tulare--Porterville, CA MSA	368,021	-0.032	-0.118	-0.417	-0.439	-0.024	147	-0.038	80	-0.007	-0.049	103
Dayton--Springfield, OH MSA	950,558	-0.018	-0.124	-0.481	-0.513	-0.031	172	-0.028	71	-0.001	-0.049	104
Greensboro--Winston-Salem--High Point, NC MSA	1,251,509	-0.044	-0.129	-0.432	-0.455	-0.018	127	-0.049	88	-0.006	-0.049	105
Grand Rapids--Muskegon--Holland, MI MSA	1,088,514	0.006	-0.121	-0.536	-0.580	-0.044	197	-0.008	53	0.004	-0.049	106
Louisville, KY--IN MSA	1,025,598	-0.041	-0.128	-0.437	-0.461	-0.020	138	-0.046	85	-0.006	-0.050	107
Omaha, NE--IA MSA	716,998	-0.066	-0.140	-0.417	-0.437	-0.007	101	-0.067	105	-0.008	-0.050	108
Myrtle Beach, SC MSA	196,629	-0.168	-0.121	-0.058	-0.067	0.042	36	-0.146	207	-0.045	-0.051	109
Appleton--Oshkosh--Neenah, WI MSA	358,365	-0.045	-0.133	-0.447	-0.472	-0.020	136	-0.050	89	-0.007	-0.052	110
Lafayette, IN MSA	182,821	-0.067	-0.129	-0.367	-0.382	-0.009	109	-0.067	104	-0.015	-0.052	111
Bakersfield, CA MSA	661,645	0.026	-0.141	-0.678	-0.755	-0.058	218	0.006	44	0.013	-0.055	112
Champaign--Urbana, IL MSA	179,669	-0.079	-0.129	-0.336	-0.348	-0.006	98	-0.077	117	-0.021	-0.055	113
Panama City, FL MSA	148,217	-0.150	-0.141	-0.190	-0.197	0.031	45	-0.133	196	-0.036	-0.055	114
non-metropolitan areas, AZ	942,343	-0.159	-0.135	-0.139	-0.146	0.035		-0.140		-0.041	-0.055	
Lincoln, NE MSA	250,291	-0.131	-0.148	-0.273	-0.282	0.021	59	-0.120	178	-0.029	-0.056	115
Janesville--Beloit, WI MSA	152,307	-0.002	-0.151	-0.641	-0.705	-0.045	201	-0.017	60	0.008	-0.056	116
Spokane, WA MSA	417,939	-0.096	-0.144	-0.353	-0.366	0.002	83	-0.091	140	-0.021	-0.057	117
Daytona Beach, FL MSA	493,175	-0.157	-0.148	-0.203	-0.211	0.032	44	-0.140	202	-0.038	-0.058	118
Baton Rouge, LA MSA	602,894	-0.043	-0.151	-0.531	-0.568	-0.026	155	-0.050	90	-0.005	-0.058	119
Athens, GA MSA	153,444	-0.134	-0.137	-0.221	-0.227	0.019	61	-0.120	180	-0.036	-0.058	120
Greenville--Spartanburg--Anderson, SC MSA	962,441	-0.057	-0.154	-0.504	-0.536	-0.019	135	-0.062	98	-0.008	-0.058	121
Yuma, AZ MSA	160,026	-0.104	-0.148	-0.349	-0.362	0.004	79	-0.098	149	-0.024	-0.059	122
Melbourne--Titusville--Palm Bay, FL MSA	476,230	-0.107	-0.153	-0.362	-0.375	0.005	77	-0.101	153	-0.023	-0.059	123
Bloomington--Normal, IL MSA	150,433	0.029	-0.152	-0.731	-0.823	-0.064	230	0.007	43	0.013	-0.060	124
Rochester, MN MSA	124,277	0.022	-0.159	-0.741	-0.834	-0.060	224	0.000	47	0.014	-0.060	125
Toledo, OH MSA	618,203	-0.024	-0.153	-0.590	-0.639	-0.038	189	-0.035	77	-0.002	-0.061	126

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

Full Name of Metropolitan Area	Population	Adjusted Differentials: Wages	Adjusted Differentials: Housing Costs	Land Rents: Linear	Land Rents: Quadratic	Quality of Life: Value	Quality of Life: Rank	Trade-Productivity: Value	Trade-Productivity: Rank	Federal Tax Differential	Total Amenity Values: Value	Total Amenity Values: Rank
Reading, PA MSA	373,638	0.000	-0.161	-0.691	-0.766	-0.052	212	-0.017	59	0.006	-0.063	127
non-metropolitan areas, UT	531,967	-0.132	-0.158	-0.312	-0.322	0.014		-0.121		-0.032	-0.063	
York, PA MSA	381,751	-0.024	-0.162	-0.630	-0.687	-0.041	193	-0.036	79	-0.001	-0.064	128
Little Rock--North Little Rock, AR MSA	583,845	-0.100	-0.174	-0.470	-0.495	-0.003	92	-0.098	148	-0.018	-0.065	129
Dover, DE MSA	126,697	-0.083	-0.163	-0.467	-0.492	-0.013	118	-0.083	130	-0.019	-0.066	130
Tulsa, OK MSA	803,235	-0.080	-0.180	-0.551	-0.587	-0.014	120	-0.082	128	-0.012	-0.067	131
Sheboygan, WI MSA	112,646	-0.062	-0.172	-0.567	-0.608	-0.024	149	-0.067	106	-0.011	-0.067	132
Pittsburgh, PA MSA	2,358,695	-0.037	-0.171	-0.635	-0.691	-0.038	188	-0.047	87	-0.005	-0.068	133
Sioux Falls, SD MSA	172,412	-0.124	-0.180	-0.431	-0.451	0.007	76	-0.118	175	-0.026	-0.069	134
Buffalo--Niagara Falls, NY MSA	1,170,111	-0.027	-0.170	-0.654	-0.716	-0.045	200	-0.039	81	-0.005	-0.070	135
Tuscaloosa, AL MSA	164,875	-0.097	-0.180	-0.503	-0.532	-0.009	111	-0.096	146	-0.020	-0.071	136
Corpus Christi, TX MSA	380,783	-0.081	-0.182	-0.558	-0.596	-0.019	134	-0.083	129	-0.016	-0.072	137
Davenport--Moline--Rock Island, IA--IL MSA	359,062	-0.079	-0.184	-0.570	-0.609	-0.020	137	-0.082	126	-0.016	-0.072	138
Montgomery, AL MSA	333,055	-0.120	-0.183	-0.455	-0.477	0.001	84	-0.114	169	-0.027	-0.073	139
San Antonio, TX MSA	1,592,383	-0.089	-0.187	-0.556	-0.593	-0.016	125	-0.091	138	-0.019	-0.074	140
Kalamazoo--Battle Creek, MI MSA	452,851	-0.018	-0.185	-0.745	-0.829	-0.053	214	-0.034	75	-0.001	-0.075	141
La Crosse, WI--MN MSA	126,838	-0.121	-0.190	-0.480	-0.505	-0.003	91	-0.116	171	-0.029	-0.077	142
Knoxville, TN MSA	687,249	-0.113	-0.197	-0.534	-0.565	-0.007	99	-0.111	164	-0.024	-0.077	143
Benton Harbor, MI MSA	162,453	-0.074	-0.187	-0.598	-0.643	-0.027	159	-0.079	121	-0.018	-0.078	144
Greenville, NC MSA	133,798	-0.079	-0.201	-0.645	-0.697	-0.024	148	-0.084	132	-0.014	-0.078	145
Pensacola, FL MSA	412,153	-0.155	-0.201	-0.435	-0.455	0.014	65	-0.144	206	-0.035	-0.078	146
Fayetteville, NC MSA	302,963	-0.190	-0.191	-0.294	-0.307	0.030	47	-0.171	223	-0.049	-0.079	147
Tyler, TX MSA	174,706	-0.103	-0.198	-0.566	-0.603	-0.013	119	-0.103	155	-0.022	-0.079	148
Springfield, IL MSA	201,437	-0.073	-0.194	-0.630	-0.681	-0.029	165	-0.078	120	-0.017	-0.080	149
Fayetteville--Springdale--Rogers, AR MSA	311,121	-0.139	-0.208	-0.508	-0.536	0.005	78	-0.132	194	-0.029	-0.080	150
Oklahoma City, OK MSA	1,083,346	-0.123	-0.210	-0.560	-0.595	-0.003	93	-0.120	179	-0.024	-0.080	151
Rockford, IL MSA	371,236	0.004	-0.201	-0.876	-1.006	-0.069	235	-0.018	63	0.007	-0.080	152
Canton--Massillon, OH MSA	406,934	-0.074	-0.199	-0.649	-0.703	-0.029	163	-0.080	124	-0.015	-0.080	153
Columbia, MO MSA	135,454	-0.182	-0.199	-0.354	-0.369	0.025	55	-0.165	219	-0.045	-0.080	154
Hickory--Morganton--Lenoir, NC MSA	341,851	-0.125	-0.204	-0.530	-0.561	-0.004	97	-0.121	181	-0.028	-0.081	155
Jackson, MS MSA	440,801	-0.092	-0.212	-0.656	-0.709	-0.020	139	-0.095	145	-0.016	-0.082	156
Chattanooga, TN--GA MSA	465,161	-0.092	-0.207	-0.634	-0.683	-0.021	140	-0.095	144	-0.018	-0.082	157
Roanoke, VA MSA	235,932	-0.107	-0.208	-0.598	-0.640	-0.015	123	-0.107	161	-0.024	-0.084	158
non-metropolitan areas, FL	1,222,532	-0.173	-0.215	-0.446	-0.468	0.018		-0.159		-0.039	-0.084	
Glens Falls, NY MSA	124,345	-0.110	-0.197	-0.542	-0.576	-0.015	122	-0.108	162	-0.030	-0.084	159
Evansville--Henderson, IN--KY MSA	296,195	-0.087	-0.212	-0.669	-0.725	-0.026	156	-0.091	139	-0.018	-0.085	160
Saginaw--Bay City--Midland, MI MSA	403,070	-0.010	-0.213	-0.887	-1.017	-0.066	232	-0.031	74	0.003	-0.086	161
South Bend, IN MSA	265,559	-0.058	-0.219	-0.779	-0.865	-0.042	194	-0.069	108	-0.009	-0.087	162
Columbus, GA--AL MSA	274,624	-0.127	-0.213	-0.562	-0.597	-0.008	105	-0.123	184	-0.031	-0.087	163
non-metropolitan areas, ME	1,033,664	-0.185	-0.226	-0.460	-0.484	0.021		-0.170		-0.041	-0.087	
Mobile, AL MSA	540,258	-0.126	-0.221	-0.603	-0.644	-0.009	108	-0.123	183	-0.027	-0.087	164
Peoria--Pekin, IL MSA	347,387	-0.020	-0.220	-0.886	-1.013	-0.063	227	-0.040	82	0.001	-0.088	165
Lakeland--Winter Haven, FL MSA	483,924	-0.117	-0.229	-0.659	-0.711	-0.014	121	-0.117	173	-0.023	-0.089	166
Amarillo, TX MSA	217,858	-0.143	-0.224	-0.565	-0.600	-0.001	89	-0.137	199	-0.033	-0.089	167
Biloxi--Gulfport--Pascagoula, MS MSA	363,988	-0.130	-0.230	-0.627	-0.672	-0.008	107	-0.128	190	-0.027	-0.090	168
Huntsville, AL MSA	342,376	-0.038	-0.234	-0.897	-1.023	-0.055	215	-0.055	94	-0.001	-0.090	169
Kokomo, IN MSA	101,541	0.073	-0.239	-1.224	-1.561	-0.111	241	0.032	32	0.031	-0.091	170

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

		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
Jackson, MI MSA	158,422	-0.015	-0.227	-0.933	-1.078	-0.068	234	-0.036	78	0.002	-0.091	171
non-metropolitan areas, MT	774,080	-0.266	-0.240	-0.296	-0.317	0.059		-0.236		-0.062	-0.092	
non-metropolitan areas, NY	1,744,930	-0.111	-0.216	-0.621	-0.666	-0.021		-0.111		-0.030	-0.092	
Wichita, KS MSA	545,220	-0.063	-0.245	-0.878	-0.991	-0.044	198	-0.076	116	-0.005	-0.093	172
Killeen--Temple, TX MSA	312,952	-0.232	-0.230	-0.348	-0.367	0.040	39	-0.208	236	-0.058	-0.093	173
Rocky Mount, NC MSA	143,026	-0.106	-0.238	-0.729	-0.796	-0.024	145	-0.109	163	-0.021	-0.094	174
Las Cruces, NM MSA	174,682	-0.208	-0.240	-0.455	-0.479	0.027	51	-0.190	232	-0.049	-0.094	175
Lubbock, TX MSA	242,628	-0.162	-0.239	-0.579	-0.616	0.003	81	-0.153	212	-0.038	-0.095	176
Syracuse, NY MSA	732,117	-0.038	-0.234	-0.900	-1.027	-0.061	226	-0.055	93	-0.006	-0.096	177
non-metropolitan areas, NC	2,632,956	-0.148	-0.242	-0.628	-0.673	-0.005		-0.143		-0.034	-0.097	
Billings, MT MSA	129,352	-0.178	-0.256	-0.608	-0.649	0.011	71	-0.168	222	-0.036	-0.097	178
Lafayette, LA MSA	385,647	-0.099	-0.248	-0.792	-0.875	-0.030	167	-0.105	158	-0.018	-0.097	179
Pueblo, CO MSA	141,472	-0.159	-0.246	-0.614	-0.656	0.000	86	-0.152	211	-0.036	-0.097	180
Augusta--Aiken, GA--SC MSA	477,441	-0.072	-0.249	-0.867	-0.976	-0.044	199	-0.083	131	-0.011	-0.098	181
non-metropolitan areas, ID	863,855	-0.177	-0.252	-0.590	-0.628	0.008		-0.167		-0.040	-0.099	
Scranton--Wilkes-Barre--Hazleton, PA MSA	624,776	-0.102	-0.246	-0.776	-0.855	-0.031	168	-0.107	160	-0.021	-0.099	182
Auburn--Opelika, AL MSA	115,092	-0.126	-0.253	-0.738	-0.805	-0.019	133	-0.127	189	-0.026	-0.100	183
Fort Wayne, IN MSA	502,141	-0.048	-0.255	-0.959	-1.105	-0.059	220	-0.065	102	-0.004	-0.100	184
Wausau, WI MSA	125,834	-0.074	-0.257	-0.898	-1.015	-0.046	202	-0.086	133	-0.011	-0.101	185
non-metropolitan areas, WI	1,866,585	-0.116	-0.252	-0.762	-0.835	-0.025		-0.119		-0.025	-0.101	
Waterloo--Cedar Falls, IA MSA	128,012	-0.129	-0.261	-0.766	-0.838	-0.019	132	-0.130	192	-0.025	-0.101	186
non-metropolitan areas, SC	1,616,255	-0.126	-0.259	-0.762	-0.834	-0.020		-0.127		-0.026	-0.102	
Eau Claire, WI MSA	148,337	-0.119	-0.258	-0.776	-0.852	-0.025	151	-0.122	182	-0.025	-0.103	187
non-metropolitan areas, MI	2,178,963	-0.073	-0.254	-0.889	-1.004	-0.050		-0.085		-0.015	-0.104	
non-metropolitan areas, WY	493,849	-0.193	-0.270	-0.625	-0.668	0.012		-0.181		-0.042	-0.104	
Shreveport--Bossier City, LA MSA	392,302	-0.113	-0.266	-0.830	-0.921	-0.029	162	-0.118	176	-0.021	-0.104	188
Sioux City, IA--NE MSA	124,130	-0.122	-0.271	-0.825	-0.913	-0.025	150	-0.126	187	-0.023	-0.105	189
Macon, GA MSA	322,549	-0.058	-0.267	-0.986	-1.139	-0.058	219	-0.074	113	-0.007	-0.106	190
Jackson, TN MSA	107,377	-0.079	-0.273	-0.951	-1.086	-0.048	204	-0.092	142	-0.011	-0.106	191
Topeka, KS MSA	169,871	-0.139	-0.273	-0.787	-0.864	-0.018	128	-0.139	201	-0.028	-0.107	192
Ocala, FL MSA	258,916	-0.168	-0.274	-0.712	-0.771	-0.003	95	-0.162	218	-0.036	-0.107	193
Erie, PA MSA	280,843	-0.105	-0.269	-0.864	-0.966	-0.036	183	-0.112	167	-0.021	-0.108	194
Fargo--Moorhead, ND--MN MSA	174,367	-0.159	-0.280	-0.762	-0.832	-0.008	104	-0.156	216	-0.032	-0.108	195
Monroe, LA MSA	147,250	-0.120	-0.277	-0.855	-0.951	-0.029	160	-0.125	185	-0.023	-0.109	196
Youngstown--Warren, OH MSA	594,746	-0.075	-0.273	-0.964	-1.104	-0.052	213	-0.089	136	-0.013	-0.109	197
Muncie, IN MSA	118,769	-0.111	-0.274	-0.870	-0.972	-0.035	180	-0.117	174	-0.023	-0.110	198
Waco, TX MSA	213,517	-0.107	-0.278	-0.896	-1.007	-0.037	185	-0.114	170	-0.020	-0.110	199
Springfield, MO MSA	325,721	-0.185	-0.276	-0.673	-0.723	0.002	82	-0.176	227	-0.043	-0.110	200
Clarksville--Hopkinsville, TN--KY MSA	207,033	-0.206	-0.280	-0.636	-0.681	0.012	68	-0.192	233	-0.047	-0.111	201
Lake Charles, LA MSA	183,577	-0.062	-0.286	-1.058	-1.240	-0.060	225	-0.079	122	-0.005	-0.111	202
Goldsboro, NC MSA	113,329	-0.182	-0.286	-0.724	-0.784	-0.003	96	-0.175	226	-0.043	-0.115	203
Williamsport, PA MSA	120,044	-0.121	-0.288	-0.901	-1.010	-0.035	181	-0.126	188	-0.025	-0.115	204
Houma, LA MSA	194,477	-0.093	-0.296	-1.012	-1.166	-0.048	206	-0.105	159	-0.014	-0.116	205
Lynchburg, VA MSA	214,911	-0.134	-0.297	-0.904	-1.013	-0.031	171	-0.138	200	-0.029	-0.119	206
Mansfield, OH MSA	175,818	-0.101	-0.299	-1.003	-1.151	-0.049	207	-0.112	166	-0.020	-0.120	207
St. Cloud, MN MSA	167,392	-0.101	-0.300	-1.009	-1.160	-0.049	210	-0.112	165	-0.020	-0.120	208
Longview--Marshall, TX MSA	208,780	-0.126	-0.305	-0.962	-1.090	-0.036	182	-0.132	195	-0.025	-0.121	209

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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
Decatur, AL MSA	145,867	-0.061	-0.312	-1.170	-1.406	-0.069	236	-0.082	125	-0.004	-0.121	210
Johnson City--Kingsport--Bristol, TN--VA MSA	480,091	-0.155	-0.309	-0.900	-1.004	-0.022	142	-0.156	215	-0.032	-0.122	211
Albany, GA MSA	120,822	-0.081	-0.307	-1.091	-1.281	-0.060	222	-0.097	147	-0.013	-0.122	212
non-metropolitan areas, GA	2,744,802	-0.124	-0.303	-0.958	-1.085	-0.039		-0.131		-0.026	-0.122	
Binghamton, NY MSA	252,320	-0.109	-0.295	-0.965	-1.098	-0.047	203	-0.118	177	-0.026	-0.122	213
El Paso, TX MSA	679,622	-0.137	-0.308	-0.943	-1.063	-0.032	174	-0.141	203	-0.028	-0.122	214
non-metropolitan areas, NM	783,050	-0.212	-0.312	-0.753	-0.818	0.006		-0.201		-0.047	-0.122	
Wichita Falls, TX MSA	140,518	-0.226	-0.310	-0.707	-0.763	0.012	70	-0.212	237	-0.053	-0.124	215
Laredo, TX MSA	193,117	-0.220	-0.311	-0.726	-0.786	0.009	73	-0.207	235	-0.051	-0.124	216
non-metropolitan areas, IN	1,791,003	-0.096	-0.316	-1.091	-1.276	-0.055		-0.110		-0.017	-0.126	
Abilene, TX MSA	126,555	-0.236	-0.318	-0.713	-0.770	0.014	64	-0.221	238	-0.056	-0.127	217
Duluth--Superior, MN--WI MSA	243,815	-0.082	-0.323	-1.161	-1.383	-0.065	231	-0.099	151	-0.012	-0.128	218
non-metropolitan areas, VA	1,640,567	-0.157	-0.322	-0.949	-1.067	-0.028		-0.158		-0.035	-0.130	
non-metropolitan areas, OH	2,548,986	-0.099	-0.323	-1.113	-1.307	-0.057		-0.113		-0.018	-0.130	
Fort Smith, AR--OK MSA	207,290	-0.176	-0.334	-0.948	-1.064	-0.018	130	-0.175	225	-0.035	-0.130	219
Lima, OH MSA	155,084	-0.082	-0.326	-1.169	-1.396	-0.066	233	-0.100	152	-0.013	-0.130	220
Sharon, PA MSA	120,293	-0.147	-0.325	-0.990	-1.123	-0.034	179	-0.151	210	-0.032	-0.131	221
Florence, AL MSA	142,950	-0.136	-0.334	-1.059	-1.221	-0.040	191	-0.143	205	-0.026	-0.132	222
St. Joseph, MO MSA	102,490	-0.164	-0.335	-0.985	-1.115	-0.026	157	-0.165	220	-0.034	-0.132	223
Alexandria, LA MSA	126,337	-0.167	-0.336	-0.978	-1.104	-0.025	152	-0.168	221	-0.035	-0.133	224
Beaumont--Port Arthur, TX MSA	385,090	-0.034	-0.343	-1.375	-1.758	-0.093	240	-0.063	99	0.003	-0.134	225
Odessa--Midland, TX MSA	237,132	-0.125	-0.343	-1.127	-1.320	-0.049	208	-0.135	198	-0.023	-0.135	226
Hattiesburg, MS MSA	111,674	-0.176	-0.346	-0.999	-1.131	-0.024	146	-0.176	228	-0.037	-0.137	227
Utica--Rome, NY MSA	299,896	-0.113	-0.333	-1.113	-1.304	-0.057	217	-0.125	186	-0.026	-0.137	228
Decatur, IL MSA	114,706	-0.055	-0.343	-1.322	-1.652	-0.086	239	-0.080	123	-0.005	-0.137	229
Sumter, SC MSA	104,646	-0.177	-0.350	-1.012	-1.149	-0.026	153	-0.177	229	-0.038	-0.139	230
non-metropolitan areas, PA	2,023,193	-0.129	-0.360	-1.188	-1.409	-0.054		-0.141		-0.025	-0.144	
Terre Haute, IN MSA	149,192	-0.120	-0.367	-1.240	-1.492	-0.060	223	-0.134	197	-0.022	-0.146	231
non-metropolitan areas, IA	1,863,270	-0.183	-0.374	-1.100	-1.268	-0.029		-0.185		-0.037	-0.147	
non-metropolitan areas, MN	1,565,030	-0.157	-0.364	-1.129	-1.314	-0.043		-0.163		-0.035	-0.148	
Altoona, PA MSA	129,144	-0.146	-0.372	-1.192	-1.410	-0.050	211	-0.155	214	-0.030	-0.149	232
non-metropolitan areas, IL	2,202,549	-0.135	-0.369	-1.210	-1.441	-0.056		-0.146		-0.029	-0.150	
Dothan, AL MSA	137,916	-0.180	-0.380	-1.134	-1.317	-0.033	178	-0.183	230	-0.037	-0.151	233
non-metropolitan areas, TN	2,123,330	-0.181	-0.393	-1.184	-1.389	-0.036		-0.185		-0.036	-0.154	
Danville, VA MSA	110,156	-0.151	-0.399	-1.297	-1.570	-0.056	216	-0.162	217	-0.030	-0.159	234
non-metropolitan areas, TX	4,030,376	-0.186	-0.406	-1.228	-1.453	-0.039		-0.191		-0.038	-0.161	
Jamestown, NY MSA	139,750	-0.143	-0.394	-1.298	-1.574	-0.063	228	-0.155	213	-0.032	-0.162	235
non-metropolitan areas, KS	1,366,517	-0.227	-0.410	-1.133	-1.307	-0.020		-0.223		-0.050	-0.163	
non-metropolitan areas, LA	1,415,540	-0.149	-0.420	-1.391	-1.723	-0.061		-0.163		-0.026	-0.165	
Gadsden, AL MSA	103,459	-0.131	-0.425	-1.464	-1.860	-0.072	238	-0.149	209	-0.021	-0.167	236
Joplin, MO MSA	157,322	-0.254	-0.418	-1.091	-1.245	-0.010	113	-0.246	241	-0.058	-0.167	237
Anniston, AL MSA	112,249	-0.181	-0.427	-1.331	-1.613	-0.048	205	-0.189	231	-0.036	-0.169	238
non-metropolitan areas, SD	629,811	-0.273	-0.435	-1.111	-1.270	-0.001		-0.262		-0.058	-0.169	
non-metropolitan areas, KY	2,828,647	-0.154	-0.432	-1.427	-1.782	-0.063		-0.168		-0.028	-0.170	
non-metropolitan areas, AR	1,607,993	-0.226	-0.437	-1.251	-1.478	-0.027		-0.225		-0.046	-0.171	
non-metropolitan areas, WV	1,809,034	-0.172	-0.444	-1.428	-1.777	-0.056		-0.184		-0.031	-0.174	
non-metropolitan areas, NE	878,760	-0.254	-0.451	-1.232	-1.443	-0.018		-0.249		-0.054	-0.178	

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

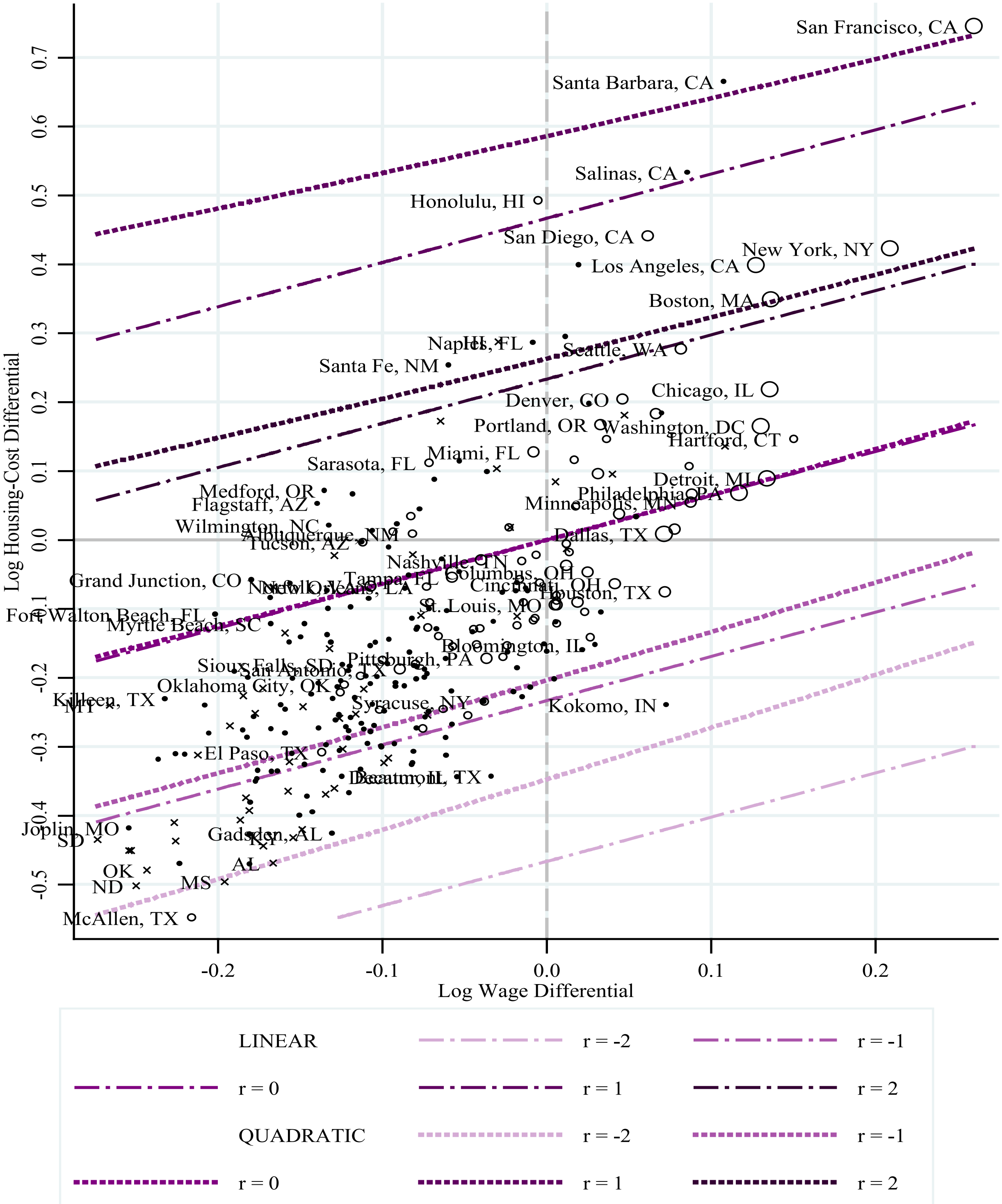
		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity			Total Amenity Values	
Full Name of Metropolitan Area	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank	Federal Tax Differential	Value	Rank
non-metropolitan areas, MO	1,798,819	-0.253	-0.451	-1.236	-1.449	-0.021		-0.248		-0.056	-0.180	
non-metropolitan areas, AL	1,504,381	-0.166	-0.469	-1.551	-2.003	-0.068		-0.182		-0.030	-0.185	
Brownsville--Harlingen--San Benito, TX MSA	335,227	-0.223	-0.469	-1.397	-1.706	-0.041	192	-0.227	239	-0.046	-0.186	239
Johnstown, PA MSA	232,621	-0.181	-0.470	-1.518	-1.932	-0.064	229	-0.193	234	-0.036	-0.188	240
non-metropolitan areas, OK	1,862,951	-0.243	-0.479	-1.384	-1.678	-0.033		-0.243		-0.050	-0.189	
non-metropolitan areas, MS	1,869,256	-0.196	-0.496	-1.585	-2.051	-0.062		-0.208		-0.036	-0.195	
non-metropolitan areas, ND	521,239	-0.250	-0.502	-1.463	-1.806	-0.035		-0.251		-0.050	-0.196	
McAllen--Edinburg--Mission, TX MSA	569,463	-0.216	-0.548	-1.753	-2.390	-0.069	237	-0.229	240	-0.041	-0.216	241

Populations in non-metropolitan areas are approximate.

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

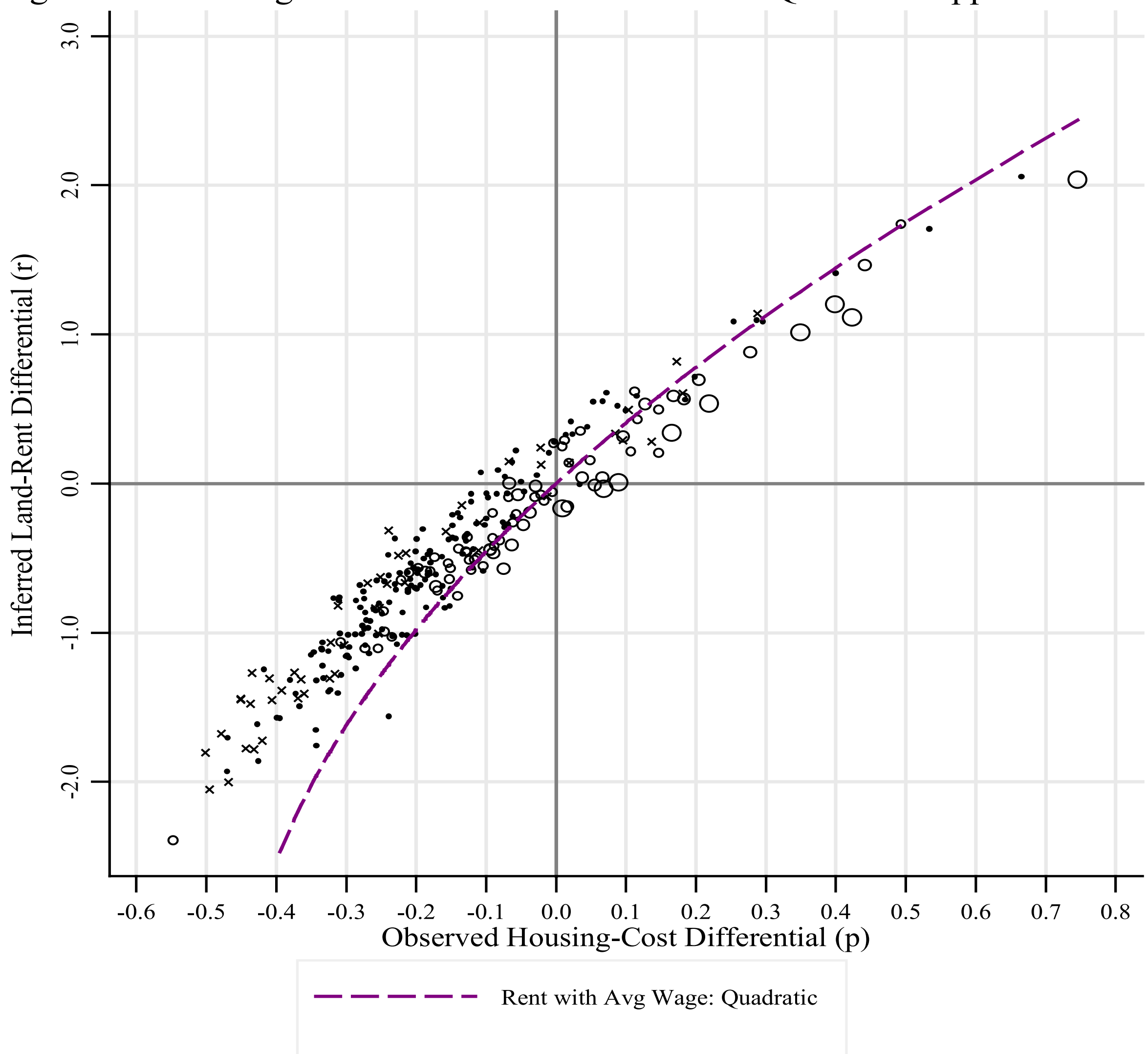
		Adjusted Differentials		Land Rents		Quality of Life		Trade-Productivity		Federal Tax Differential	Total Amenity Values	
State Name	Population	Wages	Housing Costs	Linear	Quadratic	Value	Rank	Value	Rank		Value	Rank
Hawaii	1,211,717	-0.013	0.431	1.883	1.559	0.149	1	0.036	12	-0.017	0.172	1
California	33,884,660	0.133	0.435	1.497	1.274	0.074	2	0.152	2	0.021	0.171	2
New Jersey	8,416,753	0.190	0.351	0.980	0.880	0.017	15	0.188	1	0.039	0.137	3
Massachusetts	6,353,449	0.103	0.277	0.902	0.816	0.037	8	0.111	4	0.018	0.109	4
Connecticut	3,408,068	0.154	0.244	0.624	0.573	0.000	21	0.148	3	0.032	0.095	5
Washington	5,894,780	0.030	0.166	0.627	0.567	0.039	7	0.041	9	0.003	0.065	6
New York	18,976,061	0.094	0.166	0.454	0.355	0.006	19	0.092	6	0.019	0.065	7
District of Columbia	571,753	0.130	0.165	0.350	0.339	-0.013	.	0.120	.	0.029	0.064	.
Colorado	4,300,832	-0.011	0.157	0.705	0.643	0.058	4	0.008	15	-0.008	0.063	8
Alaska	626,187	0.051	0.128	0.407	0.389	0.016	16	0.054	8	0.009	0.05	9
Maryland	5,299,635	0.111	0.129	0.249	0.236	-0.015	29	0.101	5	0.025	0.05	10
Oregon	3,424,928	-0.043	0.089	0.501	0.464	0.052	6	-0.024	19	-0.014	0.036	11
Nevada	2,000,306	0.064	0.079	0.161	0.148	-0.008	24	0.059	7	0.014	0.03	12
New Hampshire	1,234,816	-0.001	0.062	0.269	0.252	0.021	13	0.006	16	-0.002	0.025	13
Rhode island	1,048,463	0.022	0.049	0.148	0.135	0.005	20	0.023	13	0.004	0.019	14
Arizona	5,133,711	-0.030	0.036	0.239	0.225	0.028	10	-0.020	18	-0.009	0.015	15
Illinois	12,417,190	0.045	0.013	-0.070	-0.156	-0.019	31	0.037	11	0.011	0.004	16
Delaware	783,216	0.049	-0.002	-0.143	-0.152	-0.026	36	0.038	10	0.013	-0.002	17
Florida	15,986,890	-0.064	-0.019	0.095	0.074	0.027	11	-0.052	26	-0.016	-0.006	18
Utah	2,230,835	-0.063	-0.047	-0.031	-0.036	0.017	14	-0.054	27	-0.015	-0.018	19
Virginia	7,080,588	-0.015	-0.051	-0.176	-0.218	-0.009	26	-0.018	17	-0.002	-0.02	20
Vermont	608,387	-0.166	-0.068	0.167	0.149	0.064	3	-0.139	37	-0.041	-0.024	21
Michigan	9,935,711	0.034	-0.080	-0.436	-0.492	-0.044	47	0.018	14	0.011	-0.032	22
North Carolina	8,047,735	-0.071	-0.115	-0.296	-0.320	-0.001	23	-0.069	29	-0.015	-0.045	23
New Mexico	1,818,615	-0.143	-0.119	-0.118	-0.168	0.035	9	-0.126	36	-0.033	-0.045	24
Georgia	8,186,187	-0.015	-0.125	-0.496	-0.555	-0.033	40	-0.025	20	0	-0.05	25
Wisconsin	5,357,182	-0.056	-0.133	-0.415	-0.463	-0.015	28	-0.059	28	-0.01	-0.052	26
Minnesota	4,912,048	-0.026	-0.147	-0.559	-0.651	-0.035	42	-0.037	22	-0.002	-0.058	27
Ohio	11,353,531	-0.023	-0.148	-0.569	-0.641	-0.037	43	-0.034	21	-0.002	-0.058	28
Texas	20,848,171	-0.034	-0.155	-0.572	-0.665	-0.033	41	-0.043	24	-0.004	-0.061	29
Pennsylvania	12,275,624	-0.027	-0.161	-0.618	-0.708	-0.039	44	-0.039	23	-0.002	-0.064	30
South Carolina	4,013,644	-0.096	-0.177	-0.491	-0.539	-0.008	25	-0.095	30	-0.02	-0.069	31
Maine	1,275,357	-0.170	-0.188	-0.338	-0.362	0.026	12	-0.154	41	-0.038	-0.072	32
Indiana	6,081,521	-0.039	-0.185	-0.685	-0.794	-0.041	45	-0.050	25	-0.004	-0.073	33
Idaho	1,294,016	-0.148	-0.209	-0.488	-0.517	0.008	18	-0.139	38	-0.032	-0.081	34
Tennessee	5,688,335	-0.100	-0.231	-0.713	-0.812	-0.024	35	-0.104	31	-0.019	-0.09	35
Montana	902,740	-0.255	-0.242	-0.336	-0.360	0.053	5	-0.227	48	-0.059	-0.092	36
Missouri	5,595,490	-0.111	-0.245	-0.747	-0.845	-0.023	34	-0.114	33	-0.021	-0.096	37
Louisiana	4,469,586	-0.103	-0.251	-0.793	-0.938	-0.029	38	-0.108	32	-0.019	-0.098	38
Wyoming	493,849	-0.193	-0.270	-0.625	-0.668	0.012	17	-0.181	43	-0.042	-0.104	39
Iowa	2,923,345	-0.147	-0.300	-0.882	-1.006	-0.022	32	-0.149	40	-0.029	-0.117	40
Kansas	2,687,110	-0.139	-0.301	-0.908	-1.032	-0.027	37	-0.142	39	-0.027	-0.118	41
Alabama	4,446,543	-0.111	-0.309	-1.016	-1.234	-0.044	46	-0.121	34	-0.019	-0.121	42
Kentucky	4,040,856	-0.111	-0.321	-1.073	-1.313	-0.048	49	-0.122	35	-0.019	-0.126	43
Nebraska	1,709,804	-0.188	-0.329	-0.894	-1.028	-0.010	27	-0.184	46	-0.039	-0.128	44
Arkansas	2,672,286	-0.185	-0.346	-0.972	-1.124	-0.017	30	-0.183	44	-0.037	-0.135	45
Oklahoma	3,450,058	-0.187	-0.365	-1.051	-1.241	-0.023	33	-0.187	47	-0.037	-0.142	46
South Dakota	753,887	-0.254	-0.402	-1.022	-1.163	0.000	22	-0.244	50	-0.054	-0.156	47
Mississippi	2,844,004	-0.164	-0.403	-1.277	-1.605	-0.047	48	-0.172	42	-0.03	-0.158	48
West Virginia	1,809,034	-0.172	-0.444	-1.428	-1.777	-0.056	50	-0.184	45	-0.031	-0.174	49
North Dakota	642,412	-0.234	-0.464	-1.344	-1.641	-0.031	39	-0.235	49	-0.047	-0.181	50

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



Iso-rent curves based on calibration: phiL =.233333, phiN =.616667, sigmaY =.666667

Figure A2: Housing Costs and Inferred Land Rents: Quadratic Approximation



Inferred land rents based on calibration: phiL =.233333, phiN =.616667, sigmaY =.666667