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An Explicit Spatial Approach to the Value of Local Social Amenities in Metro and Non-Metro Counties in the U.S.: Implications for Comprehensive Wealth Measurement

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Abstract: This study extends and reinterprets Roback's general spatial equilibrium model by casting it within the comprehensive wealth framework. Considering the explicit spatial effects among regions, the analysis refines estimates of the contribution of natural, built, social, cultural, and human capital to residents' wealth. We develop an empirical model and apply it to secondary data from 3109 counties in the United States. Our analysis provides a means of partitioning the sources of wealth in traditionally measured financial wealth and various types of amenities, while avoiding double counting the values of natural and publicly provided assets. Our findings indicate that rising property values are not simply an outcome of limited supply but are often an indicator of rising demand for improving amenities, suggesting different strategies for property and income taxation policy. There are apparently differences between the value of amenities in metro and non-metro counties. Our model explicitly estimates the spatial spillover and feedback effects of policy changes on local land values and wages. It also measures the differences in determinants of asset values and wages in metro from non-metro counties in the U.S.

Keywords: comprehensive wealth; spatial equilibrium model; metro and non-metro regions; spatial interaction; place-based intangible assets; housing supply/affordability

JEL Classification: C31; C81; O18; R1

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1. Introduction

Over the last quarter century, there has been rising interest among economists regarding the concept of comprehensive wealth. It has been defined in numerous ways, but in all definitions, comprehensive wealth includes various types of tangible and intangible, appropriated (marketed) and unappropriated (free or non-marketed), and private (excludable) and public (non-excludable) assets (Arrow et al., 2012 [1]; Cobb and Daly, 1989 [2]; Pender et al., 2014 [3]; United Nations University–International Human Dimensions Programme and United Nations Environment Programme, 2014 [4]; World Bank, 2006, 2011 [5,6]). The comprehensive wealth framework is built on the concept of inclusive, sustainable, or Fisherian income. The relationship between Fisherian income and comprehensive wealth was formally described by William Nordhaus, the 2018 winner of the Nobel Prize in Economic Sciences. Nordhaus (1995, 2000) [7,8] distinguishes between Hicksian and Fisherian income and relates the latter to comprehensive consumption and net investment of appropriated, unappropriated, privately, and publicly provided goods and services. As explained in detail below, Hicksian income (value) determines wealth, whereas Fisherian income is determined by the sustainable flow of value from wealth.

To estimate the level of, and changes in, comprehensive wealth, one must first identify and measure all assets. Next, one must estimate the flow of value from these assets. Roback's (1982) [9] framework provides a useful starting point for measuring comprehensive wealth because it allows indirect estimation of values placed on nonmarket assets and disentangles overlapping market and nonmarket valuations (avoiding double counting the value of local amenities). The Roback model links property values and local wage markets to immobile assets and proposes a method for joint estimation of the demand and supply of land and labor. The model assumes that mobile resources (labor and capital) will move to those locations where they receive the highest monetary and nonmarket benefits until prices adjust and equilibrium is achieved. At that point, the value of immobile land and local wages will reflect the value of amenities and other assets [1]. We find that rising property values are not simply an issue of supply relative to the demand for housing services, but can be an indicator of rising demand for local amenities. This suggests different policy strategies. For example, rising property values due to improving public services and amenities is a justification for higher property taxes. Furthermore, an increased supply of affordable housing accompanied by the declining quality of amenities should not be viewed as desirable.

Additionally, it is probable that people migrate on the basis of social issues (including social status) as well as income. This study particularly defines social amenities as region-specific flows from investments in social capital. Investments in social capital have both private and public returns, known as "demonstrable externalities" (Putnam, 2001, p. 1, [15]). Local residents and newcomers will experience the amenities regardless of where the original investor resides.

This study estimates the marginal valuation of various local amenities and assets indirectly indicated by variations in land values and wage rates in 3109 U.S. counties (the states of Alaska and Hawaii are excluded). Including all counties in the model, we explicitly consider spatial interactions in land values and wages because of potential spillover effects across county lines. The benefits generated by some amenities are not constrained by jurisdictional boundaries, and thus, the value of amenities is expected to influence land prices and wage rates in neighboring counties. In particular, employing all urban and rural counties in the pooled regression allows us to separate the effects of local and nearby amenities for spatial analysis. We also develop a somewhat different definition of expected average income than that used by Roback (1982) [9]; ours more closely reflects locally sourced income.

Together, these modeling innovations lead to more accurate and precise estimates of the contributions of various components of comprehensive wealth to residents of metro and non-metro counties. These estimated contributions can then be used to fine-tune and justify local policies related to taxation, public investments, conservation programs, and intergovernmental cooperation.

2. Roback's General Spatial Equilibrium Model and Comprehensive Wealth

The Roback model was primarily developed to estimate the contribution of certain amenities to spatial variations in land values and wage rates. The more recent concept of comprehensive wealth was not a rationale for the Roback model, but the approach is very compatible with the concept of comprehensive wealth. This section elaborates on Roback's general spatial equilibrium model and its relevance to comprehensive wealth.

Recently, there have been several efforts undertaken to broaden the concept of wealth to include nonmarketed and intangible assets, such as human capital (e.g., Arrow et al., 2012 [1]; Pender et al., 2014 [3]; World Bank, 2006, 2011 [5,6]). With the consideration of sustainability [2], the very broad definition of wealth described by Pender et al. (2014) [3] that this study adopted refers to "the stock of all assets, net of liabilities, which can contribute to the well-being of an individual or group" (p. 19). The Roback model yields strong implications for relationships between various types of tangible and intangible amenities. The model assumes that local amenities affect local land prices (a natural capital stock) and wages (a flow). Local amenities are flow benefits that can come from the accumulated stocks of various regional assets. In the comprehensive wealth framework, the benefits of local amenities are usually nonmarketable and immobile and have both external (nonexcludable) and internal (excludable) benefits. The Roback model can help us differentiate external (e.g., public investments in local amenities) from internal benefits (e.g., land prices), which helps improve our ability to estimate comprehensive wealth.

Increased levels of human capital (a stock) through investments in quality of education (a flow) and better physical capital (a stock) through public investments (a flow) can attract more firms (Wu and Gopinath, 2008 [17]). The increased supply of workers and residents attracted by higher levels of natural amenities tends to reduce the labor costs of local firms (Deller et al., 2001 [18]). If amenities attract workers and thereby decrease firms' costs, then land values will be bid up by both consumers and employers (Osei and Winters, 2019 [19]). Additionally, government economic development programs can minimize costs of firms (e.g., taxation policy, minimum wages and poverty reduction programs, and improvements in public infrastructure and telecommunications; Deller et al., 2001 [18]; Rappaport and Sachs, 2003 [20]; Wu and Gopinath, 2008 [17]).

An important feature of the comprehensive wealth framework is that it makes a clear distinction between stocks of assets and the flow of benefits (and costs) from these assets. This distinction is often overlooked in economic research but is essential when estimating true and comprehensive wealth, as well as when disentangling sources of wealth. Because many place-specific assets (local amenities) provide nonmarket benefits (flows) that are capitalized into land values (a stock) and into wage rates (a flow), we must carefully interpret the results of estimated relationships. In addition, the connection to comprehensive wealth is the identification of the overlap of financial wealth (land values and wages) and local amenities (flow benefits). This is important since it is necessary to avoid double counting when measuring wealth.

The broader way to measure development in the comprehensive wealth framework focuses our policy strategies on local assets, drawing attention to the returns on investments in public assets and the relationship between these public investments and private wealth creation. The model predicts that the value of non-marketed immobile amenities and public goods will be fully capitalized into land rents (natural capital), whereas the productive value of mobile human and other non-marketed forms of assets will be reflected in local wages. Knowing these relationships would be very helpful for successful economic development, which generally requires investments in a portfolio of different types of wealth. Important from a policymaking perspective, it recognizes that investing in one capital will have impacts—both positive and negative—on other capitals and, therefore, on sustainability.

3. Comprehensive Wealth Measurement Typology: The Concept and Sources of Social Amenities

This study defines a social amenity as the sum of (1) local externalities of private investments in mobile social capital, (2) local externalities of private investments in immobile social capital, and (3) social and public benefits of public investments in physical and social capital. Frank (1985) [21] and Roback (1982) [9] indicate that people often acquire certain goods through labor and housing markets by choosing jobs and homes which increase their utility; for instance, if people move from one community to another community, they may accept a lower income but increase their social status and thus their utility. Based on the underlying logic of the spatial hedonic model, workers are willing to accept somewhat lower incomes if they can live in places that provide better amenities. This includes social amenities such as income distribution. Additionally, based on social capital theories, investments in social capital by individuals can have both private and public returns, known as "demonstrable externalities" (Putnam, 2001, p. 1 [15]). At the community level, these externalities are social amenities, sometimes positive and sometimes negative.

People do not purchase social amenities in the market, so the services that flow from social amenities are nonmarketable. Similarly, natural amenities, which flow from natural capital, are typically not directly marketable (Pender et al., 2014 [3]) but contribute to each individual's comprehensive wealth and thus affect their behavior. Differentiating immobile (tied to place) from mobile (tied to people) capital and external (nonexcludable) from internal (excludable) benefits provides a useful way to understand and value amenities. Social amenities share the characteristics of public goods, which are nonrivalrous and nonexcludable, and largely immobile. In this study, we focus on public investments by local governments. The external benefits of public services are defined as social amenities in this study.

Figure 1 shows how public investments (in physical and social capital) produce both private and social benefits, which can contribute to residents' and a community's aggregate comprehensive wealth. For instance, public investments in parks, libraries, educational services, and community centers generate local amenities, which can attract people who value these amenities. These investments can produce private benefits such as higher property values, improved health, better public services, and profitable businesses (e.g., better public policies and services for education and businesses), as well as social benefits (as externalities) such as lower crime rates, lower poverty, and more equal distribution of income. Empirically, the significance and sign of the GINI coefficient would suggest that workers prefer to live in communities with less divergence of income. This may predict a process of socioeconomic homogenization, but more importantly, it suggests that communities that reduce poverty will be more attractive to both lower and higher-income workers.

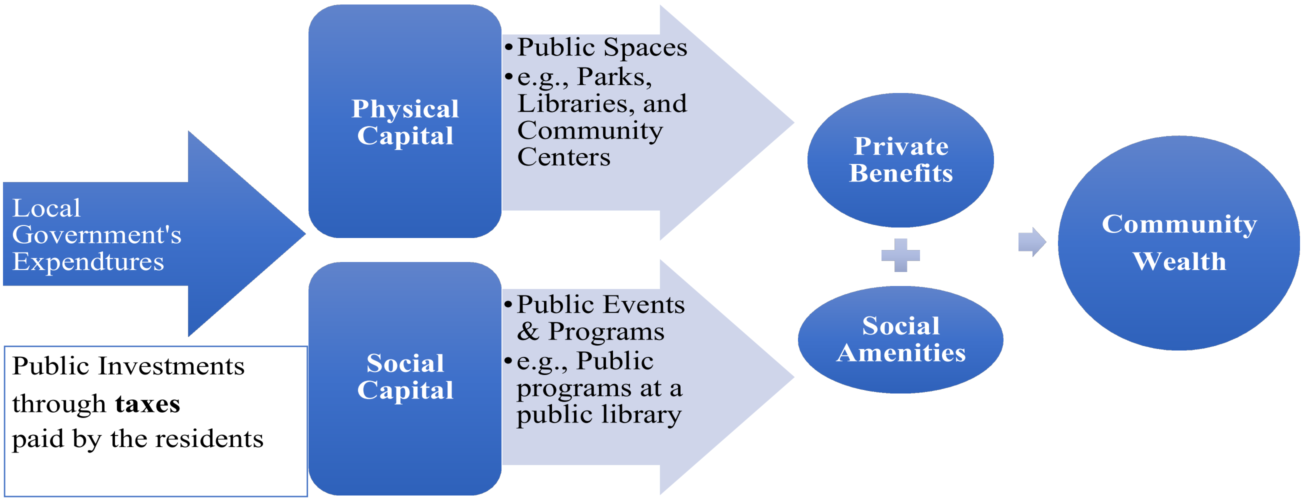

Figure 1. Conceptual logic: sources of social amenities from public investments.

There may also be negative externalities from public investments. Infrastructure investments may increase traffic, create congestion, increase air pollution, etc. Roback's general spatial equilibrium model implies that local wages and land values will adjust through people's mobility to maximize utility and account for these differences in amenities. The positive and negative externalities are assumed to be fully capitalized into the values of wages and land values at the equilibrium.

4. The Relationship among Social Amenities, Natural Amenities, Land Values, and Wages

The theory and performance of the methods to value and capitalize nonmarket and intangible assets, such as environmental resources and amenities, have been a major consideration of environmental economists over the past several decades (Smith, 1997) [22]. However, the relationship between amenity valuation and comprehensive wealth is a relatively recent concern of economists. The spatial hedonic model following from Roback (1982) [9] yields strong implications for measuring the comprehensive wealth of communities. The model provides a linking mechanism between the flows of the value of non-market assets (i.e., local amenities) and tangible assets (i.e., land values and wages). The Roback model (1982) [9] links property values and local wage markets and proposes a method for joint estimation of the demand and supply of land and labor. The model predicts that mobile resources (labor and capital) will move to those locations where they receive more monetary and non-market benefits until prices adjust and they achieve equilibrium. At that point, the value of immobile land and local wages will reflect the value of amenities.

5. Estimation Approach

This study makes similar assumptions regarding equilibrium and optimal consumption of public services (g), arguing that everyone in the county has the same utility function and income. However, in this case, we assume that g is measured in terms of quantity and quality of public services. Then, the marginal utility of one dollar of g is equal to the marginal utility of one dollar of x (tradable goods).

In equilibrium, the county residents' utility functions are:

$$V = U(l, N, s) = U\left(x^*, l^{c^*}, g^*; s\right) \tag{1}$$

and their incomes are:

$$w + I = x^* + t + l^{c*} \cdot r \tag{2}$$

where x is tradable goods, l^c is the residential land in a county, N is workers, w is wage income, I is nonwage income, $w + I$ is the county's income, t is the annual tax revenues, and r is the price per unit of residential space.

In equilibrium, the following optimizing conditions are required:

$$\begin{gathered} MRS_{gx} = \frac{\partial t}{\partial g} (\text{since the price of } x \text{ is } 1) \\ MRS_{gl^c} = \frac{\frac{\partial t}{\partial g}}{r}, \text{and} \\ MRS_{l^c x} = r, \text{ since the price of } x \text{ is } 1 \end{gathered} \tag{3}$$

and the demand function is:

$$g = f\left(\frac{\partial t}{\partial g}, \ w + I, \ r, \ l^c\right), \tag{4}$$

where $\frac{\partial t}{\partial g}\left(= \frac{t}{g}\right)$ is the implicit price of g, l^c is the residential land in a county, r is the county's expected average housing rents, and w is the county's expected average income.

Equation (3) indicates that the expenditures on x and g have the same marginal values for residents. If g is always optimal, the MRS_{gx} would be equal to the price ratio [3]. In itself, g is a function of the quality of services and the unit cost to residents is t/g. In equilibrium, the implicit price of government services (social amenities, g) is (t/g).

On the production side, the total cost to produce g is:

$$TC = f\ (g) = C\ (g,\ Z_g) \times g \tag{5}$$

where C is the average cost per unit of g. This indicates that the total cost of g depends on a vector of the county's characteristics or cost conditions Z_g.

From the demand function for g (4), Equation (5), and assuming that nonwage income I is independent of location as in Roback, we can derive the following functions:

$$\begin{gathered} r = f\ \left(\frac{\partial t}{\partial g}, w, Z_g,\ l^c\right) \\ w = f\ \left(\frac{\partial t}{\partial g},\ r,\ Z_g,\ l^c\right) \end{gathered} \tag{6}$$

Using Equation (6), we can test if g is at its optimum level. If we find that the implicit value of public services expressed through wage and rent differences is significantly different than zero, it indicates that g is not at its optimum. If the implicit price is positive, g is underprovided. If the implicit price is negative, g is overprovided. This would be a good way to determine if the system is in equilibrium. If we find that the system is not in equilibrium and that the implicit value of government services is greater than the price, residents and firms would be willing to pay extra for the services and would capitalize this WTP in land values and wages. Employing this approach allows us to determine if the amenity values are changing.

6. Non-Spatial and Spatial Models

6.1. Non-Spatial Model

Equation (6) is a simultaneous system since land rent (r) is a function of the wage rate (w) and vice versa. To derive consistent estimates, we must find instrumental variables (IV) that satisfy the following two properties (Baum, 2006 [23]; Wooldridge, 2002, 2006 [24,25]). (1) The instrument Z_g must be uncorrelated with an error term (u) but (2) it has to be correlated with the dependent variable through the instrumented one (r or w, respectively). In other words, the instrument Z_g in the rents equation (r) is a factor of the rent but should not be a significant factor in the wage (w) equation. The simple model for single-equation instrumental variables regression can be written as follows:

$$\begin{aligned} Y_i &= Y_j\gamma_1 + X_{1i}\beta_2 + u_i \\ Y_j &= X_{1i}\Pi_1 + X_{2i}\Pi_2 + \mathrm{v}_i \end{aligned} \tag{7}$$

where Y_i represents the dependent variable for the ith observation (log county rent or wage), Y_j are the endogenous regressors, X_{1i} are the included exogenous regressors, X_{2i} represents the excluded exogenous regressors. X_{1i} and X_{2i} are called the instruments. u_i and v_i are zero-mean error terms, presuming that the correlations between u_i and the elements of v_i are non-zero.

6.2. Spatial Model

To implement spatial models, this study employs the contiguity-based spatial weight matrices from J. Kim, Johnson, and Pender (2017) [26]. This study, thus, defines neighbors as counties having common borders (adjacent). This study reports spatial regression results for the entire continental Unites States.

The model of interest follows the econometric model of Drukker, Prucha, and Raciborski (2011) [27]:

$$y = Y\pi + X\beta + \lambda Wy + u \tag{8}$$

$$u = \rho Mu + \epsilon \tag{9}$$

where y is an $n \times 1$ vector of observations on the dependent variables (i.e., r and w), Y is an $n \times p$ matrix of observations on p right-hand side endogenous variables, π is the corresponding $p \times 1$ parameter vector, and X is an $n \times k$ matrix of observations on k right-hand side exogenous variables. The sum of the right-hand side exogenous variables may be spatial lags of exogenous variables (Drukker et al., 2011 [27]). β is the corresponding $p \times 1$ parameter vector. There are $n \times n$ spatial weighting matrices, W and M with zero diagonal elements (which are taken to be known and non-stochastic, Drukker et al., 2011 [27]), an $n \times 1$ vector of spatial lags, Wy and Mu, and the corresponding scalar parameters, known as SAR parameters, λ and ρ, and an $n \times 1$ vector of innovations, ϵ, which are assumed to be (1) independent and identically distributed or (2) independent but heteroskedastically distributed.

Equations (8) and (9) are modeled to include exogenous and additional endogenous regressors incorporating spatial interactions through spatial lags. The spatial interactions model allows for spatial interactions in the dependent and the exogenous variables, and in the error terms (Drukker et al., 2011 [27]).

Setting $\rho = 0$ causes the model to be reduced to a spatial lag model (known as the SAR):

$$y = Y\pi + X\beta + \lambda Wy + \epsilon \tag{10}$$

In this model, the spatial lag, Wy, is an endogenous variable by construction, indicating the dependence of the dependent variable on neighboring outcomes via the spatial lag (Drukker et al., 2011, 2013 [27,28]). Letting $\overline{y} = Wy$, $\overline{y_i}$ denoting the ith element of $\overline{y}$ and y, respectively, w_{ij} as the (I, j)th element of W, we can write the dependence of y_i on neighboring outcomes through the spatial lag $\overline{y}$ as follows:

$$\overline{y_i} = \sum_{j=1}^{n} w_{ij} y_j \tag{11}$$

In the model, the SAR parameter lambda (λ) measures the extent of the interactions through the spatial lags (the weights w_{ij}, Drukker et al., 2011 [27]).

Setting $\lambda = 0$ reduces the model to a spatial error model (SEM):

$y = Y\pi + X\beta + u$, where $u = \rho Mu + \epsilon$. Setting both SAR parameters λ and $\rho = 0$ leads to a linear regression model with endogenous variables.

7. Data

7.1. Expected Average Income

One of the dependent variables in this study, w, is defined as the expected average county income. The measure for w, as closely as possible, reflects earnings from local sources only. According to the underlying logic of the spatial hedonic model, people are willing to accept lower incomes if they can live in places that provide better amenities. The income that is relevant is that which they receive because they live in a particular place. Income that is unrelated to place (e.g., pension, retirement benefits, return on financial investments) does not affect their choices because they can obtain that income anywhere. The Bureau of Economic Analysis' (BEA) personal income totals for each county are based on place of residence. Personal income is equal to the sum of net earnings by place of residence, property income (personal dividends, interest, and rental income), and current personal transfer receipts earned by the residents of each county. The ideal measure of income would not include personal interest income, dividends, rent, and most types of transfer receipts because these could be earned even if the individuals moved to another place. The BEA data on net earnings by place of residence [4] closely reflects the ideal measure, allowing us to exclude dividends, interest, rent, and personal current transfer receipts. The income that counts is wage income, business income (sole proprietorships and partnerships), and farm income (since 2004, the BEA has revised its income data to include the U.S. Department of Agriculture's farm income data). In order to derive the net earnings by place-of-residence estimates, the BEA calculates a residence adjustment estimate for each county. Essentially, the procedure makes negative adjustments in areas that are work centers (most urban centers) and positive adjustments in suburban counties.

To calculate our final measure of variable w, we divide the BEA's "net earnings by place-of-residence estimates" by the labor force by place of residence from the U.S. Bureau of Labor Statistics. This indicator of income implicitly includes the risk of being unemployed. For instance, if 5% of people in the labor force are unemployed, then the average person will expect to be unemployed 5% of the time, and our estimate of net earnings will reflect this.

Figure 2 shows the distribution of w across counties. Spatial patterns in Figure 1 indicate that darker colors represent higher values of the dependent variable, w. Expected average income has mean values of 46,677.61 for the nation, 511,180.93 for the metro, and 43,993.65 for the non-metro.

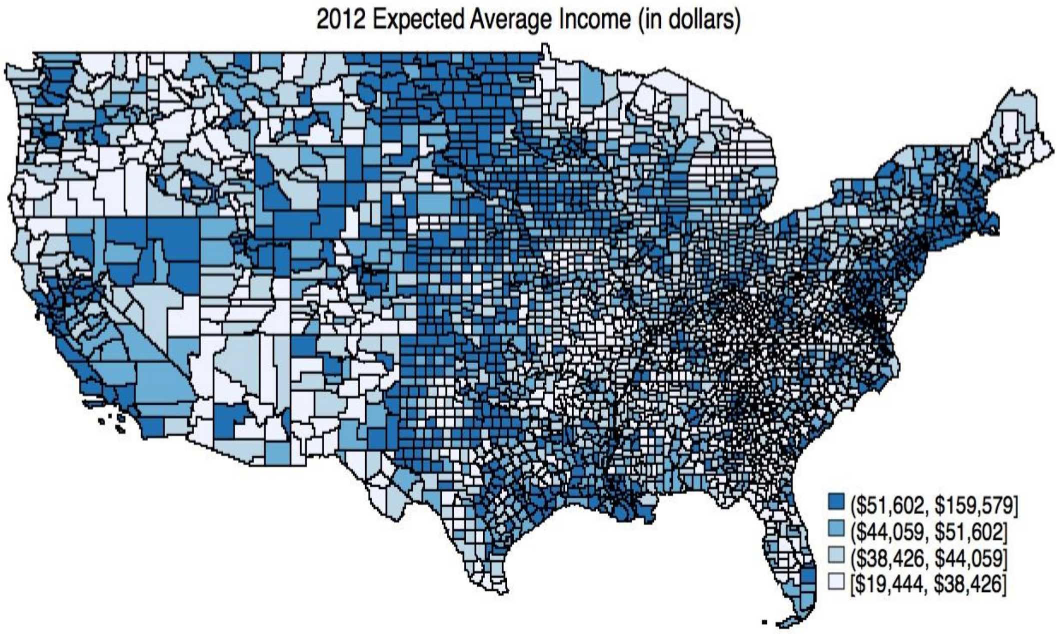

Figure 2. Expected average income for counties in the continental United States. Source: created by the authors using STATA software.

7.2. Expected Average Rent for Residential Sites

The economic rent of land is intended to be a measure of the variable *r*. This study defines *r* as expected average rents. This is based on a Ricardian rent concept and is equal to the value of unimproved land [5]. Therefore, the amount that people pay to lease homes and the implicit value of owner-occupied dwellings is too high because it includes the value derived from the public and private improvements (buildings, street access, water service, etc.). Because the value of improvements is not equal in all locations, we need to separate the value of improvements from that of the land to accurately estimate the variable. Our county-based data, though not having the spatial specificity of the micro data used by Roback, include a broader range of residential sites than that of Roback (1982) [9] [6]. We employ data on owner-occupied housing values from the American Community Survey in order to have comparable data for all 3109 counties [7].

To calculate the implicit price of an amenity as in Roback (1982) [9], housing values and earnings should be for the same time unit. The partial derivative of housing values with respect to an amenity includes the present value of all expected future benefits of owning the house, so here we translate housing values into annual rent. To calculate the rent, this study adapts the user cost method (Himmelberg et al., 2005 [29]; Poterba, 1984, 1992 [30,31]):

$$r = P\,[rf + \omega - \tau\,(rm + \omega) + \delta_t - \gamma_{t+1} + \varepsilon_t], \tag{12}$$

where P is the average county housing value [8]; rf is the risk-free interest rate; ω is the property tax rate; τ is the marginal income tax rate; rm is the mortgage interest rate; δ_t is the depreciation rate; γ_{t+1} is the expected capital gain rate; and ε_t is the owner's risk premium.

The user cost method (Himmelberg et al., 2005 [29]; Poterba, 1984, 1992 [30,31]) estimates the real economic cost of homeownership in addition to the inclusion of direct payments for local public goods via property taxes (as cited in Bieri et al., 2023, p. 18 [32]), which can control the tax rates' impact on the amenity (effects on land values) [9].

The risk-free rate is a 10-year average of 3-month Treasury bill rates and is set at rf = 0.045 (4.5%). This is the opportunity cost of money invested in the home. In addition, the mortgage rate is the 10-year average of the 30-year fixed-rate mortgage and is set at rm = 0.055 and δ_t = 0.025. These values are based on estimates from Harding et al. (2007) [34].

We employed the 5-year average (2005–2009) of county property tax rates for the property tax rate (ω; the most recent available), assuming that changes between the 2005–2009 average and 2012 have been proportional across jurisdictions. The national average annual property tax rate on owner-occupied housing is 0.97%. These data were obtained from the Tax Foundation (property taxes on owner-occupied housing, by county, 5-year average, 2005–2009; http://www.taxfoundation.org accessed on 9 November 2022.).

The term $\tau\ (rm + \omega)$ is the income tax savings to homeowners because mortgage interest (rm) and property taxes (ω) are deductible from income for tax purposes. The income tax savings is subtracted from other costs because it is a benefit of home ownership.

Regarding the expected capital gain, we set average values of appreciation (40-year average rate of appreciation minus long-run inflation of 3.78% [10]) at the state level, which indicates that the value varies across states (real estate appreciation data from http://www.estateofmindsites.com), whereas Bieri et al. (2023) [32] treated the expected capital gain as constant (γ_{t+1}= 0.038, which was a long-run inflation of 2.0% plus a real appreciation of 1.8%). If homeowners maintain their homes in a constant physical condition (i.e., offset depreciation with repairs), the expected capital gain and appreciation rates are the same.

Figure 3 shows the distribution of expected average rents across counties. The darker colors in Figure 3 represent higher values of annual costs of housing consumption. It is interesting that the darker colored areas in Figure 1 match many of the light areas in Figure 2 in many areas, or vice versa. For instance, the middle band of the United States is visually distinct. This seems to support the idea that a place with higher amenities has relatively higher land values and lower wages, which is consistent with Roback's (1982) [9] spatial equilibrium model. Expected average rents have mean values, of 12,498.28 for the nation, 15,293.33 for the metro, and 10,832.43 for the non-metro. More information on other variables (e.g., how to measure, sources, and descriptive statistics) is included in Appendix A.

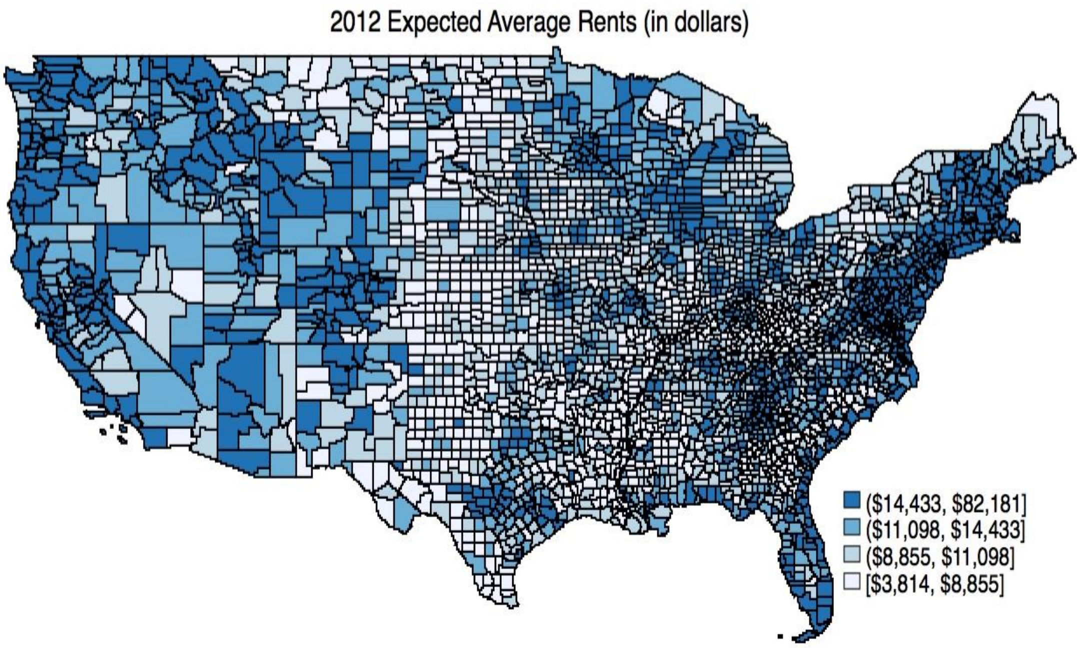

Figure 3. Expected average rents for counties in the continental United States. Source: created by the authors using STATA software.

8. Results: Non-Spatial vs. Spatial Models and Metro vs. Non-Metro Models

To employ spatial econometrics, we estimate equations for the entire continental United States because the spatial econometric models require spatial weights matrices to estimate the influence of neighboring counties, and thus dividing metro and non-metro counties into separate models is not possible.

We then employ the created contiguity-based spatial weight matrices from J. Kim et al. (2017) [26]. This study, thus, defines neighbors as counties having common borders (adjacent). At the same time, the model considers an endogenous variable in each equation. A dependent variable in one equation becomes a right-hand side variable in another equation.

We performed a Wald test on the estimated SAR coefficient (λ), and SAR models were statistically insignificant for both wage and rent equations. On the other hand, the estimated SEM coefficient (ρ) is positive and statistically significant, indicating spatial autocorrelation in the error term (ϵ). Therefore, this study reports results from the SEM model, which is preferable to the SAR model.

To test for differences in the marginal effects of the variables between metro and non-metro counties, we include a metro dummy variable and cross-products of the metro dummy with each of the variables. To implement 2SLS, we include all cross-products of each of the explanatory variables in the second stage. However, we need to consider interaction terms for the predicted endogenous variable in the second stage and thus each equation is assumed to have two endogenous variables (e.g., log county income and metro $\times$ log county income) and other excluded instruments, which consist of all instrumental variables and all cross-products of the metro dummy with each of the instrumental variables.

This section describes the SEM 2SLS with an assumption of normality of the error term. The spatial econometric model in this study assumes the term $\boldsymbol{\epsilon}$ in the specification of the equation to be independent and identically distributed (IID) or independent but heteroskedastically distributed, where the heteroskedasticity is an unknown form (see Drukker et al., 2011, 2013 [27,28]). We implemented both cases of homoskedastic and heteroskedastic specification in the econometric models and the results were identical, except for the spatial autoregressive parameters for both wage and rent equations. The spatial autoregressive parameters in the heteroskedastic specification were slightly higher than the values in the homoskedastic specification [11]. Both specifications produced consistent estimates from the pretesting. Thus, we only report estimates from SEM 2SLS with an assumption of IID ϵ.

Table 1 presents estimated coefficients based on the second-stage coefficients, which are estimates of the structural parameters. The coefficients indicate the direct effects of independent variables. Including spatial interactions produce slightly different direct marginal effects compared with non-spatial models for metro counties. Non-metro counties have very similar marginal effect values between spatial and non-spatial models. For metro counties, the inclusion of spatial effects decreases the directs effects of violent crime and child poverty, which implies that people in metro counties prefer places with less violence and less child poverty. For physical activity, both equations for metro and non-metro counties have positive effects on rent. The inclusion of spatial effects decreases slightly the direct marginal effect of physical activity opportunities in both metro and non-metro counties.

Tables 2–4 below present estimated coefficients and calculated marginal effects for metro and non-metro for non-spatial and spatial models based on the reduced-form coefficients, which are estimates of the total (direct and indirect) effects of each of the variables. In Table 2, we see a decreased magnitude gap for county revenues between metro and non-metro counties when including spatial interactions.

Child poverty, high school graduation rates, extreme temperature, and PM 2.5 have unexpected signs for the full implicit price. Large negative wage effects of child poverty and PM 2.5 outweigh the impacts on property values. Enhanced environmental policies affecting firms in metro counties might increase the costs of production. The higher human capital stock also might increase firms' costs in metro counties.

Table 1. Direct marginal effects for rent equations: non-spatial versus spatial models in the continental United States.

	Metro		Non-metro	
Variable	**Non-Spatial 2SLS Rent**	**Spatial 2SLS Rent**	**Non-Spatial 2SLS Rent**	**Spatial 2SLS Rent**
Log County Income	−0.23	-0.83×10^{-1}	−0.25	−0.25
County Revenue	0.22×10^{-1}	0.12×10^{-1}	0.31×10^{-2}	0.31×10^{-2}
Land Share	0.61×10^{1}	0.67×10^{1}	0.73×10^{1}	0.73×10^{1}
County Population	0.50×10^{-7}	0.40×10^{-7}	0.15×10^{-5}	0.12×10^{-5}
High School Graduation	0.52×10^{-3}	0.42×10^{-3}	0.11×10^{-3}	0.23×10^{-3}
Extreme Temp	-0.42×10^{-4}	-0.26×10^{-4}	-0.23×10^{-4}	-0.18×10^{-4}
PM 2.5	-0.71×10^{-2}	-0.40×10^{-2}	-0.42×10^{-2}	-0.26×10^{-2}
County Violent Crime	-0.36×10^{-4}	-0.67×10^{-5}	0.37×10^{-4}	0.39×10^{-4}
County GINI	0.69	0.30	-0.74×10^{-1}	−0.15
Mammography	0.11×10^{-2}	0.12×10^{-2}	0.11×10^{-2}	0.79×10^{-3}
Physical Activity	0.18×10^{-2}	0.11×10^{-2}	0.39×10^{-3}	0.39×10^{-3}
Child Poverty	-0.13×10^{-1}	-0.66×10^{-2}	-0.96×10^{-2}	-0.78×10^{-2}

Note. The values are based on Table A13 (see Appendix A). See Appendix A for all other variables' information.

Table 2. Total marginal effects for rent equations in the continental United States: metro versus non-metro and non-spatial versus spatial models.

Rent Equation	**Non-Spatial Model**		**Spatial Model**	
Variable	**Non-Metro**	**Metro**	**Non-Metro**	**Metro**
County Revenue	0.35×10^{-2}	0.12×10^{-1}	0.34×10^{-2}	0.92×10^{-2}
Land Share	0.74×10^{1}	0.60×10^{1}	0.74×10^{1}	0.66×10^{1}
County Violent Crime	0.15×10^{-4}	-0.39×10^{-4}	0.20×10^{-4}	-0.14×10^{-4}
Private Public School	0.13×10^{-2}	0.13×10^{-2}	0.71×10^{-3}	0.12×10^{-2}
County GINI	−0.44	0.97×10^{-1}	−0.39	-0.76×10^{-2}
Child Poverty	-0.82×10^{-2}	-0.11×10^{-1}	-0.63×10^{-2}	-0.73×10^{-2}
Physical Activity	0.45×10^{-3}	0.14×10^{-2}	0.47×10^{-3}	0.82×10^{-3}
High School Graduation	0.24×10^{-3}	0.64×10^{-3}	0.29×10^{-3}	0.41×10^{-3}
Poor Water Quality	0.31×10^{-4}	-0.52×10^{-4}	0.32×10^{-4}	-0.30×10^{-3}
Mammography	0.10×10^{-2}	0.13×10^{-2}	0.58×10^{-3}	0.11×10^{-2}
Extreme Temp	-0.18×10^{-4}	-0.46×10^{-4}	-0.13×10^{-4}	-0.34×10^{-4}
Sunshine	0.12×10^{-2}	0.18×10^{-5}	0.13×10^{-2}	0.78×10^{-3}
PM 2.5	-0.18×10^{-2}	-0.71×10^{-2}	-0.90×10^{-3}	-0.44×10^{-2}
County Unemployment	0.92×10^{-3}	0.10×10^{-1}	0.10×10^{-2}	0.48×10^{-2}
County Population	0.15×10^{-5}	0.50×10^{-7}	0.12×10^{-5}	0.30×10^{-7}
Population Growth	0.14×10^{-2}	0.23×10^{-2}	-0.99×10^{-3}	0.40×10^{-2}

Note. The values of the marginal effects are based on Table 1.

In Table 5, the inclusion of spatial interactions decreased the magnitude of the full implicit prices of both county GINI and violent crime. Conceptually, unequal distribution of income (county GINI) could have a positive or negative effect on property values. One would expect that it would be a disamenity to most residents, but if the unequal distribution leads to more property ownership by the richer segments of society, it could increase rent levels. The implicit values for county GINI are very high, but it is important to remember that this variable has potential values between 0 (perfect equality) and 1.0 (perfect inequality). Given that most of our observations are between 0.35 and 0.55, the actual differences between communities are only a fraction of this value.

Table 3. Direct marginal effects for wage equations: non-spatial versus spatial 2SLS in the continental United States.

	Metro		Non-Metro	
Variable	**Non-Spatial 2SLS Wage**	**Spatial 2SLS Wage**	**Non-Spatial 2SLS Wage**	**Spatial 2SLS Wage**
Log County Rent	0.61	0.55	0.43	0.33
County Revenue	0.42×10^{-2}	0.21×10^{-2}	0.47×10^{-2}	0.97×10^{-3}
Land Share	-0.36×10^{1}	-0.26×10^{1}	-0.42×10^{1}	-0.28×10^{1}
County Unemployment	-0.15×10^{-1}	-0.13×10^{-1}	-0.16×10^{-1}	-0.14×10^{-1}
Population Growth	-0.49×10^{-2}	-0.25×10^{-2}	0.10×10^{-1}	0.11×10^{-1}
Private Public School	0.19×10^{-2}	0.19×10^{-2}	0.74×10^{-3}	0.45×10^{-3}
Sunshine	-0.30×10^{-2}	-0.29×10^{-2}	0.28×10^{-3}	0.43×10^{-3}
County GINI	0.80	0.66	0.42	0.40
Poor Water Quality	0.75×10^{-3}	0.59×10^{-3}	-0.28×10^{-3}	-0.30×10^{-3}
Mammography	-0.17×10^{-2}	-0.16×10^{-2}	0.16×10^{-2}	0.20×10^{-2}

Note. The values are based on Table A15 (see Appendix A).

Table 4. Total marginal effects for wage equations in the continental United States: metro versus non-metro.

Rent Equation Variable	**Non-Spatial Model Non-Metro**	**Metro**	**Spatial Model Non-Metro**	**Metro**
County Revenue	0.12×10^{-2}	0.84×10^{-2}	-0.28×10^{-3}	0.75×10^{-2}
Land Share	−0.78	0.25	−0.44	0.66
County Violent Crime	0.84×10^{-4}	0.38×10^{-4}	0.69×10^{-4}	0.21×10^{-4}
Private Public School	0.89×10^{-3}	0.32×10^{-2}	0.51×10^{-3}	0.27×10^{-2}
County GINI	0.10×10^{1}	0.15×10^{1}	0.79	0.13×10^{1}
Child Poverty	-0.99×10^{-2}	-0.12×10^{-1}	-0.86×10^{-2}	-0.10×10^{-1}
Physical Activity	0.22×10^{-3}	-0.44×10^{-5}	0.14×10^{-3}	0.50×10^{-4}
High School Graduation	0.14×10^{-3}	0.80×10^{-3}	0.42×10^{-4}	0.55×10^{-3}
Poor Water Quality	0.21×10^{-4}	0.67×10^{-3}	-0.15×10^{-3}	0.38×10^{-3}
Mammography	0.13×10^{-2}	-0.13×10^{-2}	0.12×10^{-2}	-0.93×10^{-3}
Extreme Temp	0.52×10^{-5}	0.17×10^{-4}	0.77×10^{-5}	-0.18×10^{-4}
Sunshine	0.31×10^{-2}	-0.19×10^{-2}	0.33×10^{-2}	-0.19×10^{-2}
PM 2.5	-0.33×10^{-2}	-0.28×10^{-2}	-0.36×10^{-2}	-0.27×10^{-2}
County Unemployment	0.21×10^{-2}	0.67×10^{-2}	0.87×10^{-3}	0.30×10^{-2}
County Population	0.59×10^{-6}	0.16×10^{-7}	0.40×10^{-6}	0.11×10^{-7}
Population Growth	0.99×10^{-2}	-0.27×10^{-2}	0.98×10^{-2}	-0.33×10^{-2}

Note. The values of the marginal effects are based on Table A16 (see Appendix A).

Table 5. Annualized values based on non-spatial and spatial models for the metro.

	Annualized Value					
Variable	**Rent Equation**		**Wage Equation**		**Full Implicit Price**	
	Non-Spatial	**Spatial**	**Non-Spatial**	**Spatial**	**Non-Spatial**	**Spatial**
County Revenue (thousands of dollars per capita)	61.10	47.14	429.41	385.77	−368.32	−338.62
Land Share (fraction to consumer budget)	30,900.19	33,851.50	13,025.22	33,533.65	17,874.98	317.85
County Violent Crime (violent crimes/ 100,000 population)	−0.20	−0.07	1.93	1.07	−2.13	−1.14
Private Public School (fraction)	6.56	6.38	161.96	138.49	−155.40	−132.11

Table 5. *Cont.*

Variable	Annualized Value Rent Equation		Wage Equation		Full Implicit Price	
	Non-Spatial	**Spatial**	**Non-Spatial**	**Spatial**	**Non-Spatial**	**Spatial**
County GINI (index)	497.34	−38.97	78,655.21	66,045.64	−78,157.87	−66,084.60
Child Poverty (% children in poverty)	−56.52	−37.37	−602.36	−520.57	545.84	483.20
Physical Activity (% pop. with access to physical activity places)	7.21	4.19	−0.23	2.53	7.44	1.66
High School Graduation (% of graduation rate)	3.25	2.11	41.08	28.10	−37.83	−25.99
Poor Water Quality (% pop. in water violation)	−0.26	−1.56	34.10	19.35	−34.36	−20.91
Mammography (% female Medicare enrollees)	6.41	5.55	−64.7	−47.64	70.98	53.20
Extreme Temp (1 °F colder for one day)	−0.24	−0.17	−0.86	−0.91	0.62	0.74
Sunshine (% of possible)	0.01	3.98	−98.07	−97.24	98.08	101.22
PM 2.5 ($\mu g/m^3$)	−36.29	−22.55	−141.93	−136.41	105.64	113.86
County Unemployment (fraction of unemployment)	53.48	24.54	342.31	153.58	−288.83	−129.04
County Population (10,000 persons)	2.56	1.54	8.19	5.63	−5.63	−4.09
Population Growth (percentage change in pop.)	11.75	20.66	−136.24	−169.61	147.99	190.27

Note. Annualized value is in dollars. Measurement units of amenities are shown under variable names. Each entry is computed and evaluated at mean annual county income as follows: $P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w$. The average land share of the consumer's budget (k_l) is 0.01 for the metro. The average annual expected income (w) is $51,180.93 for the metro.

Table 6 shows that, as in metro counties, including spatial interactions in the non-metro model decreased the magnitude of the full implicit prices for both county GINI and violent crime. For county revenue, including spatial interactions made the positive wage effects negative, and thus there was a positive full implicit price, which indicates that g is underprovided. PM 2.5 has an unexpected positive value for the full implicit price due to the large negative wage effect.

Table 6. Annualized values based on non-spatial and spatial models for the non-metro.

Variable	Annualized Value Rent Equation		Wage Equation		Full Implicit Price	
	Non-Spatial	**Spatial**	**Non-Spatial**	**Spatial**	**Non-Spatial**	**Spatial**
County Revenue (thousands of dollars per capita)	11.59	11.15	53.39	−12.23	−41.80	23.38
Land Share (fraction to consumer budget)	24,307.93	24,271.69	−34,182.32	−19,230.98	58,490.25	43,502.67
County Violent Crime (violent crimes/ 100,000 population)	0.05	0.07	3.70	3.01	−3.65	−2.95
Private Public School (fraction)	4.31	2.33	39.31	22.30	−35.00	−19.97
County GINI (index)	−1459.08	−1280.84	44,498.96	34,632.02	−45,958.04	−35,912.86

Table 6. *Cont.*

Variable	Annualized Value Rent Equation		Wage Equation		Full Implicit Price	
	Non-Spatial	**Spatial**	**Non-Spatial**	**Spatial**	**Non-Spatial**	**Spatial**
Child Poverty (% children in poverty)	−27.14	−20.80	−433.76	−378.58	406.62	357.78
Physical Activity (% pop. with access to physical activity places)	1.48	1.55	9.58	6.05	−8.10	−4.49
High School Graduation (% of graduation rate)	0.79	0.94	6.17	1.85	−5.39	−0.90
Poor Water Quality (% pop. in water violation)	0.10	0.10	0.92	−6.78	−0.81	6.88
Mammography (% female Medicare enrollees)	3.44	1.91	58.23	54.69	−54.79	−52.78
Extreme Temp (1 °F colder for one day)	−0.06	−0.04	0.23	0.34	−0.29	−0.38
Sunshine (% of possible)	3.87	4.26	138.39	143.52	−134.52	−139.26
PM 2.5 ($\mu g/m^3$)	−6.04	−2.97	−143.15	−157.03	137.11	154.06
County Unemployment (fraction of unemployment)	3.04	3.39	94.28	38.32	−91.24	−34.93
County Population (10,000 persons)	48.17	39.26	261.41	173.83	−213.23	−134.57
Population Growth (percentage change in pop.)	4.63	−3.28	435.16	432.87	−430.53	−436.15

Note. Annualized value is in dollars. Measurement units of amenities are shown under variable names. Each entry is computed and evaluated at mean annual county income as follows: $P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w$. The average land share of the consumer's budget (k_l) is 0.075 for non-metro counties. The average annual expected income (w) is $43,993.65 for non-metro counties.

9. Concluding Remarks

The model employed in this study helps us understand the underlying forces driving spatial variations in land values and wages. Our findings indicate that changing property values are not simply an issue of supply and typical demand variables but also indicate changes in the level and demand for amenities. This suggests different policy strategies. For example, rising property values due to improving built amenities is a justification for funding these public investments with property taxes rather than other sources of revenue. Lower housing affordability (i.e., higher land prices relative to wages) is generally viewed as a negative. However, these results show that rising housing prices are sometimes an equilibrium response to the rising level of, or increased demand for amenities, which signals an increasing comprehensive wealth of residents. In the opposite case, declining housing costs, while making housing more affordable, is not necessarily desirable if it is due to the declining quality of natural and publicly provided amenities. The results of this study also help us understand the feedback and spillover effects of changing amenities on wages and land values in neighboring counties.

There are apparently differences between the value of amenities in metro and non-metro counties. Violent crime and unequal distribution of income were disamenities. For county GINI, larger positive wage effects in metro counties produced larger negative full implicit value than in non-metro counties. For county revenue, the full implicit value indicated that government services are overprovided in metro (negative value) but are underprovided in non-metro counties (positive value) in the spatial model specifications.

The general spatial equilibrium model yields strong implications for measuring comprehensive wealth by linking the value of nonmarketed immobile local amenities and local land rents and wages and by partitioning values attributable to various types of capital. Many intangible and nonmarketable assets increase the value of tangible market assets, such as land. On the basis of this model, increasing income is associated with an increased level of nonmarketed immobile local amenities, which can make wealth more sustainable. The results of this study contribute to the research literature by refining the indicators of local income, land rent, and amenities, which can contribute natural, social, and human capital to the wealth of a location.

Additionally, this study introduces several modifications to the Roback framework. We estimated an SDEM for all 3109 counties in the contiguous United States with aggregate county-level data that allowed the full range of advantages of spatial analysis. Including interactions between a metro dummy and each explanatory variable in the pooled regression allowed us to estimate distinct coefficients for metro and non-metro counties. Furthermore, this study effectively separates the effects of local and nearby amenities using spatial econometric methods. The model produces mostly expected results with relatively high R-squared values for a cross-sectional model.

There are important policy implications for this research. The results provide estimates of the relative value of various local assets and amenities, providing policymakers with a stronger basis for allocating public funding. On the basis of the empirical results, policymakers should view policies designed to reduce crime rates and income inequality as elements of their economic development toolbox. Results also indicate that policymakers must consider their spatial context and expect spatial interactions with neighboring counties. In particular, the spatial lag of cross-products of the metro dummy with violent crime indicates that a metro county's violent crime rate decreases land values and the comprehensive wealth of residents of neighboring counties. This should encourage localities to collaborate and coordinate their efforts. The same levels of amenities have different impacts on land values and wages depending on the levels of these amenities in adjacent counties. Well-designed policies and investments in immobile and nonmarketed amenities of a location will make a place more attractive and sustainable with enhanced land values, which contributes to balancing place prosperity and people prosperity.

In conclusion, spatial analysis of the value of place-specific natural, cultural, social, and publicly provided amenities and assets moves us one step closer to our goal of accurately measuring the level of, and changes in, comprehensive wealth at the local level and ultimately to public policy strategies available to enhance societal comprehensive wealth and sustainability.

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Appendix A

Appendix A.1. Calculating the Variable w

Some counties (especially in Virginia) cause a problem for the consistent measurement of w due to independent cities. The BEA combines the independent cities of Virginia with populations of fewer than 100,000 with an adjacent county and gives codes starting at 901. In the name of the combined area, the county name appears first and is followed by the city name(s).

Table A1. BEA modifications to Federal Information Processing Standard (FIFS) codes.

15901 Maui and Kalawao, HI 15005 Kalawao 15009 Maui	51939 Pittsylvania + Danville, VA 51143 Pittsylvania 51590 Danville
51901 Albermarle + Charlottesville, VA 51003 Albermarle 51540 Charlottesville	51941 Prince George + Hopewell, VA 51149 Prince George 51670 Hopewell
51903 Alleghany + Covington, VA 51005 Alleghany 51580 Covington	51942 Prince William + Manassas + Manassas Park, VA 51153 Prince William 51683 Manassas 51685 Manassas Park
51907 Augusta + Staunton + Waynesboro, VA 51015 Augusta 51790 Staunton 51820 Waynesboro	51944 Roanoke + Salem, VA 51161 Roanoke 51775 Salem
51911 Campbell + Lynchburg, VA 51031 Campbell 51680 Lynchburg	51945 Rockbridge + Buena Vista + Lexington, VA 51163 Rockbridge 51530 Buena Vista 51678 Lexington
51913 Carroll + Galax, VA 51035 Carroll 51640 Galax	51947 Rockingham + Harrisonburg, VA 51165 Rockingham 51660 Harrisonburg
51918 Dinwiddie + Colonial Heights + Petersburg, VA 51053 Dinwiddie 51570 Colonial Heights 51730 Petersburg	51949 Southampton + Franklin, VA 51175 Southampton 51620 Franklin
51919 Fairfax, Fairfax City + Falls Church, VA 51059 Fairfa x51600 Fairfax City 51610 Falls Church	51951 Spotsylvania + Fredericksburg, VA 51177 Spotsylvania 51630 Fredericksburg
51921 Frederick + Winchester, VA 51069 Frederick 51840 Winchester	51953 Washington + Bristol, VA 51191 Washington 51520 Bristol
51923 Greensville + Emporia, VA 51081 Greensville 51595 Emporia	51955 Wise + Norton, VA 51195 Wise 51720 Norton
51929 Henry + Martinsville, VA 51089 Henry 51690 Martinsville	51958 York + Poquoson, VA 51199 York 51735 Poquoson
51931 James City + Williamsburg, VA 51095 James City 51830 Williamsburg	55901 Shawano (incl. Menominee), WI (prior to 1989) 55078 Menominee 55115 Shawano
51933 Montgomery + Radford, VA 51121 Montgomery 51750 Radford	

Data preparation involved many changes, combining, separating, and removing counties' names. For instance, Bedford (independent) city, Virginia (FIPS: 51515), changed to town status and was added to Bedford County (FIPS: 51019), effective 1 July 2013. Clifton Forge (independent) city, Virginia (FIPS: 51560) changed to town status and was added to Alleghany County (FIPS: 51005), effective 1 July 2001. The separate Virginia county and independent city data are not available. This study compared the ratio of the labor force or the employed number between combined places, and both have similar values of (almost the same) the ratio. It is presumed to assign each missing value as the labor force ratio between combined places multiplied by the combined value.

Shannon county, SD, was renamed to Oglala Lakota county (FIPS: 46102), SD, in May 2015. Fairfax city is assigned to Fairfax County (FIPS: 51059). For Bedford County, the independent city of Bedford, VA (FIPS 51515), collapsed into 51019.

Table A2. Climate, geographic, and environmental variables.

Variable	Description	Source
PM 2.5	Particulate matter 2.5 µm or less in diameter	BKP (2015) *; EPA-AQS *
PM 10	Particulate matter 10 µm of less in diameter	BKP (2015); EPA-AQS
Heating Degree Days	Mean annual heating degree days (using a 65-degree F base)	BKP (2015); NOAA-NCDC *
Cooling Degree Days	Mean annual cooling degree days (using a 65-degree F base)	BKP (2015); NOAA-NCDC
Extreme Temp	Mean annual extreme temperature days (calculated as the sum of heating degree days and cooling degree days) (using a 65-degree F base)	
Sunshine **	Average % of possible	BKP (2015); NOAA-NCDC
Precipitation	Mean annual precipitation (inches p.a., 1971–2000)	BKP (2015); NOAA-NCDC
Wind Speed	Mean wind speed (m.p.h., 1961–1990)	BKP (2015); NOAA-NCDC
Natural Scale	Natural Amenities Scale (ERS) (higher score is a place with higher amenities)	Economic Research Service

* Bieri, D. S., Kuminoff, N. V., and Pope, J. C. (2023). "National Expenditures on Local Amenities," Mimeograph; EPA-AQS: 2000 data for criteria air pollutants from the Air Quality System produced by the Environmental Protection Agency (EPA); NOAA-NCDC: National Climatic Data Center of the National Oceanic and Atmospheric Administration. ** "The total time that sunshine reaches the observing station is expressed as the percentage of the maximum amount possible from sunrise to sunset in clear sky conditions" (NOAA-NCDC).

Table A3. Descriptive statistics for climate, geography, and environmental variables.

Nation				
Variables	**Min.**	**Max.**	**Mean**	**Standard Deviation**
PM 2.5	3	23.90	12.82	3.61
PM 10	5	63.80	23.90	3.99
Heating Degree Days	141	10,006.13	4912.88	2051.17
Cooling Degree Days	62	4057.56	1299.70	742.46
Extreme Temp	2602	10,241	6212.58	1426.29
Sunshine	42	84.40	60.19	6.36
Precipitation	8	124.88	38.63	13.84
Wind Speed	6	0.03	9.13	1.44
Natural Scale	−1.19	5.48	0.003	1.00

Table A3. *Cont.*

Metro				
Variables	**Min.**	**Max.**	**Mean**	**Standard Deviation**
PM 2.5	4	23.90	13.62	3.30
PM 10	5	63.80	23.31	4.36
Heating Degree Days	141	9617.44	4489.35	1934.85
Cooling Degree Days	66	4057.56	22.87	779.18
Extreme Temp	2602	38.40	5868.18	1308.53
Sunshine	46	84.40	59.40	6.64
Precipitation	8	111.25	41.30	12.54
Wind Speed	6	14.94	8.85	1.26
Natural Scale	−1.19	5.48	−0.05	1.00
Non-metro				
Variables	**Min.**	**Max.**	**Mean**	**Standard Deviation**
PM 2.5	3.43	22.85	12.34	3.70
PM 10	6.47	61.54	23.14	3.76
Heating Degree Days	381.10	10,006.13	5165.31	2077.25
Cooling Degree Days	62.26	3604.25	1252.54	715.73
Extreme Temp	3868.26	10,241.00	6417.85	1454.08
Sunshine	41.70	82.49	60.56	6.14
Precipitation	9.17	124.88	37.04	14.34
Wind Speed	6.68	32.64	9.29	1.52
Natural Scale	−1.19	1.84	0.04	1.00

Table A2 reports mean values, standard deviations, and minimum and maximum values of each climate, geographic, and environmental amenity differentiating 1161 metro from 1948 non-metro counties, as well as all counties in the continental United States. Particulate matter (PM 2.5 and PM 10) and sunshine variables have similar mean values, whereas other variables show spatially different mean values between metro, non-metro, and nation.

Appendix A.2. Opportunities for Local Physical Activity

The following data sources and descriptions on access to exercise opportunities come from County Health Rankings and Roadmaps (http://www.countyhealthrankings.org).

County Health Rankings National Data develops data on Access to Exercises Opportunities that measures “the percentage of individuals in a county who live reasonable close to a location for physical activity” (http://www.countyhealthrankings.org). The data defines locations for physical activity as “parks or recreational facilities. Parks include local, state, and national parks. Recreational facilities include businesses identified by the following Standard Industry Classification (SIC) codes and include a wide variety of facilities including gyms, community centers, YMCAs, dance studios and pools: 70110306, 79990000, 79910000, 79910100, 79910101, 79910102, 79910103, 79910202, 79910300, 79910301, 79910302, 79920000, 79970100, 79970203, 79970500, 79970501, 79970503, 79979900, 79990101, 79990102, 79990300, 79990301, 79990302, 79990303, 79990601, 79990602, 79990603, 79991102, 79991103, 79970201, 79991402, 79991109, 79991110, 79991111, 79991112, 79991113, 79991118, 79991119, 79991120, 79991121, 79991122, 79991123, 79991127, 79991412, 79999910, 79970502, 79970504, 79979904, 79979906" (http://www.countyhealthrankings.org).

The data define individuals who have adequate access to opportunities as the following individuals:

- "reside in a census block within a half mile of a park or
- in urban census tracts: reside within one mile of a recreational facility
- in rural census tracts: reside within three miles of a recreational facility" (http://www.countyhealthrankings.org).

The measurement strengths and limitations are provided by County Health Rankings and Roadmaps (http://www.countyhealthrankings.org) as follows:

> "This is the first national measure created which captures the many places where individuals have the opportunity to participate in physical activity outside of their homes. It is not without several limitations. First, no dataset accurately captures all the possible locations for physical activity within a county. One location for physical activity that is not included in this measure are sidewalks which serve as common locations for running or walking. Additionally, not all locations for physical activity are identified by their primary or secondary business code. For example, malls frequently have walking clubs and schools may have open gyms for community members. Second, although a county may contain a park or recreational facility there may still be barriers to using the facility for exercise. Cost can be a barrier as many facilities charge user fees and parks may charge entrance fees. Additionally, even if census tracts contain a park the entrance may be far or may require crossing a busy street. The buffers chosen include straight line distances, yet the street network and design can impact whether a park is truly accessible by multi-modal transportation. Finally, the buffers used in this measure were chosen based on an estimation of a 5- to 10-min walk to a park and a 5–10 min drive to a recreational facility. Very few studies exist using distances to recreational facilities and fewer still include rural communities. Different buffer distances may be appropriate for different communities. A walkable community may feel that people will travel further than $\frac{1}{2}$ mile to a park, but in some communities a $\frac{1}{2}$ mile might be viewed as too far. A final limitation is that all parks are included regardless of the amenities they include (playgrounds, sports fields, hiking trails, picnic shelters, etc.) which may be suited to specific age groups". (http://www.countyhealthrankings.org)

Table A4. Quality/outcomes of public services.

Variable	Description	Source
Private to Public School	Calculated as a percentage of private to public school enrollment; $100 \times \frac{number\ of\ private\ school\ enrollment}{number\ of\ public\ schcool\ enrollment}$	2012 American Community Survey, 5-year estimates on kindergarten to 12th grade for the percentage of enrolled population in public and private schools with the total number of enrollment.
Poor Water Quality	% of the population potentially exposed to water exceeding a violation limit during the past year	2012, Safe Drinking Water Information System; 2014 County Health Rankings National Data
Mammography	% of female Medicare enrollees aged 67–69 that receive mammography screening	Dartmouth Atlas of Health Care; 2015 County Health Rankings National Data
Physical Activity	Percentage of the population with access to places for physical activity	2010 and 2012, OneSource Global Business Browser, Delorme map data, ESRI, and US Census Tigerline Files
High School Graduation	% of ninth-grade cohort that graduate in four years	2012–2013, state sources and the National Center for Education Statistics, ED Facts; 2016 County Health Rankings National Data

Table A5. Descriptive statistics for quality/outcomes of public services.

Nation				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
Private to Public School	1	110.08	9.23	7.11
Poor Water Quality	0	100	8.94	16.56
Mammography	24	83.75	59.14	12.69
Physical Activity	1	100	51.64	24.72
High School Graduation	20	100	70.93	30.68
Metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
Private to Public School	0	65.56	11.039	6.33
Poor Water Quality	0	100	6.88	12.92
Mammography	34	83.30	62.03	8.51
Physical Activity	1	100	61.52	23.73
High School Graduation	24	100	79.64	17.92
Non-metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
Private to Public School	0	110.08	8.16	7.32
Poor Water Quality	0	100	10.17	18.29
Mammography	24	83.75	57.42	14.35
Physical Activity	1	100	45.75	23.38
High School Graduation	20	100	65.74	35.21

Table A6. County's general characteristics.

Variable	Description	Source
County Unemployment	2012 unemployment rate	U.S. Bureau of Labor Statistics (BLS)
County Population	2012 county total population	BLS
Population Density	2012 density per square mile of land area (calculated)	2010 Area in squares miles—land area, Census 2010 Summary File 1, Geographic Header Record G001. 2012 population, BLS
Population Growth	The population growth rate for 2010 and 2012 (calculated), $\left(\frac{\text{Population change}}{\text{Total population change}}\right) \times 100$	Population change follows cumulative estimates of the components of population change from 1 April 2010 to 1 July 2012—Total population change, 2012 Census Population Estimates

Table A7. Descriptive statistics for county's general characteristics.

Nation				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Unemployment	1.1	27.4	7.83	2.75
County Population	71	9,962,789	100,286.4	320,796.7
Population Density	0.11	70,919.4	264.20	1766.55
Population Growth	−22.05	20.37	0.14	2.28
Metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Unemployment	2.8	27.4	7.83	2.23
County Population	839	9,962,789	229,144.66	498,412.85
Population Density	0.71	70,919.40	634.96	2850.72
Population Growth	−6.82	13.78	1.07	2.12
Non-metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Unemployment	1.1	20.7	7.84	3.03
County Population	71	187,530	23,487.34	21,701.03
Population Density	0.11	2799.2	43.23	94.85
Population Growth	−22.05	20.37	−0.42	2.19

Table A8. Other social amenities.

Variable	**Description**	**Source**
County Total Crime	Total (property and violent) crime rate per 100,000 population	2012 U.S. County characteristics compiled by the Inter-university Consortium for Political and Social Research (ICPSR 2012)
County Property Crime	Property crime rate per 100,000 population	ICPSR 2012
County Violent Crime	Violent crime rate per 100,000 population	2010–2012, FBI Uniform Crime Reporting; ICPSR 2012
County Poverty	Poverty status	2012 ACS 5-year estimates
County Child Poverty	% of children under age 18 in poverty	2012 Small Area Income and Poverty Estimates; 2014 County Health Rankings National Data
County GINI	2012 GINI index (ranges from zero = perfect equality to one = perfect inequality)	American Community Survey (ACS) 5-year estimates

Table A9. Descriptive statistics for other social amenities.

Nation				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Total Crime	14	8957.11	2258.66	1354.35
County Property Crime	12	7163.74	2023.71	1211.18
County Violent Crime	4	1793.37	234.95	199.40
County Poverty	2.9	76.4	25.65	6.73
County Child Poverty	3.3	59.6	24.59	9.20
County GINI	0.33	0.60	0.44	0.04
Metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Total Crime	14	8957.10	2742.07	1360.26
County Property Crime	14	7163.74	2454.83	1195.77
County Violent Crime	7	1793.37	287.24	220.97
County Poverty	12.8	59.4	24.97	5.61
County Child Poverty	3.3	49.3	21.67	8.28
County GINI	0.33	0.60	0.43	0.04
Non-metro				
Variable	**Min.**	**Max.**	**Mean**	**Standard Deviation**
County Total Crime	14	7256.88	1970.54	1266.20
County Property Crime	12	6664.89	1766.76	1145.83
County Violent Crime	4	1392.11	203.78	178.26
County Poverty	2.9	76.4	26.05	7.29
County Child Poverty	4	59.6	26.32	9.27
County GINI	0.34	0.55	0.44	0.03

Table A10. Housing characteristics for rent equations and personal/household characteristics for wage equations.

Variable	**Description**	**Source**
Housing vacancy	Housing vacancy rate owner-occupied housing units	2012 ACS 5-year estimates
HStructure2	% attached units in structure owner-occupied housing units	2012 ACS 5-year estimates
HStructue7	% mobile home or other types of housing owner-occupied housing units	2012 ACS 5-year estimates
HYear2	% year structure built from 2000 to 2009—owner-occupied housing units	2012 ACS 5-year estimates
HRooms45	% 4 or 5 rooms—owner-occupied housing units	2012 ACS 5-year estimates
HBedrooms23	% 2 or 3 bedrooms—owner-occupied housing units	2012 ACS 5-year estimates
HBedrooms4	% 4 or more bedrooms—owner-occupied housing units	2012 ACS 5-year estimates

Table A10. *Cont.*

Variable	Description	Source
White	% White population	2012 Population Estimates, Census
Private Employee	Employee of private company workers (%); civilian employed population 16 years and over.	2012 ACS 5-year estimates
Occupation MBSA	Management, business, science, and arts occupations (%)	2012 ACS 5-year estimates
Occupation Sales Office	Sales and office occupations (%)	2012 ACS 5-year estimates
Occupation NCM	Natural resources, construction, and maintenance occupations (%)	2012 ACS 5-year estimates
Occupation PTM	Production, transportation, and material moving occupations (%)	2012 ACS 5-year estimates
Married	% now married (except separated); population 15 years and over	2012 ACS 5-year estimates
Veteran	% veteran status for the population 18 years and over.	2012 ACS 5-year estimates
Mean Hour	Mean usual hours worked for workers (weekly)	2012 ACS 5-year estimates and work status in the past 12 months
High School Labor Force	% high school graduate (includes equivalency) in the labor force	2012 ACS 5-year estimates

Appendix A.3. Amenities and Other Variables

Appendix A.3.1. Local Physical and Educational Opportunities

The variables of local physical and educational opportunities indicate public and private benefits from those investments (e.g., local, state, and national parks, community centers, YMCAs, and private recreational facilities such as gyms, dance studios, and pools). The private opportunities may generate external benefits in addition to the internal (private) benefits that individuals pay for. The benefits that people pay for (e.g., gym membership and golf fees and membership) will not be capitalized into rent or out of wages, but the externalities as a form of local amenities will.

Appendix A.3.2. Opportunities for Local Physical Activity

This study employs and defines a broad array of physical and social opportunities from County Health Rankings Key Findings, 2014.

The built environment contributes to local opportunities for physical activities. Greater access to exercise opportunities and facilities is more likely to increase the physical activity of residents in a community (Babey, Wolstein, Krumholz, Robertson, and Diamant, 2013; Cohen et al., 2007; County Health Rankings Key Findings 2014; Sallis et al., 1990). In particular, public investments in neighborhood/public parks can improve the physical activity of low-income and minority community residents (Cohen et al., 2007); these investments can bring about more inclusive local social capital through increased opportunities for interactions among residents in a community.

This study employs data on access to exercise opportunities from County Health Rankings and Roadmaps (http://www.countyhealthrankings.org).

Appendix A.3.3. Private School to Public School Enrollment (%)

This study develops the ratio of private school to public school enrollment as the quality/outcomes of public education service. We employed the 2012 American Community Survey estimate on kindergarten to 12th grade for the percentage of enrolled population in public and private schools with total number enrollment. After converting the percentage values into numbers, we calculated the percentage of private to public school enrollment

$(100 \times \frac{number\ of\ private\ school\ enrollment}{number\ of\ public\ schcool\ enrollment})$. Thus, higher numbers indicate a lack of confidence in the public education system (see Table A2 for descriptive statistics).

Table A11. Quality/outcomes of public services.

Variable	Definition
Private to Public School	Percentage of private to public school enrollment
Poor Water Quality	Population affected by a water violation divided by the total population with public water (% population in violation)
Mammography	Percentage of female Medicare enrollees having at least 1 mammogram in 2 years (age 67–69)
Physical Activity	Percentage of the population with access to places for physical activity
High School Graduation	Percentage of the ninth-grade cohort that graduate in four years

Tables A4 and A10 show quality levels or outcomes of public services at the county level in 2012. The private to Public School variable is an indicator of a lack of confidence in the public education system. Thus, a higher value indicates a poor public education system, which could lead to demand for a higher wage in compensation. Poor water quality has a higher value in non-metro counties, which might decrease land values. Metro counties have better access to places for physical activity than non-metro counties. More potential workers with high school education in metro counties might influence differences in county income between metro and non-metro counties. Overall, metro counties have better outcomes/quality of public services, except for the public education system (Private to Public School).

Appendix A.3.4. Local Governments' Total Revenues per Capita

Assuming the government balances its budget, this study defines g as public services in a county. This study defines $\left(\frac{\partial t}{\partial g}\right)$ as the implicit price of public services. We calculate local governments' total revenue per capita in a county as follows:

$$\text{County's Total Revenue (Expenditure)} = \frac{\sum \text{Total Revenue of All Types of Government Within County}}{\text{County's Population}}$$

We combine all types of government within a county on the basis of the 2012 County Area Finances of Census of Government (COG). There are five type codes: county, municipal, and town and township governments (type codes 1, 2, and 3); special districts (type code 4); and independent school districts (type code 5). Every municipality has a county Federal Information Processing Standards (FIPS) code that corresponds to the county that it is in. We sorted by FIPS Code State then County and then TypeCode. After sorting all types of government according to county FIPS, we aggregated the total revenues of all types of governments in a county [12].

Table A12 shows the mean values of local governments' total revenues per capita in a county, differentiating metro from non-metro counties in 2012. The mean value of total revenues in metro counties is lower than the value in non-metro counties.

Table A12. Local governments' total revenues per capita in a county.

Variable	Definition	Metro Mean	Non-metro Mean	National Mean
County Revenue	Total local governments' revenues (thousands of dollars) per capita	4.36	4.99	4.75

In Table A8, the value for total local government revenues per capita is slightly higher in non-metro counties than in metro counties.

Table A13. Second-stage results for non-spatial versus spatial 2SLS: rent equations with a metro dummy and cross-products for the continental United States.

Variable	Non-Spatial 2SLS Rent	Spatial 2SLS Rent
Log County Income	−0.25 *** (0.0404)	−0.25 *** (0.0595)
Metro × Log County Income	0.19×10^{-1} (0.0588)	0.16 *** (0.0638)
County Revenue	0.31×10^{-2} *** (0.0011)	0.31×10^{-2} *** (0.0018)
Metro × County Revenue	0.19×10^{-1} *** (0.0030)	0.93×10^{-2} *** (0.0032)
Land Share	0.73×10^{1} *** (0.1196)	0.73×10^{1} *** (0.5509)
Metro × Land Share	-0.12×10^{1} *** (0.1884)	−0.64 *** (0.4543)
County Population	0.15×10^{-5} *** (1.67×10^{-7})	0.12×10^{-5} *** (1.72×10^{-7})
Metro × Population	-0.14×10^{-5} *** (1.67×10^{-7})	-0.11×10^{-5} *** (1.72×10^{-7})
High School Graduation	0.11×10^{-3} (0.0001)	0.23×10^{-3} *** (0.0001)
Metro × High School Grad	0.41×10^{-3} (0.0003)	0.19×10^{-3} (0.0002)
Extreme Temp	-0.23×10^{-4} *** (3.22×10^{-6})	-0.18×10^{-4} *** (5.32×10^{-6})
Metro × Extreme Temp	-0.19×10^{-4} *** (4.79×10^{-6})	-0.82×10^{-5} * (4.62×10^{-6})
PM 2.5	-0.42×10^{-2} *** (0.0010)	-0.26×10^{-2} * (0.0013)
Metro × PM 2.5	-0.29×10^{-2} * (0.0016)	-0.14×10^{-2} (0.0013)
County Violent Crime	0.37×10^{-4} * (0.000019)	0.39×10^{-4} ** (0.000018)
Metro × County Violent Crime	-0.73×10^{-4} ** (0.000030)	-0.46×10^{-4} * (0.000023)
County GINI	-0.74×10^{-1} (0.1173)	−0.15 (0.1126)
Metro × County GINI	0.76 *** (0.2113)	0.45 *** (0.1884)
Mammography	0.11×10^{-2} *** (0.0002)	0.79×10^{-3} *** (0.0003)
Metro × Mammography	-0.26×10^{-5} (0.0006)	0.44×10^{-3} (0.0006)
Physical Activity	0.39×10^{-3} *** (0.0001)	0.39×10^{-3} *** (0.0002)
Metro × Physical Activity	0.14×10^{-2} *** (0.0003)	0.74×10^{-3} *** (0.0002)
Child Poverty	-0.96×10^{-2} *** (0.0008)	-0.78×10^{-2} *** (0.0010)
Metro × Child Poverty	-0.33×10^{-2} ** (0.0015)	0.12×10^{-2} (0.0014)
Metro	−0.26 (0.6297)	−1.87 *** (0.7273)
R^2	0.8764	
rho (ρ)		0.8030 ***

Note. The number of observations is 3109 (counties for the continental United States). Standard errors are in parentheses. *** Significant at 1%, ** significant at 5%, and * significant at 10%.

Table A14. Reduced-form estimates for rent equations with a metro dummy and cross-products for the continental United States.

Rent Equation	Non-Spatial Model	Spatial Model
Variable	**Coefficient**	**Coefficient**
County Revenue	0.35×10^{-2} *** (0.0010)	0.34×10^{-2} (0.0022)
Metro × County Revenue	0.84×10^{-2} *** (0.0028)	0.58×10^{-2} ** (0.0030)
Land Share	0.74×10^{1} *** (0.1188)	0.74×10^{1} *** (0.5685)
Metro × Land Share	-0.13×10^{1} *** (0.2052)	−0.74 (0.5012)
County Violent Crime	0.15×10^{-4} (0.000018)	0.20×10^{-4} (0.000017)
Metro × Violent Crime	-0.54×10^{-4} * (0.000029)	-0.34×10^{-4} (0.000023)
Private Public School	0.13×10^{-2} *** (0.0004)	0.71×10^{-3} * (0.0004)
Metro × Private Public School	-0.24×10^{-4} (0.0008)	0.54×10^{-3} (0.0006)
County GINI	−0.44 *** (0.1019)	−0.39 *** (0.1209)
Metro × County GINI	0.54 *** (0.1947)	0.38 ** (0.1844)
Child Poverty	-0.82×10^{-2} *** (0.0006)	-0.63×10^{-2} *** (0.0007)
Metro × Child Poverty	-0.28×10^{-2} ** (0.0011)	-0.10×10^{-3} (0.0010)
Physical Activity	0.45×10^{-3} *** (0.0001)	0.47×10^{-3} *** (0.0002)
Metro × Physical Activity	0.96×10^{-3} *** (0.0003)	0.35×10^{-3} (0.0003)
High School Graduation	0.24×10^{-3} ** (0.0001)	0.29×10^{-3} ** (0.0001)
Metro × High School Graduation	0.40×10^{-3} (0.0003)	0.13×10^{-3} (0.0002)
Poor Water Quality	0.31×10^{-4} (0.0001)	0.32×10^{-4} (0.0002)
Metro × Poor Water Quality	-0.83×10^{-4} (0.00034)	-0.34×10^{-3} (0.0003)
Mammography	0.10×10^{-2} *** (0.0002)	0.58×10^{-3} ** (0.0003)
Metro × Mammography	0.21×10^{-3} (0.0006)	0.51×10^{-3} (0.0005)
Extreme Temp	-0.18×10^{-4} *** (3.60×10^{-6})	-0.13×10^{-4} ** (6.13×10^{-6})
Metro × Extreme Temp	-0.28×10^{-4} *** (5.70×10^{-6})	-0.21×10^{-4} *** (6.30×10^{-6})
Sunshine	0.12×10^{-2} * (0.0007)	0.13×10^{-2} (0.0013)
Metro × Sunshine	-0.12×10^{-2} (0.0010)	-0.51×10^{-3} (0.0011)
PM 2.5	-0.18×10^{-2} * (0.0009)	-0.90×10^{-3} (0.0013)
Metro × PM 2.5	-0.53×10^{-2} *** (0.0016)	-0.35×10^{-2} *** (0.0014)

Table A14. *Cont.*

Rent Equation	Non-Spatial Model	Spatial Model
Variable	**Coefficient**	**Coefficient**
County Unemployment	0.92×10^{-3} (0.0016)	0.10×10^{-2} (0.0017)
Metro × Unemployment	0.95×10^{-2} *** (0.0029)	0.38×10^{-2} (0.0030)
County Population	0.15×10^{-5} *** (1.71×10^{-7})	0.12×10^{-5} *** (1.95×10^{-7})
Metro × Population	-0.14×10^{-5} *** (1.71×10^{-7})	-0.12×10^{-5} *** (1.95×10^{-7})
Population Growth	0.14×10^{-2} (0.0015)	-0.99×10^{-3} (0.0019)
Metro × Population Growth	0.89×10^{-3} (0.0027)	0.50×10^{-2} ** (0.0027)
Metro	0.15×10^{1} *** (0.3740)	0.75 (0.5271)
rho (ρ)		0.7879 *** (0.0211)
R^2	0.8928	

Note. The number of observations is 3109 (counties for the continental United States). Standard errors are in parentheses. *** Significant at 1%, ** significant at 5%, and * significant at 10%. Full statistics for all variables can be provided upon request.

Table A15. Second-stage results for wage equations with a metro dummy and cross-products for the continental United States: non-spatial versus spatial 2SLS.

Variable	Non-Spatial 2SLS Wage	Spatial 2SLS Wage
Log County Rent	0.43 *** (0.0605)	0.33 *** (0.0810)
Metro × Log County Rent	0.19 ** (0.0781)	0.23 *** (0.0851)
County × Revenue	0.47×10^{-2} *** (0.0014)	0.97×10^{-3} (0.0039)
Metro × County Revenue	-0.54×10^{-3} (0.0037)	0.12×10^{-2} (0.0047)
Land Share	-0.42×10^{1} *** (0.5236)	-0.28×10^{1} *** (0.8252)
Metro × Land Share	0.58 (0.6789)	0.18 (0.8045)
County Unemployment	-0.16×10^{-1} *** (0.0017)	-0.14×10^{-1} *** (0.0024)
Metro × County Unemployment	0.13×10^{-2} (0.0030)	0.11×10^{-2} (0.0033)
Population Growth	0.10×10^{-1} *** (0.0020)	0.11×10^{-1} *** (0.0034)
Metro × Population Growth	-0.15×10^{-1} *** (0.0035)	-0.14×10^{-1} *** (0.0040)
Private Public School	0.74×10^{-3} (0.0006)	0.45×10^{-3} (0.0007)
Metro × Private Public School	0.12×10^{-2} (0.0011)	0.11×10^{-2} (0.0011)
Sunshine	0.28×10^{-3} (0.0008)	0.43×10^{-3} (0.0012)
Metro × Sunshine	-0.33×10^{-2} *** (0.0011)	-0.33×10^{-2} *** (0.0012)
County GINI	0.42 *** (0.1349)	0.40 *** (0.1590)

Table A15. *Cont.*

Variable	Non-Spatial 2SLS Wage	Spatial 2SLS Wage
Metro × County GIN	0.38 * (0.2097)	0.26 (0.1971)
Poor Water Quality	-0.28×10^{-3} (0.0002)	-0.30×10^{-3} (0.0002)
Metro × Poor Water Quality	0.10×10^{-2} ** (0.0005)	0.89×10^{-3} ** (0.0004)
Mammography	0.24×10^{-2} *** (0.0003)	0.20×10^{-2} *** (0.0005)
Metro × Mammography	-0.41×10^{-2} *** (0.0007)	-0.36×10^{-2} *** (0.0009)
Metro	− 1.52 *** (0.6850)	−1.82 *** (0.7315)
R^2	0.5011	
rho (ρ)		0.6413 ***

Note. The number of observations is 3109 (counties for the continental United States). Standard errors are in parentheses. *** Significant at 1%, ** significant at 5%, and * significant at 10%.

Table A16. Reduced-form estimates: wage equations with a metro dummy and cross-products for the continental United States.

Wage Equation	Non-Spatial Model	Spatial Model
Variable	**Coefficient**	**Coefficient**
County Revenue	0.12×10^{-2} (0.0012)	-0.32×10^{-3} (0.0028)
Metro × County Revenue	0.72×10^{-2} ** (0.0034)	0.78×10^{-2} ** (0.0034)
Land Share	−0.78 *** (0.1418)	−0.44 ** (0.2036)
Metro × Land Share	0.10×10^{1} *** (0.2449)	0.11×10^{1} *** (0.2413)
County Violent Crime	0.84×10^{-4} *** (0.000022)	0.69×10^{-4} *** (0.000025)
Metro × Violent Crime	-0.46×10^{-4} (0.000035)	-0.48×10^{-4} (0.000029)
Private Public School	0.89×10^{-3} * (0.0005)	0.51×10^{-3} (0.0006)
Metro × Private Public School	0.23×10^{-2} ** (0.0009)	0.22×10^{-2} ** (0.0010)
County GINI	0.10×10^{1} *** (0.1217)	0.79 *** (0.1558)
Metro × County GINI	0.53 ** (0.2324)	0.50 ** (0.2320)
Child Poverty	-0.99×10^{-2} *** (0.0007)	-0.86×10^{-2} *** (0.0009)
Metro × Child Poverty	-0.19×10^{-2} (0.0014)	-0.16×10^{-2} (0.0012)
Physical Activity	0.22×10^{-3} (0.0002)	0.14×10^{-3} (0.0002)
Metro × Physical Activity	-0.22×10^{-3} (0.0003)	-0.88×10^{-4} (0.0003)
High School Graduation	0.14×10^{-3} (0.0001)	0.42×10^{-4} (0.0001)
Metro × High School Graduation	0.66×10^{-3} ** (0.0003)	0.51×10^{-3} * (0.0003)
Poor Water Quality	0.21×10^{-4} (0.0002)	-0.15×10^{-3} (0.0002)

Table A16. *Cont.*

Wage Equation	Non-Spatial Model	Spatial Model
Variable	**Coefficient**	**Coefficient**
Metro × Poor Water Quality	0.65×10^{-3} (0.0004)	0.53×10^{-3} (0.0004)
Mammography	0.13×10^{-2} *** (0.0003)	0.12×10^{-2} *** (0.0005)
Metro × Mammography	-0.26×10^{-2} *** (0.0007)	-0.22×10^{-2} *** (0.0008)
Extreme Temp	0.52×10^{-5} (4.29×10^{-6})	0.52×10^{-5} (6.39×10^{-6})
Metro × Extreme Temp	-0.22×10^{-4} *** (6.81×10^{-6})	-0.26×10^{-4} *** (7.38×10^{-6})
Sunshine	0.31×10^{-2} *** (0.0008)	0.33×10^{-2} *** (0.0012)
Metro × Sunshine	-0.51×10^{-2} *** (0.0012)	-0.52×10^{-2} *** (0.0013)
PM 2.5	-0.33×10^{-2} *** (0.0011)	-0.36×10^{-2} ** (0.0016)
Metro × PM 2.5	0.48×10^{-3} (0.0020)	0.90×10^{-3} (0.0018)
County Unemployment	0.21×10^{-2} (0.0019)	0.87×10^{-3} (0.0026)
Metro × Unemployment	0.45×10^{-2} (0.0034)	0.21×10^{-2} (0.0032)
County Population	0.59×10^{-6} *** (2.04×10^{-7})	0.40×10^{-6} ** (1.98×10^{-7})
Metro × County Population	-0.58×10^{-6} *** (2.04×10^{-7})	-0.38×10^{-6} * (1.99×10^{-7})
Population Growth	0.99×10^{-2} *** (0.0017)	0.98×10^{-2} *** (0.0030)
Metro × Population Growth	-0.13×10^{-1} *** (0.0032)	-0.13×10^{-1} *** (0.0038)
Metro	−0.31 ** (0.4465)	−0.01 (0.5204)

Note. The number of observations is 3109 (counties for the continental United States). Standard errors are in parentheses. *** Significant at 1%, ** significant at 5%, and * significant at 10%. Full statistics for all variables can be provided upon request.

Notes

1 As Partridge, Rickman, Olfert, and Tan (2015) point out [10], empirical estimations may produce biased estimates of amenity values because of the time required to achieve equilibrium. On the other hand, the test results of Evans (1990) [11], Greenwood et al. (1991) [12], Rappaport (2007) [13], and Mueser and Graves (1995) [14] indicate that disequilibrium population changes are found in only a few states and suggest that equilibrium can occur quickly even if population adjustment is slow.

2 Here the term sustainability is equivalent to the concept of weak sustainability defined by Arrow et al. (2012) [1], in which development is sustainable if and only if comprehensive wealth is non-decreasing. Strong sustainability requires sustaining the total stock of natural capital constantly over time (Daly, 1991) [16].

3 If g is only defined as the expenditures on government services, the price ratio will be equal to one, which means the marginal utility of one unit of income spent on x would be equal to the marginal utility of t.

4 Total earnings by place of work consist of earnings by place of work, minus contributions for government social insurance (employee and self-employed contributions for government social insurance, employer contributions for government social insurance), plus adjustment for residence, dividends, interest, rent, and personal current transfer receipts. This study employs the BEA's calculated net earnings by place of residence, which is total earnings by place of work minus contributions for government social insurance, plus adjustment for residence.

5 Unimproved land value is the value of property without buildings, fences, drainage, irrigation, and other investments.

6 The study acknowledged that low-income families were overrepresented because the data were collected only for Federal Housing Association–qualifying families (p. 1269).

[7] These data exclude values for renter-occupied housing units and vacant housing units, which creates different limitations on the land value measure in this study.

[8] We used the 2012 American Community Survey 5-year estimates of aggregate value by owner-occupied housing units and calculated the average county housing value (P) by dividing by the total owner-occupied housing units.

[9] Oates (1969) [33] described the possibility of simultaneous effects of the tax rates and the amenity effects on land values.

[10] "The U.S. dollar saw inflation at an average rate of 3.78% per year between 1975 and 2015" (http://www.in2013dollars.com/1975-dollars-to-2015-dollars; the Bureau of Labor Statistic's annual Consumer Price Index [CPI], established in 1913).

[11] The values of the spatial autoregressive parameters in the homoscedastic specification are 0.76 for the rent equation and 0.64 for the wage equation.

[12] COG finance data on total revenues of special school districts follows item codes for revenues. For instance, education revenues and expenditures follow the item codes A09–A12, B21, C21, and D21 for revenue and E12, E16, and E21 for expenditures. These codes are for units other than special school districts. But there might be possible errors due to school districts operating in multiple counties. We expect that the error in the by-county total revenue will be less when including the potential possibility of school districts that serve multiple counties than if school districts are left out completely.

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