COMPREHENSIVE WEALTH MEASUREMENT AND SPATIAL HEDONIC ANALYSIS:

SOCIAL CAPITAL AND SOCIAL AMENITIES

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JINHYOUNG KIM

Dr. Thomas G. Johnson, Dissertation Supervisor

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

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presented by Jinhyoung Kim,

a candidate for the degree of doctor of philosophy,

and hereby certify that, in their opinion, it is worthy of acceptance.

Dr. Thomas G. Johnson

Dr. Laura McCann

Dr. Corinne Valdivia

Dr. David J. O'Brien

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ABSTRACT

The last decade has seen a growing interest in the concept of *comprehensive wealth,* which is defined as including intangible and non-market as well as tangible and market assets. This dissertation responds to this rising interest by developing explicit concepts, indicators, and sources of data necessary to measure comprehensive wealth at various spatial scales. It achieves this by generalizing the general spatial equilibrium model proposed by Roback (1982).

The key contributions of this research are the extension and application of the comprehensive wealth concept to measure the value of social amenities generated as a result of public and private investments in social and other types of capital. This dissertation extends the Roback model by identifying appropriate data on local income, land values, and place-based amenities at the county level in the contiguous 48 states of the United States.

This dissertation reports substantial findings based on the empirical analysis. While the results are largely consistent with those of Roback and other, more recent papers and with theoretical expectations, this study found significantly different effects of amenities on wages and land values between metro and non-metro counties due to different marginal effects on wages and land values. The analysis also found significant spatial interaction effects, which influence the magnitude of the full implicit price for social amenity variables, again with significant differences between metro and non-metro counties. Finally, the extended model is able to determine whether the social amenities are at optimal levels.

There are important implications of this research. Policies to enhance social amenities from immobile social capital and local public services can reduce both real costs of production and the societal opportunity costs of development in the long term. Well-designed policy and investment in immobile and non-marketed amenities of a location will make a place more attractive and sustainable, conferring benefits to residents and local businesses. The proposed typology can be useful for designing policy and investment plans for sustainable regional economic development. The model can also be used to conduct simulations to predict the effects of policy on comprehensive wealth given locally unique and dynamic combinations of regional assets.

Keywords:

Comprehensive Wealth; Spatial Equilibrium Model; Non-market Valuation; Social Amenities; Social Capital

Chapter 1: Introduction

Since the 2000s there has been rising interest among economists regarding the valuation of non-market and intangible assets in order to better understand the concept of comprehensive wealth. What is comprehensive wealth? *Comprehensive wealth* has been defined by including intangible and non-marketable as well as tangible and marketable assets (Arrow, Dasgupta, Goulder, Mumford, & Oleson et al.,. 2012; Cobb & Daly, 1989; Pender et al., 2014; UNU-IHDP & UNEP, 2012; World Bank, 2006, 2011). The spatial hedonic equilibrium model proposed by Roback (1982) has been widely used in valuation of non-market assets in terms of location decisions for individual and firms that are based on willingness to pay for local amenities. This spatial hedonic framework yields strong implications when measuring the comprehensive wealth of a community, by showing how local amenities (i.e., non-marketable assets) can be reflected in interregional wage differentials and land values (i.e., marketable assets).

Most spatial equilibrium models beginning with Roback (1982) have focused on natural and publicly provided amenities (e.g., public parks, golf courses). There have been few hedonic studies that explicitly define and deal with social amenities and social capital, especially privately provided social amenities. Like many natural amenities, social amenities are generally not purchased in the market and they are location-dependent. This dissertation defines social amenities as site-specific (i.e., immobile or less mobile) assets and identifies how social amenities can be created through investment in social capital, both privately and publicly. Social amenities vary across regions and contribute to place-based wealth, which can explain spatial differences that are already reflected in wage differentials and land values.

Another crucial notion in this dissertation is the role of social context in economic activities. Individuals and institutions do not behave “as atoms outside a social context” (Granovetter, 1985, p. 487). Social relations and structures affect decisions regarding places to live and work for individuals and firms. Robert Frank, in his 1985 book *Choosing the Right Pond*, argued that people’s preferences for wages, housing, and other consumption goods are relative to others rather than, or in addition to, the absolute levels often assumed in economic theories. While it is not possible to identify the precise effects of social standing on individual willingness-to-pay without detailed information on individuals, it is possible that this phenomenon will lead to a relationship between aggregate wage rates and indicators of household income inequality, such as the GINI index of income inequality for U.S. counties. In other words, differences in social structures between regions will contribute to decisions regarding where to live and work. Barry Schwartz (2015), in an editorial in *The New York Times* titled “Rethinking Work,” reported that according to a Gallup survey, people care about more than wages (absolute value of money) in their decision to work, which might contradict “Adam Smith’s description of wage-driven idlers” (Schwartz, 2015), implying the crucial role of social structure in their work-performance. Social structures might be embedded or valued differently by individuals and institutions in different locations. This dissertation aims to estimate the value of local amenities including social amenities (i.e., site-specific intangible and non-market assets), from spatial variations in land values and wage differentials, thereby expanding the hedonic spatial equilibrium model to include more elements of comprehensive wealth. The fundamental argument is that all types of amenities, including social amenities, influence individuals' and businesses' willingness to pay.

Traditional economic indicators (e.g., gross domestic product [GDP], employment rate, income, and taxable sales revenue) are representative of certain static, aggregated macro measures, ignoring levels of, and changes in assets. By ignoring assets, these indicators do not manifest the well-being of people or impact on economic sustainability of such stresses as natural disasters (e.g., Hurricane Andrew) or asset-based (e.g., the Bakken shale oil formation in North Dakota) economic booms. The notions of comprehensive wealth (e.g., Arrow et al., 2012; Pender, Marré, & Reeder, 2012; Pender et al., 2014; UNU-IHDP & UNEP, 2012; World Bank, 2006) and quality of life from the spatial hedonic type of analysis (e.g., Blomquist, Berger, & Hoehn, 1988; Roback, 1982) incorporate considerations of the economic valuation of both intangible and tangible assets. This dissertation, thus, responds to the rising interest among economists in the value of non-market and intangible assets, combining comprehensive wealth concepts and the hedonic spatial equilibrium approach to better understand the dynamics of wealth. Employing this type of spatial economics model to evaluate regional wealth contributes, especially, to rural regional studies, given the heavy urban-focus of most regional research, although this dissertation proposes a method to measure for both urban and rural regional wealth. As Kilkenny (2010) pointed out, rural regional research should incorporate spatial attributes/economics mainly due to uneven geographic characteristics in terms of “distribution of population, industry, and returns to nonfarm economic activities, given geographic variation in natural endowments” (Kilkenny, 2010, p. 449). In addition, operationalizing measures of comprehensive wealth yields implications for both national and local policy.

Chapter 2: Literature Review

2.1 Rationale for Comprehensive Wealth Accounting

This chapter provides a rationale for employing a comprehensive wealth accounting framework as an alternative indicator of economic performance. When we evaluate regional wealth—in particular wealth based on specific assets such as natural resource development (e.g., the Bakken Formation shale oil boom in North Dakota), a disaster (e.g., Hurricane Andrew; see Pender et al., 2014, for an illustration of this example), or an economic boom, it is important to understand the interactions between tangible and intangible wealth. Traditional economic indicators, such as GDP, employment change, and sales tax revenue, indicate short-term economic impacts on the impacted regions. However, if the focus is on human welfare and sustainability, we need to understand how people's comprehensive wealth has been, or could be affected (Pender et al., 2014, p. 3). Measuring flows and changes in wealth matter. Increasing income by depleting wealth is not sustainable. Consider the shale oil boom in North Dakota. The 10 county region of North Dakota has experienced rapid economic growth based on exploitation of the largest known and accessible petroleum reserves in the United States ("Oil & Shale," 2013). The boom has led to a very high rate of job creation (Gallup Daily, 2013) and some of the highest average weekly wages in the country (U.S. Department of Labor, 2013). Unlike many of the region's residents, including politicians, who had positive expectations about the impact of the economic boom (e.g., individual benefits in terms of employment opportunities, local business revenues, higher incomes, and increased tax revenues), other residents have found that these economic benefits have come with depletion of other types of wealth (e.g., economic, social and environmental; T. G. Johnson & Kim, 2014). This example illustrates the importance of understanding both tangible and intangible types of wealth and their interrelationships.

In general usage, *wealth* is defined as financial assets minus liabilities. However, this general measure of wealth does not account for all types of wealth (Pender et al., 2014). Financial wealth ignores nonmonetized types of wealth, such as environmental capital, social relations, and trust, which can be depleted or enhanced during the accumulation of financial wealth (Pender et al., 2014). Furthermore, in order to measure sustainability, we need to know the interactions between the various types of wealth. For instance, increasing financial wealth by depleting other types of wealth (e.g., social, natural, and human capital) may not be sustainable. In other cases, tangible and intangible capital may be complementary or co-produced as in the case of social and cultural capital. Thus, to ensure sustainability, we must understand the interrelationships among the multiple types of wealth (Pender et al., 2014).

2.2 A Broader Definition of Wealth

Recently, there have been several efforts undertaken to more rigorously define the concepts of sustainable economic growth and well-being by including nonfinancial assets in measures of macroeconomic performance (e.g., sustainability and the measurement of wealth, Arrow et al., 2012; genuine progress indicator [GPI], Talberth, Cobb, & Slattery, 2007; index of sustainable economic welfare [ISEW], Cobb & Daly, 1989; comprehensive wealth measure, Pender et al., 2014; System of Environmental-Economic

Accounting, 2012; UNU-IHDP & UNEP, 2012; World Bank, 2006, 2011). This dissertation adopts the very broad definition of wealth described by Pender et al. (2014), in which wealth is “all assets, net of liabilities, that can contribute to the well-being of an individual or group” (p. 17), including both tangible assets (e.g., physical and built capital) and intangible assets (e.g., human, political, cultural, and social capital). This definition has some similarities to the definition proposed by Arrow et al. (2012), but Pender et al. (2014) provided two distinguishing features. First, “it is useful to consider many different types of assets as wealth, even if they cannot all be aggregated into a single monetary measure” (Pender et al., 2014, p. 17). Second, “although we indicate that wealth can contribute to well-being, wealth doesn’t necessarily determine well-being, since well-being depends upon how wealth and the costs and benefits of investing in wealth are distributed, and on how wealth is used” (Pender et al., 2014, p. 17).

Pender et al. (2014) identified eight types of capital: physical, produced or built capital; financial capital; natural capital; human or individual capital; intellectual capital; social capital; political capital; and cultural capital[1].

Sustainable growth requires constantly increasing comprehensive wealth (Arrow et al., 2012). The comprehensive wealth framework will indicate why distinguishing between flows of economic activity and changes in wealth, and accounting for wealth distribution are critical in evaluating wealth (Pender et al., 2012; Pender et al., 2014).

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[1] See Appendix 1 for capitals definitions.

2.3 Comprehensive Wealth Accounting

2.3.1 Welfare and Wealth

Welfare economics and comprehensive wealth deal with all aspects of well-being of each individual. Standard welfare economics rest on the abstract concept of utility, which implies the importance of understanding an individual's well-being. The individual's well-being depends on the consumption of all types of goods and services. These goods and service can be observable or unobservable as well as marketable or nonmarketable. Long-term well-being is indirectly dependent on wealth (Pender et al., 2014) since it determines one's future rates of consumption. Social welfare and well-being require knowing where individual utility comes from and the changes in the comprehensive wealth that results (McCann, 2006; Pender et al., 2014; Roemer, 1998). Fisherian income includes all the values that constitute utility (Nordhaus, 2000, as cited in T. G. Johnson, Raines, & Pender, 2014). Unlike common Hicksian income, Fisherian income includes the flow of services from all tangible and intangible capital (T. G. Johnson et al., 2014; Nordhaus, 1995). In particular, Fisherian income includes the following elements that are ignored by Hicksian income: "1) appropriated stocks of natural resources (minerals and renewable resources), and 2) unappropriated items such as the environment, knowledge and technological change" (Class slide, AgEc 9230). Nordhaus (1995) refers to Fisherian income as sustainable income or wealth-based income because if Fisherian capital is rising, Fisherian income is rising and thus sustainable (T. G. Johnson et al., 2014). This is equivalent to the concept of a comprehensive wealth measure because Fisherian income incorporates the notion of sustainability as well as both tangible and intangible capital.

2.3.2 The Elements of Wealth Accounting: Characteristics and Concepts

Pender and colleagues (2012, 2014) offer several suggested advancements to the conceptual foundations of regional wealth creation as well as suggestions for enhancing capabilities to build a more comprehensive accounting framework.

2.3.2.1 Tangibility and Marketability

Assets can be classified as either tangible or intangible, depending on visibility. Physical, produced, or built capital (e.g., roads, bridges, and houses) and financial capital (e.g., cash, stocks, bonds, and letters of credit) are tangible assets. Some natural capital, such as land, water, flora, and fauna, can be tangible; other aspects of natural capital, such as the quality of those resources, are intangible (Pender et al., 2012; Pender et al., 2014). Human capital is intangible because "it exists in the capacities of people and is not directly observable" (Becker, 1993, as cited in Pender et al., 2012, p. 62). However, the costs of producing it, such as investments in "skill development" education and "health maintenance and improvement," can be tangible (Pender et al., 2012; Pender et al., 2014, p. 19). Intellectual capital, such as "codified knowledge in books," is tangible, whereas tacit knowledge is not observable (Pender et al., 2012, p. 62). Social, political, and cultural capital are the most intangible assets. While these assets are intangible because they are not directly observable, their impact can be observable, such as improved health and educational outcomes from enhanced social capital (Pender et al., 2012; Pender et al., 2014).

Tangibility and marketability are often related. Tangible assets (e.g., physical and financial assets) are generally marketable, whereas intangible assets (e.g., human and social capital) are generally not directly marketable (Pender et al., 2012). These characteristics of wealth can influence the demand for goods. For instance, ecosystem services, such as ecological diversity, water filtration and natural carbon sequestration, may not be easily marketed, but other natural assets, such as private land, water rights, and mineral rights whose value can be influenced by these services, can be marketed.

2.3.2.2 Rivalry and Excludability

Rivalry and excludability are important characteristics of assets. Economic theory employs the terms *rivalry* and *excludability* with regard to consumption. If goods are rivalrous in consumption, "use of the good or service by one person reduces its availability for use by other people" (Cornes and Sandler, 1996, as cited in Pender et al., 2012, p. 65). If goods are excludable, "it is possible at low cost relative to the value of the good or service to exclude others from use of the good once it is provided" (p. 65). Pure private goods, such as housing and cars, are rivalrous and excludable in consumption. In contrast, pure public goods, such as national security and air quality, are non-rivalrous and non-excludable in consumption. Most goods have some degree of rivalrous and excludability characteristics. Goods that are more non-rivalrous but relatively excludable are said to be club or toll goods. Goods that are more rivalrous but relatively non-excludable are called common property goods.

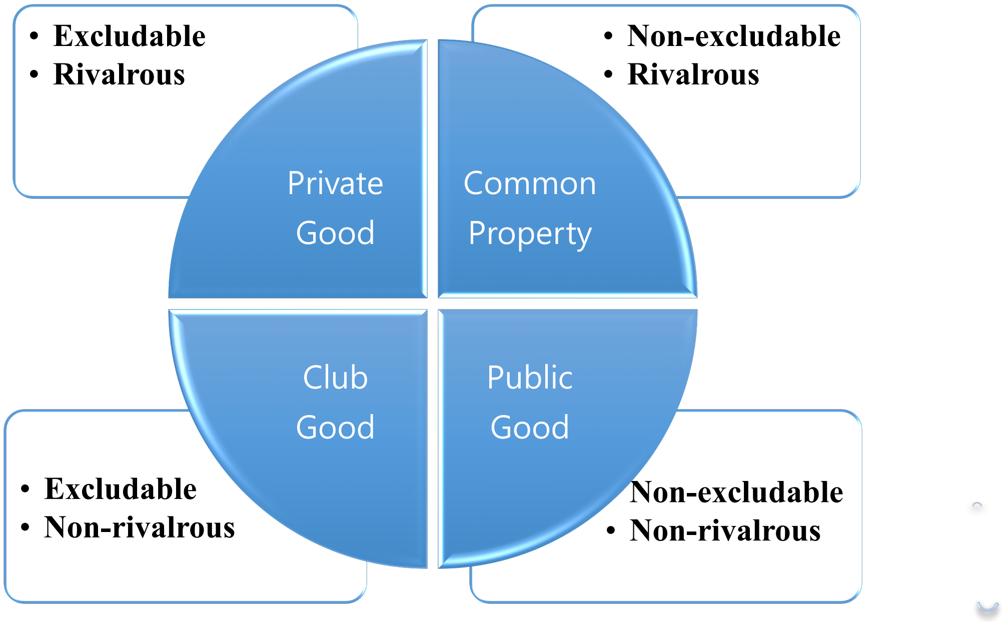

Figure 2.3.2.2.1 Classification of Goods based on Excludability and Rivalry

2.3.2.3 Private versus Public Wealth

The concept of excludability and ownership distinguish between public and private capital. Capital can be categorized as private (e.g., homes, cars, investments, education, and social connections) or public (e.g., public infrastructure, public lands and many types of natural capital) (K. M. Johnson, Winkler, & Rogers, 2013; Samuelson, 1954; Tiebout, 1956). This distinction is crucial for community life because whereas private capital primarily benefits only the private owners, public capital can benefit everyone able to access the capital (T. G. Johnson & Kim, 2014, p. 4; Tiebout, 1956). For instance, public social capital is social capital that government or other public entities, such as agencies and commissions, invest in and provide either freely or for compensation to the public. Investment by government in a community center is an investment in public built capital. Similarly, public investment in events and celebration is an investment in public social capital. Individuals benefit from these investments and they contribute to their comprehensive wealth but they share rights to the assets with others. In contrast, membership in a Rotary Club, for instance, is private social capital since members benefit from their investment in the club, although it will generate externalities for non-members in addition to the private benefits for the members, when the club provides beneficial services to their community.

2.3.2.4 Externalities

Externalities refer to "the case where an action of one economic agent affects the utility or production possibilities of another in a way that is not reflected in the marketplace" (Just, Hueth, & Schmitz, 2005, p. 527). In the imperfectly competitive world, the concept can be crucial for evaluating social welfare. This is partly because the concept of externalities is related to the concept of non-excludability (Pender et al., 2012). Most attention is generally given to negative externalities, such as traffic congestion, industrial pollution, water contamination, and farm odors, but positive externalities, such as firms' production of visual amenities and urban spillovers, also exist. These perspectives provide a rationale for public policies such as Pigouvian taxes and subsidies and laws that strengthen property rights. Consider, again, the shale oil boom in North Dakota. Although there are various economic benefits from the natural resource development activities (e.g., lower unemployment rates, higher wage rates), many social problems (e.g., eroding social relationships in communities, higher crime rates, traffic congestion and accidents) were created as negative externalities. This example illustrates the importance of understanding the interaction between tangible (development of physical and natural capital) and intangible (social capital and human health and capital) capital.

2.3.2.5 Stocks versus Flows

As Hoffer and Levy (2010) and Pender et al. (2014) point out, distinguishing stocks and flows is crucial for measuring comprehensive wealth because wealth is a stock, based on accumulated flows. “The change in wealth (a stock) over time is the cumulative effect of income and expenditures (flows)” (Pender et al., 2014, p. 32). Hoffer and Levy (2010) and Pender et al. (2012) provide a good illustration to distinguish stocks from flows. They compare changes in wealth to the changes of the water level in a bathtub. The contents of the bathtub at any time is like a stock of wealth whereas the flow into the tub is analogous to income, and draining the tub is analogous to consumption (“including direct consumption and wealth depreciation”; Pender et al., 2012, p. 3). Maintaining at least a minimum rate of consumption (outflow of stocks) into the future is required for the basis of our welfare and sustainability but this requires that inflows are at least as great as outflows (Hoffer and Levy, 2012; Pender et al., 2014, p. 32).

2.3.2.6 Willingness-to-pay and Property Rights

Asset and liability values depend on (1) how individuals value these assets or their services (i.e., individual’s willingness-to-pay for these assets or the services) and (2) the property rights of these assets that individuals and communities have (T. G. Johnson, 2014; Pender et al., 2014). Wealth depends on the real value of assets—the present value of all net benefits expected by beneficiaries of the assets.[2] An individual's willingness-to-pay for an asset or the services of the asset is the private value of the asset. The existence or use of these assets may also generate externalities. The value of externalities is the willingness-to-pay of those effected, to increase or decrease the externality (T. G. Johnson, 2014).

Strengthening property rights makes a positive contribution to wealth because strong rights "give individuals, firms, and governments bargaining power, control over assets, the opportunity to earn a fair return, and the right to receive compensation for externalities" (K. M. Johnson et al., 2013, p. 3). On the other hand, "weak or nonexistent property rights can lead to lower aggregate wealth if social costs associated with the use of the asset are greater than social benefits" (T. G. Johnson & Kim, 2014, pp. 4–5). Considering property rights when estimating wealth is important, therefore, since it allows a more complete estimation of wealth and the distribution of wealth among individuals and between private and public assets or liabilities.

2.3.2.7 People-Based versus Place-Based Wealth

A region's people-based wealth is the total of assets owned by the residents of a region "regardless of the location of those investments" (Pender et al., 2014, p. 33) less liabilities, while the region's place-based wealth is the sum of assets physically existing

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[2] Here I am referring to what might be called *social wealth*—the aggregate net value to all members of society. At any point in time, the value of an asset to the individual with ownership rights in the asset may be higher or lower than the actual present value of future net benefits to society. This may be due to uncertainties about future net benefits, short-term changes in market values due to business cycles, weak property rights, positive and negative externalities generated by the asset, or a number of other issues. In these cases social wealth would include the positive and negative benefits to nonowners of the asset, including future owners who acquire the asset at a cost above or below its real long-term value.

within a geographic region, “regardless of the location of the assets’ owners” (p. 33). “The sum of the people-based wealth of all residents is that region’s people-based wealth and is analogous to people-based product, GNP. This should not be confused with place-based wealth” (Pender et al., 2014, p. 33). All assets are included in both place- and people-based wealth just as all production is included in GDP and GNP, respectively (Pender et al., 2014).

Distinguishing people-based from place-based wealth depends on the notion of liabilities (Pender et al., 2014). *Liability* refers to “an obligation due to some prior contract or transaction” (Pender et al., 2014, p. 52). Very often, people use the terms *wealth*, *capital*, and *assets* synonymously and interchangeably but wealth is distinguished from capital and assets because it is a net measure, that is, it equals assets less liabilities. As a measure of place-based wealth, ownership (and therefore, liabilities) is irrelevant. At the global level, liabilities are irrelevant because “everyone’s liability is someone else’s asset” (Pender et al., 2014, p. 32). For example, if nonresidents own the rights to extract the shale oil in North Dakota, the region’s place-based wealth includes the oil, but the region’s people-based wealth excludes it because they do not own it.

2.3.2.8 Mobility of Capital

An interesting feature of capital is its mobility. “Mobility of capital refers to the ability of individuals to take the capital with them when they move” (T. G. Johnson, 2014, p. 209). The ownership, and ability to benefit from mobile capital remains with a person when they change locations. Owners of assets such as land and buildings can still own and benefit from these assets when they move. So in that sense, land and buildings are mobile assets. On the other hand, one cannot enjoy the benefits of immobile assets such as public infrastructure and many types of social capital when they move.

Mobility is also an attribute of intangible capital, such as social capital. Privately (individually) owned capital generates internal benefits and sometimes external benefits. Some privately owned social capital is mobile (individuals retain the wealth when they move), but some is immobile (it is reduced when the owners move)—the owners lose wealth. In this case, the external benefits of the private investment is also lost. Publicly owned social capital is probably always immobile. When a public body invests in social capital (festivals, for example), this becomes a part of the residents' wealth. If the people migrate, the social capital is lost to the individual and the place.

However, it is important to recognize that people-based wealth includes assets that may be immobile. For instance, individuals own their investment in local social clubs. When they move, this capital is lost because it does not go with them. On the other hand, place-based wealth is the sum of assets in a particular place, and some of these assets may move when people migrate, diminishing the location's wealth. Thus, "these distinctions are particularly important because immigrants and emigrants move with their wealth and some sources of wealth become unique to certain locations" (T. G. Johnson & Kim, 2014, p. 4). In this sense, it is important to know whether the benefits that one can obtain from an asset are mobile or not and whether the benefits or costs resulting from the asset are limited to its owner or involve externalities (i.e., non-excludability).

Figure 2.3.2.8 provides examples of assets classified according to the characteristics of mobility and tangibility.

	Tangible	**Intangible**
Mobile	Some types of physical capital (e.g., vehicles) Financial capital (e.g., stocks, letters of credit) Durable goods	Human capital (e.g., education, skills, mental health) Intellectual capital (e.g., innovation, stock of knowledge) Some types of private social capital (e.g., familial relationships, professional organizations) Some types of political capital (e.g., national political involvement)
Immobile	Land and buildings Infrastructure Local public physical capital (e.g., community centers, public libraries, parks) Roads, bridges, waterways Natural capital (e.g., air, water, land, flora, fauna)	Local amenities and culture Some types of local public services (e.g., community wide festival and events, public programs) Some types of private social capital (e.g., neighborhood relationships, volunteerism civic services, neighborhood watch)

Figure 2.3.2.8 Examples of Assets Classified according to Mobility and Tangibility Concepts

2.3.3 The Concept of Social Amenities and Relationship to Social Capital and Wealth

It is probable that people migrate on the basis of social issues (including social status) as well as income. Frank (1985) and Roback (1982) 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 with a high income but relatively low social status in one community move to another where they may accept a lower income but increase their social status and thus their utility.

Investments in social capital have both internal and external benefits and costs. In other words, investments in social capital have both private and public returns, “demonstrable externalities” (Putman, 2001, p. 1). External benefits of private investments in social capital appear as social amenities. Private investments in both mobile and immobile social capital can create social amenities. For instance, an individual’s investment in private and mobile social capital, such as national political involvement, produces internal benefits in the form of policies and programs which benefit the individual regardless of where they reside but these investments also can result in social amenities (both positive and negative) experienced by others. Local residents and new-comers will experience the amenities regardless of where the original investor resides.

The following section explores what social amenities are, how they can be created from investments in social capital, and how they influence the desirability of places as locations in which to live and work.

2.3.3.1 The Concept 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 (see Figure 2.3.3.6).

The term *social capital* has been used in numerous, often inconsistent, ways in the sociological and economics literature. Given the interest in this dissertation in understanding the changing place-based and people-based measures of wealth, we first distinguish mobile from immobile social capital. This distinction leads to a phenomenon I will refer to as *social amenities*. Much like natural amenities, social amenities are site-specific social characteristics that enhance a location as a place to live or work. Social amenities are produced by a range of activities, organizations, and facilities that support the formation, development and maintenance of social relationships and structure in a community. These, for instance, could include local social opportunities through various clubs, service organizations, local festivals, and other social features that most people prefer to have where they live and work. People generally do not purchase social amenities in the market; thus, social amenities are generally nonmarketable and intangible forms of wealth. Social amenities vary across regions and are tied to place-based wealth and public wealth, which are reflected in wages and land values. In the next section, I will explore how individual investments in social capital create social amenities

2.3.3.2 Social Capital and Organizations

Like other forms of capital, social capital is the cumulative level of social assets. Like other forms of capital, social capital must be 'stored' in some way. Organizations are one way in which social capital is stored. People invest in their personal social capital by joining organizations, and they expect benefits from their investments. According to social capital theorists Pretty and Smith (2003), "there are aspects of social structure and organization that act as resources for individuals, allowing them to realize their personal aims and interests” (p. 633). These organizations have value to participants because “they permit us to carry on our daily lives with a minimum of repetition and costly negotiation” (Pretty & Smith, 2003, p. 633). Brehm and Rahn (1997) suggest that positive feelings and a sense of belonging to an organization can build individual levels of social capital, and thus membership in organizations can be an indicator of the aggregate stock of social capital. Organizations are systems of norms, rules, and sanctions that foster the growth of interpersonal connections and, in turn, lead to trust and reciprocity. Norms, rules and sanctions define individual and community property rights in social capital. Organizations thus offer all of the necessary ingredients for producing and accumulating social capital.

2.3.3.3 Relationship of Social Amenities to Social Capital

Investments in social capital are crucial for creating, improving, and maintaining social amenities. That is because positive externalities are created by enhanced civic health, public spirit, and volunteerism generated through investments in social capital at both the societal and organizational levels (Adler & Kwon, 2002). Individual investments in social capital, thus, can create both private and public wealth.

Investments in social capital have been linked to a wide range of significant social phenomena (e.g., lower crime and poverty rates, better neighborhood relations, improved educational quality, and better physical and mental health) and economic phenomena (e.g., higher and more equal household income and greater productivity/efficiency of firms) (Cooke & Wills, 1999; Deller & Deller, 2012; Rupasingha, Goetz, & Freshwater, 2000; DiPasquale & Glaeser, 1999; Durlauf, 2002;

Fukuyama, 1996; Glaeser, Laibson, Scheinkman, & Soutter, 1999; Groot, Van Den Brink, & Van Praag, 2007; Kawachi, 1999; Knack & Keefer, 1997; Putnam, 2000; Rupasingha et al., 2000, 2006; Vera-Toscano & Ateca-Amestoy, 2008). When social groups or organizations seek solutions to complex socioeconomic problems, social capital becomes an important catalyst for a healthy community (Dolfsma & Dannreuther, 2003; Pretty & Frank, 2000; Putnam, 2000).

2.3.3.4 The Flow of Benefits from Social Capital

The term *capital* is generally defined as accumulated tangible and material assets (i.e., stock) over time, such as land, buildings, machinery, bonds, natural resources, etc. (Pikkety, 2014). The comprehensive wealth framework not only expands the definition of assets to include intangibles, but it also it stresses the difference between the flows and the stocks of social capital and the relationships between these stocks and flows. It is important to note that wealth is a dynamic concept. If continuous reinvestment does not continue, social capital will depreciate. There are important qualitative as well as quantitative issues as well. For instance, whereas social capital can be enriched by diversity and the infusion of new talent and experience that comes from new members (a high level of social capital stock), a rapid increase in people not invested in a region's place-based wealth can dilute the sense of trust and cohesion (T. G. Johnson & Kim, 2014).

In terms of factors that influence the level of social capital, relevant theories argue that people's mobility is negatively associated with investments in a place's social capital (e.g., DiPasquale & Glaeser, 1999; Putnam, 2000). Conversely, homeownership is positively related to investments in social capital (e.g., volunteer activity, political participation, and neighborhood relations) because ownership gives individuals more incentive to improve the social structure of their community (DiPasquale & Glaeser, 1999). This can be especially true if such investments increase property values. Haurin, Dietz, and Weinberg (2005) conclude that individuals with a higher economic status who are homeowners contribute to improving local amenities (including social amenities, such as lower crime rates) by investing more in social capital than do individuals with a lower economic status. Deller and Deller (2012) suggested that a by-product of individual investments in social capital such as familial relationships and participation in various local organizations, is a reduced rate of rural burglaries. Vera-Toscano and Ateca-Amestoy (2008) indicated that good housing requires communities to invest in social capital (places to interact with family and friends) with social amenities (security, good neighborhood, social relations, and status). In addition, as with other types of externalities, social capital externalities can be positive or negative. Negative externalities are sometimes generated by investments in things such as criminal organizations, or racist groups.

2.3.3.5 Relationship to the Concept of Comprehensive Wealth

2.3.3.5.1 Mobile versus Immobile

This dissertation focuses on how investments in social capital create social amenities and how the immobility of these social amenities create place-based wealth.

Private investments in social capital can be either mobile or immobile. Investments in familial relationships, professional organizations, and national political involvement are examples of mobile social capital because individuals can enjoy the benefits of this social capital over long distances. Investments in neighborhood relationships, volunteerism, local political capital and civic service are examples of immobile social capital because they lose their value to people when they move out the community.

Social amenities are typically produced as a by-product of these private investments in immobile social capital. Spending additional time caring for children at home can intensify familial relationships (Israel & Beaulieu, 2004). The investment in familial social capital has been shown to increase children's wellbeing (Stone, 2001; Stone & Hughes, 2002), including private benefits such as improved health, and social amenities such as improved quality of public education, and lower juvenile crime rates. Putnam (2000) posits that investments in social capital (e.g., participation in associational activities, volunteer activities, and membership in various types of formal and informal networks) is strongly negatively related to crime, poverty, tax evasion, poor health, economic inequality, and civic inequality, all external benefits (social amenities) of private investments. For instance, participation in the PTA, through fundraising and volunteer activities of teachers and parents, improves the quality of schools which benefits the volunteers but also benefits other parents and students.

Residents of a location can also contribute to local public wealth through political involvement. By voting in local elections, an individual produces both internal benefits, such as personal satisfaction, the respect of other community members and some influence on the political outcomes, and external benefits, such as improved better government (DiPasquale & Glaeser, 1999).

Nonprofit and public (governmental) organizations also invest in social capital. McKeever and Pettijohn (2014) concluded that charitable activities of the nonprofit sector contribute to the quality of social services and care, public meetings, public safety, and cultural activities, which may intensify social amenities. Nonprofit organizations (NPOs) play a pivotal role in building and maintaining social capital (Boris, 1999; Coleman, 1990; De Vita & Fleming, 2001; Putnam, 1993a) by providing means for people to interact and work toward common goals (De Vita & Fleming, 2001), which can contribute to social amenities. NPOs activities lead to "volunteers working alongside each other, staff interacting with clients, or board members promoting the organization's activities in the community" (De Vita & Fleming, 2001, p. 9), which can build ties between people and thus enhance social capital. Besides promoting individual connections, NPOs enable citizens to "work jointly on common concerns, sharing ideas, responsibilities, and resources" (p. 9) and can create collaborations between government agencies and the private sector to further community interests (De Vita & Fleming, 2001).

2.3.3.5.2 Internal and External Benefits of Social Capital

2.3.3.5.2.1 From Private Investments

As pointed out, there can be private and public benefits from investments in private and public social capital. Consider membership in a local social service organization (e.g., Rotary Club, Lions Club, or veterans' associations). These are generally private investments in private social capital but produce both private benefits and social amenities. In other words, these kinds of private investments in social capital have both private (internal) benefits and social (external) benefits for all residents of a location. These clubs are stocks of private social capital in which individuals invest through "social occasions, networking, and personal growth opportunities that encourage involvement" (Wikipedia, n.d.).

On the other hand, public organizations such as "Cooperative Extension, community development corporations, and collaborative neighborhood based initiatives" (Warner, 2001, p. 190) as well as nonprofit organizations can enhance a community's level of social capital. By enhancing social capital among residents, some types and activities of NPOs can make residents more employable (National Conference on Citizenship, 2011, 2012). They provide members with returns on their investment in the form of direct utility as well as business connections, information, and learning opportunities (private or internal benefits). In addition, however, they have external effects such as increased funds for charities, improvements in public infrastructure, and an increased sense of community among the population as a whole. These external effects are related to quality-of-life benefits for community residents who may or may not have been directly involved in the NPO, a phenomenon referred to here as *local social amenities*. Ultimately, intensified social networks/capital developed by NPOs can contribute to strengthening a community's social and economic health (De Vita & Fleming, 2001).

Private and for-profit organizations invest in social capital, too, improving or creating social amenities. If a private insurance company invests in a free festival or other event for local residents, this is an example of social capital investment by a for-profit organization. Community members, whether customers or not, benefit from the company's investments in its social capital. Locally owned cooperatives have both intra- and extra-economic value (Martin & Stiefelmeyer, 2001). The Western Area City and County Cooperative (WACCO) in Fergus Falls, MN, for instance, has enhanced members' networking and cost-saving, offering training programs for nonmembers without an annual membership fee, improving the quality of local government service, helping communities, and thus maintaining local autonomy (Martin & Stiefelmeyer, 2001; Trechter et al., 1988). In particular, this can be important for small rural governments, which are interdependent with local businesses, because they can save their taxpayers money (Trechter et al., 1988).

2.3.3.5.2.2 From Public Investments

Most, if not all, public investments in social capital contribute to improving or creating social amenities as well as private wealth. Public investments in public recreational sites such as public parks and community centers may increase property values but their primary purpose is to provide social amenities. Investments in social capital might be underestimated if the focus is on the internal and private benefits (Coleman, 1988), while ignoring the positive externalities in the forms of social amenities. Government spending on social capital produces numerous types of social amenities (e.g., crime prevention, improved public health, reduced poverty, better public education). Warner (2001) presents the role of local government in terms of building social capital, stating that the most effective way to promote community levels of social capital is government programs, decentralizing governmental power and enhancing horizontal ties.

Governmental investments in public spaces, community-wide festivals, and events provide residents with more recreational opportunities, a higher quality of life, and improved health. Moving to a place with better social amenities can provide a better job, relationships, safety, and security (Coleman, 1988).

Overall, the importance of community-based organizations is apparent in terms of building the capacity for healthy and sustainable communities. In the next section, I will sort out the nature of social capital to capture social amenities according to the conceptual characteristics of comprehensive wealth. By doing so, this dissertation develops a typology for a comprehensive wealth measure.

2.3.3.6 Sources of Social Amenities

People do not purchase social amenities in the market so social amenities are nonmarketable benefits. Differentiating immobile (tied to place) from mobile (tied to people) capital, and external (nonexcludable) from internal (excludable) benefits provides a basis for describing social amenities and distinguishing it from other types of wealth. Social amenities share the characteristics of public goods, which are nonrivalrous and nonexcludable. Investing in social capital by joining local organizations creates both internal benefits (private return on investment in social capital) and social amenities as forms of positive externalities.

	Private Investments in Mobile Social Capital	**Private Investments in Immobile Social Capital**	**Public Investments**
Type of Investments	Familial relationships Professional organizations Political involvement	Neighborhood relationships Volunteerism Civic service Neighborhood watch	Public spaces Festivals and events Public programs
Private Benefits	Higher income Better educational attainment Better jobs	Higher property values Lower taxes	Higher property values Improved health Better public services Profitable businesses
Social Amenities	Lower crime rates Lower poverty Better government Higher employment rates	Lower crime rates Lower poverty Better government Higher employment rates	Lower crime rates Lower poverty

Figure 2.3.3.6 Proposed Typology of Wealth: Investments in and Benefits from Social Capital

2.3.3.6.1 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). But the relationship between amenity valuation and comprehensive wealth is a relatively recent concern of economists. The spatial hedonic model following from Roback (1982) yields strong implications for measuring the comprehensive wealth of communities. The model provides a linking mechanism between the value of non-market assets (i.e., local amenities) and tangible assets (i.e., land values and wages). The Roback model (1982) 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. The general Roback model (1982) hypothesizes the following conclusions: 1) in terms of households' location decision, a high level of amenities results in a willingness to pay higher housing prices and willingness to accept lower wages. 2) regarding firms' location decisions, a higher level of productive capital reduces the firms' cost resulting in a willingness to pay higher rental prices and wages. The Roback model provides a basis for a spatial hedonic land value and wage estimation procedure for estimating the implicit value of non-market and intangible assets (i.e., local amenities) and explaining the spatial diversity in wages and land values (Gottlieb, 1994; Halstead & Deller, 1997; Rudzitis, 1999; Wu & Gopinath, 2008).

2.3.3.6.2 Roback (1982) Spatial Equilibrium/Hedonic Model

The comprehensive wealth framework offers a basis for understanding the relationship between the various types of capital. As discussed in the literature review, asset values are determined by individual's willingness to pay (WTP; in the welfare theoretic sense) for these assets. Roback's (1982) hedonic spatial equilibrium model provides estimates of individual indirect WTP for local amenities (i.e., marginal valuation of local amenities with respect to local wages and land values). Hedonic price analysis has been one of the methods most widely used by economists for measuring individuals' responses to quality differentials (Smith, 1997, p. 18). "The equilibrium condition implied that the marginal price will measure the marginal rate of substitution between the quality [of amenities] and a numeraire good [land values and wages]" (Smith, 1997, p. 19).

Roback (1982) shows how to estimate implicit prices of local amenities through variations in land and labor markets. "The linkages based on some form of substitution or complementarity between one or more private goods and the non-marketed environmental resource are the basis for nonmarket valuation" (Smith, 1997, p. 8). Valuing nonmarket assets (i.e., local amenities) involves analyzing how the choices of individuals and firms were motivated by the local resources (Bockstael & McConnell, 1993; Smith, 1997).

The Roback (1982) spatial equilibrium model makes several assumptions: 1) workers and firms (homogeneous representative consumers and firms) can move freely and instantaneously, and do not incur migration costs, 2) workers choose consumption of tradable goods (x) and land (l^c) to maximize utility, U(x, l^c; s), where s is a nonmarketed exogenous amenity of a location, 3) workers have identical preferences and endowments of nonwage income (I), 4) workers earn a wage (w) and make rental payments (r), 5) the workers' indirect utility function is V (w, r; s) and a partial derivative of the indirect utility function ($\partial V / \partial s$) is positive because s is an amenity, 6) there are N workers in the community and each worker inelastically supplies one unit of labor, 7) the supply curve for land is upward sloping in a community, and 8) firms produce a composite consumption commodity, X (tradable good), with a constant-returns-to-scale production function, assuming the unit cost function, C $(w, r; s) = 1$.

It is important to note that Roback's (1982) assumption about costless migration of identical utility maximizing workers ensures that all workers have the same utility everywhere:

(1) V $(w, r; s) = k$

Similarly, the costless migration of cost minimizing representative firms implies that all firms earn zero profits everywhere, because at equilibrium:

(2) C $(w, r; s) = 1$

Each condition ensures the spatial equilibrium of workers and firms, respectively, and if each condition is not satisfied, workers and firms would have an incentive to move until conditions equalized (Roback, 1982). Equations (1) and (2), then, determine the equilibrium w and r as functions of s. In the (w, r)-plane, the equilibrium w and r is determined by the intersection of the upward sloping iso-utility and downward sloping iso-cost curves. Using total differentiation of equation (1), Roy's identity and rearranging terms, the Roback (1982) hedonic price model yields the following expression to estimate the marginal value of amenities, indicating the proper joint market (both producer and consumer):

(3) $\frac{\partial WTP}{\partial s} = l^{c}\frac{dr}{ds} - \frac{dw}{ds}.$

In the figure below, the left graph represents the equilibrium level of wage and housing price in two locations with the same level of capital (productive amenities) but different levels of amenities (consumptive amenities). It is noted that Wu and Gopinath (2008) distinguish consumptive and productive amenities [although they also do not use the terms explicitly], which Roback (1982) does not. The consumptive amenities are valued by consumers according to their utility function while the productive amenities reduce firms' cost of production[3]. As Wu and Gopinath (2008) explain, "more accumulated human capital and better infrastructure" (p. 402) are productive amenities, which attract more firms. In addition to these, generally government economic development programs and regulations [the regulations may increase costs of productions] may be examples of productive amenities. While Wu and Gopinath (2008) imply better weather and lower housing costs can be consumptive amenities for retirees, the quality of education and recreation services may be general examples of publicly provided consumptive amenities. Police, fire protection, courts, transportation infrastructure, and clean water may be publicly provided amenities that serve both consumers and producers. As Wu and Gopinath(2008) point out, however, more concentrated productive amenities (called capital in Wu and Gopinath, 2008) can lead to decreases in consumptive amenities (disamenities such as more traffic and pollution from more businesses and people). If there is a higher level of amenities ($\acute{\varepsilon} > \varepsilon$), the second location will offer higher housing prices and lower wages. The right graph represents the equilibrium level of wage and housing price in the two locations with the same level of amenities but different levels of capital. If there is a higher level of capital for firms, the location will offer higher housing prices and wages.

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[3] Note that the definition *k* in Figure 2.3.3.6.1 is different from the definition of *k* in the presentation of Roback's theory.

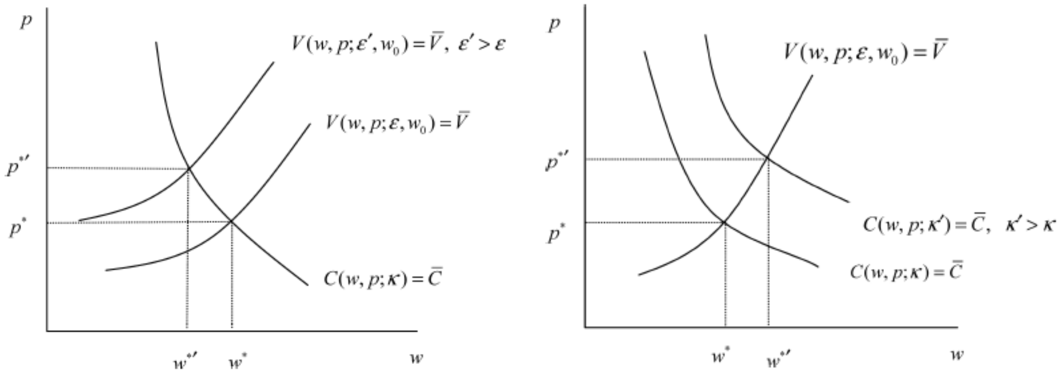

Figure 2.3.3.6.1 Determination of Spatial Equilibrium Wages and Rents in the Roback Model

Source: Wu and Gopinath (2008), Figures 1 and 2 (pp. 394 and 395, respectively)

Although Roback (1982) offers several implications about how to value local amenities in her conceptual model, the empirical section has several limitations. Roback (1982) analyzes wage data, from the May 1973 Current Population Survey, which identified 12,001 individuals in the 98 largest U.S. cities. She is interested in residential site prices rather than housing prices. For the property value analysis, Roback employed only residential site prices across cities that report average site prices per square foot for 83 of the 98 largest cities. The study acknowledged that the data overrepresented low-income families because the data are collected only for FHA-qualifying families (p. 1269). Also, the data do not have information about the location of the site within the city (p. 1269). Moreover, Roback (1982) treats local amenities as exogenous, which would not be true in cases, where the quantity and quality of amenities are enhanced in response to higher incomes and wealth for example. In addition, Roback (1982) has based her estimations of implicit value of amenities by adding the marginal valuation of wages and site values. This might overlook interrelationship between wage and site values. As Wu and Gopinath (2008) point out, there are two possible approaches for the empirical analysis: 1. "to estimate the reduced form equations of equilibrium wage and housing price directly as in Roback (1982)", and 2. to estimate the structural equations of demand and supply in the labor and housing markets" (p. 397). The reduced form approach does not account for "how amenities affect the markets for labor and land development" (p. 397) because of the dynamic process of development. On the one hand, "it is less likely that labor and land markets are always in equilibrium" (p. 397). Wu and Gopinath (2008) adopt the second approach for these reasons. Roback (1982) estimated the two models (i.e., wage and site values) as separate reduced form models, which ignore the dynamic interactions between labor and land markets. This dissertation will consider the endogeneity between labor and land markets and thus need to consider them as a system. Those markets need to consider as simultaneously determined.

With regard to improvements of data and method, Blomquist et al. (1988) and Wu and Gopinath (2008) employ cross-sectional analysis with county-level data (253 urban counties for Blomquist et al., 1988; 2,635 counties in 2000 for Wu and Gopinath, 2008). In particular, Wu and Gopinath (2008) develop the simultaneous equation system that they estimate using a three-stage least squares estimators to correct endogeneity and contemporaneous correlation after identifying spatial autocorrelation in an equation (p. 399). Both studies consider all amenities as exogenous. And, Wu and Gopinath (2008) and Blomquist et al. (1988) consider housing prices/expenditures to analyze property value whereas Roback (1982) is interested in residential site prices.

The proposed conceptual framework in this dissertation considers both endogenous and exogenous amenities. Ideally the conceptual model reflects that social amenities are endogeneously produced by local government investments in social capital. This inclusion of a government sector is important. Although Roback (1982) identifies and incorporates the interaction between labor and housing markets, as Rudd (2000) pointed out, some of studies employed Roback's (1982) spatial hedonic equilibrium model do not have satisfactory results if they include public sector (e.g., tax variables) as control factors because there might be correlation between public capital, land values, and wages (Rudd, 2000). The econometric model estimated in this research improved on the simpler method by considering endogeneity (simultaneous determination of response variables and regressors, in this case, wage, land values, and government services, and even more), while accounting for spatial interactions among them. Incorporating these considerations (e.g., multi market and spatial interactions) yields more accurate regional socio-economic structural analysis than the single isolated market analysis (Bhandari, Johnson, Robinson, & Savannah, 2007; Gyourko, Kahn, & Tracy, 1989a; Gyourko & Tracy, 1989b; Gyourko, Kahn, & Tracy, 1991; Roback, 1982).

With a large sample spatial data set, there are common econometric issues. The fundamental argument of this dissertation is that social issues as well as economic and natural resource issues influence location decisions of individuals and firms. In particular, local amenities, which are place-specific characteristics, contribute to the importance of household and business locations. As Dubin (1998) points out, the locational importance increases the possibilities of spatial autocorrelation in the regression error terms. The cross sectional data employed herein includes location information. The extended model deals with endogeneity among wages, land values, government services, and so on.

2.3.3.6.3 The Relationship Among Natural Amenities, Land Values, and Wages

In the United States, more than 290 million visitors used recreational sites such as national parks and forests during 2014 (National Park Service, 2015). The importance of natural amenities from site-specific natural and environmental capital is apparent for the quality of life and well-being of individuals. Since those assets can be valued by consumers in their utility function, they are mainly consumptive amenities. Many of the spatial hedonic studies have focused on the valuation of natural amenities, such as scenic views, access to lakes and parks, and clean air, in terms of differences in housing values and wage differentials. However, before the Roback (1982) model, most attempts at measuring the marginal value of amenities would not meet conditions for identification (Smith, 1997), which included only a single-market, such as labor or housing, functions that estimated the willingness-to-pay (WTP) function. They ignored implicit interactions (Hoehn, Berger, & Blomquist, 1987). Smith and Huang (1993, 1995) tried to find the relationship between air pollution and property values—not wages—although their negative interrelationship has not been supported by recent research (Smith, 1997). There are studies of site-specific disamenities, such as hazardous waste sites (Kiel, 1995, Kolhase, 1991, and Michaels & Smith, 1990, all as cited in Smith, 1997), incinerators (Kiel & McClain, 1995, as cited in Smith, 1997), and shoreline erosion (Kriesel et al., 1993; Van De Verg & Lent, 1994, as cited in Smith, 1997).

Roback (1982) and subsequent studies, such as Blomquist et al. (1988), estimated implicit amenity prices using cross-sectional data (253 urban counties within 186 metropolitan areas of the United States) and considering interactions between labor (wages) and housing markets. They included 11 local amenities, such as climate and environmental attributes. The natural amenities variables included precipitation, humidity, heating degree days, cooling degree days, wind speed, sunshine, and proximity to coastlines. The coefficients of the amenities variables clearly indicate an effect on housing expenditures and wages, which means that locations with more disamenities or negative features are associated with compensation in the form of higher wages and/or lower land prices (Smith, 1997). These results are similar to Gyourko and Tracy (1989a); individuals are willing to pay for more sunshine but are compensated for more cooling degree and heating degree days and for humidity.

Wu and Gopinath (2008) showed the relative valuations of natural amenities between metro and rural counties in the United States. They employed the natural amenity index developed by the U.S. Department of Agriculture (USDA) Economic Service Research Service (McGranahan, 1999, as cited in Wu & Gopinath, 2008), which is based on the average temperatures for winter, winter sunny days, low winter-summer temperature gap, summer humidity level, topographic variation, and water area proportion of total county area. Their results supported those of Deller, Tsai, Marcouiller, and English (2001) and Rappaport and Sachs (2003) that showed a positive effect of natural amenities on firms' productivity (e.g., employment). Increased supply of workers and residents attracted by higher levels of natural amenities will reduce the labor costs or increase the productivity of firms. The resulting increases in tax base from the new residents will further improve the quality of public services as long as economies of scale are achieved. In many cases, the net effect of higher amenities will depend on whether the consumption amenity effect or production amenity effect dominates. If consumption amenities also have a positive effect on firms' productivity, then land values will be higher. The wages, however, can be either lower (if the consumption amenity effect dominates) or higher (if the production amenity effect dominates) (see Figure 3 in Wu & Gopinath, 2008, p. 396). In this latter case, the theory would predict that more of the implicit value of the amenity would be capitalized into land values. Deller et al. (2001) showed that rural areas with key natural resource amenities can manage those natural endowments to capture growth more effectively.

2.3.3.6.4 The Relationship between Social Amenities and Natural Amenities

The Roback (1982) spatial equilibrium model implies that peoples' willingness to pay and willingness to accept depends not only on exogenous natural resource amenities, but also on spatially unique social characteristics as well as financial characteristics of place. However, most, if not all, research on spatial hedonics has focused on natural and publicly provided amenities (public goods). They do not differentiate and identify social amenities. Moreover, they assume that people take the stock of local amenities as exogenously determined (Smith, 1997). It is important to note that this dissertation considers the quality of amenities (including social amenities) as a by-product of economic activity as well as governmental and citizen actions.

The general Roback (1982) model can apply to all local amenities, not just natural and publicly provided amenities. Social capital theories suggest that social capital interacts with natural capital (e.g., through the management of natural resources). Pretty and Ward (2001) argue that the "social and human capital necessary for sustainable and equitable solutions to natural resource management comprise a mix of existing endowments and that which is externally facilitated" (p. 212). Communities may use outside agencies or individuals to assist in the development of institutions and processes as well as human and social capital for ensuring sustainable and equitable resource management. If successful, natural, social and human capital can interact to enhance comprehensive wealth (Pretty & Ward, 2001). In other words, the quality of social amenities can contribute to the quality of local natural amenities.

2.3.3.6.5 The Relationship between Social Amenities, Land Values, and Wages

The decision of where to live involves more than the choice of a housing unit and its objective characteristics. The choice also involves consideration of factors such as desired social status through interactions with family, friends, and neighborhoods (Vera-Toscano and Ateca-Amestoy, 2008). Good housing can also provide various intangible social amenities (e.g., "security, privacy, neighborhood and social relations, status, community facilities and services, access to jobs and control over the environment", Vera-Toscano & Ateca-Amestoy, 2008, p. 258). This should be true for the decision of where to work as well because of interactions between labor and housing markets.

Some spatial hedonic studies (e.g., Blomquist et al., 1988) have included variables that can be interpreted as social amenities (or disamenities) as defined in this dissertation (e.g., considerations of level of crime). Blomquist et al. (1988) find that violent crime rates are associated with higher housing values, which is not the expected sign. They do find that violent crime rates are associated with higher wages as expected, since higher wages must offset this disamenity. The positive effect on housing values is inconsistent with the Roback (1982) model. It is likely, however, that crime is really endogenous. The argument here is that more crime (especially property-based crime) occurs in higher income locations because the rewards are greater (Cullen & Levitt, 1996; Willis, 1997). The higher rates of crime then lead to higher compensating wage rates for workers (Gould, Weinberg, & Mustard, 2002; Roback, 1982). As Roback (1982) argues, if employers need workers in high crime locations, they have to compensate them (Gould et al., 2002).

Few or no hedonic studies have explicitly modeled the possibility that social amenities are externalities generated by investments in social capital. It has been demonstrated in the literature review above that social amenities can be interpreted as externalities generated by investments by residents and local firms, and organizations. However, the concept of mobile versus immobile social capital has apparently not been addressed, and thus the proposed research fills a gap in the literature on spatial economics.

2.3.3.7 The Key Determinants of Social Amenities

Investments in social capital that generate positive externalities would be a potential strategy for sustainable regional development. It is important to note that not all investments in social capital generate social amenities. Individual investments in social capital that do not produce external benefits to the community do not produce social amenities. In fact, some investments in social capital produce disamenities. Putnam (2000) provides an example of a negative consequence of social capital (i.e., Tim McVeigh and the Oklahoma City bombing). To potentially generate positive externalities, the investments in social capital must contribute to enhancing trust, cohesion, and positive feelings between and within residents, organizations, and governments. Any alienating effects of these investments must be outweighed by their cohesive effects. Thus, I identify the following key characteristics of social amenities. First, they are generated by investments in social capital by residents, local firms, and local organizations that generate positive externalities for other residents by facilitating and providing means for resident individuals and firms to interact and work toward common goals. Second, the investments benefit all or most residents of a location (non-excludability). Third, the magnitude (value) of the social amenities is determined by the external returns from the investments enjoyed by community members. Finally, based on this definition of *social amenities*, the relevant investments in social capital include a wide range of activities, organizations, and facilities that support the formation, development, and maintenance of social relationships and structures in a community.

Both private and public investments in the following types of immobile social capital can contribute to social amenities:

- Neighborhood relationships
- Volunteerism
- Civic service
- Public spaces

- Community/Town-wide Festivals and Events

Number, density, and membership of member organization such as Rotary Clubs are widely used indicators of social capital (Putnam, 2000; Rupasingha et al., 2000). However, these measures do not differentiate mobile from immobile social capital or whether they generate external benefits. Consider membership in service club organizations (e.g., Rotary Clubs). Active organizational participants, volunteering activities, and fundraising activities enhance immobile social capital to generate positive externalities (i.e., social amenities) in their community. These active organizational investments improve local social structure, leading to social amenities generated by enhanced trust, cohesion, and civic culture among residents.

Governments invest in social capital using taxes. Government expenditures on social capital (e.g., public meetings, parks, community centers) can generate social amenities (reduced crime, increased social cohesion, increased civic engagement). A public library provides several programs without fees that involve interactions among residents. Farmers markets (the investment in land and infrastructure) is an example of public built capital that creates social capital (perhaps measured by number of participants) that generates a social amenity. Of course, individuals also invest their time and money in these examples of social capital. For this reason, they may be viewed as public-private-partnerships for social capital investments.

2.3.3.7.1 The Role of Bonding, Bridging, and Linking Social Capital in Creating Social Amenities

Various concepts of social capital have been developed from sociology and economics (e.g., Putnam, 1993b; Fukuyama, 1996; Ostrom, 2007). Currently, bonding and bridging social capital as well as linking social capital have been widely used in research related to community or regional economic development. Bonding social capital refers to relationships of homogeneous people, such as family and close friends (Putnam, 2000). Bridging social capital refers to networks of heterogeneous groups, such as loose friends and workmates (Szreter & Woolcock, 2004). Linking social capital refers to unlike people in dissimilar situations, such as between people outside the community (Woolcock, 2001). They share characteristics of different types of social capital. Granovetter's (1973) weak ties and strong ties are similar to bridging and bonding social capital, respectively. Woolcock's (2001) horizontal and vertical metaphors are similar as bonding and bridging, and linking social capital, respectively.

Based on the proposed definition of social amenities in this dissertation, the social amenities come from a range of activities, organizations, and facilities that support the formation, development and maintenance of social relationships and structure in a community. In other words, various types of social capital can contribute to social amenities of a community. For instance, homogenous groups (bonding social capital) and bridges between groups (bridging social capital) are embedded differently in community structure. The space of the community might depend on linking social capital. If there are positive external benefits of a certain level of social capital of a community, outside/adjacent community might share the benefits as spill over effects. By linking social capital, the benefits might be enlarged over the space.

In general, social capital theories argue that a higher level of social capital may improve information flows, reduce transaction costs, and thus promote better economies. Also, a higher level of social capital, such as more networks and contacts, can lead to better access to resources and information, which can influence equity. That is because more networks might reduce opportunity of other people or of groups. There are, thus, both positive and negative effects of social capital. Various types of social capital require harmony and well-functioning relationships among the types.

Communities have both bonding (homogeneous network, such as family and close friends) and bridging social capital (heterogeneous social networks). To create positive externalities from those types of social capital (based on the definition of social amenities in my dissertation), some level of interactions between people, groups, and organizations within a community are required to create and enhance trust and cohesion among them, which can create and improve social amenities. Bonding social capital can generate and enhance the trust and cohesion within a group or organization while bridging social capital enhances the cohesion or network between groups (facilitating diverse and heterogeneous community).

Both types are crucial for creating social amenities. Bonding social capital without bridging social capital might not have positive externalities (external benefits to everyone) because of the lack of interactions with outside members. Bonding social capital with more bridging social capital may have more power to access information and connections (which can facilitate economic and political development; O’Brien, Phillips, & Patsiorkovsky, 2005). If there are pre-interactions and understanding among people, groups, and organizations from the bridging social capital, the bridges can have positive benefits from those social capital assets (e.g., improved information flows, reduced transaction costs, more understanding about diverse perspectives). Thus, more bonding with bridging social capital can contribute to facilitating interaction, to share information, to increase cohesion within a community while linking social capital can enable community members to access a wider range of resources than available in their community. In this sense, more bonding with bridging social capital (if there are enough positive externalities) can intensify community development while more linking social capital can give broader benefits at a broader level. Good linking social capital (with outside communities) might mean that they have positive spillover effects between community or regions while good bridging social capital from within a community or region. Respectively, bonding social capital can cultivate trust and collective cooperation among people and groups while bridging social capital can increase understanding diversity between/among people and groups. Linking social capital can broaden both bonding and bridging social capital by creating linkages between communities or regions. Balance among all types of social capital can create and improve social amenities within and between communities. The social amenities can be understood both as social phenomenon (e.g., trusted community with lower crime rate and poverty rate) and as positive returns from investment in social capital (like an economics term, capital).

It is important to note that the concept of the social amenities this dissertation develops more explicitly differentiates immobile assets from mobile assets in a location. Bonding, bridging, and linking social capital might be more likely to move with people when people move, and thus cannot be captured as location-based social capital.

2.3.3.8 Other Potential Exogenous Factors

2.3.3.8.1 Homeownership Rates

Haurin et al. (2005) pointed out the potential private benefits of homeownership, which include "increased household wealth, increased self-satisfaction, and improved child outcomes" (p. 4). They presented theoretical foundations (but did not include actual empirical tests) of multiple types of external benefits of homeownership. They argue that increased homeownership affects adjacent neighbors' social and economic outcomes (e.g., increasing homeownership, improved child outcomes). The neighborhood effects from homeownership would improve social amenities (e.g., decreasing crime rate and improving public education quality) and indirectly contribute to land values.

2.3.3.8.2 Life-Cycle Migration Patterns

A current interesting phenomenon is that life-cycle factors have been identified as factors in migration patterns. K. M. Johnson et al. (2013) offered clear evidence of life-cycle migration patterns[4] at the county level. They also indicate that younger age groups are

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[4] Migration age groups are the following (K. M. Johnson et al., 2013, pp. 1–2):

Emerging adults (ages 15 to 24)—Migration for this group is stimulated by the transition from parental households to independent living, such as the movement to college, the military, or first jobs. Immigrants also contribute to migration among this age group.

more mobile and that the elderly have the least mobility. It follows that the outflow of young laborers from non-metro counties to metro counties contributes to lower land values in rural areas. Migration rates will reflect amenities, but those places with a more mobile population will have different coefficients. That is because more mobile populations (younger age groups) might move to urban counties mainly due to job opportunities (more labor supply might lead to lower wage and higher housing/rental prices without more supply for job demand and housing construction) while reduced labor supplies in rural counties might lead to decrease in demand for housing/rental and fewer firms might locate in rural counties. For these and other reasons it is desirable to test for differences in implicit prices on amenities in rural and urban counties and in different regions of the country.

It is implied that each age group focuses on different types of social amenities. A younger age group might have a lower willingness to pay for amenities; in other words, they might place a higher value on wages because of their lower wealth. In contrast, the elderly might place more value on local amenities after retirement. They might want to

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Young adults (ages 25 to 29)—Migration for young adults often reflects the completion of education or training and the transition to full time, career-oriented employment.

Family age (children ages 5 to 14 and adults ages 30 to 49)—Migration for these adults and their dependent children generally reflects a life-cycle transition from independent living to family life associated with marriage, children, and home purchases.

Older adults (including those ages 50 to 74)—Although older adults are the least mobile of these age groups, they tend to migrate to locations rich in scenic and built amenities or to relocate in proximity to their own adult children.

Four different county types are the following: 1) large metro core counties, 2) large metro noncore, 3) non-metro farm counties, and 4) non-metro recreation counties.

enjoy a more bucolic lifestyle with better facilities (e.g., access to good hospitals, public services, family and friend relationships, and community centers).

2.3.3.8.3 Commuting Patterns and Commuting Times

We should look at commuting time as part of WTP for certain amenities. This will help us refine the hedonics. For instance, some workers work in the locality in which they live and enjoy the same amenities as their employers, but many commute in order to enjoy the amenities in their home locality but the higher wages in another locality (Kilkenny, 2010).

Looking at commuting time will also help us examine the effect of physical remoteness of rural areas on social capital. The time cost of traveling a long distance can be a source of decreasing social connections, which is similar to the effects of urban sprawl on social capital in Putnam's (2000) analysis (Glaeser, Laibson, & Sacerdote, 2002).

This chapter surveyed the literature regarding the social and economic factors involved in location decisions by consumers and producers and interpreted the findings of previous research in terms of the conceptual characteristics of comprehensive wealth. We conclude that the value of intangible social factors can be estimated if we can identify and measure how intangible factors are capitalized into marketed assets.

The next chapter formalizes a conceptual model in which the value of non-marketable local amenities are capitalized into land values and wages, thus providing a way to measure the value employing a general hedonic spatial equilibrium model.

Chapter 3: Theoretical Framework

In this chapter, the conceptual model is described. This framework expands upon the Roback's (1982) general spatial equilibrium model to allow for endogenous local amenities, and immobile local public services at a location. First, I describe Roback's theoretical model to understand the inherent structure of the model. Then, I expand Roback's spatial equilibrium model by including the choice of endogenous local amenities.

3.1 Roback's (1982) Spatial Hedonic Equilibrium Model: Theoretical Structure

This section presents Roback's (1982) spatial equilibrium model, which forms the foundation for our basic model. The Roback model uses market prices (e.g., property values and wages) to estimate the marginal value of site-specific amenities. The theoretical model links compensating rent and wage differentials between locations with different qualities of location-specific amenities.

Roback's (1982) spatial equilibrium model makes several simplifying assumptions: 1) workers and firms (homogeneous representative consumers and firms) can move freely and instantaneously and do not incur migration costs; 2) workers choose to consume tradable goods (x) and land (l^c) at levels that maximize utility, $U(x, l^c; s)$, where s is a non-marketed amenity of a location; 3) workers have identical preferences and endowments of nonwage income (I); 4) workers earn a wage (w) and pay a rental payments (r); 5) the workers' indirect utility function is $V(w, r; s)$ and the partial derivative of the indirect utility function ($\partial V / \partial s$) is positive because s is an amenity; 6) there are N workers in the community and each worker inelastically supplies one unit of labor; 7) the supply curve for land is fixed and upward sloping in each community; and 8) firms produce a composite consumption commodity, X (tradable good), with a constant-returns-to-scale production function, assuming the unit cost function, $C\ (w, r; s) = 1$. At each location, a household and a firm solve the following utility maximization of workers (1) and cost minimization of firms (2) problems.

$$(1) \qquad V\,(w, r, I, s) = \max_{x,l^c} U\,(x, l^c, s)$$

$$\text{subject to } w + I = x + l^c \cdot r$$

$$\rightarrow V\,(w, r, I, s) = \max_{x,l^c} U\,(x, l^c, s) + \lambda_{\mathrm{h}}\,[w + I - x - l^c \cdot r\,],$$

where w = wage income, r = housing price per unit of residential space, and I = nonwage income. Nonlabor income (I) is assumed to be independent of location.

$$(2) \qquad \mathrm{C}\,(w, r, X, s) = \min_{l^p,N}\ [r \cdot l^p + w \cdot N] \text{ subject to } f\,(l^p, N, s) = X,$$

where l^p= commercial land, N = total workers employed.

$$\rightarrow C\,(w, r, X, s) = \min_{l^p,N}\ [r \cdot l^p + w \cdot N] + \lambda_{\mathrm{f}}\,[f\,(l^p, N, s) - X]$$

Equilibrium implies that utility of households and costs of firms are equalized across all locations occupied by households and firms. In other words, individuals will be indifferent among locations given differences in wages and land rent (i.e., individuals will have the same total utility regardless of where they locate), and all firms have the same unit costs everywhere in equilibrium. Thus, no agent would be better off by moving in equilibrium. Defining the common utility of each household as $\underline{\mathrm{U}}$, note that the unit cost of firms must equal 1 because the price of the traded good has been set to 1 (in a competitive equilibrium, firms' unit cost equals the output price). Then the equilibrium conditions can be written as

(3) $\underline{U} = V(w, r, I, s)$

(4) $1 = C(w, r, s)$

There are two endogenous variables in equations (3) and (4): *w* and *r* (*s* is exogenous amenities and *I* is independent of location). The system of two equations determines unique solutions for these two endogenous variables. By the implicit function theorem, the partial derivatives of the implicit system are as follows:

$$(5) \quad \begin{bmatrix} V_w & V_r \\ C_w & C_r \end{bmatrix} \begin{bmatrix} \frac{\partial w}{\partial s} \\ \frac{\partial r}{\partial s} \end{bmatrix} = \begin{bmatrix} -V_s \\ -C_s \end{bmatrix}$$

By Cramer's rule,

$$(6) \quad \frac{\partial w}{\partial s} = \frac{1}{|A|} \begin{bmatrix} -V_s & V_r \\ -C_s & C_r \end{bmatrix} = \frac{1}{|A|} (-V_s C_r + V_r\, C_s)$$

$$(7) \quad \frac{\partial r}{\partial s} = \frac{1}{|A|} \begin{bmatrix} V_w & -V_s \\ C_w & -C_s \end{bmatrix} = \frac{1}{|A|} (-V_w C_s + V_s\, C_w),$$

where $|\mathrm{A}| = V_w C_r - V_r C_w = L(s)\, V_w\ / X > 0$, and $L(s)$ is the total land available at location *s* (Roback, 1982, p. 1262). The unit cost function $C(\cdot)$ is increasing in factor prices and thus $C_w = \frac{N}{X} > 0$, and $C_r = \frac{l^p}{X} > 0$, where l^p and N are, respectively, the land and labor used in production. The equations $XC_w = N$, $XC_r = l^p$, and $l^p + Nl^c = L$, in addition to the production function $X = f\ (N, l^p; s)$, determine the equilibrium values of N, l^p, l^c, and X.

Table 3.1 Comparative Static Results from Various Effects on Household's Utility and Firm's Cost

		Producer Side	**Producer Side**
		$C_s > 0$	$C_s < 0$
	Consumer Side	**Combined Effects**	**Combined Effects**
$\boldsymbol{\frac{\partial w}{\partial s}}$	$V_s > 0$	$< \mathbf{0}$	If $V_r\, C_s > -V_s C_r$, $\frac{\partial w}{\partial s} > \mathbf{0}$
			otherwise, $\frac{\partial w}{\partial s} < \mathbf{0}$
$\boldsymbol{\frac{\partial r}{\partial s}}$	$V_s > 0$	*If* $-V_w C_s > V_s\, C_w$, $\frac{\partial r}{\partial s} < \mathbf{0}$	$> \mathbf{0}$
		Otherwise, $\frac{\partial r}{\partial s} > \mathbf{0}$	

Assuming $V_s > 0$, $V_r < 0$, $V_w > 0$, $C_r > 0$, and $C_w > 0$ (Roback, 1982), Table 3.1 presents expected comparative static results depending on the relative strengths of the productivity and amenity effects. In terms of this ambiguity of the wage effects, the combined effects of the wage from the consumer and producer sides can be either positive, negative, or insignificant on balance, because the supply and demand effects in the labor market offset each other.

Each condition of equations (3) and (4) ensures the spatial equilibrium of workers and firms, respectively, which means that workers and firms do not have any incentive to move at equilibrium. Equations (3) and (4) determine the equilibrium *w* and *r* as functions of s. If $\frac{\partial w}{\partial s}$ and $\frac{\partial r}{\partial s}$ are observable, Roback (1982) defines the implicit price of the amenity as $P_s^* \equiv {}^{V_s}/_{V_w}$. Using total differentiation of equation (3), Roy's identity, and rearranging terms, the Roback (1982) spatial equilibrium model yields the following expression to estimate the marginal value of amenities, indicating the proper joint market for both consumer and producer:

(8) $$\frac{\partial WTP}{\partial s} = l^{c}\frac{dr}{ds} - \frac{dw}{ds}$$

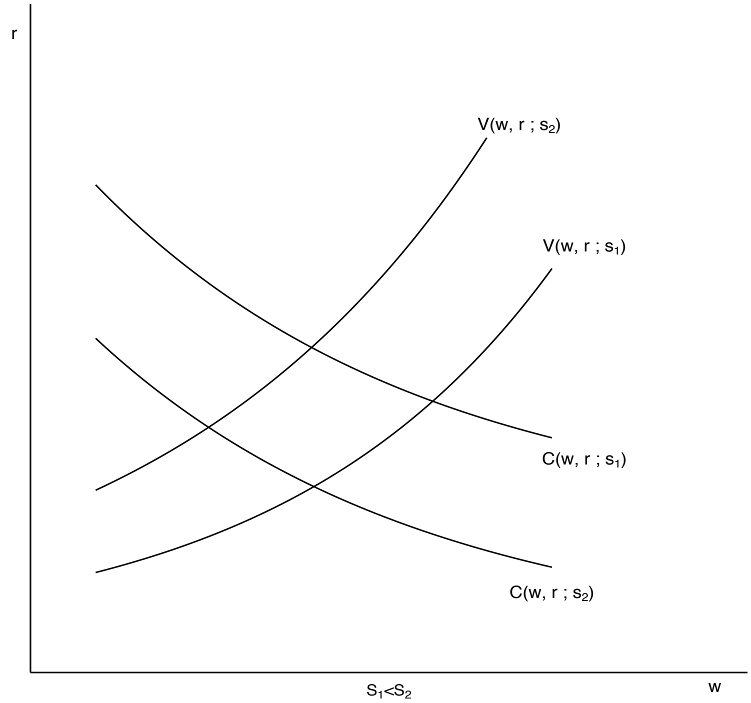

Figure 3.1 Effects of Different Quantities of s on Wages and Rents (Roback, 1982, p. 1261)

Note. Roback assumes s is unproductive in this figure and thus (for $s_1 > s_2$) factor prices must be lower in location 2 to equalize costs in both locations 1 and 2.

Figure 3.1 illustrates where firms must pay a higher wage in a low-amenity place: A household accepts a compensating wage differentials to live there (see Wu & Gopinath, 2008). The model indicates that an individual has a higher willingness to pay for housing prices and willingness to accept lower wages when that individual wants to live in a more amenable place. Amenable places offer various opportunities to consume and enjoy location-specific amenities but have relatively lower wages and higher housing/land prices.

3.2 Theoretical Expansion of Roback Model

Central to my theoretical framework is the idea that different locations have different sets of both exogenous and endogenous amenities. As defined, local amenities are non-marketable assets and include all types (natural, publicly provided, and social amenities). In particular, my model focuses on valuing social amenities as endogenous amenities, which are generated by locally provided public services. Well-provided public services (e.g., public parks, police, free programs in public library, and community-wide festivals) can facilitate interactions among residents, which contribute to locally specific social capital. Material capital, personal well-being, and social capital have been identified as major sources for quality of life (Bryden et al., 2013). Social capital very often has been considered the most, or more crucial than other types of capital (e.g., natural and material capital) in terms of decisions regarding where to live and work, controlling age, gender, education, and migration status (Bryden et al., 2013). The literature review has identified no research that deals with endogenous social amenities in the literature on spatial economics, in particular the roles of mobile versus immobile social capital in producing social amenities. This section presents a model to estimate the implicit value of local social amenities and services, expanding the Roback (1982) model by including local government's services as immobile, non-marketable, and endogenous amenities at the location. The utility maximization process considers public, place-specific expenditures that benefit everyone in the community.

3.2.1 Extension of Roback's Theoretical Model

3.2.1.1 Approach 1

The extended model adds local public goods to Roback's general spatial equilibrium framework. Local governments produce public services, *g*, using tax revenues. We assume *g* is measured in monetary units and that total tax revenues will equal the total cost of producing government services, $N \times t = AC \times g$ (where *AC* is average cost). Residents maximize utility by allocating income to private goods, land for residential purposes and local government services.

(1) $\max_{x,l^c} U(x, l^c, g, s)$

subject to $w + I = x + t + l^c \cdot r$,

where *w* = wage income, l^c = residential land, *r* = price per unit of residential space, *t* = annual taxes, and *I* = nonwage income. As in Roback (1982), nonwage income (*I*) is assumed to be independent of location. The consumer takes *w*, *r*, *g*, and *s* as given, and maximizes by choosing *x* and l^c. Spatial equilibrium implies that utility of households and costs of firms are equalized across all locations occupied by households and firms. The free mobility assumption implies that identical consumers' utilities are equalized across locations. But the equilibrium depends on *w*, *r*, *g*, and *s*. *g* is nonrival and nonexcludable and thus *g* is consumed by total workers *N*. Defining the common utility of households as $\overline{U}$,

(1a) $V(w, r, N, g, s) = \overline{U}$,

Firms minimize their cost,

(2) $C^p(w,r,g,s) = \underset{l^p,N^p}{min} [r \cdot l^p + w \cdot N^p]$

subject to $f^p(l^p,N,g,s) = X$,

where l^p = private land.

Assuming that firms' unit cost functions are affected by *s* and *g*,

(2a) $C^p(w,r,g,s) = 1.$

Assuming that the minimum total cost of producing g is $TC\ (w,r,g,s,Z_g)$, where Z_g includes factors that affect the cost of producing g that do not affect the cost function of private firms or the utility or budget constraint of consumers/workers (for example, the density of the population served by the government, quality of services delivered). Since government balances its budget and since *g* is measured in expenditures in dollars, the amount of *g* provided equals the minimum total cost of providing it.

(3) $g = TC(w,r,g,s,Z_g)$,

Equation (3) implies that the average cost of g equals 1:

(3a) $AC\ (w,r,g,s,Z_g) = {}^{TC}/_{g} = 1.$

Solving (3a) for *g* gives,

(3b) $g = f\ (w,r,s,Z_g).$

Equations (1a), (2a), and (3b) can be organized into a system of three equations in three unknowns that can be used to implicitly determine *w* and *r* as a function of *g*, *N*, and *s*:

(4) $w = w\ (g,N,s)$

(5) $r = r\ (g,N,s)$

(3b) $g = f\ (w, r, s, Z_g)$.

Substituting g (3b) into equations (4) and (5) gives a system of two equations in two unknowns (assuming N[5] is constant in equilibrium):

(4a) $w = w\ (f\ (w, r, s, Z_g), N, s)$

(5a) $r = r\ (f\ (w, r, s, Z_g), N, s)$

Now, the indirect utility function can be written:

(1b) $V\big(w, r, f\ (w, r, s, Z_g), s\big) = V\ \big(w, r, s, N, Z_g\big) = \bar{U}$,

And, the indirect cost function can be written:

(2b) $C^p\big(w, r, f\ (w, r, s, Z_g), s\big) = C^p\big(w, r, s, Z_g\big) = 1$

If *N* is exogenous, equations (1b) and (2b) can be implicitly solved for *w* and *r*:

(6) $w = w\ (N, s, Z_g)$

(7) $r = r\ (N, s, Z_g)$

Substituting equations (6) and (7) into (3b) to get the reduced form solution for *g*:

(8) $g = f\ \big(w\ \big(N, s, Z_g\big), r\ \big(N, s, Z_g\big), s, Z_g\big) = f(N, s, Z_g)$

If *g* is level (quantity) of services, the unit cost to each resident is $\frac{g}{N}$, where *g* is equal to the government revenues, assuming the government balances its budget. The sum of taxes will equal the total cost of producing *g*.

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[5] Roback (1982) assumes free mobility of workers but, assuming a system in equilibrium, treats population, in addition to population density and population growth rate, as an exogenous amenity of a location in her econometric model at the equilibrium (variables' name, POP73, DENSSMSA, and GROW6070 in Roback). In other papers (e.g., equation [2], Blomquist et al., 1988, p. 90), *N* is treated as exogenous in equilibrium.

Regarding the implicit price of an amenity as in Roback, if $\frac{\partial w}{\partial s}$, $\frac{\partial r}{\partial s}$, and $\frac{\partial g}{\partial s}$ are observable, by Roy's identity,

$$P^*_s \equiv V_s/V_w = \frac{-(V_w\frac{\partial w}{\partial s} + V_r\frac{\partial r}{\partial s} + V_g\frac{\partial g}{\partial s})}{V_w}$$

3.2.1.2 Approach 2

In this approach, I make similar assumptions regarding equilibrium and optimal consumption of *g* and that everyone in the county has the same utility function and income. However, in this case I 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*.

In equilibrium, the county's utility functions are

(9) $V = U(l, N, s) = U(x^*, l^{c^*}, g^*; s)$

and their incomes,

(10) $w + I = x^* + t + l^{c*} \cdot r$,

where,

$w + I$ 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:

(11) $MRS_{gx} = \frac{\partial t}{\partial g}$ (since the price of *x* is 1)

$MRS_{gl^c} = \frac{\partial t}{\partial g} \Big/ r$, and

$MRS_{l^c x} = r$, (since the price of *x* is 1)

and the demand function,

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

where $\frac{\partial t}{\partial g}(= \frac{t}{g})$ is 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 (11) indicates that the expenditures on *x* and *g* have the same marginal values to residents. If *g* is always optimal, the MRS_{gx}would be equal to the price ratio[6].

In itself, *g* is a function of quality and the unit cost to residents is *t*/*g*. In equilibrium, the implicit price of government services (social amenities, *g*) is equal to their price (*t*/*g*).

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

(14) $TC = f\ (g) = C\ (g, Z_g) \times g$,

where C is average cost per unit of *g*.

This indicates that the total cost of *g* depends on a vector of county's characteristics or cost conditions Z_g.

From the demand function for *g* (12), equation (14) and assuming that nonwage income I is independent of location as in Roback, we can derive the following functions

(15) $r = f\ (\frac{\partial t}{\partial g}, w, Z_g,\ l^c)$

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[6] 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*.

$$w = f\ (\frac{\partial t}{\partial g}, r, Z_g, l^c)$$

From equation (15), we can test if g is as 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 into wages.

This study employs the second approach. Employing this second approach allows us to identify if a system is in equilibrium if amenities are adjusting their values.

3.2.1.2.1 Expansion of Assumptions

Table 3.2.1.2.1 Expansion of Assumptions

	Roback's General Spatial Equilibrium Model	**Expanded Conceptual Model**
Key Assumptions	• Workers and firms (homogeneous representative consumers and firms) can move freely and instantaneously and do not incur migration costs; • workers have identical preferences and endowments of nonwage income (*I*; this is assumed to be independent of location); • workers earn a wage (*w*) and make rental payments (*r*); • there are *N* workers in the	• Individuals/workers choose consumption of tradable goods (x^c), residential land (l^c), endogenous public services (*g*), and exogenous natural and social amenities (*s*) to maximize utility, $U(x^c, l^c, s, g)$; • the extended model does not change the workers' indirect utility function, which is $V(w, r; s)$, because w is their total income that they spend on x, g (through taxes), and l^c. In

	community and each worker inelastically supplies one unit of labor; and, • the supply curve for land is fixed and upward sloping in each community.	equilibrium, the marginal utility from one dollar of x is equal to the marginal utility from one dollar of g. And a partial derivative of the indirect utility function with respect to s and g ($\frac{\partial V}{\partial s}$ and $\frac{\partial V}{\partial g}$) is positive because s and g are exogenous and endogenous amenities; • firms produce a composite consumption commodity, X (tradable goods), with a constant-returns-to-scale production function, assuming the unit cost function, $C^p(w, r, g;\ s) = 1$. The production and cost function for X is a dependent on g; • governments produce a composite public service, g, with a constant-returns-to-scale production function, assuming the unit cost function,$C^g(w, r;\ s) = g;$ and, • government pays the same wage and rental rate for land as the resident and firm pay.

Chapter 4: Empirical Applications

This chapter describes an empirical estimation of amenity values based on the general Roback's theoretical framework and then on the expanded framework described in Chapter 3. First, I present the sources of data and how to develop variables, and then present econometric models applied in the empirical analysis. Finally, I analyze the results of the econometric models, presenting the implications of a comprehensive wealth measure.

4.1 Data

The collection, and development of the data for this study has two objectives. The first objective is to develop a data set as consistent as possible with the comprehensive wealth theoretical framework and with the conceptual models' assumptions. The second objective is to contribute to developing a recent and duplicable county-level database. The units of analysis in this study are the 3,109 counties in the continental United States in 2012.

4.1.1 Main Variables

4.1.1.1 Creating Contiguity-based Spatial-weight Matrices

This study defines neighbors as counties having common borders (adjacent). I follow Drukker, Peng, Prucha, and Raciborski (2013) to create a normalized-contiguity matrix from the 2012 shapefile of the census (I downloaded tl_2012_us_county, which contains the database file and the coordinates file), using an spmat object in the STATA software package. The units of analysis in this study are the 3,109 counties in the continental

United States in 2012, which is the latest census year for ACS 5-year estimates. In contrast, Roback (1982) included only the 98 largest U.S. cities.

Table 4.1.1.1 Summary of Spatial-Weighting Object (Wcounty)

Matrix	Description
Dimensions	3,109 × 3,109
Stored as	3,109 × 3,109
Links	
Total	18,472
min	1
mean	5.94146
max	14

The table includes information for the spectral-normalized contiguity matrix. The dimensions are 3,109 × 3,109 and the number of neighbors are identified as 18,472, with each county having about 6 neighbors on average.

4.1.1.2 Dependent Variables

4.1.1.2.1 Variable *w*: Expected Average Income

One of the dependent variables in this study, *w*, is defined as expected average county income. The measure for *w* in this study, as closely as possible, reflects earnings from local sources only. Roback (1982) employed earnings for male residents over 18 in the identified cities as an indicator of wages. According to the underlying logic of Roback's (1982) 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 the income 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 get that income anywhere. The BEA's 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 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[7] in the data on personal income 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 (the BEA currently revised its income data, since 2004, 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. Regarding the final measure of variable *w*, I divide this measure of "net earnings by place-of-residence estimates" from the BEA[8] by the labor force by place of residence (including employed and unemployed members of the labor force) from the U.S. Bureau of Labor Statistics as follows:

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[7] Total earnings by place of work consist of earnings by place of work, less 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 less contributions for government social insurance, and plus adjustment for residence.

[8] See Appendix 2 for how to deal with BEA modifications to FIFS codes in this study.

$$\boldsymbol{w} = \frac{\textbf{net earnings by place}-\textbf{of}-\textbf{residence}}{\textbf{labor force by place}-\textbf{of}-\textbf{residence}}$$

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. This assumption is similar to that of the Harris-Todaro model of migration (Harris & Todaro, 1970), incorporating the probability of employment into expected wages (differences which are assumed to determine migration flows). The Roback model is an improvement on the migration model because the Roback model accounts for the effects of differential amenities on migration and firm location decisions.

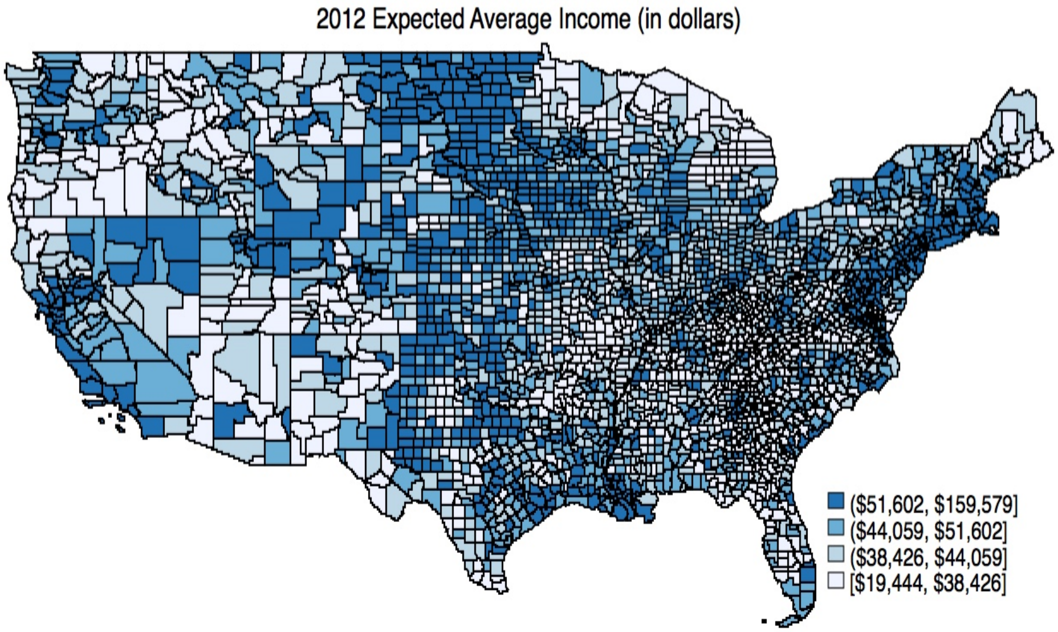

Figure 4.1 Expected Average Income for Counties in the Continental United States

Figure 4.1 shows the distribution of *w* across counties. Spatial patterns in Figure 4.1 indicates that darker colors represent higher values of the dependent variable, *w*.

4.1.1.2.2 Variable *r*: Expected Average Rent for Residential Sites

The economic rent of land is intended to be a measure for the variable *r*. This study defines r as expected average rents. This is a Ricardian rent concept and is equal to the value of unimproved land. *Unimproved* means the value without buildings, fences, drainage, irrigation, and other investments. Therefore, the amount that people pay to rent homes and the implicit value of owner-occupied dwellings is too high because it includes the value derived from the improvements. 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. Roback (1982) employed data on average residential site prices per square foot on residential sites in 83 of the 98 largest cities. The study acknowledged that low-income families were overrepresented because the data were collected only for Federal Housing Association–qualifying families (p. 1269). Also, the data did not have information about the location of the site within the city (p. 1269). Our county-based estimations, thus, includes a broader range of residential sites than that of Roback (1982). However, we employ data on owner-occupied housing values from the American Community Survey in order to have comparable data for all 3,109 counties. 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.

To calculate the implicit price of an amenity as in Roback (1982), 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 future benefits of living in a house, so here I translate housing values into annual rent. To calculate the rent, this study adapts the user cost method (Himmelberg, Mayer, & Sinai, 2005, as cited in Bieri, Kuminoff, & Pope, 2015; Poterba, 1984, 1992):

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

where P is the average county housing value[9]; 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 methodology (Himmelberg et al., 2005; Poterba, 1984, 1992) attempts to measure the real economic cost of homeownership in addition to the inclusion of direct payments for local public goods via property taxes (Bieri et al., 2015, p. 18), which can control the tax rates' impact on the amenity (effects on land values), and on land values. Oates (1969) presented the possibility of simultaneous effects of the tax rates and the amenity effects on land values.

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, δ_t = 0.025. These values come from the estimates from Harding, Rosenthal, and Sirmans (2007, as cited in Bieri et al., 2015).

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[9] I used the 2012 ACS 5-year estimates of aggregate value by owner-occupied housing units and calculated it by dividing by the total owner-occupied housing units.

I 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. This value varies across counties. The national average of property taxes 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).

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. In general, this value is relatively small (values are around 1% of the home owner's annual user cost). 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 indicate that the value varies across states (real estate appreciation data from http://www.estateofmindsites.com), whereas Bieri et al. (2015) treat the expected capital gain as constant (γ_{t+1}= 0.038, which is a long-run inflation of 2.0% plus real appreciation of 1.8%). Bieri et al. (2015) looked at the appreciation in housing values, found it to be 3.8% but reduced this by 2% to get the 1.8%. If homeowners maintain their homes at a constant physical condition (i.e., offset depreciation with repairs), the expected capital gain and appreciation rates are the same.

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[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).

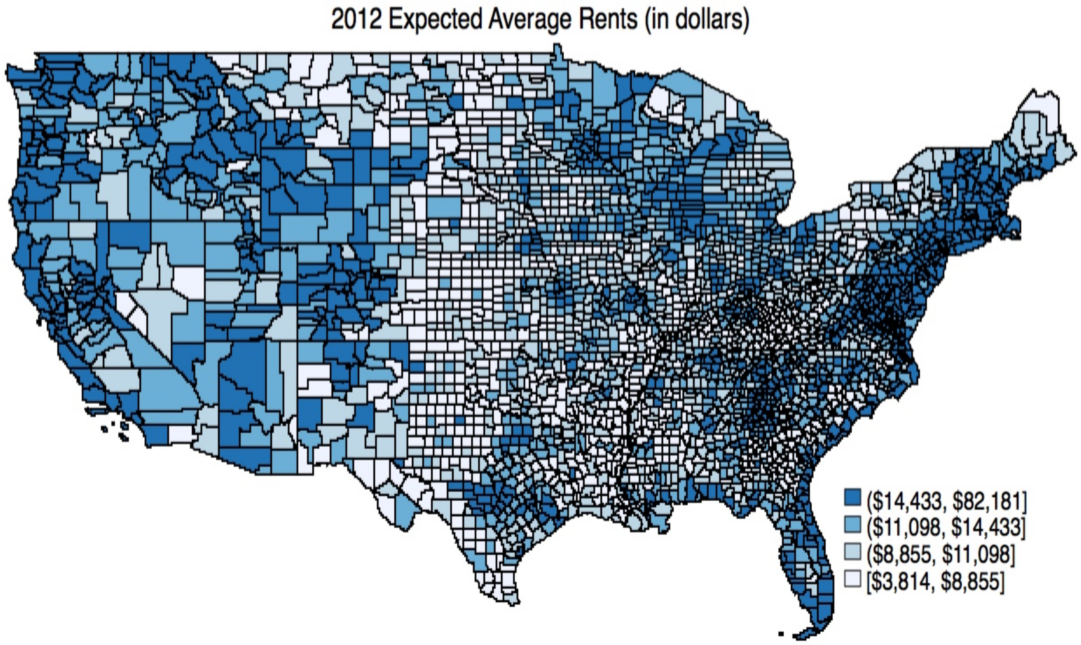

Figure 4.2 Expected Average Rents for Counties in the Continental United States

Figure 4.2 shows the distribution of expected average rents across counties. The darker colors in Figure 4.2 represent higher values of annual costs of housing consumption. It is interesting that the darker–colored areas in Figure 4.1 match many of the light areas in Figure 4.2 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) spatial equilibrium model.

The values of the measure in this study would be different than Roback's (1982) rent because the formula of rent variable I use includes the annual cost of the site and the improvements (i.e., data on the average housing values include values of buildings, infrastructure, landscaping, and so on). So, this number will be much larger than the annual site value that Roback used. I include several housing characteristics to control for improvement values.

Table 4.1.1.2 Definitions and Descriptive Statistics for the Variables

Variable	Definition	Metro Mean	Non-metro Mean	National Mean
County Income	Expected average wage	\$51,180.93	\$43,993.65	\$46,677.61
County Rent	Expected average rent	\$15,293.33	\$10,832.43	\$12,498.28
Housing Value	Average county housing value	\$204,278.60	\$139,562.6	\$163,729.6

In Table 4.1.1.2, metro counties have 16% higher average county income comparing with non-metro counties.

The value of rents can be interpreted in terms of the capitalization rate (valuing the flow of services from owner-occupied housing) as follows:

$$C = \frac{R}{V},$$

where $C =$ capitalization rate, R = rent, and V = property value. The average estimate of residential housing capitalization rates for all 3,109 counties in the continental United States is 7.92%. The capitalization rates are 7.81% and 7.98% for metro and non-metro counties, respectively.

4.1.2 Amenities and Other Variables

4.1.2.1 Climate, Geographic, and Environmental Amenities

Table 4.1.2.1.1 reports mean values of each climate, geographic, and environmental amenity differentiating 1,161 metro from 1,948 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 spatial different mean values between metro, non-metro, and nation.

Table 4.1.2.1.1 Climate, Geographic, and Environmental Variables

Variable	Definition	Metro Mean	Non-metro Mean	National Mean
PM 2.5	Particulate matter 2.5 µm or less in diameter (µg/m^3)	13.62	12.34	12.82
PM 10	Particulate matter 10 µm or less in diameter (µg/m^3)	23.31	23.14	23.20
Heating Degree Days	Mean annual heating degree days	4,489.35	5,165.31	4,912.883
Cooling Degree Days	Mean annual cooling degree days	1,378.83	1,252.54	1,299.70
Extreme Temp	Mean annual extreme temperature days	5,868.18	6,417.85	6,212.58
Sunshine	% of possible	59.40	60.66	60.19
Precipitation	Mean precipitation (inches)	41.30	37.04	38.63
Wind Speed	Mean wind speed (mph)	8.85	9.29	9.13
Natural Scale	Natural Amenities Scale (ERS)	-0.05	0.04	0.0037

Note. Number of observations is 1,161 metropolitan counties, 1,948 non-metropolitan counties, and 3,109 counties for the continental United States. The Natural Amenities Scale indicates that a higher score is a place with higher amenities. See Appendix 2 for more information and sources of variables. ERS = Economic Research Service.

4.1.2.2 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, golf fees and membership) will not be capitalized into rent or out of wages, but the externalities as a form of local amenities will.

4.1.2.2.1 Opportunities for Local Physical Activity

This study employs and defines a broad 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 physical activity of residents in a community (Babey, Wolstein, Krumholz, Robertson, & 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 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). More detailed information is included in Appendix 2.

4.1.2.2.2 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. I employ the 2012 American Community Survey estimate on kindergarten to 12th grade for percentage of enrolled population in public and private schools with total number of enrollment. After converting the percentage values into number, I calculated as percentage of private to public school enrollment ($100\times\frac{number\ of\ private\ school\ enrollment}{number\ of\ public\ schcool\ enrollment}$). Thus, the higher number indicates the lack of confidence in the public education system.

Table 4.1.2.2.2.1 Quality/Outcomes of Public Services

Variable	Definition	Metro Mean	Non-metro Mean	National Mean
Private to Public School	Percentage of private to public school enrollment	11.04	8.16	9.24
Poor Water Quality	Population affected by a water violation divided by total population with public water (% population in violation)	6.88	10.17	8.94
Mammography	Percentage of female Medicare enrollees having at least 1 mammogram in 2 years (age 67-69)	62.03	57.42	59.14
Physical Activity	Percentage of the population with access to places for physical activity	61.52	45.75	51.64
High School Graduation	Percentage of ninth-grade cohort that graduate in four years	79.64	65.74	70.93

Note. See Appendix 2 for more information and sources of variables.

Table 4.1.2.2.2.1 shows quality levels or outcomes of public services at the county level in 2012. Private to Public School variable is an indicator of lack of confidence in the public education system. Thus, a higher value indicates 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 of county income between metro and non-metro counties. Overall, metro counties have better outcomes/quality of public services except public education system (Private to Public School).

4.1.2.3 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 implicit price of public services. I calculate local governments' total revenue per capita in a county as follows:

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

I 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. I sorted by FIPS Code State then County and then TypeCode. After sorting all types of government according to county FIPS, I aggregated total revenues of all types of governments in a county.[11]

Table 4.1.2.3.1 shows 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.

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[11] The 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.

Table 4.1.2.3.1 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 4.1.2.3.1, the value for total local government revenues per capita is slightly higher in non-metro counties than in metro counties.

4.1.2.4 Local General Characteristics

Table 4.1.2.4.1 County's General Characteristics

Variable	Definition	Metro Mean	Non-metro Mean	National Mean
County Unemployment	Unemployment rate	7.83	7.84	7.83
County Population	Population size	229,144.7	23,487.34	100,286.4
Population Density	Population density	634.96	43.23	264.20
Population Growth	Population growth rate	1.07	-0.42	0.14

Note. See Appendix 2 for more information and sources of variables.

Metro counties have higher mean values for the following variables: 8.76 times larger population size, 13.69 times higher population density. The difference in population growth rates between metro and non-metro counties indicates that the population gaps are widening. Unemployment rate is almost identical between metro, non-metro, and national mean values.

In Table 4.1.2.4.2, metro counties have 41% higher violent crime rates than non-metro counties. We hypothesize that lower crime rates will lead to relatively higher land values and lower wages. However, other factors, such as higher poverty and children poverty, and less unequal distribution of income (County GINI), could decrease the land values in non-metro counties.

Table 4.1.2.4.2 Other Social Amenities

Variable	Definition	Metro Mean	Non-metro Mean	Nation Mean
County Total Crime	Total crime rate	2,742.08	1,970.54	2,258.66
County Property Crime	Property crime rate	2,454.83	1,766.76	2,023.71
County Violent Crime	Violent crime rate	287.24	203.78	234.95
County Poverty	Poverty status	24.97	26.05	25.65
County Child Poverty	Children under age 18 living in poverty (%)	21.67	26.32	24.59
County GINI	Income inequality	0.43	0.44	0.44

Note. See Appendix 2 for more information and sources of variables.

Table 4.1.2.4.3 Dummy Variables

Variable	Definition	Metro Mean	Non-metro Mean	Nation Mean
Metro	Dummy variable equals 1 if a county is metro	1		0.37
Northeast	Regional dummy equals 1 if a county is Northeast	0.11	0.04	0.07
South	Regional dummy equals 1 if a county is South	0.51	0.43	0.46
West	Regional dummy equals 1 if a county is West	0.12	0.14	0.13
Midwest	Regional dummy equals 1 if a county is Midwest	0.26	0.39	0.34

Note. This study follows 2013 Rural-urban Continuum Codes and Urban Influence Codes to differentiate metro from non-metro counties. Regional dummies follow Census Divisions.

The number of metro counties is higher in northeastern and southern regions and is lower in western and Midwestern regions.

4.1.3 Implicit Price of an Amenity

To compute the implicit prices of amenities in percentage terms and evaluated it at mean county income, I employ the following equation as in Roback (1982, p. 1263) for the estimation of a semi-log specification:

(17) $$\frac{P_s^*}{w} = k_l \frac{d \log r}{ds} - \frac{d\log w}{ds}$$

→ $$P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w,$$

where k_l is the share of land in the consumer's budget, P_s^* is "the amount of income required to compensate for a small change in *s*" (Roback, 1982, p. 1263), and w is the county's average annual expected income. The average county income is $51,180.93, $43,993.65, and $46,677 for metro, non-metro, and nation, respectively.

4.1.3.1 Variable k_l: Share of Residential Land in the Consumer's Budget

This study defines k_l as share of residential land in the consumer's budget. This study employs data on state disposable personal income for 2012 from the BEA. I calculate a county's share of the budget spent on land as follows:

(9) $$\textbf{County Land's Share of Budget} = \frac{\textbf{County's Average Rent} \times \textbf{Total Housing Units (for owneroccupied) of the State}}{\textbf{State Disposable Personal Income}}$$

Regarding national land's share of the consumer's budget, I calculate it as follows:

(10) $$\textbf{National Average of the Consumer's Budget for Land} = \frac{\sum(\textbf{Each County's Average Rent} \times \textbf{Total Units of the Each County})}{\sum(\textbf{Each State's Disposable Personal Income})}$$

The calculated values of the average land's share of the consumer's budget (k_l) is 0.10 for metro, 0.075 for non-metro, and 0.084 for the continental United States. Residents in metro counties spend a larger share of their budget for the consumption of the residential land.

4.2 Revisiting Roback's Spatial Equilibrium Model: A County-level Analysis with an Explicit Spatial Approach

Roback's (1982) spatial equilibrium model produces estimates of individuals' willingness to pay for quality differentials in non-market local amenities (e.g., climate), based on spatial variations in labor and land markets. The marginal value of non-market assets (i.e., local amenities) is measured with respect to numeraire tangible assets (i.e., land values and wages) and is interpreted as the consequences of individuals' choices of place of residence and place of work in equilibrium.

In this section, I report the results of an econometric analysis of land values, local wages, and local amenities in 3,109 counties (which excludes the states of Alaska and Hawaii). I use a slightly different definition for the dependent variable, expected average income, which is more closely related to place-specific characteristics. Using these data, I estimate a model similar to Roback's model for metropolitan counties. This study's results are compared with those of Roback's earlier analysis. I then expand the analysis to all counties in the continental Unites States and compare the results for metro and non-metro counties.

Although Roback's (1982) hedonic equilibrium model has been widely used by economists to estimate consumer's willingness to pay (WTP) for nonmarket local amenities (Smith, 1997), there is little or no research based on the Roback (1982) model that has explicitly modeled spatial interaction effects. As Tobler's first law of geography states, "everything is related to everything else, but near things are more related than distant things" (Tobler, 1970, p. 236; Drukker et al., 2013). Geographical interactions affect the model's predictions. Thus, I consider explicit spatial effects in a regression model and compare the results with Roback's (1982) standard spatial hedonic equilibrium model.

4.2.1 Models

The first goal in this study is to duplicate, as much as possible, Roback (1982) with more recent and larger datasets. After ordinary least squares (OLS)–based estimation, I conduct an explicit spatial analysis to test for spatial dependence. As Dubin (1998) points out, the locational importance increases the possibilities of spatial autocorrelation in regression error terms. Thus, the model in this study with the spatial data requires the following considerations: 1) a spatially lagged dependent variable, and 2) a spatially autocorrelated error term. The basic model in this study is a spatial-autoregressive model with spatial-autoregressive disturbances (SARAR), complemented by Drukker, Prucha, and Raciborski (2011a), which is an extension of the Cliff-Ord model (1973, 1981; as cited in Drukker et al., 2011a). The basic model is the Cliff-Ord type as follows:

(1) $\mathbf{y} = \lambda \mathbf{W}\mathbf{y} + \mathbf{X}\beta + \mathbf{u}$

(2) $\mathbf{u} = \rho \mathbf{M}\mathbf{u} + \boldsymbol{\epsilon}$

$\mathbf{y}$ denotes the $n \times 1$ vector of observations on the dependent variable, $\mathbf{W}\mathbf{y}$ is a spatial lag of $\mathbf{y}$, $\mathbf{X}$ denotes the $n \times k$ matrix of non-stochastic exogenous regressors, $\mathbf{u}$

denotes the $n \times 1$ vector of regression disturbances, $\mathbf{Mu}$ is known as a spatial lag of $\mathbf{u}$, $\boldsymbol{\epsilon}$ is an $n \times 1$ vector of the normally distributed independent error term, β is unknown parameters. λ and ρ are typically referred to as spatial autoregressive parameters. We use the spreg command in STATA to estimate the parameters of the cross-sectional spatial models (SAR [spatial autroregressive] and SEM).

4.2.1.1 Ordinary Least Squares

When $\rho = 0$ and $\lambda = 0$, the model reduces to a linear regression model with exogenous variables similar to Roback's (1982) hedonic equations of wages and land values, as follows:

(3) $\mathbf{y} = \mathbf{X}\beta + \boldsymbol{\epsilon}$

The analysis in this study has the following forms of county income and rent equations:

(3a) $\ln(w_i) = X_i\beta_w + \delta_w Z_i + \varepsilon_i$

(3b) $\ln(r_i) = X_i\beta_p + \delta_p Z_i + \varepsilon_i$

For the wage equation (3a), the county expected average income *w* in region *i* is projected on personal/household characteristics in county *i* X_i and exogenous site-specific characteristics Z_i. Regarding the rent equation (3b), the expected average rents r_i in county *i* is projected on housing characteristics in county *i* X_i and exogenous site-specific characteristics Z_i.

4.2.1.2 Spatial Lag Model

A spatial lag model is often an appropriate tool to account for spatial dependence, given that this method can capture neighborhood spillover effects in the form of a spatially lagged dependent variable (Anselin & Lozano-Gracia, 2008; C. W. Kim, Phipps, & Anselin, 2003).

Recall our basic Cliff-Ord type model as follows:

(1) $\mathbf{y} = \lambda \mathbf{W}\mathbf{y} + \mathbf{X}\beta + \mathbf{u}$

(2) $\mathbf{u} = \rho \mathbf{M}\mathbf{u} + \boldsymbol{\epsilon}.$

Setting $\rho = 0$ causes the model in equations (1) and (2) to be reduced to a spatial lag model known as the SAR model, which represents spatial dependence in the form of a spatially lagged dependent variable:

(4) $\mathbf{lny} = \lambda \mathbf{W}\mathbf{y} + \mathbf{X}\beta + \boldsymbol{\epsilon}$

(4a) $\ln(w_i) = \lambda \mathbf{W} \ln(w_i) + X_i\beta_w + \delta_w Z_i + \varepsilon_i$

(4b) $\ln(P_i) = \lambda \mathbf{W} \ln(p_i) + X_i\beta_p + \delta_p Z_i + \varepsilon_i$

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., 2011a). I employ the instrumental variables (IV) estimation method, using the spatially lagged variables as instruments. The SAR parameter lambda (λ) measures the extent of the interactions through the spatial lags (the weights w_{ij}). The spatially weighted sum of neighborhood rents/earnings is specified as an explanatory variable in the hedonic price function, and this specification is an appropriate way to capture neighborhood spillover effects (C. W. Kim et al., 2003, p. 30). Due to the endogeneity in the spatial lag term (**Wy**), we implement both a maximum likelihood (ML) estimator and a generalized spatial two-stage least-squares (GS2SLS) estimator to produce consistent estimates in addition to using an OLS model as a starting point (C. W. Kim et al., 2003).

4.2.1.3 Spatial Error Model

Setting $\lambda = 0$ reduces the basic Cliff-Ord type model to a spatial error model (SEM). In the SEM, each **u** depends on a weighted average of other observations in **u** (a spatially correlated error term), which allow for correlation among unobservables. The SEM can be written as follows:

(5) $\mathbf{y} = \mathbf{X}\beta + \mathbf{u}$

(6) $\mathbf{u} = \rho\mathbf{M}\mathbf{u} + \boldsymbol{\epsilon}$

The term $\boldsymbol{\epsilon}$ in the specification of equation (16) is assumed to be independent and identically distributed (IID) or independent but heteroskedastically distributed, where the heteroscedasticity is of an unknown form (see Drukker et al,, 2011a). The observation **y** (e.g., rents) at any location is influenced by the local characteristics (**X**) but also by the omitted variables at neighboring locations, which do not pertain to the explanatory variables (**X)** of the model (see C. W. Kim et al., 2003). An assumption of normality is required for ML estimation. According to Drukker et al. (2011a), the ML estimator does not produce consistent estimates in the heteroskedastic case, and they suggest “Lee, 2004, for some formal results for the ML estimator” and “Arraiz et al., 2010, for evidence that the ML estimator does not generally produce consistent estimates in the heteroskedastic case” (p. 223). To account for this possibility, I implement both ML for the case of normality and GS2SLS with the heteroskedastic option for the case of non-normality and consistency (see Drukker et al., 2011a; C.W. Kim et al., 2003).

4.2.2 Hypothesis

This section summarizes the empirical results of the earlier Roback's (1982) analysis and develops hypothesis for this study based on Roback's (1982) theoretical model.

Table 4.2.2.1 Roback's (1982) Equilibrium Model for 98 cities circa 1973: Wage Equation

Variable	Expected sign	Estimated coefficient	Statistical significance
Crime	+	+	Insignificant
Unemployment rate	+	+	Insignificant
Particulate level	+	+	Insignificant
Population	+	+	Significant
Population density	+	+	Insignificant
Population growth	+	+	Significant
Heating degree days	+	+	Significant
Total snowfall	+	+	Significant
Number of clear days	−	−	Significant
Number of cloudy days	+	+	Significant

Note. Roback (1982) did not run all climate variables in the same model. Roback (1982) ran four separate regressions each with a different climate amenity.

Table 4.2.2.1 shows Roback's (1982) regressions' results for the largest 98 cities in 1973. Four climate amenities have expected signs with statistical significance in the wage equation but the only other variables that were statistically significant were population and population growth.

Based on the spatial equilibrium framework of Roback, this study expects that the value of an amenity is positively related to housing/land values and negatively related to wages. But, the expected sign of coefficients in the wage equation can be ambiguous in terms of the supply and demand effects of employees and employers. Roback's (1982) spatial equilibrium model implies that the sign of marginal value of an amenity depends on the amenity's effects on firm's productivity or costs although Roback method cannot separate the value of amenities that employers and employees capitalize into wages at the equilibrium. For instance, if crime rates discouraged employers or increased their costs, they might require lower wages to locate in a high crime area, so wages might be negatively related to crime under these circumstances. In this case, the value should be reflected in the land values. If an amenity is valuable to both employers and employees, the employers will offer more and the employees will accept less. The effect of wages will be small and of indeterminate sign. Unemployment is another ambiguous variable. This study would expect that higher unemployment rates would be a disamenity to residents but an attractive feature to employers. So, unemployment could be positively related to wages (a disamenity to residents) or negatively related to wages (market effect). Regarding property values, high unemployment might depress land values because buyers cannot pay as much. Taken together, the variable unemployment might not be a good indicator of local amenities because it is temporary and endogenous.

Based on these supply and demand perspectives, this study hypothesizes that the wage coefficients can be either positive, negative, or insignificant on balance as in Table 4.2.2.2, because the supply and demand effects offset each other. The coefficients on rent should always be positive for amenities and negative for disamenities, And, they should include the combined value of the amenity to employers and employees which is not apparent in the wage rate. Thus, this study develops hypotheses about the combined impact on rent and wage, but often not for wages alone[12].

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[12] This is consistent with Roback (1982) on page 1262, “The reader can easily satisfy himself that if s were productive, the rents would rise while the change in wages would be ambiguous.”

Table 4.2.2.2 Expected Static Results for the Main Variables

Variable	Wage		Rent
	Residents	Employers	
County Total Crime	+	-	-
County Violent Crime	+	*	-
County Unemployment	+ (*)	- (*)	-
PM 2.5	+ (*)	- (*)	-
County Population	?	+	+
Population Density	+	+	*
Population Growth	- (*)	+ (*)	+
Heating Degree Days	+ (*)	-	-
Precipitation	- (*)	+ (*)	+
Wind Speed	+	*	-
Sunshine	-	*	+
County Poverty	+ (*)	- (*)	-
County GINI	+	(*)	*

Note. * means that it may be very weak or ambiguous.

4.2.2 Analysis

In this section, I report several sets of regression results. To approximate the Roback (1982) analysis, I first estimated models for metropolitan counties only. This is then followed with estimates for non-metropolitan and for all counties.

4.2.2.1 Base Model: Approximation of Roback's (1982) Model

In the base model, I used total crime and replaced total particulate level with PM 2.5, including the poverty indicator for the wage equation only. From several pre-testing, including poverty in the rents equation did not significantly improve the equation. Climate variables are heating degree days, precipitation, wind speed, and sunshine.

Table 4.2.2.1.1 Base Model: Approximation of Roback's Model

	Rent Equation Coefficient	Wage Equation Coefficient
County Total Crime	-0.23×10^{-4}*** (-4.42)	-0.17×10^{-4}*** (-4.38)
County Unemployment	-0.54×10^{-2} (-1.57)	0.40×10^{-3} (0.17)
PM 2.5	-0.11×10^{-1}*** (-4.98)	-0.94×10^{-3} (-0.68)
County Population	0.96×10^{-7}*** (6.74)	0.31×10^{-7}*** (3.45)
Population Density	0.48×10^{-5} (1.41)	0.93×10^{-6} (0.61)
Population Growth	0.17×10^{-1}*** (4.68)	-0.24×10^{-2} (-0.97)
Heating Degree Days	-0.63×10^{-6} (-0.12)	-0.60×10^{-6} (-0.17)
Precipitation	0.42×10^{-2}*** (6.67)	-0.10×10^{-2}** (-2.52)
Wind Speed	-0.32×10^{-2} (-0.48)	0.18×10^{-1} *** (4.51)
Sunshine	0.41×10^{-3} (0.31)	-0.27×10^{-2}*** (-3.2)
County Poverty		0.0005115
R^2	0.6511	0.6918
Adjusted R^2	0.6459	0.6861

Note. Regressions include all housing characteristics for rent equation and personal/household characteristics for wage equation. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Roback (1982) ran separate regressions for the four climate amenities (i.e., heating degree days, total snow days, number of clear days, and number of cloudy days). To avoid the risk of double-counting in measuring the marginal effects of the amenities, we include all amenities in the same model[13].

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[13] See Appendix 3 for the results of the pretests of four separate regressions.

Table 4.2.2.1.2 Implicit Prices Based on the Base Model

	Annualized Value		
Variable	Rent Equation	Wage Equation	Full Implicit Price
County Total Crime (total crimes/100,000 population)	−0.12	−0.86	0.74
County Unemployment (fraction unemployed)	−27.67	20.24	−47.91
PM 2.5 (µg/m3)	−55.44	−48.06	−7.38
County Population (10,000 persons)	4.9	15.76	−10.86
Population Density (100 persons/square mile)	2.47	4.78	−2.31
Population Growth (percentage change in population)	87.91	−120.58	208.49
Heating Degree Days (1°F colder for one day)	−0.0032	−0.031	0.03
Precipitation (inches)	21.66	−51.79	73.45
Wind Speed (mph)	−16.25	940.21	−956.46
Sunshine (% of possible)	2.11	−139	141.11
County Poverty (fraction poverty status)		26.18	−26.18

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 and evaluated at mean annual county income as follows: $P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w$. Average annual county income (w) = \$51,180.93, average land share in the consumer budget = 0.10.

In Table 4.2.2.1.2, the total crime variable produces a positive aggregate implicit value which, while unexpected since crime is a disamenity is probably due to the endogeneity discussed above. The Population density and Heating Degree Days variables are statistically insignificant. Population density (-) and population growth rate (+) have opposite signs compared with Roback.

Based on the pretest regressions in this study,[14] I drop violent crime for the wage equation and unemployment rate for both rents and wage equations, mainly due to endogeneity and statistical insignificance. Regarding crime variables, Roback (1982; used total crime) and Blomquist et al. (1988, used violent crime) have positive coefficients for both wage and rents equations. On the other hand, the pretesting in this study always produced negative coefficients for both wage and rents equations. For the wage equation, the violent crime variable was insignificant suggesting an offsetting depressing effect on wage offers by employers. Also, Cullen and Levitt (1999) provide a possible reason for the negative influences, suggesting the linkage between rising city crime rates and urban flight. Currently, in addition to this research, an article in *The New York Times* ("How to Predict Gentrification: Look for Falling Crime," January 5, 2017) states that lower crimes in cities induce people with higher incomes and more education into lower income areas, which might mean that these areas will see an increase in their average income compared with the past. Those two articles suggest that income and home/land values are negatively associated with violent crimes. However, this relationship might be very dynamic or temporary, which would require time-series data to understand.

This study adds an income inequality indicator (i.e., GINI index of income inequality from the census) in addition to a poverty indicator[15] (as in Roback, 1982) to

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[14] The intermediate regression run to select variables are reported in Appendix 3. Approximation of Roback's (1982) model and several versions with different sets of climate amenities are reported in this appendix in addition to pretest regressions for variables' selection.

[15] The correlation between GINI index and poverty was 0.11 (11%) for the continental United States, 0.14 (14%) for metro, and 0.10 (10%) for non-metro.

allow for the possibility that unequal distribution of income has an effect on property values distinct from that of poverty. However, poverty was never statistically significant so I dropped it. For population growth rates (Population Growth), I replaced Roback's 10-year percentage change in population with a two-year percentage change in population from 2010 to 2012.

To compute the implicit prices of amenities in percentage terms, we employ the following equation as in Roback (1982, p. 1263) for the estimation of a semi-log specification:

(7) $\frac{P_s^*}{w} = k_l \frac{d \log r}{ds} - \frac{d\log w}{ds}$

→ $P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w$,

where k_l is the share of land in the consumer's budget, P_s^* is "the amount of income required to compensate for a small change in *s*" (Roback, 1982, p. 1263), and w is the county's average annual expected income. The calculated values of the average land's share of the consumer's budget (k_l) is 0.10 for metro, 0.075 for non-metro, and 0.084 for the continental United States. Average annual expected income (w) is \$51,180.93 for metro, \$43,993.65 for non-metro, and \$46,677.61 for all 3,109 counties.

For comparison purposes with Roback (1982), annualized values of County Population, and Population Density are multiplied by 10,000 (10,000 persons), and 100 (100 persons/square mile), respectively.

4.2.2.2 Approach 1: Models for Metro Counties

4.2.2.2.1 Climate Amenities Set 1: Heating Degree Days, Precipitation, Wind Speed, and Sunshine

I divide metro and non-metro counties into separate models to facilitate a closer comparison to Roback's city model and to identify possible differences between metro and non-metro counties.

Table 4.2.2.2.1.1 Rent and Wage Equations' Results: Metro versus Non-metro

Variable	Rent Equation Metro	Rent Equation Non-metro	Wage Equation Metro	Wage Equation Non-metro
County Violent Crime	-0.25×10^{-3}***	-0.14×10^{-4}		
	(-7.49)	(-0.41)		
PM 2.5	-0.10×10^{-1}***	-0.35×10^{-2}*	-0.87×10^{-2}	-0.21×10^{-2}
	(-4.93)	(-1.93)	(-0.63)	(-1.40)
County Population	0.87×10^{-7}***	0.20×10^{-5}***	0.28×10^{-7}***	0.57×10^{-6}**
	(6.19)	(6.58)	(3.12)	(2.27)
Population Density	0.61×10^{-5}*	0.15×10^{-3}**	0.13×10^{-5}	0.17×10^{-4}
	(1.81)	(2.36)	(0.83)	(0.34)
Population Growth	0.17×10^{-1}***	0.52×10^{-2}**	-0.55×10^{-4}	0.10×10^{-1}***
	(4.85)	(1.97)	(-0.02)	(4.96)
Heating Degree Days	0.46×10^{-5}	0.40×10^{-4}***	0.41×10^{-5}	0.23×10^{-4}***
	(0.87)	(8.14)	(1.14)	(6.44)
Precipitation	0.38×10^{-2}***	0.33×10^{-2}***	-0.12×10^{-2}***	-0.14×10^{-2}***
	(6.12)	(5.47)	(-3.01)	(-2.87)
Wind Speed	0.20×10^{-2}	-0.74×10^{-2}	0.18×10^{-1}***	0.20×10^{-1}***
	(0.32)	(-1.54)	(4.68)	(5.36)
Sunshine	0.13×10^{-2}	0.48×10^{-2}***	-0.29×10^{-2}***	0.15×10^{-2}
	(1.00)	(3.45)	(-1.00)	(1.39)
County GINI	0.13×10***	-0.69***	0.75	0.62×10^{-1}
	(6.49)	(-3.96)	(4.93)	(0.42)
R^2	0.6656	0.5132	0.6929	0.3976
Adjusted R^2	0.6606	0.5090	0.6878	0.3917

Note. Regressions include all control variables for housing characteristics and personal characteristics. See Appendix 3 for full statistics for all variables. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. t-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

In Table 4.2.2.2.1.1, all variables produce the expected signs for full implicit prices. PM2.5 was statistically significant and negative in the metro rent equation as expected. Sunshine was negative in the metro wage equation, and positive in the non-metro rent equations as expected. Population Growth is positive in both non-metro and in the metro rent equations. This led to opposite signs on the implicit value of growth in metro and non-metro counties. This latter result may be due to the offsetting effects on residents/workers and employers. For instance, if population growth's positive effects on employers are smaller in metro counties than in non-metro counties, negative effects on residents are larger in non-metro counties than in metro counties, or the compensating wage effect outweighs the effect on the property values in non-metro counties, we could see these different effects between metro and non-metro.

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 rents levels. The full implicit prices of County GINI in both metro and non-metro areas have negative numbers, which suggests the disamenity affect prevails. The marginal effect of the County GINI is much larger in metro areas.

In Table 4.2.2.2.1.2, the full implicit value of County Violent Crime is −\$1.26 (violent crime/100,000 population), which is similar to BBH's value of −\$1.03. Roback's (1982) values of total crime produced mixed positive (\$ 0.90) and negative values (−\$9.25, −\$8.05, and −\$9.15) for four regressions with a different climate amenities. The total crime's influence was not always statistically significant in Roback's (1982) results, indicating that in some cases the positive compensating wage effect of crime was large enough to outweigh its effect on rent values.

Table 4.2.2.2.1.2 Implicit prices based on Model Rent and Wage Equations for Metro Counties

Variable	Annualized value Model Rent	Model Wage	Full Implicit Price
County Violent Crime (violent crimes/100,000 population)	−1.26		−1.26
PM 2.5 (μg/m^3)	−53.23	−44.55	−8.68
County Population (10,000 persons)	4.44	14.24	−9.80
Population Density (100 persons/square mile)	3.12	6.40	−3.28
Population Growth (percentage change in population)	85.80	−2.79	88.59
Heating Degree Days (1°F colder for one day)	0.024	0.21	−0.19
Precipitation (inches)	19.52	−61.76	81.28
Wind Speed (mph)	10.01	944.50	−934.49
Sunshine (% of possible)	6.66	−145.94	152.60
County GINI (index)	6,905.62	38,626.61	−31,720.99

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.10 for metro counties. Average annual expected income (w) is \$51,180.93 for metro counties.

The implicit values for County GINI is very high but it is important to remember that this variable has potential values between 0 (perfect equality) and 1.0 (perfect inequality). Since most of our observations are between 0.35 and 0.55 the actual differences between communities is only a fraction of this value. Thus, the value of a 1% change in the GINI coefficient would be between $69 and $386.

All climate amenities have the expected signs. Heating degree days is similar to values in Roback (−$0.20) and BBH (−$0.08). To evaluate the expenditure on heating degree days at the mean value and the marginal price, we need the average number of heating degree days in the sample, which is 4,489.35 for metro counties. And thus, the total implicit price is $852.98 (−0.19×4,489.35).

Table 4.2.2.2.1.3 Implicit prices based on Model Rent and Wage Equations for Non-Metro Counties

Variable	Annualized value Model Rent	Model Wage	Full Implicit Price
County Violent Crime (violent crimes/100,000 population)	−0.047		−0.047
PM 2.5 ($\mu g/m^3$)	−11.65	−90.47	78.82
County Population (10,000 persons)	65.53	248.7	−183.17
Population Density (100 persons/square mile)	49.05	73.07	−24.02
Population Growth (percentage change in population)	17.25	458.49	−441.24
Heating Degree Days (1°F colder for one day)	0.13	1.03	−0.9
Precipitation (inches)	11.01	−60.22	71.23
Wind Speed (mph)	−24.54	864.27	−888.81
Sunshine (% of possible)	15.81	67.94	−52.13
County GINI (index)	−2,271.59	2,705.91	−4,977.5

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

The values of other climate amenities are larger than reported by BBH. The implicit prices of county population variable has the expected sign for both metro and non-metro counties. The estimated coefficients in both rent and wage equations in both metro and non-metro counties have very low standard errors and high statistical significance. The average person would be willing to pay $9.80 in metro counties (Table 4.2.2.2.1.2) to avoid additional 10,000 persons in the county whereas non-metro residents would be willing to pay $183.17 (Table 4.2.2.2.1.3).

In Table 4.2.2.2.1.4, on the basis of the wage equation, we tested the hypothesis that "the observed earnings differentials are in fact proxies for different amenity levels" (Roback, 1982, p. 1271). In the table, regional dummies for both metro and non-metro counties play a reduced role in explaining expected average income when differences in amenities are taken into account in the second and fourth columns. These results are consistent with Roback (1982). The only exception is the effect of the southern region for metro counties. Although the regional dummies play a reduced role when differences in observed amenities are taken into account, there are still significant earnings differences across regions in this case. As Roback (1982) argued, the region dummies may be "a proxy for some unmeasured desirable climatic or cultural attributes" (p. 1272).

Table 4.2.2.2.1.4 Region Dummies for Wage Equation: Metro versus Non-metro

Variable	Wage Equation Metro	Wage Equation Metro	Wage Equation Non-metro	Wage Equation Non-metro
Northeast	0.078***	0.054***	0.039**	0.033
	(5.32)	(3.5)	(1.75)	(1.33)
South	−0.063***	-0.054***	−0.15***	-0.080***
	(−5.81)	(-3.84)	(−12.65)	(-4.91)
West	−0.0045	0.055***	−0.087 ***	-0.081***
	(−0.30)	(2.81)	(−5.63)	(-4.47)
PM 2.5		0.16×10^{-2}		-0.16×10^{-2}
		(1.14)		(−1.06)
County Population		0.85×10^{-8}		0.44×10^{-6}*
		(0.94)		(1.67)
Population Density		-0.14×10^{-6}		0.33×10^{-4}
		(−0.09)		(0.67)
Population Growth		0.27×10^{-2}		0.12×10^{-1}***
		(1.14)		(5.51)
Heating Degree Days		-0.92×10^{-5}**		0.17×10^{-4}***
		(−2.24)		(3.66)
Precipitation		-0.13×10^{-2}***		-0.11×10^{-2}**
		(−3.31)		(−2.18)
Wind Speed		0.22×10^{-1}***		0.12×10^{-1}***
		(4.51)		(2.83)
Sunshine		-0.41×10^{-2}***		0.33×10^{-2}***
		(−4.41)		(2.62)
County GINI		0.85***		0.18
		(5.7)		(1.22)
R^2	0.6911	0.7096	0.3781	0.4099
Adjusted R^2	0.6876	0.7040	0.3739	0.4032

Note. Regressions include all control variables for personal/households characteristics. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

On the basis of the wage equation in the continental United States, I ran separate models for each of the regions to measure the degree to which residents of the regions values the various amenities (Table 4.2.2.2.1.5). There are 217 counties for Northeast, 1,423 counties for South, 414 counties for West, and 1,055 counties for Midwest in the continental United States.

For all regions, high wages are associated with high population growth rates with statistical significance. In terms of magnitude of the effects, the population growth rates in western counties have largest and positive effects on wages. Heating degree days in northeastern and western counties have negative coefficients whereas positive coefficients in southern and midwestern counties. That indicates that average residents in northeastern and western counties value the heating degree days as amenity whereas as disamenity in southern and midwestern counties. Sunshine has negative effects in northeastern, southern, and western counties but has positive effects in midwestern counties.

Table 4.2.2.2.1.5 Region Differences for Wage Equation

	Northeast	South	West	Midwest
PM25	0.44×10^{-2} (1.22)	0.30×10^{-3} (0.18)	-0.22×10^{-2} (-0.72)	0.26×10^{-2} (1.12)
County Population	-0.71×10^{-8} (−0.19)	-0.46×10^{-9} (−0.02)	-0.16×10^{-8} (−0.09)	-0.26×10^{-7} (0.59)
Population Density	-0.27×10^{-5} (−1.36)	0.12×10^{-4} (1.39)	0.16×10^{-4} (1.44)	0.27×10^{-6} (0.01)
Population Growth	$0.18 \times 10^{-1*}$ (1.88)	$0.13 \times 10^{-1***}$ (5.71)	$0.19 \times 10^{-1***}$ (3.99)	$0.91 \times 10^{-2***}$ (3.13)
Heating Degree Days	$-0.63 \times 10^{-4}\ ^{***}$ (−3.93)	0.11×10^{-4} (1.94)	$-0.33 \times 10^{-4***}$ (-3.56)	$0.24 \times 10^{-4***}$ (3.25)
Precipitation	-0.50×10^{-3} (−0.35)	-0.18×10^{-3} (−0.29)	-0.74×10^{-3} (−1.23)	$-0.38 \times 10^{-2***}$ (−2.86)
Wind Speed	0.55×10^{-2} (1.49)	$0.51 \times 10^{-1***}$ (7.74)	0.14×10^{-1} (1.15)	-0.19×10^{-1} (−1.54)
Sunshine	-0.47×10^{-2} (−1.13)	$-0.55 \times 10^{-2***}$ (−3.43)	$-0.25 \times 10^{-2*}$ (−1.73)	$0.74 \times 10^{-2***}$ (2.92)
County GINI	$0.10 \times 10^{1***}$ (2.65)	0.29^{**} (2.02)	-0.47 (−1.31)	0.35 (1.63)
R^2	0.8356	0.5653	0.4827	0.4693
Adjusted R^2	0.8198	0.5594	0.4578	0.4596

Note. Regressions include all control variables for personal/households characteristics. Number of observations is 217 counties for Northeast, 1,423 counties for South, 414 counties for West, and 1,055 counties for Midwest. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.1.6 Differences for Rent Equation

	Northeast	South	West	Midwest
County Violent Crime	-0.35×10^{-3}***	-0.50×10^{-4}	-0.25×10^{-3}***	0.84×10^{-5}
	(−2.79)	(−1.57)	(−2.99)	(0.23)
PM25	-0.71×10^{-2}	-0.62×10^{-2}***	-0.48×10^{-2}	0.56×10^{-2}**
	(−1.21)	(−2.60)	(−1.19)	(2.4)
County Population	0.20×10^{-6}***	0.14×10^{-7}	0.45×10^{-7}*	0.64×10^{-7}
	(3.22)	(0.42)	(1.91)	(1.43)
Population Density	-0.17×10^{-5}	-0.49×10^{-4}***	-0.22×10^{-4}	0.38×10^{-4}
	(−0.26)	(3.61)	(−1.21)	(1.38)
Population Growth	0.36×10^{-1}**	0.15×10^{-1}***	0.87×10^{-2}	0.10×10^{-1}***
	(2.26)	(5.13)	(1.42)	(3.5)
Heating Degree Days	-0.74×10^{-4}***	-0.13×10^{-4}	0.58×10^{-4}***	0.13×10^{-4}
	(−2.93)	(−1.58)	(4.78)	(1.6)
Precipitation	0.69×10^{-2}***	0.32×10^{-2}***	0.35×10^{-2}***	0.26×10^{-2}*
	(2.82)	(3.71)	(4.37)	(1.95)
Wind Speed	0.27×10^{-1}***	0.22×10^{-1}**	-0.84×10^{-1}***	-0.20×10^{-1}
	(4.33)	(2.18)	(−5.32)	(1.56)
Sunshine	0.27×10^{-1}***	-0.51×10^{-2}**	0.44×10^{-2}**	-0.12×10^{-1}***
	(3.85)	(−2.32)	(2.02)	(−4.79)
County GINI	0.33×10^{1}***	−0.20	0.31	−0.49**
	(5.53)	(−1.01)	(0.73)	(−2.47)
R^2	0.8560	0.6356	0.6304	0.6629
Adjusted R^2	0.8437	0.6312	0.6146	0.6574

Note. Regressions include all control variables for housing characteristics. Number of observations is 217 counties for Northeast, 1,423 counties for South, 414 counties for West, and 1,055 counties for Midwest. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Regarding the magnitude of the effects in the rent equation (Table 4.2.2.2.1.6), County GINI has stronger positive effects with statistical significance in northeastern counties, implying that the more unequal income distribution contributes more to land value. On the other hand, the GINI has negative effects with statistical significance in midwestern counties, which imply that people residents in Midwest regions prefer places with more equal distribution of income.

4.2.2.2.1.1 Estimating Standard Errors of the Implicit Prices

In this section, I estimate the standard errors of the implicit prices that this study estimated in section 4.2.2.2.1. The estimated rent and wage equations are considered a system and the implicit prices are a linear combination of the coefficients from the wage and rent equations. First, this study employs the *suest* command in STATA to get simultaneous results for models X (rent equation) and Y (wage equation). Then, this study employs the *lincom* command to get linear combinations of parameters. The *lincom* command allows us to get the standard errors of the implicit prices, using the formula of the implicit price of an amenity, $P = (k_l \frac{dr}{ds} - \frac{dw}{ds})w$, where w is the county's average annual expected income, and k_l is the share of land in the consumer's budget. The average county income is \$51,180.93 for metro, and \$43,993.65 for non-metro counties. The calculated values of the average land's share of the consumer's budget (k_l) is 0.10 for metro, and 0.075 for non-metro counties. The *lincom* command computes the variance of the implicit price using the cross equation variances and covariances of the estimated parameters. Then, the *lincom* command computes the square root, which is the standard error, in the output, storing variance-covariance matrix in e(V).

The following table presents robust standard errors for the simultaneous results for metro and non-metro counties.

Table 4.2.2.2.1.1.1 Robust Standard Error for the Simultaneous Results: Metro versus Non-metro Counties

a. 1,161 Metro Counties

Simultaneous Results for X, Y Number of Obs. = 1,161 X	Robust Std. Err.	Y	Robust Std. Err.
County Violent Crime	0.0000406***		
PM 2.5	0.0018965***	PM 2.5	0.0016357
County Population	1.53×10^{-8}***	County Population	7.46×10^{-9}***
Population Density	5.05×10^{-6}	Population Density	2.02×10^{-6}
Population Growth	0.0040057***	Population Growth	0.0030513
Heating Degree Days	5.65×10^{-6}	Heating Degree Days	4.60×10^{-6}
Precipitation	0.0005971***	Precipitation	0.0004965**
Wind Speed	0.0075222	Wind Speed	0.0048433***
Sunshine	0.001387	Sunshine	0.0012926
County GINI	0.2763084***	County GINI	0.201212***

Note. Regressions include all control variables for housing characteristics and personal characteristics. X and Y refer to rent equation and wage equation, respectively. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

b. 1,948 Non-metro Counties

Simultaneous Results for X, Y Number of Obs. = 1,948 X	Robust Std. Err.	Y	Robust Std. Err.
County Violent Crime	0.0000334		
PM 2.5	0.0019096*	PM 2.5	0.0015149
County Population	3.20×10^{-7}***	County Population	2.15×10^{-7}***
Population Density	0.0000667**	Population Density	0.000046
Population Growth	0.0035397	Population Growth	0.0029625***
Heating Degree Days	6.86×10^{-6}***	Heating Degree Days	4.18×10^{-6}***
Precipitation	0.0007078***	Precipitation	0.0004906***
Wind Speed	0.0053889	Wind Speed	0.0055541***
Sunshine	0.0017194***	Sunshine	0.0011859

County GINI	0.2268619***	County GINI	0.1794612

Note. Regressions include all control variables for housing characteristics and personal characteristics. X and Y refer to rent equation and wage equation, respectively. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.2.1.1.2 Implicit Prices, Estimated Standard Error, and Statistical Significance for the Full Implicit Price of an Amenity

	Metro		Non-metro	
Annualized Value (dollar)	Full Implicit Price	Estimated SE	Full Implicit Price	Estimated SE
County Violent Crime (violent crimes/100,000 population)	−1.26	0.21***	−0.05	0.11
PM 2.5 (µg/m^3)	−8.68	83.38	78.82	66.89
County Population (10,000 persons)	−9.80	3.84***	−183.17	93.12**
Population Density (100 persons/square mile)	−3.28	11.84	−24.02	193.44
Population Growth (percentage change in population)	88.59	155.93	−441.24	134.66***
Heating Degree Days (1°F colder for one day)	−0.19	0.24	−0.9	0.19***
Precipitation (inches)	81.28	25.31***	71.23	21.71***
Wind Speed (mph)	−934.49	245.35***	−888.81	253.32***
Sunshine (% of possible)	152.60	65.10**	−52.13	52.22
County GINI (index)	−31,720.99	10044.73***	−4,977.5	7979.45

Note. Measurement units of amenities shown under variable name. ***Significant at 1%, ** significant at 5%, and * significant at 10%. The estimated standard errors for the full implicit prices are based on Tables 4.2.2.2.1.2 and 4.2.2.2.1.3. To estimate variance of the implicit prices, this study follows the formula, $P_s^* = (k_l \frac{d\log r}{ds} - \frac{d\log w}{ds})w$, and computes V ($P_s^*$) $= \text{V}(k_l wX - w\text{Y}) = (k_l w)^2\text{V(X)} + (w)^2\text{V(Y)} - 2(k_l w)Cov$ (X, Y), where k_l is the share of land in the consumer's budget, w is the average county income, X is the rent equation and Y is the wage equation. The average county income w is \$51,180.93, and \$43,993.65, for metro and non-metro, respectively. For comparison purposes with Roback (1982), annualized full implicit values of

County Population, and Population Density are multiplied by 10,000 (10,000 persons), and 100 (100 persons/square mile), respectively, and reflected in estimating the standard error.

Table 4.2.2.2.1.1.2 summarizes the implicit prices, estimated standard errors, and statistical significances for each amenity for both metro and non-metro counties. For metro counties, the estimated standard errors of county violent crime, population size, precipitation, wind speed, sunshine, and county GINI are statistically significant. For the implicit price of county violent crime, the estimated standard error is 0.21 and thus the full implicit price will be $\$-1.26 \pm 0.21$.

4.2.2.2.2 Climate Amenities Set 2: Extreme Temp and Sunshine

In this section, I employ another set of climate amenities, mean annual extreme temperature days and sunshine (% of possible). Based on Roback, rent values are positively associated with sunshine (amenity) whereas negatively associated with extreme temperature (disamenity). The full implicit values of sunshine and extreme temperature are supposed to be positive and negative, respectively.

Table 4.2.2.2.2.1 Metro Results

Variable	Rent Equation Coefficient	Wage Equation Coefficient
County Violent Crime	-0.25×10^{-3}***	
	(-7.65)	
PM 2.5	-0.11×10^{-1}***	-0.34×10^{-2}**
	(-5.63)	(-2.54)
County Population	0.74×10^{-7}***	0.32×10^{-7}***
	(5.25)	(3.5)
Population Density	0.43×10^{-5}	0.20×10^{-5}
	(1.28)	(1.3)
Population Growth	0.14×10^{-1}***	-0.19×10^{-2}
	(3.98)	(-0.8)
Extreme Temp	-0.36×10^{-4}***	0.13×10^{-4}***

	(−5.44)	(3.23)
Sunshine	-0.31×10^{-2}***	-0.22×10^{-2}***
	(−2.65)	(−2.87)
County GINI	0.13×10^{1}***	0.64***
	(6.11)	(4.15)
R^2	0.6626	0.6797
Adjusted R^2	0.6582	0.6749

Note. Regressions include housing characteristics for rent equation and personal/household characteristics for wage equation. Number of observations is 1,161 metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

In Table 4.2.2.2.2.1, the results for the rent equation have all expected signs except sunshine. However, the combined value from the rent and wage equations has expected positive (Table 4.2.2.2.2.2), which suggest it is an amenity.

Table 4.2.2.2.2.2 Implicit Prices: Metro

Variable	Annualized Value Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 pop.)	−1.29	0	−1.29
PM 2.5 (µg/m^3)	−58.49	−176.46	117.97
County Population (10,000 persons)	3.77	16.2	−12.43
Population Density (100 persons/square mile)	2.22	10.21	−7.99
Population Growth (% change in pop.)	69.68	−99.69	169.37
Extreme Temp (1°F change for one day)	−0.19	0.68	−0.87
Sunshine (% of possible)	−15.92	−113.17	97.25
County GINI (index)	6,484.06	32,650.81	−26,166.75

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.10 for metro counties. Average annual expected income (w) is \$51,180.93 for metro counties.

Based on Roback's framework, all variables have expected signs for full implicit prices. The implicit prices of Extreme Temp is small per degree day, but the average number of degree days in a year is 5,868.18 in metro counties and thus total implicit price is \$5,105.32 (−0.87 × 5,868.18) at the mean value and the marginal price. The average residents in metro counties will be willing to pay \$5,105.32 to have temperatures at 65 degrees, and they will be willing to pay \$97.25 for a 1% increase in sunshine.

The full implicit prices of PM25 (and PM10[16] from the pretesting regressions) have positive signs.

Table 4.2.2.2.2.3 Non-metro Results

Variable	Rent Equation Coefficient	Wage Equation Coefficient
County Violent Crime	-0.24×10^{-4}	
	(-0.68)	
PM 2.5	-0.29×10^{-2}	-0.36×10^{-2}**
	(-1.61)	(-2.51)
County Population	0.21×10^{-5}***	0.59×10^{-6}**
	(6.89)	(2.33)
Population Density	0.14×10^{-3}**	0.37×10^{-4}
	(2.13)	(0.73)
Population Growth	0.30×10^{-2}	0.99×10^{-2}***
	(1.13)	(4.7)
Extreme Temp	0.24×10^{-4}***	0.49×10^{-4}***
	(3.52)	(11.19)
Sunshine	-0.48×10^{-3}	0.28×10^{-2}***
	(-0.39)	(2.84)
County GINI	-0.74***	-0.79×10^{-3}
	(-4.22)	(-0.01)
R^2	0.4972	0.3877

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[16] Pretesting regressions' results are in Appendix 2.

Adjusted R^2	0.4933	0.3823

Note. Regressions include all control variables. Number of observations is 1,948 non-metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.2.2.4 Implicit Prices: Non-metro

Variable	Annualized value Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 pop.)	−0.08	0	−0.08
PM 2.5 (µg/m^3)	−9.58	−160.3	150.72
County Population (10,000 persons)	69.72	257.98	−188.26
Population Density (100 persons/square mile)	45.08	161.15	−116.07
Population Growth (% change in pop.)	9.99	437.65	−427.66
Extreme Temp (1°F change for one day)	0.078	2.15	−2.072
Sunshine (% of possible)	−1.57	122.75	−124.32
County GINI (index)	−2,439	−34.61	−2,404.39

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is \$43,993.65 for non-metro counties.

The full implicit prices of violent crime and GINI are lower in non-metro counties than in metro counties. The full implicit price of extreme temperature is higher in non-metro than in metro. For sunshine, the full implicit value has opposite sign compared with metro because the positive wage effect outweighs the negative impact on the property value in non-metro.

4.2.2.2.3 Climate Amenities Set 3: Natural Amenities Scale

Table 4.2.2.2.3.1 Metro Results

Variable	Rent Equation Coefficient	Wage Equation Coefficient
County Violent Crime	-0.24×10^{-3}***	
	(-7.4)	
PM 2.5	-0.84×10^{-2}***	-0.40×10^{-2}***
	(-4.27)	(-2.99)
County Population	0.77×10^{-7}***	0.27×10^{-7}***
	(5.48)	(3.01)
Population Density	0.87×10^{-5}**	0.28×10^{-5}*
	(2.52)	(1.81)
Population Growth	0.17×10^{-1}***	-0.36×10^{-2}
	(5.13)	(-1.51)
Natural Amenities Scale	0.16×10^{-1}**	-0.64×10^{-2}
	(2.51)	(-1.48)
County GINI	0.15×10^{1}***	0.46***
	(7.64)	(3.07)
R^2	0.6553	0.6730
Adjusted R^2	0.6511	0.6684

Note. Regressions include all control variables. Number of observations is 1,161 metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.2.3.2 Implicit Prices: Metro

Variable	Annualized Value Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 pop.)	−1.23	0	−1.23
PM 2.5 (μg/m^3)	−42.84	−202.22	159.38
County Population (10,000 persons)	3.96	13.97	−10.01
Population Density (100 persons/square mile)	4.44	14.33	−9.89
Population Growth (% change in pop.)	89.19	−185.25	274.44
Natural Amenities Scale (score)	80.77	−326.33	407.1
County GINI	7,928.73	23,429.7	−15,500.97

(index)

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.10 for metro counties. Average annual expected income (w) is $51,180.93 for metro counties.

The natural amenities scale awards higher scores to counties with higher amenities, and thus the full implicit price has the expected positive value. The average person in metro counties will be willing to pay $407.10 to accept increase of 1% of one unit score of natural amenities scale. The full implicit prices of PM25 and PM10 have positive signs.

Table 4.2.2.2.3.3 Non-metro Results

Variable	Rent Equation Coefficient	Wage Equation Coefficient
County Violent Crime	-0.11×10^{-4} (-0.32)	
PM 2.5	-0.41×10^{-2}** (-2.41)	-0.67×10^{-2}** (-4.8)
County Population	0.21×10^{-5}*** (7.07)	0.52×10^{-6}** (2.07)
Population Density	0.94×10^{-4} (1.52)	-0.43×10^{-5} (-0.09)
Population Growth	0.42×10^{-2} (1.59)	0.13×10^{-1}*** (6.04)
Natural Amenities Scale	0.45×10^{-1}*** (7.62)	-0.44×10^{-1}*** (-9.1)
County GINI	-0.81*** (-4.75)	-0.37*** (-2.59)
R^2	0.5074	0.3736
Adjusted R^2	0.5039	0.3685

Note. Regressions include all housing characteristics for rent equation and personal/households characteristics for wage equation. Number of observations is 1,948 non-metropolitan counties. *t*-statistics are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

All variables have expected signs for the rent equation in the non-metro counties (Table 4.2.2.2.3.3). For County GINI, the negative effect on land values suggests that unequal distribution of income is a disamenity in non-metro counties.

Table 4.2.2.2.3.4 Implicit Prices: Non-metro

Variable	Annualized Value Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 pop.)	−0.04		−0.04
PM 2.5 (µg/m^3)	−13.43	−296.9	283.47
County Population (10,000 persons)	68.6	228.77	−160.17
Population Density (100 persons/square mile)	31.04	−18.83	49.87
Population Growth (% change in pop.)	13.85	564.02	−550.17
Natural Amenities Scale (score)	149.15	−1,952.19	2,101.34
County GINI (index)	−2,667.89	−16,447.61	13,779.72

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is \$43,993.65 for non-metro counties.

The Natural Amenities Scale has higher full implicit value in non-metro than in metro counties. This suggests that the natural amenities, weighted as they are in the Natural Amenities Scale, are more valuable for residents in non-metro counties than those of metro counties.

On the basis of three different sets of climate amenities and pretest regressions, most of the PM 2.5 and PM 10 had negative influence for both rents and wage equations.

Their statistical significances were mixed especially for the wage equation. On the basis of the EPA Air Quality Index (AQI), the values of the poor category range from 91 to 120 μg/m^3 for PM2.5 and of 251 to 350 for PM10 (http://www.airveda.com/understanding_data.html). The data based on metro counties in this study have maximum values of 23.90 for PM2.5 and 63.80 for PM 10. No observation exceeds the poor category. Thus, the estimates coefficients for PM 2.5 and PM 10, may simply indicate that air pollution is not a relevant disamenity in most communities.

4.2.2.2.4 Climate Amenities Set 1 without PM 2.5 (see Appendix 3)

For non-metro counties, the full implicit price of population growth rate has negative value and sunshine's influence is insignificantly different from zero for the wage equation.

4.2.2.3 Approach 2: Models for the Continental United States: Non-spatial versus Spatial

I next estimate equations for the entire continental United States employing spatial econometrics. Because these models require spatial weights matrices to estimate the influence of neighboring counties, dividing metro and non-metro counties into separate models is not possible. However, this study effectively accomplishes separate regressions for metro and non-metro by including interactions between a metro dummy and each explanatory variable in the pooled regression. Using this approach, the coefficients that are not interacted with a metro dummy would represent the coefficients for non-metro counties, and the interaction coefficients would represent the difference in the coefficient between metro and non-metro counties. This study therefore reports spatial regression results based on the combined dataset of the continental United States.

I performed a Wald test on the estimated SAR coefficient (lambda)[17], and SAR models were statistically insignificant for both wage and rents equations, indicating the SAR model is not preferable to an OLS model. The estimated SEM coefficient, however, (rho) is positive and statistically significant, indicating spatial dependence in the error term. In other words, an exogenous shock to one county will lead to changes in the dependent variable (*w* and *r*) in the neighboring counties.

Recall equations (5) and (6) for SEM models,

(5) $\mathbf{y} = \mathbf{X}\beta + \mathbf{u}$

(6) $\mathbf{u} = \rho\mathbf{Mu} + \boldsymbol{\epsilon}$

As seen in equation (6), spatial dependence is present in the error term ($\mathbf{u}$) and $\boldsymbol{\epsilon}$ is assumed to be a vector of IID errors. As mentioned in the section on SEM, $\boldsymbol{\epsilon}$ are assumed to be IID or independent but heteroskedastically distributed (Drukker et al., 2011a; C. W. Kim et al., 2003). This study reports results for heteroskedasticity. The maximum likelihood (ML) estimator generally does not produce consistent estimates in the heteroskedastic case, but the generalized spatial two-stage least-squares (GS2SLS) estimator with specification of the heteroskedastic option produces consistent estimates in either case where the heteroskedasticity is an unknown form (Drukker et al., 2011a). This study, thus, implements OLS, and SEM with and without the assumption of normality to

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[17] The values of the estimated lambda are -0.0001 and 0.001 for the wage equation, and -0.0033 and -0.0016 for the rent equation with statistical insignificance in SAR ML and SAR GS2SLS models respectively.

compare estimates between them. But I focus on comparing estimated parameters between OLS and the GS2SLS estimator with specification of the heteroskedastic option.

First, I report estimated coefficients for all 3,109 counties in the continental United States (Table 4.2.2.3.2). Then, we include a metro dummy variable (Table 4.2.2.3.3). In the last step, we include cross products of the metro dummy with each of variables to test for differences in the marginal effects of the variables (Table 4.2.2.3.4). In all three tables below, the spatial autocorrelation coefficient estimates for spatial error models (rho) are positive and statistically significant, indicating the presence of spatial autocorrelation in the regression relationship.

Table 4.2.2.3.1 Testing for Heteroskedasticity in the Error Distribution

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Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity
H_0: Constant variance
Variables: fitted values for Log County Income

chi2(1) = **17.60**
Prob > chi2 = **0.0000**

Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity
H_0: Constant variance
Variables: PM 2.5, County Population, Population Density, Population Growth, Heating Degree Days, Precipitation, Wind Speed, Sunshine, County GINI, White, Private Employee, Occupation MBSA, Occupation Sales Office, Occupation NCM, Occupation PTM, Married, Veteran, Mean Hour, High School Labor Force

chi2(19) = **317.53**
Prob > chi2 = **0.0000**

White's general test statistic: **981.5933** Chi-sq(209) P-value = **3.e-100**

First, Table 4.2.2.3.1 reports the results of the tests for heteroscedasticity, which indicate that there is a significant degree of heteroscedasticity in the model.

Table 4.2.2.3.2 Models for Wage Equation for the Continental United States

Variable	Wage OLS	Wage SEM ML	Wage SEM GS2SLS
PM 2.5	-0.15×10^{-2}	-0.24×10^{-2}*	-0.18×10^{-2}
	(0.0011)	(0.0014)	(0.0016)
County Population	0.31×10^{-7}***	0.18×10^{-7}*	0.19×10^{-7}***
	(1.13×10^{-8})	(1.06×10^{-8})	(7.27×10^{-9})
Population Density	0.29×10^{-5}	0.48×10^{-5}**	0.43×10^{-5}
	(1.94×10^{-6})	(2.06×10^{-6})	(3.91×10^{-6})
Population Growth	0.95×10^{-2}***	0.98×10^{-2}***	0.99×10^{-2}***
	(0.0016)	(0.0015)	(0.0024)
Heating Degree Days	0.11×10^{-4}***	0.47×10^{-5}	0.80×10^{-5}
	(2.61×10^{-6})	(0.00045)	(5.58×10^{-6})
Precipitation	-0.13×10^{-2}***	-0.17×10^{-2}***	-0.14×10^{-2}***
	(0.0003)	(0.0004)	(0.0005)
Wind Speed	0.19×10^{-1}***	0.12×10^{-1}***	0.15×10^{-1}**
	(0.0028)	(0.0041)	(0.0061)
Sunshine	-0.17×10^{-2}**	-0.33×10^{-2}***	-0.22×10^{-2}
	(0.0007)	(0.0010)	(0.0019)
County GINI	0.53×10^{-1}	0.31***	0.34**
	(0.1093)	(0.1029)	(0.1339)
Adjusted R^2	0.5112		
rho (ρ)		0.6575***	0.6695***

Note. Regressions include all personal characteristics. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.2 presents results of models for wage equation for the continental United States with and without spatial effects. Including the spatial interactions, population size, heating degree days, and precipitation decreased their effects on wages in terms of magnitude. However, heating degree days become insignificant including the spatial effects, decreasing the standard error, compared with non-spatial OLS model. Other variables increased their effects in terms of magnitude. Regarding County GINI, there are significant differences in the statistical significant coefficients between OLS and SEM GS2SLS model.

Table 4.2.2.3.3 Wage Equation for the Continental United States with Metro Dummy

Variable	Wage OLS	Wage SEM ML	Wage SEM GS2SLS
PM 2.5	-0.18×10^{-2}*	-0.26×10^{-2}*	-0.21×10^{-2}
	(0.0011)	(0.0014)	(0.0017)
County Population	0.26×10^{-7}**	0.16×10^{-7}	0.16×10^{-7}**
	(1.13×10^{-8})	(1.06×10^{-8})	(7.35×10^{-9})
Population Density	0.28×10^{-5}	0.46×10^{-5}**	0.41×10^{-5}
	(1.93×10^{-6})	(2.05×10^{-6})	(4.06×10^{-6})
Population Growth	0.85×10^{-2}***	0.91×10^{-2}***	0.91×10^{-2}***
	(0.016)	(0.0015)	(0.0024)
Heating Degree Days	-0.13×10^{-4}***	0.64×10^{-5}*	0.97×10^{-5}*
	(2.62×10^{-6})	(3.90×10^{-6})	(5.67×10^{-6})
Precipitation	-0.12×10^{-2}***	-0.16×10^{-2}***	-0.14×10^{-2}**
	(0.0003)	(0.0004)	(0.0006)
Wind Speed	0.19×10^{-1}***	0.12×10^{-1}***	0.15×10^{-1}**
	(0.0028)	(0.0041)	(0.0061)
Sunshine	-0.15×10^{-2}**	-0.31×10^{-2}***	-0.20×10^{-2}
	(0.0007)	(0.0010)	(0.0019)
County GINI	0.15	0.36***	0.40***
	(0.1104)	(0.1031)	(0.1343)
Metro	0.46×10^{-1}***	0.39×10^{-1}***	0.41×10^{-1}***
	(0.0085)	(0.0077)	(0.0065)
Adjusted R^2	0.5157		
rho (ρ)		0.6548***	0.6661***

Note. Regressions include all control variables. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.3 reports results of the wage equation for the continental United States with a metro dummy and indicates that there are different effects on wages between metro and non-metro counties. Inclusion of spatial interactions slightly decreases the differences of the effects on wages between metro and non-metro.

Table 4.2.2.3.4 Wage Equation for the Continental United States with Metro Dummy and Cross Products

Variable	Wage OLS	Wage SEM ML	Wage SEM GS2SLS
PM 2.5	-0.15×10^{-2}	-0.21×10^{-2}	-0.15×10^{-2}
	(0.0013)	(0.0016)	(0.0018)
County Population	0.54×10^{-6}**	0.50×10^{-6}**	0.53×10^{-6} ***
	(2.18×10^{-7})	(1.98×10^{-7})	(1.69×10^{-7})
Population Density	0.13×10^{-5}	-0.35×10^{-5}	0.32×10^{-5}
	(0.000045)	(0.000039)	(0.000037)
Population Growth	0.96×10^{-2} ***	0.97×10^{-2} ***	0.98×10^{-2} ***
	(0.0019)	(0.0018)	(0.0030)
Heating Degree Days	0.16×10^{-4}***	0.10×10^{-4}**	0.13×10^{-4}**
	(3.20×10^{-6})	(4.43×10^{-6})	(5.78×10^{-6})
Precipitation	-0.15×10^{-2}***	-0.18×10^{-2}***	-0.15×10^{-2}***
	(0.0004)	(0.0005)	(0.0006)
Wind Speed	0.17×10^{-1}***	0.13×10^{-1}***	0.15×10^{-1}**
	(0.0033)	(0.0044)	(0.0063)
Sunshine	-0.80×10^{-5}	-0.12×10^{-2}	-0.12×10^{-3}
	(0.0010)	(0.0013)	(0.0017)
County GINI	-0.85×10^{-2}	0.24**	0.26
	(0.1315)	(0.1211)	(0.1626)
Metro	0.20×10^{-1}	0.86×10^{-1}	0.17
	(0.1692)	(0.1590)	(0.2099)
Metro×PM 2.5	-0.35×10^{-3}	-0.59×10^{-3}	-0.99×10^{-3}
	(0.0022)	(0.0021)	(0.0021)
Metro×Population	-0.52×10^{-6}**	-0.52×10^{-6}**	-0.51×10^{-6}***
	(2.17×10^{-7})	(1.97×10^{-7})	(1.68×10^{-7})
Metro×Pop Density	0.80×10^{-6}	0.76×10^{-5}	0.59×10^{-6}
	(0.000045)	(0.000039)	(0.000037)
Metro×Pop Growth	-0.49×10^{-2}	-0.26×10^{-2}	-0.29×10^{-2}
	(0.0033)	(0.0030)	(0.0039)
Metro×Heating Degree	-0.10×10^{-4}**	-0.88×10^{-5}*	-0.11×10^{-4}*
	(5.12×10^{-6})	(4.96E-06)	(5.71×10^{-6})
Metro×Precipitation	0.66×10^{-3}	0.77×10^{-3}	0.55×10^{-3}
	(0.0007)	(0.0007)	(0.0007)
Metro×Wind Speed	0.65×10^{-2}	0.20×10^{-2}	0.17×10^{-2}
	(0.0060)	(0.0063)	(0.0071)
Metro×Sunshine	-0.33×10^{-2}**	-0.33×10^{-2}**	-0.40×10^{-2}**
	(0.0014)	(0.0014)	(0.0017)
Metro×GINI	0.48**	0.39**	0.37*
	(0.2074)	(0.1837)	(0.2056)
Adjusted R^2	0.5194		
rho (ρ)		0.6516***	0.6673***

Note. Regressions include personal/household characteristics for wage equation and household characteristics for rent equation. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.5 Non-Spatial Marginal Effects for Wage Equation in the Continental United States: Metro versus Non-Metro

Variable	Non-metro	Metro
PM 2.5	-0.15×10^{-2}	-0.18×10^{-2}
	(0.0013)	(0.0017673)
County Population	0.54×10^{-6}**	0.26×10^{-7}
	(2.18×10^{-7})	(1.15×10^{-8})
Population Density	0.13×10^{-5}	0.21×10^{-5}
	(0.000045)	(1.96×10^{-6})
Population Growth	0.96×10^{-2} ***	0.47×10^{-2}*
	(0.0019)	(0.0028165)
Heating Degree Days	0.16×10^{-4}***	0.54×10^{-5}
	(3.20×10^{-6})	(4.29×10^{-6})
Precipitation	-0.15×10^{-2}***	-0.87×10^{-3}*
	(0.0004)	(0.0005245)
Wind Speed	0.17×10^{-1}***	0.24×10^{-1}***
	(0.0033)	(0.0050696)
Sunshine	-0.80×10^{-5}	-0.33×10^{-2}***
	(0.0010)	(0.0010485)
County GINI	-0.85×10^{-2}	0.47***
	(0.1315)	(0.1760528)

Note. The values of the marginal effects are based on Table 4.2.2.3.4. Standard errors[18] are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

This analysis includes all the interactions with a metro dummy so that we can effectively estimate the effects of each variable separately for metro versus non-metro counties (Table 4.2.2.3.4). Table 4.2.2.3.5 reports the differences in marginal effects on

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[18] We can recover the standard errors of the results for metro counties including a non-metro dummy and cross products of the dummy with explanatory variables. In this model, the coefficients that are not interacted with the non-metro dummy represent coefficients for metro counties.

wages between metro and non-metro counties based on the estimated coefficients of OLS in Table 4.2.2.3.4.

In Tables 4.2.2.3.5 and 4.2.2.3.6, amenity variables have different impacts on metro and non-metro counties. For instance, population growth has significantly smaller positive impact on wages in metro counties in both non-spatial and spatial regressions. There might be agglomeration effects with respect to some facility development in rural counties. Deller et al. (2001) raised a question regarding the possibility that rural communities can capture agglomeration effects that may exist across amenity types in rural counties (p. 363-365).

Table 4.2.2.3.6 Spatial SEM GS2SLS Marginal Effects for Wage Equation in the Continental United States: Metro versus Non-Metro

Variable	Non-metro	Metro
PM 2.5	-0.15×10^{-2}	-0.20×10^{-2}
	(0.0018)	(0.0020272)
County Population	0.53×10^{-6} ***	0.15×10^{-7}*
	(1.69×10^{-7})	(7.67×10^{-9})
Population Density	0.32×10^{-5}	0.36×10^{-5}
	(0.000037)	(4.14×10^{-6})
Population Growth	0.98×10^{-2} ***	0.71×10^{-2}**
	(0.0030)	(0.0027709)
Heating Degree Days	0.13×10^{-4}**	0.37×10^{-5}
	(5.78×10^{-6})	(6.24×10^{-6})
Precipitation	-0.15×10^{-2}***	-0.83×10^{-2}
	(0.0006)	(0.0006847)
Wind Speed	0.15×10^{-1}**	0.18×10^{-1}**
	(0.0063)	(0.0072544)
Sunshine	-0.12×10^{-3}	-0.37×10^{-2}*
	(0.0017)	(0.0020229)
County GINI	0.26	0.70***
	(0.1626)	(0.1728166)

Note. The values of the marginal effects are based on Table 4.2.2.3.4. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

The interest of this study lies in the differences in marginal effects of site-specific characteristics between metro and non-metro counties with and without spatial effects, and thus I focus on Tables 4.2.2.3.4 and 4.2.2.3.9 estimated results. The estimated rho is positive, strong, and significant, indicating spatial autoregressive dependence in the error term. I compare estimates between OLS and SEM GS2SLS.

PM 2.5 and Population Density have slightly different coefficients between OLS and SEM GS2SLS but are consistently insignificant. County population, population growth, heating degree days, precipitation, and wind speed, also produce slightly different coefficients between the two sets of parameter estimates but they are consistently statistically significant. Thus, the inference of significance from OLS is likely to be reliable.

Regarding cross products, Metro×Population ($p < 0.01$), Metro×Heating Degree ($p < 0.10$), Metro×Sunshine ($p < 0.05$), and Metro×GINI ($p < 0.10$) are only slightly different among OLS, SEM ML, and SEM GS2SLS. They are consistently statistically significant. For Metro×GINI, the magnitude from the spatial error model (with heteroscedasticity) is decreased slightly compared with the OLS estimates. This means that allowing spatial interactions decreases the differences between the marginal effects of income inequality on metro and on non-metro counties. In addition, the decreased magnitude indicates that expected average income for counties is less sensitive to the income inequality. Based on the OLS model, the coefficient for County GINI in non-metro areas is -0.01 and the coefficient in metro areas is about 0.47 ($-0.0085 + 0.48$). Based on the SEM GS2SLS coefficients for County GINI, are 0.25 for non-metro areas and 0.62 (0.25 + 0.37) for metro areas. There are differences in the statistically significance coefficients between OLS and SEM GS2SLS models. Thus, we can conclude that the inference of the significance from the OLS is likely to be less reliable. In addition to these, there are different estimates of the standard errors between non-spatial (OLS) and spatial models due to violation of the independence assumption.

The following analysis for the rent equation follows the same steps as in the analysis of the wage equation. In Tables 4.2.2.3.7, 4.2.2.3.8, and 4.2.2.3.9, the estimated spatial autoregressive terms (rho) are positive and statistically significant. This indicates that an exogenous shocks to one county leads to moderate changes in the dependent variable, wages, in the neighboring counties. This is possible because of inter-county commuting and shopping patterns.

Table 4.2.2.3.7 Rent Equations for the Continental United States

Variable	Rent OLS	Rent SEM ML	Rent SEM GS2SLS
County Violent Crime	-0.33×10^{-4}	-0.60×10^{-4}***	-0.56×10^{-4}**
	(0.000025)	(0.000022)	(0.000023)
PM 2.5	-0.64×10^{-2}***	-0.51×10^{-2}**	-0.54×10^{-2}**
	(0.0015)	(0.0020)	(0.0022)
County Population	0.13×10^{-6}***	0.50×10^{-7}***	0.66×10^{-7}***
	(1.59×10^{-8})	(1.42×10^{-8})	(1.50×10^{-8})
Population Density	0.18×10^{-4}***	0.17×10^{-4}***	0.16×10^{-4}***
	(3.09×10^{-6})	(3.08×10^{-6})	(3.68×10^{-6})
Population Growth	0.14×10^{-1}***	0.13×10^{-1}***	0.13×10^{-1}***
	(0.0022)	(0.0020)	(0.0034)
Heating Degree Days	0.26×10^{-4}***	0.21×10^{-4}***	0.21×10^{-4}***
	(3.70×10^{-6})	(5.93×10^{-6})	(7.43×10^{-6})
Precipitation	0.39×10^{-2}***	0.45×10^{-2}***	0.43×10^{-2}***
	(0.0005)	(0.0006)	(0.0007)
Wind Speed	-0.97×10^{-2}**	-0.99×10^{-2}*	-0.11×10^{-1}
	(0.0040)	(0.0060)	(0.0070)
Sunshine	0.46×10^{-3}	0.14×10^{-2}	0.60×10^{-3}
	(0.0010)	(0.0015)	(0.0018)
County GINI	0.14×10^{-1}	0.74***	0.60***

	(0.1414)	(0.1244)	(0.1693)
Adjusted R^2	0.5933		
rho (ρ)		0.7754***	0.7767***

Note. Regressions include all housing characteristics. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.8 Rent Equations for the Continental United States with Metro Dummy

Variable	Rent OLS	Rent SEM ML	Rent SEM GS2SLS
County Violent Crime	-0.64×10^{-4}**	-0.66×10^{-4}***	-0.65×10^{-4}***
	(0.000025)	(0.000022)	(0.000023)
PM 2.5	-0.66×10^{-2}***	-0.52×10^{-2}***	-0.56×10^{-2}***
	(0.0015)	(0.0020)	(0.0022)
County Population	0.11×10^{-6}***	0.47×10^{-7}***	0.61×10^{-7}***
	(1.59×10^{-8})	(1.42×10^{-8})	(1.53×10^{-8})
Population Density	0.16×10^{-4}***	0.16×10^{-4}***	0.15×10^{-4}***
	(3.06×10^{-6})	(3.07×10^{-6})	(3.63×10^{-6})
Population Growth	0.12×10^{-1}***	0.12×10^{-1}***	0.11×10^{-1} ***
	(0.0022)	(0.0020)	(0.0033)
Heating Degree Days	0.31×10^{-4}***	0.24×10^{-4}***	0.25×10^{-4}***
	(3.70×10^{-6})	(5.87×10^{-6})	(7.31×10^{-6})
Precipitation	0.40×10^{-2}***	0.46×10^{-2}***	0.44×10^{-2}***
	(0.0005)	(0.0006)	(0.0007)
Wind Speed	-0.86×10^{-2}**	-0.98×10^{-2}*	-0.11×10^{-1}
	(0.0040)	(0.0059)	(0.0069)
Sunshine	0.14×10^{-2}	0.14×10^{-2}	0.10×10^{-2}
	(0.0010)	(0.0015)	(0.0018)
County GINI	0.13	0.78***	0.65***
	(0.1405)	(0.1242)	(0.1704)
Metro	0.10***	0.52×10^{-1}***	0.61×10^{-1}***
	(0.0111)	(0.0099)	(0.0092)
Adjusted R^2	0.6037		
rho (ρ)		0.7653***	0.7653***

Note. Regressions include all housing characteristics. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.9 Rent Equations for the Continental United States with Metro Dummy and Cross Products

Variable	Rent OLS	Rent SEM ML	Rent SEM GS2SLS
County Violent Crime	-0.21×10^{-4}	-0.16×10^{-4}	-0.15×10^{-4}
	(0.000033)	(0.000030)	(0.0000319)
PM 2.5	-0.35×10^{-2}**	-0.32×10^{-2}	-0.37×10^{-2}
	(0.0018)	(0.0022)	(0.0025)
County Population	0.27×10^{-5}***	0.18×10^{-5}***	0.20×10^{-5}***
	(2.81×10^{-7})	(2.49×10^{-7})	(2.87×10^{-7})
Population Density	0.19×10^{-3}***	0.12×10^{-3}**	0.14×10^{-3}**
	(0.0001)	(0.0001)	(0.0001)
Population Growth	0.69×10^{-2}***	0.66×10^{-2}***	0.66×10^{-2}
	(0.0025)	(0.0023)	(0.0041)
Heating Degree Days	0.37×10^{-4}***	0.35×10^{-4}***	0.34×10^{-4}***
	(4.46×10^{-6})	(6.40×10^{-6})	(8.68×10^{-6})
Precipitation	0.39×10^{-2}***	0.49×10^{-2}***	0.45×10^{-2}***
	(0.0006)	(0.0007)	(0.0009)
Wind Speed	-0.14×10^{-1}***	-0.99×10^{-2}	-0.12×10^{-1}
	(0.0046)	(0.0061)	(0.0078)
Sunshine	0.61×10^{-2}***	0.62×10^{-2}***	0.52×10^{-2}**
	(0.0013)	(0.0019)	(0.0025)
County GINI	−0.60***	0.29*	0.81×10^{-1}
	(0.1684)	(0.1517)	(0.2255)
Metro	−0.40*	-0.41×10^{-1}	−0.17
	(0.2301)	(0.2095)	(0.2546)
Metro×Violnet Crime	-0.23×10^{-3}***	-0.18×10^{-3}***	-0.19×10^{-3}***
	(0.00005)	(0.000041)	(0.000047)
Metro×PM 2.5	-0.64×10^{-2}**	-0.21×10^{-2}	-0.24×10^{-2}
	(0.0030)	(0.0027)	(0.0026)
Metro×Population	-0.26×10^{-5}***	-0.18×10^{-5}***	-0.19×10^{-5}***
	(2.82×10^{-7})	(2.49×10^{-7})	(2.87×10^{-7})
Metro×Pop Density	-0.17×10^{-3}***	-0.11×10^{-3}**	-0.12×10^{-3}*
	(0.0001)	(0.0001)	(0.0001)
Metro×Pop Growth	0.62×10^{-2}	0.92×10^{-2}**	0.85×10^{-2}
	(0.0045)	(0.0039)	(0.0055)
Metro×Heating Degree	-0.14×10^{-4}**	-0.17×10^{-4}***	-0.15×10^{-4}**
	(6.92×10^{-6})	(6.50×10^{-6})	(7.25×10^{-6})
Metro×Precipitation	-0.66×10^{-3}	-0.10×10^{-2}	-0.89×10^{-3}
	(0.0009)	(0.0009)	(0.0009)
Metro×Wind Speed	0.28×10^{-1}***	0.16×10^{-1}*	0.19×10^{-1}**
	(0.0081)	(0.0084)	(0.0092)
Metro×Sunshine	-0.67×10^{-2}***	-0.65×10^{-2}***	-0.59×10^{-2}***
	(0.0019)	(0.0018)	(0.0020)

Metro×GINI	2.2598***	1.3882***	1.5415***
	(0.2885)	(0.2442)	(0.3451)
Adjusted R^2	0.6300		
rho (ρ		0.7488***	0.7419***

Regressions include all housing characteristics. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.10 Non-Spatial Marginal Effects for Rent Equation in the Continental United States: Metro versus Non-Metro

	Non-metro	Metro
County Violent Crime	-0.21×10^{-4}	-0.25×10^{-3}***
	(0.000033)	(0.0000368)
PM 2.5	-0.35×10^{-2}**	-0.99×10^{-2}***
	(0.0018)	(0.0023776)
County Population	0.27×10^{-5}***	0.96×10^{-7}***
	(2.81×10^{-7})	(1.57×10^{-8})
Population Density	0.19×10^{-3}***	0.14×10^{-4}***
	(0.0001)	(2.98×10^{-6})
Population Growth	0.69×10^{-2}***	0.13×10^{-1}***
	(0.0025)	(0.0037539)
Heating Degree Days	0.37×10^{-4}***	0.23×10^{-4}***
	(4.46×10^{-6})	(5.45×10^{-6})
Precipitation	0.39×10^{-2}***	0.32×10^{-2}***
	(0.0006)	(0.0004564)
Wind Speed	-0.14×10^{-1}***	0.14×10^{-1}**
	(0.0046)	(0.0068539)
Sunshine	0.61×10^{-2}***	-0.67×10^{-3}
	(0.0013)	(0.0013432)
County GINI	-0.60***	0.17×10^{1}***
	(0.1684)	(.2342029)

Note. The values of the marginal effects are based on Table 4.2.2.3.9. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.2.2.3.11 Spatial SEM GS2SLS Marginal Effects for Rent Equation in the Continental United States: Metro versus Non-Metro

	Non-metro	Metro
County Violent Crime	-0.15×10^{-4}	-0.20×10^{-3}***
	(0.0000319)	(0.0000372)
PM 2.5	-0.37×10^{-2}	-0.64×10^{-2}***
	(0.0025)	(0.0023855)
County Population	0.20×10^{-5}***	0.60×10^{-7}***
	(2.87×10^{-7})	(1.45×10^{-8})
Population Density	0.14×10^{-3}**	0.14×10^{-4}***
	(0.0001)	(3.52×10^{-6})
Population Growth	0.66×10^{-2}	0.15×10^{-1}***
	(0.0041)	(0.004096)
Heating Degree Days	0.34×10^{-4}***	0.21×10^{-4}***
	(8.68×10^{-6})	(7.78×10^{-6})
Precipitation	0.45×10^{-2}***	0.43×10^{-2}***
	(0.0009)	(0.0007151)
Wind Speed	-0.12×10^{-1}	0.85×10^{-2}
	(0.0078)	(0.0097361)
Sunshine	0.52×10^{-2}**	-0.17×10^{-3}
	(0.0025)	(0.0019226)
County GINI	0.81×10^{-1}	0.16×10^{1}***
	(0.2255)	(0.268528)

Note. The values of the marginal effects are based on Table 4.2.2.3.9. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

In Table 4.2.2.3.9, the coefficients for wind speed, GINI, and Metro×PM 2.5 are statistically significant in explaining property values based on the OLS but insignificant in the spatial models. Thus, the inference from the OLS estimates for wind speed, GINI, and Metro×PM 2.5 are deemed to be unreliable. Non-spatial OLS ignores spatial effects and leads us to conclude that these variables are significant in explaining expected average rents for counties. On the other hand, the spatial error models lead us to conclude that those variables are not statistically significant, and thus, the OLS estimates for the inference of significance for these variables based on OLS is likely to be unreliable.

Table 4.2.2.3.12 Non-spatial Annualized values: Metro

Variable	Annualized Value Rents	Wage	Full implicit price
County Violent Crime (violent crimes/100,000 population)	−1.28		−1.28
PM 2.5 (µg/m^3)	−51.17	−93.03	41.88
County Population (10,000 persons)	4.95	13.51	−8.56
Population Density (100 persons/square mile)	7.27	10.68	−3.43
Population Growth (percentage change in population)	67.76	240.91	−173.15
Heating Degree Days (1°F colder for one day)	0.12	0.27	−0.15
Precipitation (inches)	18.52	−44.3	62.82
Wind Speed (mph)	72.92	1,214.52	−1,141.60
Sunshine (% of possible)	−1.67	−168.82	167.15
County GINI (index)	8,431.90	24,107.5	−15,675.60

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is \$51,180.93 for metro.

Table 4.2.2.3.13 Annualized Values Based on Spatial Model (SEM GS2SLS): Metro

Variable	Annualized Value Rents - Spatial	Wage - Spatial	Full implicit price
County Violent Crime (violent crimes/100 population)	−1.03		−1.03
PM 2.5 (µg/m^3)	−31.34	−100.73	68.18
County Population (10,000 persons)	3.07	7.62	−4.54
Population Density (100 persons/square mile)	6.84	18.42	−11.16

Population Growth (percentage change in population)	77.28	360.57	−281.97
Heating Degree Days (1°F colder for one day)	0.10	0.19	−0.08
Precipitation (inches)	18.66	−42.49	63.38
Wind Speed (mph)	38.62	918.81	−875.11
Sunshine (% of possible)	−3.28	−189.02	188.13
County GINI (index)	8,390.67	36,033.46	−27,687.99

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is \$51,180.93 for metro.

It interesting that including spatial interactions increased the magnitude of the full implicit price for County GINI but decreased it for violent crime. Including spatial interactions, an average person in a metro county would be willing to pay a lower price to avoid for an additional violent crime and a higher price for a change in GINI, comparing non-spatial (Table 4.2.2.3.12) to spatial (Table 4.2.2.3.13) models.

Table 4.2.2.3.14 Non-spatial Annualized values: Non-Metro

Variable	Annualized Value		
	Rents	Wage	Full implicit price
County Violent Crime (violent crimes/100 population)	−0.07		−0.07
PM 2.5 (μg/m^3)	−11.45	−64.79	53.34
County Population (10,000 persons)	88.76	238.8	−150.11
Population Density (100 persons/square mile)	62.29	5.68	56.61
Population Growth (percentage change in population)	22.80	421.12	−398.32

Heading Degree Days (1°F colder for one day)	0.12	0.68	−0.56
Precipitation (inches)	12.82	−66.92	79.74
Wind Speed (mph)	−45.65	758.61	−804.26
Sunshine (% of possible)	20.05	−0.35	20.4
County GINI (index)	−1,994.97	−374.03	−1,620.94

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is \$43,993.65 for non-metro counties.

Table 4.2.2.3.15 Spatial SEM GS2SLS Annualized values: Non-Metro

Variable	Annualized Value		
	Rents - Spatial	Wage - Spatial	Full implicit price
County Violent Crime (violent crimes/100,000 population)	−0.05		−0.05
PM 2.5 ($\mu g/m^3$)	−12.05	−67.89	55.85
County Population (10,000 persons)	65.00	233.17	−168.17
Population Density (100 persons/square mile)	44.81	14.17	30.64
Population Growth (percentage change in population)	21.76	431.71	−409.95
Heating Degree Days (1°F colder for one day)	0.11	0.57	−0.46
Precipitation (inches)	15.02	−68.01	83.09
Wind Speed (mph)	−39.11	654.21	−693.32
Sunshine (% of possible)	17.30	−5.54	22.84
County GINI (index)	331.49	11,478.77	−11,147.27

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

Likewise in metro areas, inclusion of spatial effects increased the marginal effect of GINI but decreased the marginal effect of violent crime. Different levels of effects on wages and land values between metro and non-metro counties cause different levels of implicit prices of GINI and violent crime in non-metro counties.

4.2.2.3.1 Consideration of Spatial Lag of Explanatory Variables

This section employs the spatial Durbin error model (SDEM) as a local spatial spillovers (to neighboring observations) specification, which includes spatial lags of all explanatory variables in addition to spatially lagged errors (SEM), as follows:

$$y = X\beta_1 + WX\beta_2 + u$$

$$u = \rho Wu + \varepsilon$$

$$\varepsilon \sim N(0, \sigma_\varepsilon^2 I_N)$$

WX is a spatial lag that forms a linear combination of values from the matrix X, reflecting neighboring region values (LeSage, 2014). Taking cross-partial derivatives ($\frac{\partial y_i}{\partial x_j^k} = W\beta_2$), we can get the spatial spillovers to only neighboring regions and interpret the coefficient β_2 as the cumulative indirect spillover effect to other-region while the own-region partial derivatives $\frac{\partial y_i}{\partial x_i^k} = \beta_1$ as direct own-region impacts (LeSage, 2014).

Also, this model incorporates the disturbances that allows for global diffusion of shocks to the model disturbances (LeSage, 2014).

To employ the spatial Durbin error model and estimate coefficients for metro and non-metro, this study includes interactions between a metro dummy and each of the explanatory variable in the pooled regression. Conceptually, this study estimates the following function:

$Rent\ or\ Wage\ Equation = f\ (X, D, D\times X, WX, WD, WDX)$,

where

$X =$ explanatory variable, $D =$ metro dummy, $D\times X =$ cross products of the metro dummy with each of variables, $WX =$ spatial lag of the explanatory variables, $WD =$ spatial lag of the dummy variable, and $WDX =$ spatial lag of $D\times X$. The coefficients of X, D, and $D\times X$ are used for own-region partial derivatives (direct effect) while WX, WD, and WDX are used for cross-partial derivatives (indirect or spillover effect).

Table 4.2.2.3.1.1 Rent Equation: Direct and Indirect Effects from the Spatial Durbin Error Model

Direct Effect	Coef.	Std. Err.	Indirect Effect	Coef.	Std. Err.
County Violent Crime	-0.0000164	0.000029	W County Violent Crime	0.0001065	0.0001
PM25	-0.0032229	0.0021	W PM 2.5	-0.0011479	0.0037
County Population	1.41×10^{-6}***	2.54×10^{-7}	W County Population	7.92×10^{-7}	6.52×10^{-7}
Population Density	0.0000934*	0.0001	W Population Density	-0.0000216	0.0001
Population Growth	0.0049717**	0.0023	W Population Growth	-0.0030259	0.0056
Heating Degree Days	0.000036***	6.46×10^{-6}	W Heating Degree Days	0.0000186**	8.63×10^{-6}
Precipitation	0.0038943***	0.0007	W Precipitation	0.0001225	0.0012
Wind Speed	-0.0075285	0.0059	W Wind Speed	-0.0045704	0.0096
Sunshine	0.0038839**	0.0018	W Sunshine	0.0052984**	0.0026
County GINI	0.0509199*	0.1476	W County GINI	-0.327985	0.3519

Metro×Crime	-0.0002016***	0.000041	W Metro×ViolentCrime	-0.000242**	0.0001
Metro×PM 2.5	-0.0041809	0.0027	W MetrovPM25	-0.0046789	0.0068
Metro×Population	-1.35×10^{-6}***	2.54×10^{-7}	W Metro×Population	-7.14×10^{-7}	6.52×10^{-7}
Metro×Population Density	-0.0000863*	0.0001	W Metro×Population Density	0.0000295	0.0001
Metro×Growth	0.0153246***	0.0041	W Metro×Growth	0.0168957	0.0110
Metro×Heating Degree Days	-0.0000319***	7.24×10^{-6}	W Metro×Heating Degree Days	-0.0000136	0.000017
Metro×Precipitation	0.0002929	0.0009	W Metro×Precipitation	0.0011206	0.0020
Metro×Wind Speed	0.004092	0.0086	W Metro×Wind Speed	-0.0070897	0.0190
Metro×Sunshine	-0.0025303**	0.0019	W Metro×Sunshine	-0.0054632	0.0044
Metro×County GINI	1.316889***	0.2442	W Metro×GINI	0.3931326	0.6525

Note. Number of observations is 3,109 (counties for the continental United States). ***Significant at 1%, ** significant at 5%, and * significant at 10%. See Appendix 4 for full statistics for all variables. The value of *rho* is positive (0.7113) and statistical significant.

In Table 4.2.2.3.1.1, county population, population density, population growth rate, heating degree days, precipitation, sunshine, and GINI have positive direct (own-region) impacts with statistical significance. Cross products of the metro dummy with population, population density, population growth rate, heating degree days, sunshine, and GINI are statistically significant, which indicates differences in those coefficients between metro and non-metro counties.

Spatial lags of heating degree days, sunshine, and cross product of the metro dummy with violent crime are statistically significant spillover impacts.

Table 4.2.2.3.1.2 Direct Marginal Effects for Rent Equation from the Spatial Durbin Error Model: Metro versus Non-Metro

Direct Marginal Effect	Metro	Non-metro
County Violent Crime	-0.000218	-0.0000164
PM 2.5	-0.0074038	-0.0032229
County Population	6.00E-08	1.41E-06
Population Density	0.0000071	0.0000934
Population Growth	0.0202963	0.0049717
Heating Degree Days	0.0000041	0.000036
Precipitation	0.0041872	0.0038943
Wind Speed	-0.0034365	-0.0075285
Sunshine	0.0013536	0.0038839
County GINI	1.3678089	0.0509199

Note. The values of the marginal effects are based on Table 4.2.2.3.1.1.

In Table 4.2.2.3.1.2, the magnitude of own-region impacts for county violent crime, PM 2.5, population growth rate, precipitation, and county GINI are larger in metro than in non-metro counties. On the other hand, population density, heating degree days, wind speed, and sunshine have larger impacts on land values in non-metro than in metro counties.

Table 4.2.2.3.1.3 Indirect Marginal Effects for Rent Equation from the Spatial Durbin Error Model: Metro versus Non-Metro

Indirect Marginal Effect	Metro	Non-metro
W County Violent Crime	-0.0001355	0.0001065
W PM 2.5	-0.0058268	-0.0011479
W County Population	7.80E-08	7.92E-07
W Population Density	0.0000079	-0.0000216
W Population Growth	0.0138698	-0.0030259
W Heating Degree Days	0.000005	0.0000186
W Precipitation	0.0012431	0.0001225
W Wind Speed	-0.0116601	-0.0045704

W Sunshine	-0.0001648	0.0052984
W County GINI	0.0651476	-0.327985

Note. The values of the marginal effects are based on Table 4.2.2.3.1.1. W refers to a spatial lag.

In Table 4.2.2.3.1.3, the magnitude of the spillover effects for county violent crime, PM 2.5, population growth rate, precipitation, and wind speed are larger in metro than in non-metro counties. The county population, population density, heating degree days, sunshine, and county GINI have larger spillover impacts on neighboring land values in non-metro than in metro counties.

Table 4.2.2.3.1.4 Wage Equation: Direct and Indirect Effects from the Spatial Durbin Error Model

Direct Effect	Coef.	Std. Err.	Indirect Effect	Coef.	Std. Err.
PM 2.5	-0.0020394	0.0016	W PM 2.5	0.0036553	0.0030
County Population	0.000000561***	2.06×10^{-7}	W County Population	0.000000113	5.17×10^{-7}
Population Density	0.0000178	0.000039	W Population Density	0.0001562	0.0001
Population Growth	0.0109985***	0.0018	W Population Growth	0.0006739	0.0044
Heating Degree Days	0.0000196***	4.49×10^{-6}	W Heating Degree Days	0.00000716	6.12×10^{-6}
Precipitation	-0.0014086***	0.0005	W Precipitation	-0.000476	0.0009
Wind Speed	0.0180855***	0.0043	W Wind Speed	0.0093942	0.0071
Sunshine	0.0022757*	0.0014	W Sunshine	0.0014614	0.0019
County GINI	0.2756734**	0.1211	W County GINI	-0.0705374	0.2727
Metro×PM25	-0.0000538	0.0021	W Metro×PM 2.5	-0.0057506	0.0053
Metro×Population	-0.000000543***	2.07×10^{-6}	W Metro×Population	-0.000000103	5.18×10^{-7}
Metro×Population Density	-0.0000148	0.000039	W Metro×Population Density	-0.0001502	0.0001
Metro×Growth	-0.0100053***	0.0033	W Metro×Growth	-0.0010677	0.0091
Metro×Heating Degree Days	-0.0000192***	5.44×10^{-6}	W Metro×Heating Degree Days	-0.00000357	0.000013
Metro× Precipitation	0.000019	0.0007	W Metro×Precipitation	-0.0000164	0.0015
Metro×Wind Speed	-0.0090872	0.0064	W Metro×Wind Speed	-0.0333493**	0.0144

Metro×Sunshine	-0.0048375***	0.0015	W Metro×Sunshine	-0.0077709**	0.0034
Metro×County GINI	0.6057368***	0.2142	W Metro×County GINI	-0.0305772	0.5579

Note. Number of observations is 3,109 (counties for the continental United States). W refers to a spatial lag. ***Significant at 1%, ** significant at 5%, and * significant at 10%. See Appendix 4 for full statistics for all variables. The value of *rho* is positive (0.6465) and statistical significant.

Two spatial lags of cross products of the metro dummy with wind speed and sunshine are statistically significant in the wage equation. On the other hand, almost all local characteristics have different direct (own-region) impacts on wages with statistical significance between metro and non-metro counties in Table 4.2.2.3.1.4 and the marginal effects on wage equation for metro and non-metro counties is calculated in Table 4.2.2.3.1.5.

Table 4.2.2.3.1.5 Direct Marginal Effects for Wage Equation from the Spatial Durbin Error Model: Metro versus Non-Metro

Direct Marginal Effect	Metro	Non-metro
PM 2.5	-0.0020932	-0.0020394
County Population	0.000000018	0.000000561
Population Density	0.000003	0.0000178
Population Growth	0.0009932	0.0109985
Heating Degree Days	0.0000004	0.0000196
Precipitation	-0.0013896	-0.0014086
Wind Speed	0.0089983	0.0180855
Sunshine	-0.0025618	0.0022757
County GINI	0.8814102	0.2756734

Note. The values of the marginal effects are based on Table 4.2.2.3.1.4.

Table 4.2.2.3.1.6 Indirect Marginal Effects for the Wage Equation from the Spatial Durbin Error Model: Metro versus Non-Metro

Indirect Marginal Effect	Metro	Non-metro
W PM 2.5	-0.0020953	0.0036553
W County Population	0.00000001	0.000000113
W Population Density	6E-06	0.0001562
W Population Growth	-0.0003938	0.0006739
W Heating Degree Days	0.00000359	0.00000716
W Precipitation	-0.0004924	-0.000476
W Wind Speed	-0.0239551	0.0093942
W Sunshine	-0.0063095	0.0014614
W County GINI	-0.1011146	-0.0705374

Note. The values of the marginal effects are based on Table 4.2.2.3.1.4. W refers to a spatial lag.

Table 4.2.2.3.1.7 Annualized Values based on Direct Effects for Metro

		Annualized Value	
Metro	Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 population)	−1.12		−1.12
PM 2.5 (µg/m^3)	−37.89	−107.13	69.24
County Population (10,000 persons)	3.07	9.21	−6.14
Population Density (100 persons/square mile)	3.63	15.35	−11.72
Population Growth (percentage change in population)	103.88	50.83	53.05
Heating Degree Days (1°F colder for one day)	0.02	0.02	0.00051
Precipitation (inches)	21.43	−71.12	92.55
Wind Speed (mph)	−17.59	460.54	−478.13
Sunshine (% of possible)	6.93	−131.11	138.04

County GINI (index)	7,000.57	45,111.39	−38,110.82

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is $51,180.93 for metro.

Compared with annualized values based on SEM (Table 4.2.2.3.13) for metro counties, the full implicit prices have slightly different values. The inclusion of the spatial lag of explanatory variables increased the magnitude of the violent crime, precipitation, and GINI impacts whereas it decreased the magnitude of the PM 2.5, population density, heating degree days, wind speed, and sunshine impacts.

Table 4.2.2.3.1.8 Annualized Values based on Direct Effects for Non-metro

		Annualized Value	
Non-metro	Rent Equation	Wage Equation	Full Implicit Price
County Violent Crime (violent crimes/100,000 population)	−0.05		−0.05
PM 2.5 (μg/m^3)	−10.63	−89.72	79.09
County Population (10,000 persons)	46.52	246.81	−200.29
Population Density (100 persons/square mile)	30.82	78.31	−47.49
Population Growth (percentage change in population)	16.40	483.90	−467.49
Heating Degree Days (1°F colder for one day)	0.12	0.86	−0.74
Precipitation (inches)	12.85	−61.98	74.83
Wind Speed (mph)	−24.84	795.76	−820.60
Sunshine (% of possible)	12.82	100.13	−87.32
County GINI	168.01	12,130.08	−11,962.07

(index)

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

Compared with the annualized values based on SEM (Table 4.2.2.3.14) for non-metro counties, the inclusion of the spatial lag of explanatory variables increased the magnitude of the full implicit prices of PM 2.5, population size, population growth, heating degree days, wind speed, sunshine, and GINI whereas it decreased the magnitude of violent crime, population density, and precipitation implicit prices.

4.2.4 Implications for Comprehensive Wealth Measurement and Concluding remarks

Roback's (1982) spatial equilibrium model yields important implications for measuring comprehensive wealth of communities (Marré & Pender, 2014). The Roback model assumes that the value of non-marketed immobile natural amenities and public goods (i.e., natural capital) will be fully capitalized into land rents, which can be observed in land market values. One of the challenges when measuring comprehensive wealth is to avoid double-counting the value of non-financial assets. Many intangible and non-marketable assets increase the value of tangible assets such as land. The spatial equilibrium framework will help us avoid double-counting by indicating the magnitude of the indirect effects of the non-marketed immobile assets on market assets. The accuracy of the estimated value depends on the methods used to estimate local income and property and land values.

Note that amenities have more statistical significance and are more often of the expected signs in rent equations. These results imply that place-based immobile non-marketable assets are more likely to be capitalizing into land values.

I implemented OLS for metro, non-metro, and the continental United States, following Roback's (1982) framework. The models in this section achieved expected results with relatively high *R*-squared values for the cross-sectional models. Apparently, the effects of amenities have different magnitudes in metro versus non-metro areas.

For testing spatial dependence, I implemented both spatial lag and spatial error models (SAR and SEM, respectively) for all 3,109 counties for the continental United States. The diagnostic testing for spatial coefficients (i.e., λ and ρ) indicated that the error terms include spatial dependence, which favored SEM. The SEM pertains to effects of the local characteristics at any location but also to the effects of the exogenous shocks on neighboring locations in the unobserved variables (the errors) (C. W. Kim et al., 2003). The significance of lagged values of explanatory variables in the spatial Durbin model suggests that there could be omitted variable bias in OLS and SEM models. Thus, the spatial Durbin error model is the preferred model. As LeSage (1997) argued, considering spatial effects with regard to the spatial configuration of the observations produces different inferences (p. 88). Ignoring the spatial effects may lead to an inappropriate model specification (LeSage, 1997). It is important to note that we found that inclusion of spatial effects influenced the marginal effect of violent crime and income inequality

(County GINI) in both metro and non-metro areas. Both suggest that violent crime and unequal distribution of income are disamenities, implying that people prefer places with less violent crime and a more equal distribution of income.

The system based on Roback's (1982) general spatial hedonic equilibrium framework is highly interconnected (interaction between labor and land markets) and some variables (e.g., crime, unemployment) are endogenous. Future research needs to identify structures of the system and dynamics of endogenous variables.

4.3 Extending Roback's Spatial Equilibrium Model: Public Services as Immobile and Non-Marketed Endogenous Amenities

4.3.1 Introduction

Roback's (1982) spatial equilibrium model assumes that individual utility maximizes people's consumptions of marketable goods (i.e., tradable goods and land) given exogenous local amenities (e.g., climate). The model produces the basis of individuals' willingness to pay estimations for quality differentials of exogenous amenities considering interactions between land and labor markets assuming spatial equilibrium. This widely used general spatial equilibrium model yields strong implications for measuring the comprehensive wealth of a community using market values. The model, specifically, captures how non-marketed immobile assets (i.e., local amenities and public goods) are capitalized into marketed assets (i.e., land rents). The model helps us measure and value comprehensive wealth of a location and its residents.

Although much subsequent research has been attempted to test the value of various types of exogenous amenities, there is little or no research that has modeled endogenous amenities publicly provided by local governments at the county level. Also, almost no research focuses only on consumers' consumption of private and marketable goods given exogenous local amenities. According to Gyourko et al. (1991), and Tiebout (1956), consumers consider the consumption of public services in location decisions in addition to the consumption of private goods. In addition, the rent differential between locations can be attributed to the difference in supply conditions of climate and the locally provided public goods and services (Jones, 1980, p. 341). This study, thus, expands Roback's spatial equilibrium model by including the choice of endogenous local amenities, defining local public services as immobile, non-marketable, and endogenous amenities at a location. The expanded model in this study proposes a way to value these immobile, non-marketable, and exogenous and endogenous local amenities, which allows us to more accurately measure comprehensive wealth of a location.

Economic theory predicts that in equilibrium, the opportunity cost of government services is the value of inputs, labor and land consumed to produce it. The empirical analysis produces coefficients that can be used to impute the implicit price of government services. Furthermore, the statistical significance and sign of the implicit value of government services provides a way to determine whether the system is in equilibrium and if not in equilibrium, whether the public service is over- or underprovided. Fundamentally, the expanded model captures the effects of externalities from local public finance.

4.3.2 Comprehensive Wealth Measurement Typology

4.3.2.1 Sources of Social Amenities

People do not purchase social amenities in the market, so the services that flow from social amenities are nonmarketable and access to them is a component of comprehensive wealth. This is similar to social and natural capital, which are also nonmarketable, at least not directly marketable (Pender et al., 2014). Differentiating immobile (tied to place) from mobile (tied to people) capital and external (nonexcludable) from internal (excludable) benefits provides a useful way to define social 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.

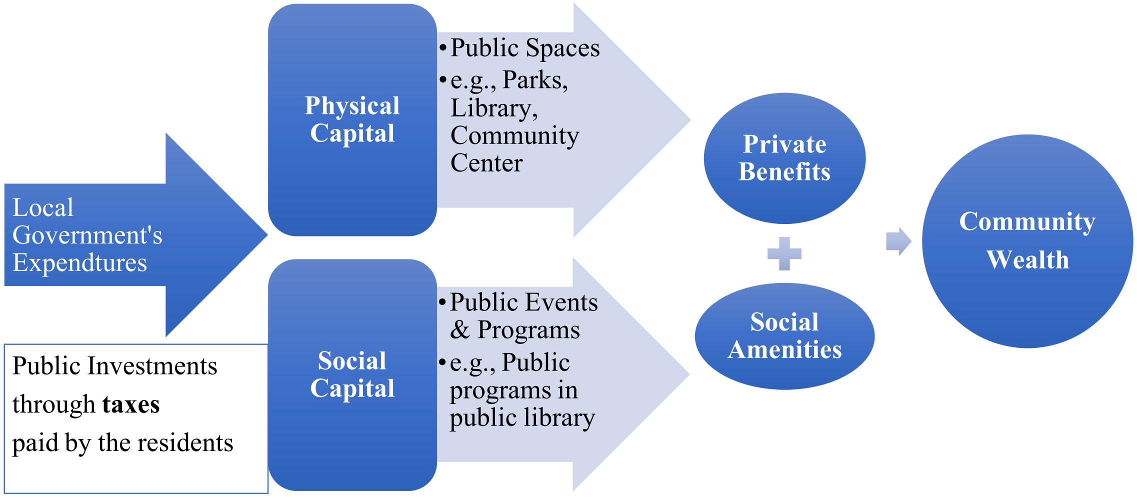

Figure 4.3.2.1.1 Conceptual Logic: Sources of Social Amenities from Public Investments

Figure 4.3.2.1.1 shows how public investments (in physical and social capital) produce both private and social benefits, which can contribute to community's comprehensive wealth. For instance, public investments in parks, library, educational services, and community centers can improve 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.

There may also be negative externalities from public investments. Infrastructure investments may increase traffic, create congestion, increase air pollution, etc. However, the 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 balancing benefits of both positive and negative externalities are assumed to be fully capitalized into the values of wages and land rents values at the equilibrium.

4.3.3 Hypothesis and Models

4.3.3.1 Hypothesis

This section adds theoretical hypothesis for public services (*g*) in addition to Roback's general hypothesis. First, I summarize hypotheses for signs of the implicit values of amenities based on Roback's framework again. And then I present the theoretical hypothesis for *g*.

Recall equation for the marginal value of amenities (section 3.1, equation [8]),

(1) $$\frac{\partial WTP}{\partial s} = l^c \frac{dr}{ds} - \frac{dw}{ds}.$$

Generally, we expect that the marginal value of an amenity is positively related to housing/land values and negatively related to wages, whereas disamenities will have the opposite sign. Based on comparative static results of Roback, however, the expected sign of coefficients in the wage equation can be ambiguous, depending on the supply and demand effects of employees (workers) and employers (firms), whereas the coefficients on rent should always be positive for amenities and negative for disamenities. Although the Roback method cannot separate the value of amenities that employers and employees capitalize into wages at the equilibrium, the wage coefficients can be either positive, negative, or insignificant on balance according to the combined value of the amenity to employers and employees. Thus, this study can have hypotheses about the combined impact on rent and wage, but often nor for wage alone.

From the theoretical section for the implicit price of government services (*g*) (section 3.2.1.2.1, equation [12]), the derived demand function for *g* is the following:

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

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

(3) $$TC = f\ (g) = C\ (g, Z_g) \times g,$$

where C is average cost per unit of *g*.

This indicates that the total cost of *g* depends on a vector of county's characteristics or cost conditions Z_g.

From the demand function for *g* (2), equation (3) and assuming that nonwage income I is independent of location as in Roback, we can derive the following functions

(4) $r = f\,(\frac{\partial t}{\partial g}, w, Z_g,\ l^c)$

$w = f\,(\frac{\partial t}{\partial g}, r, Z_g, l^c)$

From equations (4), we can test if g is as 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 into wages. All in one, this approach allows us to identify if a system is in equilibrium if amenities are adjusting their values.

Table 4.3.3.1.1 Expected Static Results for the Main Variables

Variable	Wage		Rent
	Residents	Employers	
County Income			+
County Rent	+	*	
County Revenue			
Land Share	+	-	+
County Unemployment	+ (*)	- (*)	+
County Population		+	*
Population Growth	- (*)	+ (*)	+
PM 2.5	+ (*)	- (*)	-
Extreme Temp	+ (*)	- (*)	-
Sunshine	-	*	+
Private to Public School	-	+ (*)	+
Poor Water Quality	+ (*)	- (*)	-
Mammography	-	+ (*)	+
Physical Activity	-	+ (*)	+

High School Graduation	-	+ (*)	+
County Violent Crime	+	*	-
County Child Poverty	+ (*)	- (*)	-
County GINI	+	(*)	*

Note. * means that it may be very weak or ambiguous.

It is important to note that the insignificant County Revenue suggests the system is in equilibrium and that the benefits and costs of taxes are about equal based on the theoretical hypothesis.

4.3.3.2 Two-stage Least Squares

Recall equations (4),

(4) $$r = f\ (\frac{\partial t}{\partial g}, w, Z_g,\ l^c)$$

$$w = f\ (\frac{\partial t}{\partial g}, r, Z_g, l^c)$$

Each equation in equations (4) has an endogenous variable, which means that land rent (r) is a function of wage (w) and vice versa. To derive consistent estimates, we must find instrumental variables (IV) that satisfies the following two properties (Baum, 2006; Wooldridge, 2002, 2006): 1) the instrument Z_1 (Z_2) must be uncorrelated with an error term (u) but 2) must be highly correlated with the dependent variable (r or w, respectively). In other words, the instrument Z_1 in the rents equation (r) is a factor of the rent but should not be a significant factor in the wage (w). The simple model for single-equation instrumental variables regression can be written as follows:

(5) $$Y_i = Y_j\gamma_1 + X_{1i}\beta_2 + u_i$$

$$Y_j = X_{1i}\Pi_1 + X_{2i}\Pi_2 + \mathrm{v}_i, \text{ where}$$

Y_i represents the dependent variable for the *i*th observation (log county rent or wage), Y_j is the endogenous regressors, X_{1i} is 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 nonzero.

The models for the system in this research are the following:

(5a) **Rent equation in metro counties**

Log County Rent = f (Log County Income, County Revenue per capita, Land Share, County Population, High School Graduation, Extreme Temp, PM25, County Violent Crime, County GINI, Mammography, Physical Activity, Child Poverty, HStructure2, HStructure7, HYyear2, HRooms45, HBedrooms23, HBedrooms4),

where

Log County Income = f (County Unemployment, Pop Growth, Private Public School, Sunshine, Poor Water Quality, Private Employee, Occupation MBSA, Veteran, Mean Hour)

(5b) **Wage equation in metro counties**

Log County Income = f (Log County Rent, County Revenue per capita, Land Share, County Unemployment, Pop Growth, Private Public School, Sunshine, *County GINI, Poor Water Quality, Mammography, Private Employee, Occupation MBSA, Veteran, Mean Hour),*

where

Log County Rent = f (County Population, High School Graduation, Extreme Temp, PM25, County Violent Crime, Physical Activity, Child Poverty, HStructure2, HStructure7, HYyear2, HRooms45, HBedrooms23, HBedrooms4)

From equations (5a) and (5b), the variables County Revenue per capita, Land Share, County GINI, and Mammography appear in both rent and wage equations. The variables County Unemployment, Pop Growth, Private Public School, Sunshine, Poor Water Quality, Private Employee, Occupation MBSA, Veteran, Mean Hour appear in the wage equation (Log County Income) but not in the rent equation (Log County Rent), and thus they are essentially IVs.

The variables County Population, High School Graduation, Extreme Temp, PM25, County Violent Crime, Physical Activity, Child Poverty, HStructure2, HStructure7, HYyear2, HRooms45, HBedrooms23, HBedrooms4 appear in the rent equation but not in the wage equation, and thus IVs for the rent equation.

4.3.3.3 SAR and SEM Models with Additional Endogenous Variables

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

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

(6) $y = Y\pi + X\beta + \lambda Wy + u$

(7) $u = \rho Mu + \epsilon,$

where y is and $n \times 1$ vector of observations on the dependent variable (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 some of the right-hand-side exogenous variables may be spatial lags of exogenous variables (Drukker et al., 2011b). 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 nonstochastic, Drukker et al., 2011b), and $n \times 1$ vector spatial lags, Wy and Mu, and the corresponding scalar parameters, known as SAR parameters, λ and ρ, and $n \times 1$ vector of innovations is ϵ, which are assumed to be 1) independent and identically distributed or 2) independent but heteroskedastically distributed.

Equations (6) and (7) are modeled to include exogenous and additional endogenous regressors incorporating spatial interactions through spatial lags. The spatial interactions are modeled, allowing the model for spatial interactions in the dependent and the exogenous variables, and the error terms (Drukker et al., 2011b).

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

(8) $y = Y\pi + X\beta + \lambda Wy + \epsilon.$

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., 2011a, 2011b). Letting $\bar{y} = Wy$, $\bar{y_l}$ denoting the *i*th element of $\bar{y}$ 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 $\bar{y}$ as follows:

(9) $\bar{y_l} = \sum_{j=1}^{n} w_{ij}\, y_j.$

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., 2011b).

Setting $\lambda = 0$ reduced 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.

4.3.3.3 Implicit Price of an Amenity

To compute the implicit prices of the amenity in percentage terms and evaluate it at mean county income, this study employs the following equation from Roback (1982, p. 1263):

$$\frac{P_s^*}{w} = k_l \frac{d \log r}{ds} - \frac{d\log w}{ds}$$

$$\rightarrow \qquad P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w.$$

The average land's share of a consumer's budget (k_l) is 0.10 for metro, 0.075 for non-metro, and 0.084 for the continental United States. Average annual expected income (w) is \$51,180.93 for metro, \$43,993.65 for non-metro, and \$46,677.61 for all 3,109 counties.

For comparison purposes with Roback (1982), annualized values of County Violent Crime, and County Population are multiplied by 1,000 (crimes/100 pop.), and 10,000 (10,000 persons), respectively.

4.3.4 Analysis

4.3.4.1 Non-Spatial 2SLS Models: Metro versus Non-Metro

The units of analysis in this study are the 3,109 counties in the continental United States in 2012, which is the latest census year. Differentiating metro counties from non-metro counties, the results in this study are compared with those of Roback's earlier analysis for the 98 largest U.S. cities. To approximate the Roback (1982) sample, I first estimated the model for metropolitan counties only. Then, I followed with estimates for non-metropolitan and for the entire counties for the continental United States.

Table 4.3.4.1.1 Second-stage Results for Rent Equation: Metro versus Non-metro

Variable	Rent Equation Metro	Rent Equation Non-metro
Log County Income	-0.27***	-0.26***
	(0.0414)	(0.0437)
County Revenue	0.17×10^{-1}***	0.36×10^{-2}***
	(0.0025)	(0.0012)
Land Share	0.60×10^{1}***	0.72×10^{1}***
	(0.1550)	(0.1380)
County Population	0.48×10^{-7}***	0.15×10^{-5}***
	(8.53×10^{-9})	(1.78×10^{-7})
High School Graduation	0.57×10^{-3}***	0.33×10^{-4}
	(0.0002)	(0.0001)
Extreme Temp	-0.56×10^{-4}***	-0.17×10^{-4}***
	(4.10×10^{-6})	(3.53×10^{-6})
PM 2.5	-0.80×10^{-2}***	-0.49×10^{-2}***
	(0.0012)	(0.0010)
County Violent Crime	-0.43×10^{-4}**	0.40×10^{-4}*
	(0.000021)	(0.000020)
County GINI	0.59***	-0.47×10^{-1}
	(0.1586)	(0.1218)
Mammography	0.14×10^{-2}***	0.11×10^{-2}***
	(0.0005)	(0.0003)
Physical Activity	0.14×10^{-2}***	0.50×10^{-3}***
	(0.0002)	(0.0002)
Child Poverty	-0.13×10^{-1}***	-0.10×10^{-1}***
	(0.0011)	(0.0008)
R^2	0.8774	0.8307

Note. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%. See Appendix 4 for full statistics for all variables.

Table 4.3.4.1.2 Endogenous Tests for Rent Equation: Metro versus Non-Metro

Rent Equation for Metro

Tests of endogeneity
H_0: variables are exogenous

Durbin (score) chi2(1) = 71.4189 (p = 0.0000)
Wu-Hausman F (1,1141) = 74.7892 (p = 0.0000)

Rent Equation for Non-metro

Tests of endogeneity
H_0: variables are exogenous

Durbin (score) chi2(1)	= 20.516 (p = 0.0000)
Wu-Hausman F (1,1141)	= 20.5215 (p = 0.0000)

The endogenous tests reject the null hypothesis that Log County Income is exogenous at significant levels (Table 4.3.4.1.2).

Regarding Log County Income for both metro and non-metro rent equations, the negative sign indicate that a system is not quite in equilibrium. If the level of taxation required to provide public services were at equilibrium levels households would not have additional WTP (positive or negative) for public services. In places with high publicly provided amenities families are bidding up rent and bidding down wages. The second-stage results in Table 4.3.4.1.1 indicate direct effects of each variable on land values and different magnitude of the effects between metro and non-metro counties. All have expected signs for both metro and non-metro except the variable County GINI. GINI has positive effects on land values in metro whereas negative effects in non-metro but statistically insignificant for non-metro counties. This might imply that the unequal distribution of income leads to more property ownership by the richer segments in metro counties.

Table 4.3.4.1.3 First-stage Regression Summary Statistics for the Rent Equation: Metro versus Non-Metro

a. Rent Equation for Metro Counties

First-stage Regression Summary Statistics

Variable	R^2	Adjusted R^2	Partial R^2	F (9, 1134)	Prob > F
Log County Income	0.7668	0.7614	0.3744	75.3948	0.0000

Minimum Eigenvalue Statistic = 75.3948

Critical Values H_0: Instruments are weak			# of endogenous regressors: 1 # of excluded instruments: 9	
2SLS relative bias	5%	10%	20%	30%
	20.53	11.46	6.65	4.92
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	36.19	19.71	14.01	11.07
LIML Size of nominal 5% Wald test	3.81	2.93	2.54	2.32

b. Rent Equation for Non-metro Counties

First-stage Regression Summary Statistics

Variable	R^2	Adjusted R^2	Partial R^2	F (9, 1134)	Prob > F
Log County Income	0.5113	0.5047	0.1587	40.2537	0.0000

Minimum Eigenvalue Statistic = 40.2537

Critical Values H_0: Instruments are weak			# of endogenous regressors: 1 # of excluded instruments: 9	
2SLS relative bias	5%	10%	20%	30%
	20.53	11.46	6.65	4.92
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	36.19	19.71	14.01	11.07
LIML Size of nominal 5% Wald test	3.81	2.93	2.54	2.32

In first-stage regression summary statistics (Table 4.3.4.1.3), high R-squared and adjusted R-squared values indicate strong instruments. The column marked "Prob > F" indicates that the additional instruments have significant explanatory power for Log County Income after controlling for the effects of other variables in the rent equation. According to Hall, Rudebusch, and Wilcox (1996), and Stock, Wright, and Yogo (2002), simply having an *F* statistics that is significant is not sufficient. The *F* statistic should exceed 10 for inference based on the 2SLS estimator to be reliable when there is only one endogenous regressor. Using the minimum eigenvalue statistic as a further test of weak instruments is needed (Cragg & Donald, 1993). The test statistic in the sample is 73.40, which is identical to the *F* statistic because the model in this study contains one endogenous regressor.

The null hypothesis of each of Hausman, Stock, and Yogo's (2005) tests is that the set of instruments is weak. First, to perform these test, we must choose either the largest relative bias of the 2SLS estimator we are willing to tolerate or the largest rejection rate of a nominal 5% Wald test we are willing to tolerate. The test statistics of 73.40 exceeds all critical values of all the weak instrument tests (2SLS relative bias, 2SLS Size of nominal 5% Wald test, LIML Size of nominal 5% Walt test), and thus we can reject the null hypothesis of weak instruments.

Table 4.3.4.1.4 Reduced-form Results for Rent Equation: Metro versus Non-metro

Reduced-form	Metro		Non-metro	
Rent Equation	Coefficient	t-statistics	Coefficient	t-statistics
County Unemployment	0.10×10^{-1}***		0.92×10^{-3}	
	(0.0021)	4.99	(0.0017)	0.55
Population Growth	0.23×10^{-2}		0.14×10^{-2}	
	(0.0020)	1.15	(0.0016)	0.9
Private Public School	0.13×10^{-2}**		0.13×10^{-2}***	
	(0.0006)	2.2	(0.0004)	2.99
Sunshine	0.18×10^{-5}		0.12×10^{-2}	
	(0.0007)	0	(0.0007)	1.63
Poor Water Quality	-0.52×10^{-4}		0.31×10^{-4}	
	(0.0003)	-0.2	(0.0002)	0.18
County Revenue	0.12×10^{-1}***		0.35×10^{-2}***	
	(0.0023)	5.19	(0.0011)	3.15

Land Share	0.60×10^{1}***		0.74×10^{1}***	
	(0.1467)	41.16	(0.1267)	58.16
County Population	0.51×10^{-7}***		0.15×10^{-5}***	
	(7.89×10^{-9})	6.5	(1.82×10^{-7})	8
High School Graduation	0.64×10^{-3}***		0.24×10^{-3}**	
	(0.0002)	3.15	(0.0001)	2.05
Extreme Temp	-0.46×10^{-4}***		-0.18×10^{-4}***	
	(3.88×10^{-6})	−11.88	(3.84×10^{-6})	−4.62
PM 2.5	-0.71×10^{-2}***		-0.18×10^{-2}*	
	(0.0012)	−6.06	(0.0010)	−1.78
County Violent Crime	-0.39×10^{-4}**		0.15×10^{-4}	
	(0.000019)	−1.98	(0.000019)	0.75
County GINI	0.97×10^{-1}		−0.44***	
	(0.1454)	0.67	(0.1087)	−4.07
Mammography	0.13×10^{-2}***		0.10×10^{-2}***	
	(0.0004)	2.83	(0.0003)	4.07
Physical Activity	0.14×10^{-2}***		0.45×10^{-3}***	
	(0.0002)	6.27	(0.0002)	2.98
Child Poverty	-0.11×10^{-1}***		-0.82×10^{-2}***	
	(0.0009)	−12.95	(0.0006)	−13.09

Note. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Theoretically, the reduced form coefficients are estimates of the total (direct and indirect) effects of each of the variables. The second-stage coefficients in 2SLS are estimates of the structural parameters, which allow us to estimate the direct effects of the independent variables. Mathematically, over-identified system cannot find a solution to the structural equation model. It will be possible to choose a good IV for each equation for the structural model. This study employs the reduced-form coefficients estimates to compute the implicit prices of amenities.

Land Share is associated with high rent. Based on Roback's framework, the unit cost function is increasing in both factor prices (land and labor) on the producer side. And, increased residential land share lead to lower land share for firms, and thus leading to increase prices for firms. The increased residential land share might make residential area less competitive for consumer use given fixed land amount. The positive effects of the residential land share on rent have a larger magnitude in non-metro than in metro.

Table 4.3.4.1.5 Second-stage Results for Wage Equation: Metro versus Non-metro

Variable	Wage Equation Metro	Wage Equation Non-metro
Log County Rent	0.50***	0.43***
	(0.0430)	(0.0679)
County Revenue	0.43×10^{-2}*	0.51×10^{-2}***
	(0.0025)	(0.0016)
Land Share	-0.32×10^{1}***	-0.43×10^{1}***
	(0.3270)	(0.5823)
County Unemployment	-0.95×10^{-2}***	-0.19×10^{-1}***
	(0.0021)	(0.0020)
Population Growth	-0.69×10^{-2}***	0.10×10^{-1}***
	(0.0021)	(0.0022)
Private Public School	0.20×10^{-2}***	0.57×10^{-3}
	(0.0007)	(0.0006)
Sunshine	-0.27×10^{-2}***	0.26×10^{-3}
	(0.0006)	(0.0009)
County GINI	0.82***	0.43***
	(0.1280)	(0.1514)
Poor Water Quality	0.63×10^{-3}**	-0.30×10^{-3}
	(0.0003)	(0.0002)
Mammography	-0.14×10^{-2}***	0.23×10^{-2}***
	(0.0005)	(0.0004)
R^2	0.7019	0.3359

Note. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%. See Appendix 4 for full statistics for all variables.

In Table 4.3.4.1.5, population growth has a positive impact on wages in non-metro counties but a negative impact in metro counties. Agglomeration economies might be more relevant to non-metro region. Sunshine indicates the amenity effect in metro whereas it indicates the disamenity effect in non-metro counties but is statistically insignificant.

Table 4.3.4.1.6 Endogenous Tests for Wage Equation: Metro versus Non-metro

Wage Equation for Metro	
Tests of endogeneity	
H_0: variables are exogenous	
Durbin (score) chi2(1)	= 40.6324 (p = 0.0000)
Wu-Hausman F (1,1141)	= 41.5257 (p = 0.0000)
Wage Equation for Non-metro	
Tests of endogeneity	
H_0: variables are exogenous	
Durbin (score) chi2(1)	= 51.3962 (p = 0.0000)
Wu-Hausman F (1,1141)	= 52.3554 (p = 0.0000)

Table 4.3.4.1.6 indicates that the endogenous variable in the wage equation for both metro and non-metro meets tests of endogeneity.

Regarding the wage equation for non-metro, the *F* statistic exceeds 10 in the case of one endogenous regressor (Table 4.3.4.1.7). The row market 2SLS Size of nominal 5% Wald test contains critical value (35.32) pertaining to Hausman and colleagues' (2005) second characterization of weak instruments, which defines a set of instruments to be weak if a Wald test at the 5% level can have an actual rejection rate of no more than 10%, 15%, 20%, or 25%, which suggests that we are not able to reject the null hypothesis of weak instruments at most 10%. On the other hand, if we use the LIML estimator, we can reject the null hypothesis because 35.32 > 3.42.

Table 4.3.4.1.7 First-stage Regression Summary Statistics for Wage Equation: Metro versus Non-metro

a. Wage Equation for Metro Counties

First-stage Regression Summary Statistics

Variable	R^2	Adjusted R^2	Partial R^2	F (9, 1134)	Prob > F
Log County Rent	0.9004	0.8981	0.3817	53.8546	0.0000

Minimum Eigenvalue Statistic = 53.8546

Critical Values # of endogenous regressors: 1
H_0: Instruments are weak # of excluded instruments: 13

2SLS relative bias	5%	10%	20%	30%
	21.10	11.52	6.49	4.71
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	45.64	24.42	17.14	13.41
LIML Size of nominal 5% Wald test	3.42	2.63	2.29	2.10

b. Wage Equation for Non-metro Counties

First-stage Regression Summary Statistics

Variable	R^2	Adjusted R^2	Partial R^2	F (9, 1134)	Prob > F
Log County Income	0.8470	0.8449	0.1929	35.3243	0.0000

Minimum Eigenvalue Statistic = 35.3243

Critical Values # of endogenous regressors: 1
H_0: Instruments are weak # of excluded instruments: 13

2SLS relative bias	5%	10%	20%	30%
	21.10	11.52	6.49	4.71
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	45.64	24.42	17.14	13.41

LIML Size of nominal 5% Wald test	3.42	2.63	2.29	2.10

The rent equation's results meet all tests of endogeneity and weak instruments. The signs of all variables for metro counties are all expected based on the hypothesis in this study. Regarding the variable private to public school enrollment ratio, the variable indicates lack of confidence in the public system. The positive effect on wages implies when the public system is considered poor (high private to public ratio), residents will demand a higher wage in compensation.

Table 4.3.4.1.8 Reduced-form Results for Wage Equation Results: Metro versus Non-metro

Reduced-form Wage Equation	Metro Coefficient	*t*-statistics	Non-metro Coefficient	*t*-statistics
County Population	0.17×10^{-7}**		0.59×10^{-6}***	
	(8.03×10^{-9})	2.05	(2.29×10^{-7})	2.59
High School Graduation	0.80×10^{-3}***		0.14×10^{-3}	
	(0.0002)	3.9	(0.0001)	0.96
Extreme Temp	-0.17×10^{-4}***		0.52×10^{-5}	
	(3.95×10^{-6})	−4.26	(4.82×10^{-6})	1.08
PM 2.5	-0.28×10^{-2}**		-0.33×10^{-2}**	
	(0.0012)	−2.33	(0.0013)	−2.52
County Violent Crime	0.38×10^{-4}*		0.84×10^{-4}***	
	(0.000020)	1.87	(0.0000249)	3.37
Physical Activity	-0.45×10^{-5}		0.22×10^{-3}	
	(0.0002)	−0.02	(0.0002)	1.15
Child Poverty	-0.12×10^{-1}***		-0.99×10^{-2}***	
	(0.0009)	−13.56	(0.0008)	−12.48
County Revenue	0.84×10^{-2}***		0.12×10^{-2}	
	(0.0023)	3.59	(0.0014)	0.87
Land Share	0.25*		−0.78***	
	(0.1493)	1.7	(0.1592)	−4.88
County Unemployment	0.67×10^{-2}***		0.21×10^{-2}	
	(0.0021)	3.14	(0.0021)	1.01
Population Growth	-0.27×10^{-2}		0.99×10^{-2}***	
	(0.0020)	−1.31	(0.0020)	5.06
Private Public School	0.32×10^{-2}***	5.35	0.89×10^{-3}	1.63

	(0.0006)		(0.0005)	
Sunshine	$-0.19 \times 10^{-2***}$		$0.31 \times 10^{-2***}$	
	(0.0007)	−2.83	(0.0009)	3.48
County GINI	$0.15 \times 10^{1***}$		$0.10 \times 10^{1***}$	
	(0.1479)	10.39	(0.1366)	7.4
Poor Water Quality	0.67×10^{-3}		0.21×10^{-4}	
	(0.0003)	2.48	(0.0002)	0.1
Mammography	$-0.13 \times 10^{-2***}$		$0.13 \times 10^{-2***}$	
	(0.0005)	−2.8	(0.0003)	4.11

Note. Number of observations is 1,161 metropolitan counties and 1,948 non-metropolitan counties. Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%. See Appendix 4 for full statistics for all variables.

Table 4.3.4.1.9 Annualized Values: Metro

		Annualized Value	
Variable	Model Rent	Model Wage	Full Implicit Price
County Revenue (thousands of dollars per capita)	61.10	429.41	−368.32
Land Share (fraction to consumer budget)	30,900.19	13,025.45	17,874.75
County Unemployment (fraction to unemployment)	53.48	342.32	−288.84
Population Growth (percentage change in pop)	11.75	−136.24	147.99
Private Public School (fraction)	6.56	161.97	−155.41
Sunshine (% of possible)	0.0093	−98.08	98.09
County GINI (index)	497.34	78,664.43	−78167.10
Poor Water Quality (% pop. in water violation)	−0.26	34.11	−34.37
Mammography (% female Medicare enrollees)	6.41	−64.59	71.00
County Population (10,000 persons)	2.63	8.45	−5.82
High School Graduation (% of graduation rate)	3.25	41.10	−37.84
Extreme Temp (1°F colder for one day)	−0.24	−0.86	0.62
PM 2.5 (μg/m^3)	−36.29	−141.97	105.68

County Violent Crime (violent crimes/100,000 population)	−0.20	1.93	−2.13
Physical Activity (% pop. with access for physical activity place)	7.21	−0.23	7.44
Child Poverty (% children in poverty)	−56.52	−602.54	546.02

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is \$51,180.93 for metro.

Table 4.3.4.1.9 presents annualized values of variables from the wage and rent equations, and full implicit prices. The negative value of county revenue indicates that government services (g) may be overprovided, which imply that residents and firms are being compensated for higher taxes with higher income and lower land prices. The second-stage result for the rent equation indicate a negative sign of Log County Income indicating that a system is not quite not in equilibrium.

The full implicit prices of Social amenities variables, Private Public School, County GINI, Poor Water Quality, Mammography, County Violent Crime, and Physical Activity, have expected signs.

High school graduation rates, extreme temperature, PM 2.5, and child poverty have unexpected signs on the full implicit prices.

Table 4.3.4.1.10 Annualized Values: Non-metro

		Annualized Value	
Variable	Model Rent	Model Wage	Full Implicit Price
County Revenue (thousands of dollars per capita)	11.59	0.00	11.59
Land Share (fraction to consumer budget)	24,307.93	−0.84	24,308.77
County Unemployment (fraction to unemployment)	3.04	0.00	3.04
Population Growth (percentage change in pop)	4.63	0.03	4.60
Private Public School (fraction)	4.31	0.00	4.30
Sunshine (% of possible)	3.87	0.02	3.86
County GINI (index)	−1,459.08	6.14	−1,465.22
Poor Water Quality (% pop. in water violation)	0.10	0.00	0.10
Mammography (% female Medicare enrollees)	3.44	0.01	3.43
County Population (10,000 persons)	48.17	0.05	48.12
High School Graduation (% of graduation rate)	0.79	0.00	0.79
Extreme Temp (1°F colder for one day)	−0.06	0.00	−0.06
PM 2.5 ($\mu g/m^3$)	−6.04	−0.04	−6.00
County Violent Crime (violent crimes/100,000 population)	0.049	0.001	0.048
Physical Activity (% pop. with access for physical activity place)	1.48	0.00	1.48
Child Poverty (% children in poverty)	−27.14	−0.15	−26.99

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

Table 4.3.4.1.10 presents the annualized values of local amenity variables from the rent and wage equations, and the full implicit prices of amenities for non-metro counties. There are significant differences in the signs of the amenity values between metro and non-metro counties. County Revenue has a positive value in non-metro counties where as a negative value in metro counties. Government services in non-metro counties are underprovided. Private Public School's full implicit price value indicates amenity for non-metro counties. Residents in non-metro counties prefer private education system to public education. High school graduation rates are an amenity in non-metro (positive value of the full implicit price) whereas disamenity in metro (negative value of the full implicit price). County population's full implicit price indicates that it is an amenity in non-metro (positive number) whereas disamenity in metro (negative number). More populous rural areas are preferred but smaller urban areas are preferred.

The negative values of County GINI and Children Poverty indicate that they are disamenities.

4.3.4.2 Spatial Models with Additional Endogenous Variables

This section's approach is similar to the section 4.2.2.2 (Approach 2: Models for the Continental United States: Non-spatial versus Spatial). To employ spatial econometrics, I estimate equation for the entire continental United States. This study reports spatial regression results for the entire continental Unites States. That is 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.

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

I 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, I include a metro dummy variable and cross products of the metro dummy with each of variables. To implement 2SLS, I include all cross products of each of the explanatory variables at the second stage. But we need to consider interaction terms for the predicted endogenous variable at the second stage and thus each equation is assumed to have two endogenous variables (e.g., Log County Income and Metro×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 implements 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 equation (6, in section 4.2.1.3) to be independent and identically distributed (IID) or independent but heteroskedastically distributed, where the heteroskedasticity is of an unknown (see Drukker et al., 2011a, 2011b). I implemented both cases of homoskedastic and heteroskedastic specification in the econometric models and the results were identical except spatial autoregressive parameters for both wage and rent equations. The spatial autoregressive parameters in the heteroskedastic specification had slightly higher than the value in the homoskedastic specification.[19] Both specifications produced consistent estimates from the pretesting. Thus, I only report estimates from SEM 2SLS with an assumption of IID ϵ.

Table 4.3.4.2.1 Second-stage Results for Non-spatial versus Spatial 2SLS: Rent Equation 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***	-0.25***
	(0.0404)	(0.0595)
Metro×Log County Income	0.19×10^{-1}	0.16***
	(0.0588)	(0.0638)
County Revenue	0.31×10^{-2}***	0.31×10^{-2}***
	(0.0011)	(0.0018)
Metro×County Revenue	0.19×10^{-1}***	0.93×10^{-2}***
	(0.0030)	(0.0032)
Land Share	0.73×10^{1}***	0.73×10^{1}***
	(0.1196)	(0.5509)
Metro×Land Share	-0.12×10^{1}***	-0.64***
	(0.1884)	(0.4543)
County Population	0.15×10^{-5}***	0.12×10^{-5}***
	(1.67×10^{-7})	(1.72×10^{-7})
Metro×Population	-0.14×10^{-5}***	-0.11×10^{-5}***
	(1.67×10^{-7})	(1.72×10^{-7})
High School Graduation	0.11×10^{-3}	0.23×10^{-3}***
	(0.0001)	(0.0001)
Metro×High School Grad	0.41×10^{-3}	0.19×10^{-3}
	(0.0003)	(0.0002)
Extreme Temp	-0.23×10^{-4}***	-0.18×10^{-4}***

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[19] 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.

	(3.22×10^{-6})	(5.32×10^{-6})
Metro×Extreme Temp	-0.19×10^{-4}***	-0.82×10^{-5}*
	(4.79×10^{-6})	(4.62×10^{-6})
PM 2.5	-0.42×10^{-2}***	-0.26×10^{-2}*
	(0.0010)	(0.0013)
Metro×PM 2.5	-0.29×10^{-2}*	-0.14×10^{-2}
	(0.0016)	(0.0013)
County Violent Crime	0.37×10^{-4}*	0.39×10^{-4}**
	(0.000019)	(0.000018)
Metro×County Violent Crime	-0.73×10^{-4}**	-0.46×10^{-4}*
	(0.000030)	(0.000023)
County GINI	-0.74×10^{-1}	-0.15
	(0.1173)	(0.1126)
Metro×County GINI	0.76***	0.45***
	(0.2113)	(0.1884)
Mammography	0.11×10^{-2}***	0.79×10^{-3}***
	(0.0002)	(0.0003)
Metro×Mammography	-0.26×10^{-5}	0.44×10^{-3}
	(0.0006)	(0.0006)
Physical Activity	0.39×10^{-3}***	0.39×10^{-3}***
	(0.0001)	(0.0002)
Metro×Physical Activity	0.14×10^{-2}***	0.74×10^{-3}***
	(0.0003)	(0.0002)
Child Poverty	-0.96×10^{-2}***	-0.78×10^{-2}***
	(0.0008)	(0.0010)
Metro×Child Poverty	-0.33×10^{-2}**	0.12×10^{-2}
	(0.0015)	(0.0014)
Metro	-0.26	-1.87***
	(0.6297)	(0.7273)
R^2	0.8764	
rho (ρ)		0.8030***

Note. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.3.4.2.2 Direct Marginal Effects for Rent Equation: 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 4.3.4.2.1.

Table 4.3.4.2.2 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 effects values between spatial and non-spatial models. For metro counties, inclusion of spatial effects decreases the directs effects of violent crime and child poverty, which imply 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. Inclusion of spatial effects decreases slightly the direct marginal effect of physical activity opportunities in both metro and non-metro counties.

Table 4.3.4.2.3 Reduced-form Estimates for Rent Equation with a Metro Dummy and Cross Products for the Continental United States

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

	(0.0006)	(0.0005)
Extreme Temp	-0.18×10^{-4}***	-0.13×10^{-4}**
	(3.60×10^{-6})	(6.13×10^{-6})
Metro×Extreme Temp	-0.28×10^{-4}***	-0.21×10^{-4}***
	(5.70×10^{-6})	(6.30×10^{-6})
Sunshine	0.12×10^{-2}*	0.13×10^{-2}
	(0.0007)	(0.0013)
Metro×Sunshine	-0.12×10^{-2}	-0.51×10^{-3}
	(0.0010)	(0.0011)
PM 2.5	-0.18×10^{-2}*	-0.90×10^{-3}
	(0.0009)	(0.0013)
Metro×PM 2.5	-0.53×10^{-2}***	-0.35×10^{-2}***
	(0.0016)	(0.0014)
County Unemployment	0.92×10^{-3}	0.10×10^{-2}
	(0.0016)	(0.0017)
Metro×Unemployment	0.95×10^{-2}***	0.38×10^{-2}
	(0.0029)	(0.0030)
County Population	0.15×10^{-5}***	0.12×10^{-5}***
	(1.71×10^{-7})	(1.95×10^{-7})
Metro×Population	-0.14×10^{-5}***	-0.12×10^{-5}***
	(1.71×10^{-7})	(1.95×10^{-7})
Population Growth	0.14×10^{-2}	-0.99×10^{-3}
	(0.0015)	(0.0019)
Metro×Population Growth	0.89×10^{-3}	0.50×10^{-2}**
	(0.0027)	(0.0027)
Metro	0.15×10^{1}***	0.75
	(0.3740)	(0.5271)
rho (ρ)		0.7879***
		(0.0211)
R^2	0.8928	

Note. See Appendix 4 for full statistics for all variables. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.3.4.2.4 Total Marginal Effects for Rent Equation in the Continental United States: Metro versus Non-Metro and Non-spatial versus Spatial Model

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 4.3.4.2.2.

Tables 4.3.4.2.4 and 4.3.4.2.8 present estimated coefficients and calculated marginal effects between metro and non-metro for non-spatial and spatial models based on the reduced-form coefficients, which are estimates of total (direct and indirect) effects of each of the variables. In Table 4.3.2.4, we see decreased magnitude gap for County Revenues between metro and non-metro counties when including spatial interactions.

Table 4.3.4.2.5 Second-stage Results for Wage Equation 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***	0.33***
	(0.0605)	(0.0810)
Metro×Log County Rent	0.19**	0.23***
	(0.0781)	(0.0851)
County×Revenue	0.47×10^{-2}***	0.97×10^{-3}
	(0.0014)	(0.0039)
Metro×County Revenue	-0.54×10^{-3}	0.12×10^{-2}
	(0.0037)	(0.0047)
Land Share	-0.42×10^{1}***	-0.28×10^{1}***
	(0.5236)	(0.8252)
Metro×Land Share	0.58	0.18
	(0.6789)	(0.8045)
County Unemployment	-0.16×10^{-1}***	-0.14×10^{-1}***
	(0.0017)	(0.0024)
Metro×County Unemployment	0.13×10^{-2}	0.11×10^{-2}
	(0.0030)	(0.0033)
Population Growth	0.10×10^{-1}***	0.11×10^{-1}***
	(0.0020)	(0.0034)
Metro×Population Growth	-0.15×10^{-1}***	-0.14×10^{-1}***
	(0.0035)	(0.0040)
Private Public School	0.74×10^{-3}	0.45×10^{-3}
	(0.0006)	(0.0007)
Metro×Private Public School	0.12×10^{-2}	0.11×10^{-2}
	(0.0011)	(0.0011)
Sunshine	0.28×10^{-3}	0.43×10^{-3}
	(0.0008)	(0.0012)
Metro×Sunshine	-0.33×10^{-2}***	-0.33×10^{-2}***
	(0.0011)	(0.0012)
County GINI	0.42***	0.40***
	(0.1349)	(0.1590)
Metro×County GIN	0.38*	0.26
	(0.2097)	(0.1971)
Poor Water Quality	-0.28×10^{-3}	-0.30×10^{-3}
	(0.0002)	(0.0002)
Metro×Poor Water Quality	0.10×10^{-2}**	0.89×10^{-3}**
	(0.0005)	(0.0004)
Mammography	0.24×10^{-2}***	0.20×10^{-2}***
	(0.0003)	(0.0005)
Metro×Mammography	-0.41×10^{-2}***	-0.36×10^{-2}***
	(0.0007)	(0.0009)

Metro	−1.52***	−1.82***
	(0.6850)	(0.7315)
R^2	0.5011	
rho (ρ)		0.6413***

Note. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.3.4.2.6 Direct Marginal Effects for Wage Equation: 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 4.3.4.2.5.

Table 4.3.4.2.7 Reduced-Form Estimates: Wage Equation 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}	-0.32×10^{-3}
	(0.0012)	(0.0028)
Metro×County Revenue	0.72×10^{-2}**	0.78×10^{-2}**
	(0.0034)	(0.0034)
Land Share	−0.78***	−0.44**
	(0.1418)	(0.2036)
Metro×Land Share	0.10×10^{1}***	0.11×10^{1}***

	(0.2449)	(0.2413)
County Violent Crime	0.84×10^{-4}***	0.69×10^{-4}***
	(0.000022)	(0.000025)
Metro×Violent Crime	-0.46×10^{-4}	-0.48×10^{-4}
	(0.000035)	(0.000029)
Private Public School	0.89×10^{-3}*	0.51×10^{-3}
	(0.0005)	(0.0006)
Metro×Private Public School	0.23×10^{-2}**	0.22×10^{-2}**
	(0.0009)	(0.0010)
County GINI	0.10×10^{1}***	0.79***
	(0.1217)	(0.1558)
Metro×County GINI	0.53**	0.50**
	(0.2324)	(0.2320)
Child Poverty	-0.99×10^{-2}***	-0.86×10^{-2}***
	(0.0007)	(0.0009)
Metro×Child Poverty	-0.19×10^{-2}	-0.16×10^{-2}
	(0.0014)	(0.0012)
Physical Activity	0.22×10^{-3}	0.14×10^{-3}
	(0.0002)	(0.0002)
Metro×Physical Activity	-0.22×10^{-3}	-0.88×10^{-4}
	(0.0003)	(0.0003)
High School Graduation	0.14×10^{-3}	0.42×10^{-4}
	(0.0001)	(0.0001)
Metro×High School Graduation	0.66×10^{-3}**	0.51×10^{-3}*
	(0.0003)	(0.0003)
Poor Water Quality	0.21×10^{-4}	-0.15×10^{-3}
	(0.0002)	(0.0002)
Metro×Poor Water Quality	0.65×10^{-3}	0.53×10^{-3}
	(0.0004)	(0.0004)
Mammography	0.13×10^{-2}***	0.12×10^{-2}***
	(0.0003)	(0.0005)
Metro×Mammography	-0.26×10^{-2}***	-0.22×10^{-2}***
	(0.0007)	(0.0008)
Extreme Temp	0.52×10^{-5}	0.52×10^{-5}
	(4.29×10^{-6})	(6.39×10^{-6})
Metro×Extreme Temp	-0.22×10^{-4}***	-0.26×10^{-4}***
	(6.81×10^{-6})	(7.38×10^{-6})
Sunshine	0.31×10^{-2}***	0.33×10^{-2}***
	(0.0008)	(0.0012)
Metro×Sunshine	-0.51×10^{-2}***	-0.52×10^{-2}***
	(0.0012)	(0.0013)
PM 2.5	-0.33×10^{-2}***	-0.36×10^{-2}**
	(0.0011)	(0.0016)
Metro×PM 2.5	0.48×10^{-3}	0.90×10^{-3}
	(0.0020)	(0.0018)

County Unemployment	0.21×10^{-2}	0.87×10^{-3}
	(0.0019)	(0.0026)
Metro×Unemployment	0.45×10^{-2}	0.21×10^{-2}
	(0.0034)	(0.0032)
County Population	0.59×10^{-6}***	0.40×10^{-6}**
	(2.04×10^{-7})	(1.98×10^{-7})
Metro×County Population	-0.58×10^{-6}***	-0.38×10^{-6}*
	(2.04×10^{-7})	(1.99×10^{-7})
Population Growth	0.99×10^{-2}***	0.98×10^{-2}***
	(0.0017)	(0.0030)
Metro×Population Growth	-0.13×10^{-1}***	-0.13×10^{-1}***
	(0.0032)	(0.0038)
Metro	-0.31**	-0.01
	(0.4465)	(0.5204)

Note. See Appendix 4 for full statistics for all variables. Number of observations is 3,109 (counties for the continental United States). Standard errors are in parentheses. ***Significant at 1%, ** significant at 5%, and * significant at 10%.

Table 4.3.4.2.8 Total Marginal Effects for Wage Equation in the Continental United States: Metro versus Non-metro

Rent Equation	Non-spatial Model		Spatial Model	
Variable	Non-metro	Metro	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 4.3.4.2.7.

Table 4.3.4.2.9 Annualized Values based on Non-spatial Model for Metro

	Annualized Value		
Variable	Rent Equation	Wage Equation	Full Implicit Price
County Revenue (thousands of dollars per capita)	61.10	429.41	−368.32
Land Share (fraction to consumer budget)	30,900.19	13,025.22	17,874.98
County Violent Crime (violent crimes/100,000 population)	−0.20	1.93	−2.13
Private Public School (fraction)	6.56	161.96	−155.40
County GINI (index)	497.34	78,655.21	−78,157.87
Child Poverty (% children in poverty)	−56.52	−602.36	545.84
Physical Activity (% pop. with access for physical activity place)	7.21	−0.23	7.44
High School Graduation (% of graduation rate)	3.25	41.08	−37.83
Poor Water Quality (% pop. in water violation)	−0.26	34.10	−34.36
Mammography (% female Medicare enrollees)	6.41	−64.7	70.98
Extreme Temp (1°F colder for one day)	−0.24	−0.86	0.62
Sunshine (% of possible)	0.01	-98.07	98.08
PM 2.5 ($\mu g/m^3$)	−36.29	−141.93	105.64
County Unemployment (fraction to unemployment)	53.48	342.31	−288.83
County Population (10,000 persons)	2.56	8.19	−5.63
Population Growth (percentage change in pop)	11.75	−136.24	147.99

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is \$51,180.93 for metro.

Child Poverty, high school graduation rates, extreme temperature, and PM 2.5 have unexpected sign 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 effecting firms in metro counties might increase costs of production. Higher human capital stock also might increase firms' costs in metro counties.

Table 4.3.4.2.10 Annualized Values based on Spatial Model for Metro

		Annualized Value	
Variable	Rent Equation	Wage Equation	Full Implicit Price
County Revenue (thousands of dollars per capita)	47.14	385.77	−338.62
Land Share (fraction to consumer budget)	33,851.50	33,533.65	317.85
County Violent Crime (violent crimes/100,000 population)	−0.07	1.07	−1.14
Private Public School (fraction)	6.38	138.49	−132.11
County GINI (index)	−38.97	66,045.64	−66,084.60
Child Poverty (% children in poverty)	−37.37	−520.57	483.20
Physical Activity (% pop. with access for physical activity place)	4.19	2.53	1.66
High School Graduation (% of graduation rate)	2.11	28.10	−25.99
Poor Water Quality (% pop. in water violation)	−1.56	19.35	−20.91
Mammography (% female Medicare enrollees)	5.55	−47.64	53.20
Extreme Temp (1°F colder for one day)	−0.17	−0.91	0.74
Sunshine (% of possible)	3.98	−97.24	101.22

PM 2.5 (µg/m^3)	−22.55	−136.41	113.86
County Unemployment (fraction to unemployment)	24.54	153.58	−129.04
County Population (10,000 persons)	1.54	5.63	−4.09
Population Growth (percentage change in pop)	20.66	−169.61	190.27

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.01 for metro. Average annual expected income (w) is \$51,180.93 for metro.

In Tables 4.3.4.2.9 and 4.3.2.10, the inclusion of spatial interactions decreased the magnitude of the full implicit prices both County GINI and violent crime. This is presented for non-metro counties in Tables 4.3.4.2.11 and 4.3.4.2.12.

Table 4.3.4.2.11 Annualized Values based on Non-spatial Model for Non-metro

		Annualized Value	
Variable	Rent Equation	Wage Equation	Full Implicit Price
County Revenue (thousands of dollars per capita)	11.59	53.39	−41.80
Land Share (fraction to consumer budget)	24307.93	−34,182.32	58,490.25
County Violent Crime (violent crimes/100,000 population)	0.05	3.70	−3.65
Private Public School (fraction)	4.31	39.31	−35.00
County GINI (index)	−1,459.08	44,498.96	−45,958.04
Child Poverty (% children in poverty)	−27.14	−433.76	406.62
Physical Activity (% pop. with access for physical activity place)	1.48	9.58	−8.10
High School Graduation (% of graduation rate)	0.79	6.17	−5.39
Poor Water Quality (% pop. in water violation)	0.10	0.92	−0.81

Mammography (% female Medicare enrollees)	3.44	58.23	−54.79
Extreme Temp (1°F colder for one day)	−0.06	0.23	−0.29
Sunshine (% of possible)	3.87	138.39	−134.52
PM 2.5 ($\mu g/m^3$)	−6.04	−143.15	137.11
County Unemployment (fraction to unemployment)	3.04	94.28	−91.24
County Population (10,000 persons)	48.17	261.41	−213.23
Population Growth (percentage change in pop)	4.63	435.16	−430.53

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

Table 4.3.4.2.12 Annualized Values based on Spatial Model for Non-metro

		Annualized Value	
Variable	Rent Equation	Wage Equation	Full Implicit Price
County Revenue (thousands of dollars per capita)	11.15	−12.23	23.38
Land Share (fraction to consumer budget)	24,271.69	−19,230.98	43,502.67
County Violent Crime (violent crimes/100,000 population)	0.07	3.01	−2.95
Private Public School (fraction)	2.33	22.30	−19.97
County GINI (index)	−1,280.84	34,632.02	−35,912.86
Child Poverty (% children in poverty)	−20.80	−378.58	357.78
Physical Activity (% pop. with access for physical activity place)	1.55	6.05	−4.49
High School Graduation (% of graduation rate)	0.94	1.85	−0.90

Poor Water Quality (% pop. in water violation)	0.10	−6.78	6.88
Mammography (% female Medicare enrollees)	1.91	54.69	−52.78
Extreme Temp (1°F colder for one day)	−0.04	0.34	−0.38
Sunshine (% of possible)	4.26	143.52	−139.26
PM 2.5 ($\mu g/m^3$)	−2.97	−157.03	154.06
County Unemployment (fraction to unemployment)	3.39	38.32	−34.93
County Population (10,000 persons)	39.26	173.83	−134.57
Population Growth (percentage change in pop)	−3.28	432.87	−436.15

Note. Annualized value is in dollars. Measurement units of amenities shown under variable name. Each entry is computed using equation (17) in section 4.1.3 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's share of the consumer's budget (k_l) is 0.075 for non-metro counties. Average annual expected income (w) is $43,993.65 for non-metro counties.

Like metro counties, including spatial interactions 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 positive full implicit price, which indicates g is underprovided. PM 2.5 has unexpected positive value for the full implicit price due to large negative wage effect.

4.3.5 Implications and Concluding Remarks

The results of this second empirical application are largely consistent with those of Roback and others. Like the first empirical application, rent equations are better fit than the wage equations in terms of the expected values of local amenities. This seem to support the idea that place-based immobile non-marketed assets are more likely to capitalized into the land values than into wages which are influenced by factors such as minimum wages, company policies, and union contracts.

There are apparently differences between 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 empirical results seem to fit better to metro counties than to non-metro counties. In the first empirical application, this study tested regional differences differentiating metro from non-metro, using a metro dummy. Also, this study considered spatial dependency in the error term in the neighboring counties. Still, it might seem to fit better for metro counties than for non-metro counties. It may be possible to better understand the spatial relationship by more explicitly considering the interactions between non-metro counties adjacent to metro versus those not adjacent to metros. Rural-urban continuum codes (RUCC) and urban influence codes (UIC) may provide more categories for metro and non-metro counties according to adjacency to metro areas and population. If we divide more non-metro counties (e.g., non-core adjacent to large metro, micropolitan area adjacent to large metro, non-core adjacent to small metro area and contains a town of at least 2,500 residents, etc.), we may be able to identify differences between non-metro with metro and non-metro without metro counties. There are 9

(RUCC) or 12 (UIC) categories for metro and non-metro divisions. Thus, the models will be expanded as 9 or 12 models for each dependent variable.

Some amenities are more related to consumers whereas others are related to firms. Other amenities are related to both consumers and producers. Combining these, further study needs to identify what amenities are related to consumers and producers, incorporating migration patterns or flows. Then, we may be able to identify which locations will be more consumption-based or production-based locations, reflecting the assumption of the costless migration in the model.

Chapter 5: Summary and Conclusions

Although consensus has emerged among scholars from various disciplines regarding the importance of measuring comprehensive wealth, substantial gaps remain in our knowledge about explicit wealth concepts, measurements, methods, appropriate indicators, and availability of data at various spatial scales. Thus, one of the major contributions in this study was to fill some of these knowledge gaps.

This dissertation provided explicit concepts of comprehensive wealth, surveying literature from sociological to economic theories. In particular, this study focused on how different types of assets (mobile versus immobile) can produce different types of benefits (marketed versus non-marketed) according to comprehensive wealth concepts. It is especially identified how investments in intangible assets can contribute to benefits for both marketable and non-marketable benefits. Differentiating immobile from mobile capital and external from internal benefits help us to define social amenities of a location explicitly. For instance, public investments in social capital and public programs can produce both private benefits, such as higher property values and improved health, and social benefits as positive externalities, such as lower crime rates and lower poverty.

One of the crucial notions in this dissertation was the role of social context in economic activities. Given its focus on exogenous natural and publicly provided amenities in the spatial economics literature, this study extended the Roback model to include endogenous social amenities provided by both private and public investments. Extending and applying the comprehensive wealth concept to measure the value of social amenities generated as a result of public and private investments in addition to various sets of natural amenities are major contributions of this research. Using data on all counties in the contiguous 48 states, this study estimates the value that households place on amenities (including social amenities) in metro versus non-metro counties and in the major regions. The empirical analysis estimated the marginal effects of variations in spatial characteristics (including social amenities) on land values and wages. Thus, this study incorporated differences in spatial attributes (largely due to uneven regional specific characteristics, as pointed out by Kilkenny, 2010) between metro and non-metro counties in the continental United States.

The general hedonic spatial equilibrium framework this study employed allowed us to determine how intangible and non-marketable assets (i.e., local amenities) are capitalized into marketable assets (e.g., land values), and to determine their implicit values using market values. This dissertation selected the Roback spatial equilibrium model to measure comprehensive wealth of a location for the following reasons: 1) to avoid double-counting the value of assets, and 2) to capture interaction effects between tangible marketed and largely intangible non-marketed assets using market values.

One of the challenges when measuring the value of wealth is to avoid double-counting the value of assets. Many intangible and non-marketable assets increase the value of tangible assets such as land. The spatial equilibrium framework can help us to avoid the double-counting by capturing the indirect effects of the non-marketed immobile assets on market assets. In addition to these, since the model assumes that balancing benefits of both positive and negative externalities are capitalized into the values of wages and land rents values at the equilibrium, we do not need to estimate the both sources of externalities separately.

The accuracy of the captured value depends on the methods and data used to estimate local income, property and land values. Thus, this dissertation focused on developing more accurate data on local income, property and land values, which are more related to place-based measurement at the county-level. In particular, development of expected average county income reflects earnings from local sources only. Excluding income that is unrelated to place (e.g., pension, retirement benefits, return on financial investments) allows us to estimate more accurately, the effects of location decision if households or firms move to a certain location. The developed data on the county income can help us to identify how much income from local sources will be received if we live in a particular place.

Also, development of expected average county rent for residential sites controls simultaneous effects of the tax rates and the amenity effects on land values. Oates' (1969) results imply that people appear willing to pay more to live in a location which provides high-quality public services or same level of public services with lower tax rates. For instance, Gyourko et al. (1991) includes tax rates and amenities that could be influenced by the level of public services in their model and thus the simultaneous effects of those tax rates and the amenity effects on land values. In addition, as Oates (1969) indicates, the quality or level of local public services, such as public education system, enhances the local residential property values, not all property values. Thus, estimated rent values for the residential sites in this study differentiate amenity effects on residential sites from the effects on other types of land. Identifying what amenities enhance the residential site value in this study can provide reasonable reflections of the benefits from the local public services, offsetting depressive effects of the higher taxes required to finance the expanded public program.

This dissertation includes substantial findings and observations from empirical analyses. First, the results here are largely consistent with those of Roback and others (e.g., BBH), and with theoretical expectations. Roback's spatial equilibrium theoretical framework hypothesizes that the value of an amenity is positively related to land values and negatively related to wages. Because of the interactions between production and consumption benefits of amenities, the expected sign of coefficients in the wage equation can be ambiguous. This study hypothesized that the wage coefficients can be either positive, negative, and or insignificant on balance based on the supply and demand perspective in terms of consumer and producer sides of labor market. Thus, we identify why the sign and values of some coefficients in the wage equations differed from case to case. However, the full implicit values depend on the combined impact on both rent and wage equation.

We observed significantly different effects of amenities on wages and land values between metro and non-metro counties. For instance, the compensating wage effect of population growth outweighs the effect on the property value in non-metro counties but the opposite in metro counties, and thus the sign of the full implicit values was different between metro (positive) and non-metro (negative).

In addition, this study found significant differences between value of amenities in metro and non-metro counties even when there is no spatial variation in terms of each variable's mean value, such as climate or environmental amenities (e.g., particulate matter and sunshine variables indicate no differences of the mean values between metro, non-metro, and nation.).

Also, this study analyzed regional differences using two approaches. First, this study employed regional dummies as in Roback and found that the regional dummy played a reduced role when differences in observed amenities are taken into account. In addition, we ran separate models for each of the regions (i.e., Northeast, South, West, and Midwest) to measure the degree to which residents of the regions values the various amenities differently. For instance, one of the results indicated that average residents in northeastern and western counties value the heating degree days as an amenity whereas it was considered a disamenity in southern and midwestern counties. In the rent equation results, unequal distribution of income (County GINI) has positive effects on land values in northeastern counties but negative effects in midwestern counties.

Another crucial contribution of this study is to expand the Roback model by the inclusion of spatial interactions in the econometric specification. In particular, the spatial effects influenced social amenity variables, such as GINI and violent crime, rather than exogenous climate amenities, such as sunshine. From the results of the first empirical application (section 4.2 Revisiting Roback's Spatial Equilibrium Model: A County-level Analysis with an Explicit Analysis), including spatial interaction increased the magnitude of the full implicit price for County GINI but decreased it for violent crime for both metro and non-metro, indicating violent and unequal distribution of income are disamenities. From the results of the second empirical application (section 4.3 Extending Roback's Spatial Equilibrium Model: Public Services as Immobile and Non-marketed Endogenous Amenities), including spatial interaction decreased the magnitude of the full implicit price for both County GINI and violent crime, indicating disamenities, which are consistent with the previous analysis. This implies that people prefer places with less violent crime and a more equal distribution of income.

The developed model in this study provided a good way to determine if the system is in equilibrium if amenities are adjusting their values. In addition, the model allowed us to identify the relationship between government services (*g*) and their price (tax, government expenditures, or revenues) if the services are overprovided or underprovided, by using the estimated implicit price of the services. For instance, the results indicated that *g* is overprovided in metro counties but underprovided in non-metro counties, including spatial effects in model specification (section 4.3.4.2).

There are important policy implications of this research. Policies to enhance social amenities from immobile social capital and local public services may be a feasible regional growth strategy in many counties, reducing both real costs of production and the societal opportunity costs of development in the long-term. It is important to note that place-based immobile non-marketable assets including social amenities are more likely to be capitalized into land values rather than wages. Well-designed policy and investment in immobile and non-marketed amenities of a location will make a place more attractive and sustainable with enhanced land values, which cannot move. The proposed typology can be useful for designing policy and investment plans for sustainable regional economic development. Also, the model will be able to conduct simulations to predict effects of changing dynamics of wealth among different combinations of regional assets.

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Appendix 1: Capitals Definitions

The following definitions come from Pender et al. (2014, pp. 18–20):

“Physical, produced or built capital includes the stock of produced capital goods (i.e., buildings and equipment) used by firms to produce outputs; infrastructure used to reduce costs of commerce (e.g., roads, bridges, waterways, telecommunication networks) or provide public services (e.g., water and sewer treatment plants); and durable goods used by households for either production or consumption purposes (e.g., houses, vehicles, household equipment).

Physical capital depreciates over time and with use and requires ongoing investment to maintain its value. Depreciated physical capital may not be wealth at all; in fact it may be detrimental to well-being. Like all forms of capital, physical capital can contribute to well-being by contributing to other forms of wealth. For example, sewer and water treatment plants contribute to human capital (health). Schools contribute to human capital (skill development) and social capital (if they are used as community gathering places) and may contribute to natural capital (if they include natural areas that are maintained or protected by the school).

Financial capital is the stock of money and other liquid financial assets, such as stocks, bonds, and letters of credit – net of financial liabilities – that can be readily converted to money. Financial capital includes claims of rights to flows of income or services from other forms of capital. For example, owners of stock shares of a corporation own rights to earnings that flow from the use of the corporation’s full set of assets. For many forms of financial capital, such as bonds and other forms of credit, one person’s asset is someone else’s liability, so these do not contribute directly to the net wealth of society as a whole, although they contribute positively to the wealth of some and negatively to others. Financial capital, if well-managed, generates monetary returns that can be used for further investment or consumption. Unlike some other forms of capital, financial capital does not contribute directly to production or well-being. Rather, its contribution is instrumental, by facilitating transactions in other forms of capital and in goods and services, providing liquidity and helping people to manage risk. Natural capital is the stock of healthy environmental assets (e.g. air, water, land, flora, fauna, etc.) in a region that are capable of producing returns in the form of flows of goods, services, and/or ecosystems services on a sustainable basis (Costanza and Daly, 1992).

Natural capital includes: 1) non-renewable resources such as oil and minerals that are extracted from ecosystems, and 2) renewable resources such as fish, wood, and drinking water that are produced and maintained by the processes and functions of ecosystems. Investments in natural capital include restoration and maintenance. ―Income from natural capital includes a sustainable supply of raw materials and environmental services such as maintenance of the quality of the atmosphere, climate, operation of the hydrological cycle including flood controls and drinking water supply, waste assimilation, recycling of nutrients, generation of soils, pollination of crops, and the maintenance of a vast genetic library. Natural capital and its systems are essential for life. People can destroy, degrade, impair and/or restore natural capital but cannot create it.

Human or individual capital is the stock of skills and physical and mental health of people. Investments in human capital include spending on skill development (e.g. literacy, numeracy, computer literacy, technical skills, etc.) and health maintenance and improvement. ―Income from investments in human capital includes psychic and physical energy for productive engagement and capacity to use and apply existing knowledge and internalize new knowledge to increase productivity.

Intellectual capital is the stock of knowledge, innovation and ideas embodied not in individual minds – as individual capital is – but instead in the enduring intellectual products those minds have created. Intellectual capital is thus dependent on the human capital involved in creating it, but exists separately from particular individuals. Innovation involves creating new knowledge and discovering new products, ideas or new ways of organizing human activities. Investment in intellectual capital is often through research and development and support for activities that engage the imagination, as well as diffusion of new knowledge and applications. Intellectual capital may be owned privately or in common by the public (e.g., common knowledge). Intellectual property rights, such as patents and copyright protections, are used to provide private rights to intellectual capital, to increase incentives for private individuals and firms to invest in creating it. ―Income‖ from intellectual capital includes the economic and psychic returns from inventions, new discoveries, new knowledge, and new ways of seeing.

Social capital is the stock of trust, relationships, and networks that support civil society (Putnam, 1993). There are two forms of social capital; bridging and bonding (Gittell and Vidal, 1998). Investments in bridging social capital are those that lead to unprecedented conversations, shared experiences, and connections between otherwise unconnected individuals and groups. Investments in bonding social capital are those that strengthen relationships within groups. For example, sponsoring a town-wide festival could be seen as an investment in bonding social capital for town residents. As with other forms of capital, aspects of social capital may be owned by individuals (e.g. the social obligations that one friend ―owes to another, which are one person's asset and the other's liability), or by groups (e.g., a social network). ―Income from investment in social capital includes returns from improved coordination and collective action, such as improved health outcomes, educational outcomes, and reduced transaction costs, among others.

Political capital is the stock of power and goodwill held by individuals, groups, and evidenced by the ability of an individual or a group to influence the distribution of resources within a social unit, including helping set the agenda of what resources are available. Investments in political capital are made through inclusive organizing that includes information gathering and dissemination, and increasing voice, access to and inclusion among decision-makers. ―Income from investments in political capital includes increased influence in decision making, increased access to and control over other forms of capital, and the ability to engage in reciprocal relationships, among others.

Cultural capital is the stock of practices that reflect values and identity rooted in place, class, and/or ethnicity (Baumann and Sinha, 2009). Cultural capital influences the ways in which individuals and groups access other forms of capital. Cultural capital includes the dynamics of who we know and feel comfortable with, what heritages are valued, collaboration across races, ethnicities, and generations, etc. Investments in cultural capital create or sustain the values, traditions, beliefs, and/or language that become the currency to leverage other types of capital. Investments in cultural capital could include support for venues to showcase cultural achievements, programs to preserve and pass on cultural knowledge and skills, and support for cultural transformations, among other things. ―Income from investments in cultural capital may include increased ―buy in to institutional rules and shared norms of behavior, strengthened social capital and increased access to other capitals through increased visibility and appreciation of cultural attributes and through cultural transformation, e.g. acquisition of language skills (Bebbington, 1999; Jeannotte, 2003)".

Appendix 2: Detailed Data Description and Sources

Calculating the variable *w*:

Some counties (especially in Virginia) cause a problem for the consistent measure 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).

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 Fairfax 51600 Fairfax City 51610 Falls Church	51951 Spotsylvania + Fredericksburg, VA 51177 Spotsylvania 51630 Fredericksburg
51921 Frederick + Winchester, VA	51953 Washington + Bristol, VA

51069 Frederick 51840 Winchester	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 July 1, 2013. Clifton Forge (independent) city, Virginia (FIPS: 51560) changed to town status and was added to Alleghany County (FIPS: 51005) effective July 1, 2001. The separate Virginia county and independent city data are not available. This study compared the ratio of labor force or employed number between combined places, and the both have similar values of (almost the same) the ratio. It is presumed to assign each missing value as labor force ratio between combined places multiplied by combined value.

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

Table 4.1.2.1.1 Climate, Geographic, and Environmental Variables

Variable	Descriptive	Source
PM 2.5	Particulate matter 2.5 micrometers 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 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., & Pope, J. C. (2015). "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).

4.1.2.2.1 Opportunities for Local Physical Activity

The following data sources and descriptions on access to exercise opportunities come from County Health Rankings & 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 for 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-minute walk to a park and a 5-10 minute 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 ½ mile to a park, but in some communities a ½ 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 4.1.2.2.2.1 Quality/Outcomes of Public Services

Variable	Descriptive	Source
Private to Public School	Calculated as 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 percentage of enrolled population in public and private schools with total number of enrollment.
Poor Water Quality	% of 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 ages 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 & 2012, OneSource Global Business Browser, Delorme map data, ESRI, & 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 4.1.2.4.1 County's General Characteristics

Variable	Descriptive	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	Population growth rate for 2010 and 2012 (calculated), $(\frac{\text{Population change}}{\text{Total population change}})\times 100$	Population change follows cumulative estimates of the components of population change from April 1, 2010 to July 1, 2012 – Total population change, 2012 Census Population Estimates

Table 4.1.2.4.2 Other Social Amenities

Variable	Descriptive	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

Housing Characteristics for Rent Equation and Personal/Households Characteristics for Wage Equation

Variable	Descriptive	Source
Housing vacancy	Housing vacancy rate owner-occupied housing units	2012 ACS 5yrs estimates
HStructure2	% attached units in structure owner-occupied housing units	2012 ACS 5yrs estimates
HStructue7	% mobile home or other type of housing owner-occupied housing units	2012 ACS 5yrs estimates
HYear2	% year structure built from 2000 to 2009 – owner-occupied housing units	2012 ACS 5yrs estimates
HRooms45	% 4 or 5 rooms – owner-occupied housing units	2012 ACS 5yrs estimates
HBedrooms23	% 2 or 3 bedrooms – owner-occupied housing units	2012 ACS 5yrs estimates
HBedrooms4	% 4 or more bedrooms – owner-occupied housing units	2012 ACS 5yrs estimates
White	% White population	2012 Population Estimates, Census
Private Employee	Employee of private company workers (%); Civilian employed population 16 years and over.	2012 ACS 5yrs estimates
Occupation MBSA	Management, business, science, and arts occupations (%)	2012 ACS 5yrs estimates
Occupation Sales Office	Sales and office occupations (%)	2012 ACS 5yrs estimates
Occupation NCM	Natural resources, construction, and maintenance occupations (%)	2012 ACS 5yrs estimates
Occupation PTM	Production, transportation, and material moving occupations (%)	2012 ACS 5yrs estimates
Married	% now married (except separated); population 15 years and over	2012 ACS 5yrs estimates
Veteran	% veteran status for the population 18 years and over.	2012 ACS 5yrs estimates
Mean Hour	Mean usual hours worked for workers (weekly)	2012 ACS 5yrs estimates, Work status in the past 12 months
High School Labor Force	% high school graduate (includes equivalency) in labor force	2012 ACS 5yrs estimates

Appendix 3: Pretesting Regressions

Note. I included all person/household characteristics for wage equation and housing characteristics for rents equation but reported selected variables. In the pretesting.
I calculate the implicit price of the amenity in percentage terms as follows (section 4.1.3, equation [17]):

$$\frac{P_s^*}{w} = k_l \frac{d \log r}{ds} - \frac{d\log w}{ds}$$

$$\rightarrow \quad P_s^* = (k_l \frac{d \log r}{ds} - \frac{d\log w}{ds})w,$$

where k_l is the share of land in the consumer's budget, P_s^* is "the amount of income required to compensate for a small change in *s*" (Roback, 1982, p. 1263), and w is the county's average annual expected income.

The average county income is \$51,180.93, \$43,993.65, and \$46,677 for metro, non-metro and nation, respectively.

The calculated values of the average land's share of the consumer's budget (k_l) is 0.10 for metro, 0.075 for non-metro, and 0.084 for the continental United States.

This section includes 8 versions for the pretesting regressions.

For all versions, this study ran separate sets of regressions with a different climate amenity in addition to all climate variables in the same model. Roback (1982) ran four separate regressions each with a different climate amenity. Thus, this study followed Roback's analysis.

Version 1: Approximating Roback (1982)

This version is based on 1,161 metropolitan counties. I used total crime and replaced total particulate level with PM2.5, including poverty indicator for wage equation only. Climate variables are heating degree days, precipitation, wind speed, and sunshine.

Wage Equation	Model1	Model2	Model3	Model4	Model5
County Total Crime	-.00001788***	-.00001876***	-.00001789***	-.00001884***	-.00001678***
County Unemployment	-0.00246794	-0.00369904	-0.00054709	-0.00322555	0.00039554
PM 2.5	-0.00224376	-0.00226498	-0.00072016	-.00357664**	-0.00093896

County Population	3.119e-08***	2.570e-08**	2.902e-08**	3.360e-08***	3.077e-08***
Population Density	1.29E-06	2.01E-06	1.17E-06	1.75E-06	9.34E-07
Population Growth	-0.00314408	-0.0046347	-0.00285496	-.00508192*	-2.36E-03
Heating Degree Days	.00001112***				-5.97E-07
Precipitation		-.00108188**			-.0010119*
Wind Speed			.02130912***		.01837042***
Sunshine				-.00236381**	-.00271593**
County Poverty	0.00076936	0.00053528	0.00035395	0.00065403	0.00051151
Adjusted R^2	0.67814603	0.67621334	0.68257021	0.67633593	0.68614172
Root MSE	0.13108627	0.13147926	0.1301822	0.13145437	0.12944777

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Rent Equation	Model1	Model2	Model3	Model4	Model5
County Total Crime	-.00002112***	-.00002214***	-.00001944***	-.00001689**	-.00002286***
County Unemployment	-0.0049269	-0.00483625	-0.00615871	-0.00396324	-0.00540678
PM 2.5	-.00806514***	-.01057101***	-.00831805***	-.00761273***	-.01083289***
County Population	8.698e-08***	9.691e-08***	9.120e-08***	9.492e-08***	9.582e-08***
Population Density	6.02E-06	4.83E-06	6.36E-06	6.11E-06	4.83E-06
Population Growth	.01633378***	.01747565***	.01801265***	.01879371***	.01717689***
Heating Degree Days	-.0000116*				-6.30E-07
Precipitation		.00424601***			.00423296***
Wind Speed			-0.01220542		-0.0031744
Sunshine				-0.00214875	0.00041321
Adjusted R^2	0.63027289	0.64670493	0.62938465	0.6293196	0.64592433
Root MSE	0.21128562	0.2065371	0.21153926	0.21155783	0.20676515

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

For comparison purpose, this study includes poverty indicator to rents equation and report as below. The poverty variable does not add very much to the equation.

Rent Equation	Model1	Model2	Model3	Model4	Model5
County Total Crime	-.00002153***	-.00002232***	-.00001951***	-.00001696**	-.0000233***
County Unemployment	-0.00466943	-0.00454756	-0.00601493	-0.00387755	-0.00506921
PM 2.5	-.00811589***	-.01056993***	-.00829767***	-.00759262***	-.01083324***
County Population	8.712e-08***	9.754e-08***	9.147e-08***	9.506e-08***	9.599e-08***
Population Density	6.22E-06	5.07E-06	6.48E-06	6.20E-06	5.07E-06
Population Growth	.0157993***	.01713465***	.01785955***	.01868313***	.016625***
Heating Degree Days	-.00001261**				-1.66E-06
Precipitation		.00428541***			.00425891***
Wind Speed			-0.01215865		-0.00263347
Sunshine				-0.00211031	0.00048033
County Poverty	-0.00123319	-0.00118507	-0.00055424	-0.0003772	-0.00130705
Adjusted R^2	0.63030632	0.64673828	0.62913609	0.6290303	0.64601255
Root MSE	0.21127607	0.20652735	0.21161019	0.21164037	0.20673939

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

The following full statistics tables of all variables present Model 5 for the rent (excluding the poverty) and wage equations.

Rent Equation	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Total Crime	-0.0000229	5.18E-06	-4.42	0	-0.000033	-0.0000127
County Unemployment	-0.0054068	0.0034411	-1.57	0.116	-0.0121583	0.0013448
PM 2.5	-0.0108329	0.002177	-4.98	0	-0.0151042	-0.0065616
County Population	9.58E-08	1.42E-08	6.74	0	6.79E-08	1.24E-07
Population Density	4.83E-06	3.43E-06	1.41	0.16	-1.90E-06	0.0000116
Population Growth	0.0171769	0.0036668	4.68	0	0.0099824	0.0243714
Heating Degree Days	-6.30E-07	5.34E-06	-0.12	0.906	-0.0000111	9.86E-06
Precipitation	0.004233	0.0006345	6.67	0	0.0029881	0.0054778
Wind Speed	-0.0031744	0.0065638	-0.48	0.629	-0.0160528	0.009704
Sunshine	0.0004132	0.0013251	0.31	0.755	-0.0021867	0.0030131

Housing Vacancy	0.007422	0.0060852	1.22	0.223	-0.0045174	0.0193614
HSTRUCTURE2	0.009987	0.001324	7.54	0	0.0073893	0.0125847
HSTRUCTURE7	-0.0150927	0.0011689	-12.91	0	-0.0173861	-0.0127993
HYEAR2	0.0118829	0.0008635	13.76	0	0.0101887	0.0135772
HROOMS45	-0.0119268	0.001779	-6.7	0	-0.0154172	-0.0084364
HBEDROOMS23	-0.0447392	0.0047905	-9.34	0	-0.0541384	-0.03534
HBEDROOMS4	-0.0414961	0.0048624	-8.53	0	-0.0510362	-0.0319559
_cons	13.97448	0.5080978	27.5	0	12.97757	14.97139

Wage Equation	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
County Total Crime	-0.0000168	3.83E-06	-4.38	0	-0.0000243	-9.26E-06
County Unemployment	0.0003955	0.0022787	0.17	0.862	-0.0040754	0.0048665
PM 2.5	-0.000939	0.001387	-0.68	0.499	-0.0036602	0.0017823
County Population	3.08E-08	8.92E-09	3.45	0.001	1.33E-08	4.83E-08
Population Density	9.34E-07	1.53E-06	0.61	0.541	-2.06E-06	3.93E-06
Population Growth	-0.002356	0.0024286	-0.97	0.332	-0.0071209	0.002409
Heating Degree Days	-5.97E-07	3.48E-06	-0.17	0.864	-7.42E-06	6.22E-06
Precipitation	-0.0010119	0.000401	-2.52	0.012	-0.0017986	-0.0002252
Wind Speed	0.0183704	0.0040735	4.51	0	0.0103781	0.0263628
Sunshine	-0.0027159	0.0008474	-3.2	0.001	-0.0043786	-0.0010533
County Poverty	0.0005115	0.000774	0.66	0.509	-0.0010072	0.0020302
White	-0.001903	0.0004353	-4.37	0	-0.002757	-0.0010489
Private Employee	0.0092757	0.0009031	10.27	0	0.0075038	0.0110477
Occupation MBSA	0.0252299	0.0017587	14.35	0	0.0217792	0.0286806
Occupation Sales Office	0.0031547	0.0022835	1.38	0.167	-0.0013256	0.007635
Occupation NCM	0.0043301	0.0023751	1.82	0.069	-0.0003299	0.0089901
Occupation PTM	-0.0007469	0.0018683	-0.4	0.689	-0.0044126	0.0029187
Married	-0.000256	0.0010599	-0.24	0.809	-0.0023355	0.0018235
Veteran	-0.0077703	0.0034572	-2.25	0.025	-0.0145536	-0.0009871
Mean Hour	0.0502668	0.0040625	12.37	0	0.042296	0.0582376
High School Labor Force	-0.001634	0.0011144	-1.47	0.143	-0.0038205	0.0005524

_cons	7.634767	0.2111955	36.15	0	7.220391	8.049143

Version 2: Replacing total crime with violent crime and adding income inequality indicator (i.e., GINI index)

Wage Equation	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00003998	-.00004708*	-0.00004435	-0.00003092	-0.00003681
County Unemployment	-0.00285459	-.0045826*	-0.0010899	-0.004166	-1.37E-06
PM 2.5	-0.00224358	-0.00240811	-0.00081502	-.00404284**	-0.00082555
County Population	2.970e-08***	2.305e-08*	2.755e-08**	3.253e-08***	2.842e-08**
Population Density	1.66E-06	2.86E-06	1.88E-06	2.58E-06	1.29E-06
Population Growth	-0.00093908	-0.00356783	-0.00172507	-0.00422425	-0.00015307
Heating Degree Days	.00001665***				4.35E-06
Precipitation		-.00145703***			-.00120678**
Wind Speed			.02409356***		.01824204***
Sunshine				-.00264728***	-.00269517**
County Poverty	0.00086946	0.00060097	0.00038895	0.00077628	0.00058361
County GINI	.78914692***	.6215872***	.60376923***	.54279098***	.78477814***
Adjusted R^2	0.67929201	0.67455228	0.68129849	0.67322969	0.68781396
Root MSE	0.13085269	0.13181608	0.13044271	0.13208365	0.12910246

Root MSE refers to the root mean square error. legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

This version for wage equation improved on the Roback model because 1) violent crime is statistically zero rather than the wrong sign, 2) three of the climate amenities are significant and the right sign, 3) the County GINI is significant and the right sign, indicating that uneven income distribution is a disamenity.

Rent Equation	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-.00024572***	-.00023522***	-.00024059***	-.0002317***	-.00023961***
County Unemployment	-0.00487595	-0.00506673	-0.00565676	-0.00448949	-0.00523706
PM 2.5	-.0079772***	-.01027474***	-.00812997***	-.00778025***	-.00988493***

County Population	8.051e-08***	8.829e-08***	8.201e-08***	8.373e-08***	8.857e-08***
Population Density	6.692e-06*	5.54E-06	6.753e-06*	6.53E-06	6.04E-06
Population Growth	.01406335***	.01435412***	.01504607***	.01557623***	.01480224***
Heating Degree Days	-6.18E-06				4.08E-06
Precipitation		.00349894***			.00383389***
Wind Speed			-0.0065294		-0.00035872
Sunshine				-0.00124676	0.00147759
County Poverty	-0.00111991	-0.0011998	-0.00082496	-0.00075488	-0.00118735
County GINI	1.5224549***	1.3406796***	1.56246***	1.5771561***	1.3658992***
Adjusted R^2	0.64996618	0.66162224	0.6497675	0.64979104	0.66114282
Root MSE	0.20558163	0.20212973	0.20563996	0.20563305	0.20227287

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

All okay except County GINI. County GINI increases property values, which suggest that unequal income distribution leads to greater demand for property by the rich and possibly rental property for the poor.

Version 3: Dropping crime variable for both rents and wage equations

Wage Equation	Model1	Model2	Model3	Model4	Model5
County Unemployment	-0.00301911	-.00480124*	-0.00130355	-0.00424992	-0.00012872
PM 2.5	-0.0022075	-0.00240044	-0.00079438	-.00404608**	-0.00085199
County Population	2.856e-08**	2.185e-08*	2.629e-08**	3.188e-08***	2.767e-08**
Population Density	1.61E-06	2.81E-06	1.84E-06	2.53E-06	1.24E-06
Population Growth	-0.0006856	-0.00331561	-0.00147471	-0.00402165	0.00005144
Heating Degree Days	.00001672***				4.25E-06
Precipitation		-.00141711***			-.00119971**
Wind Speed			.02396398***		.01816499***
Sunshine				-.00277521***	-.00285329***
County Poverty	0.00090839	0.0006473	0.00043271	0.00081104	0.00062502
County GINI	.75063021***	.57202231***	.55938621***	.51442157***	.74854517***

Adjusted R^2	0.67873432	0.67367811	0.68054609	0.6730225	0.68738828
Root MSE	0.13096641	0.13199299	0.1305966	0.13212552	0.12919045

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

This version for wage equation is better than version 2.

Rent Equation	Model1	Model2	Model3	Model4	Model5
County Unemployment	-.00871211**	-.00899246**	-.00939262**	-.00794452*	-.00862251*
PM 2.5	-.00725078***	-.01002921***	-.00763944***	-.00789427***	-.0096396***
County Population	7.096e-08***	7.753e-08***	7.100e-08***	7.517e-08***	8.039e-08***
Population Density	4.81E-06	3.48E-06	4.73E-06	4.08E-06	3.72E-06
Population Growth	.01391494***	.01316453***	.01393144***	.01478983***	.0145589***
Heating Degree Days	-1.11E-06				6.76E-06
Precipitation		.00357584***			.00377671***
Wind Speed			-0.004768		0.00022212
Sunshine				-.00289299*	-0.00004765
County Poverty	-0.00113296	-0.00142674	-0.00105932	-0.00082005	-0.00115438
County GINI	1.0687184***	.84170773***	1.0640995***	1.1019219***	.91213154***
Adjusted R^2	0.63363495	0.64634194	0.63379588	0.63562991	0.6460474
Root MSE	0.21032278	0.20664318	0.21027658	0.20974936	0.20672921

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Version 2 for rents equation is better than this version.

Version 4: Dropping unemployment rate variable but keeping violent crime variable.

Wage Equation	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00004124	-.00004943*	-0.00004488	-0.00003217	-0.00003681
PM 2.5	-0.00251227	-.00289655*	-0.00087568	-.00454861***	-0.00082563
County Population	2.889e-08**	2.147e-08*	2.722e-08**	3.155e-08***	2.842e-08**
Population Density	1.56E-06	2.76E-06	1.84E-06	2.48E-06	1.29E-06

Population Growth	-0.00033937	-0.00277928	-0.00149891	-0.00351816	-0.00015278
Heating Degree Days	.00001729***				4.35E-06
Precipitation		-.00150209***			-.00120678**
Wind Speed			.02458547***		.01824261***
Sunshine				-.00282217***	-.00269521**
County Poverty	0.00087192	0.00058987	0.00038141	0.00077573	0.0005836
County GINI	.78699824***	.60374312***	.60102299***	.52593049***	.78477627***
Adjusted R^2	0.67911528	0.67362522	0.68151398	0.67252599	0.68808805
Root MSE	0.13088874	0.13200369	0.13039861	0.13222579	0.12904577

Root MSE refers to the root mean square error. legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

This version for wage equation is better than version 2 or 3.

Rent Equation	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-.00025352***	-.00024372***	-.00024876***	-.00023871***	-.00024681***
PM 2.5	-.00864878***	-.01098869***	-.00859378***	-.00844258***	-.0103567***
County Population	7.866e-08***	8.623e-08***	8.010e-08***	8.202e-08***	8.682e-08***
Population Density	6.952e-06*	5.80E-06	7.097e-06*	6.730e-06*	6.31E-06
Population Growth	.01537058***	.01564902***	.01650478***	.01673229***	.01609819***
Heating Degree Days	-5.85E-06				3.71E-06
Precipitation		.0034826***			.0038339***
Wind Speed			-0.00367698		0.00240043
Sunshine				-0.00132655	0.00136528
County Poverty	-0.00121189	-0.00130826	-0.0009548	-0.00084529	-0.00131339
County GINI	1.5149126***	1.3305235***	1.5604666***	1.5666951***	1.3601442***
Adjusted R^2	0.64960034	0.66119127	0.64923654	0.64952778	0.66072364
Root MSE	0.20568903	0.20225841	0.20579578	0.20571032	0.20239794

Root MSE refers to the root mean square error. legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

This version for rents equation is better than either version 2 or 3. The coefficients are about the same but it better because unemployment is removed.

Version 5: Dropping both violent crime and unemployment rates variables

Wage Equation	Model1	Model2	Model3	Model4	Model5
PM 2.5	-0.00249099	-.002913*	-0.00086679	-.00456259***	-0.00085989
County Population	2.767e-08**	2.013e-08*	2.588e-08**	3.085e-08***	2.764e-08**
Population Density	1.50E-06	2.71E-06	1.78E-06	2.42E-06	1.23E-06
Population Growth	-0.00004172	-0.00247425	-0.00119996	-0.0032924	0.00007952
Heating Degree Days	.00001739***				4.25E-06
Precipitation		-.00146234***			-.00120006**
Wind Speed			.02455184***		.01821794***
Sunshine				-.00295904***	-.00285773***
County Poverty	0.00091229	0.00063808	0.00042429	0.00081191	0.00062448
County GINI	.74707017***	.5506855***	.55545082***	.49603668***	.74832461***
Adjusted R^2	0.6785031	0.67263114	0.68073448	0.67227852	0.68766162
Root MSE	0.13101353	0.13220456	0.13055809	0.13227575	0.12913395

Root MSE refers to the root mean square error. legend: * $p<0.05$; ** $p<0.01$; *** $p<0.001$

This version for wage equation is better than version 2, 3, or 4.

Rent Equation	Model1	Model2	Model3	Model4	Model5
PM 2.5	-.00843919***	-.01131662***	-.00839895***	-.00910053***	-.01041935***
County Population	6.702e-08***	7.306e-08***	6.713e-08***	7.160e-08***	7.704e-08***
Population Density	5.18E-06	3.82E-06	5.19E-06	4.31E-06	4.06E-06
Population Growth	.01630186***	.01545045***	.01634478***	.01684122***	.01672261***
Heating Degree Days	-2.10E-07				6.28E-06
Precipitation		.00355108***			.00377384***
Wind Speed			0.00017846		0.00488427
Sunshine				-.00312787**	-0.00031323
County Poverty	-0.00130227	-0.00163976	-0.00129337	-0.00098743	-0.00136434
County GINI	1.0284913***	.79023802***	1.0319736***	1.0569014***	.8795605***
Adjusted R^2	0.63175775	0.64429828	0.63175738	0.63412478	0.6443797

Root MSE	0.21086092	0.20723937	0.21086102	0.21018213	0.20721565

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Version 6: Version 2 for non-metro counties and the continental U.S. and adding spatial relationship for the continental U.S.

First, I run regressions for non-metro counties.

Wage_Non-metro	Model1	Model2	Model3	Model4	Model5
County Violent Crime	0.00004843	-2.08E-06	3.90E-06	0.0000124	0.0000403
County Unemployment	-.02285451***	-.02173017***	-.02060558***	-.0244779***	-.02029179***
PM 2.5	-.00349189*	-.00427869**	-.00478876***	-.00666244***	-0.00217616
County Population	5.948e-07*	8.013e-07**	6.001e-07*	5.184e-07*	7.002e-07**
Population Density	6.34E-08	-0.00001335	-8.25E-06	-0.00003095	0.00001016
Population Growth	.00687283***	.00838317***	.00921241***	.00824165***	.00734187***
Heating Degree Days	.00002756***				.00002472***
Precipitation		-.00239987***			-.00092791*
Wind Speed			.01728609***		.00779655*
Sunshine				-.00216847*	0.00088549
County Poverty	-.00143378*	-.00173955**	-.00171019**	-.00181514**	-.00137699*
County GINI	0.18569865	-0.04436196	-0.13095053	-0.16406499	0.21388825
Adjusted R^2	0.41556575	0.39789686	0.39336983	0.38820501	0.41849304
Root MSE	0.18418097	0.18694436	0.18764583	0.18844294	0.18371913

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Rent_Non-metro	Model1	Model2	Model3	Model4	Model5
County Violent Crime	0.0000142	-0.00005412	-0.00005826	-0.00002321	0.00001439
County Unemployment	-.01006193***	-.00831173**	-.00870034**	-.00857267***	-.01571057***
PM 2.5	-0.00105886	-.00419648*	-.00354695*	-.0038388*	-0.00325026
County Population	2.278e-06***	2.213e-06***	2.371e-06***	2.158e-06***	2.172e-06***
Population Density	.00017268**	0.00011365	0.00011298	0.00010805	.0001707**
Population Growth	0.00054327	0.00329243	0.00230191	0.00190492	0.0017961
Heating Degree	.00003052***				.00004548***

Days					
Precipitation		.00209357***			.00360504***
Wind Speed			-.01334798**		-.01707056***
Sunshine				-.00374753***	.00354343*
County Poverty	.00281167***	.00227491**	.00231246**	.00257694***	.00258754***
County GINI	-.54370348**	-.91976585***	-.85594094***	-.80638829***	-.56230485**
Adjusted R^2	0.50737938	0.49691472	0.49480093	0.49585053	0.52019264
Root MSE	0.24040558	0.24294561	0.24345546	0.24320243	0.23725846

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

The following two tables are regressions for the continental United States.

Wage_US	Model1	Model2	Model3	Model4	Model5
County Violent Crime	4.60E-06	-0.00001606	-0.00001049	8.21E-07	7.00E-06
County Unemployment	-.01704124***	-.01726709***	-.01494917***	-.01859035***	-.01456772***
PM 2.5	-.00216908*	-.00269465**	-.00225283*	-.00475952***	-0.0013157
County Population	4.070e-08***	3.291e-08**	3.809e-08***	4.404e-08***	3.766e-08***
Population Density	3.75E-06	5.317e-06**	4.410e-06*	4.761e-06*	3.34E-06
Population Growth	.00716016***	.00671709***	.00742391***	.00589775***	.00744166***
Heating Degree Days	.00001918***				.00001167***
Precipitation		-.00171632***			-.00106538**
Wind Speed			.0192852***		.01085771***
Sunshine				-.00277257***	-.00166246*
County Poverty	-.00117749*	-.00137663**	-.00133992**	-.001302*	-.00115781*
County GINI	0.15147604	0.014947	-0.03525214	-0.0581862	0.15216954
Adjusted R^2	0.51970951	0.51160458	0.51338337	0.50894067	0.52362329
Root MSE	0.17227655	0.17372406	0.17340741	0.1741972	0.17157319

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Rent_US	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00002654	-.00006168*	-.00006417*	-0.00002477	-0.00001658
County Unemployment	-0.0030821	-.00452487*	-0.00420988	-.00421309*	-.00931016***
PM 2.5	-0.00180951	-.00598599***	-.00429328**	-.00493863***	-.0059161***
County Population	1.236e-07***	1.158e-07***	1.102e-07***	1.194e-07***	1.315e-07***
Population Density	.00001906***	.00001565***	.00001741***	.00001627***	.00001764***
Population Growth	.01188942***	.0113932***	.01067881***	.01070676***	.01235956***
Heating Degree Days	.00001794***				.00002779***
Precipitation		.00339294***			.0040056***
Wind Speed			-.01372709**		-.01564951***
Sunshine				-.00529793***	-0.00002444
County Poverty	0.00104276	0.0005964	0.00067684	0.00111229	0.00109584
County GINI	0.15458909	-0.16726622	-0.0305365	0.00975753	0.04195256
Adjusted R^2	0.58128155	0.58581482	0.57822365	0.58219912	0.5957673
Root MSE	0.24797546	0.24662945	0.2488793	0.24770361	0.2436483

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Then, I add spatial relationship to the continental United States' Models (SEM-GS2SLS with heteroskedastic option) as follows.

Wage_US_Spatial	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00001499	-0.00002238	-0.00001961	-0.00001492	-0.00001444
County Unemployment	-.01352395***	-.01377251***	-.01299052***	-.01468503***	-.01217565***
PM 2.5	-0.0022966	-0.00229009	-0.0022848	-.00399562**	-0.00163944
County Population	2.068e-08**	1.711e-08*	1.951e-08**	2.182e-08**	1.997e-08**
Population Density	5.11E-06	5.72E-06	5.41E-06	5.50E-06	4.78E-06
Population Growth	.00852111***	.00821645***	.00839734***	.00797655***	.00849734***
Heating Degree Days	.00001583***				7.08E-06
Precipitation		-.00159399***			-.00127602*
Wind Speed			.01550449*		0.00978456
Sunshine				-.00265174*	-0.00220699

County Poverty	-.00142962*	-.00151888*	-.00148815*	-.00145999*	-.00139678*
County GINI	.38684182**	.32548471*	.31166019*	.31028026*	.38328786**

legend: * p<0.05; ** p<0.01; *** p<0.001

Rent_US_Spatial	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00003576	-0.00004158	-0.00004356	-0.00002997	-0.00003103
County Unemployment	-.01585369***	-.01830007***	-.01768516***	-.01667531***	-.01951114***
PM 2.5	-0.00055793	-0.00402326	-0.00218456	-0.00193688	-.00421402*
County Population	6.313e-08***	6.231e-08***	5.905e-08***	6.585e-08***	6.612e-08***
Population Density	.00001612***	.00001421***	.00001477***	.0000143***	.00001615***
Population Growth	.01039935**	.01007349**	.00984697**	.01025407**	.0104883***
Heating Degree Days	7.01E-06				.00002235**
Precipitation		.0043657***			.00473917***
Wind Speed			-.01866339*		-.0187517*
Sunshine				-.00481619*	-0.0000374
County Poverty	0.00108631	0.00098729	0.00100432	0.00115114	0.00109707
County GINI	.72380945***	.5879057***	.65993572***	.69315452***	.67769395***

legend: * p<0.05; ** p<0.01; *** p<0.001

Version 7: Version 4 for non-metro and the continental U.S. and adding spatial relationship for the continental U.S.

Wage_Non-metro	Model1	Model2	Model3	Model4	Model5
County Violent Crime	0.00004118	-0.00001227	-2.69E-07	-3.76E-06	0.00003067
PM 2.5	-.00490217***	-.00509162***	-.00502324***	-.00832401***	-0.00207403
County Population	2.89E-07	5.854e-07*	3.46E-07	2.18E-07	5.130e-07*
Population Density	-1.57E-06	-0.0000142	-2.82E-06	-0.0000315	0.00001822
Population Growth	.01006612***	.01132815***	.01219542***	.01196105***	.01034292***
Heating Degree Days	.0000298***				.00002351***
Precipitation		-.00322579***			-.00137232**
Wind Speed			.02959257***		.01957269***
Sunshine				-0.00162094	0.00137767

County Poverty	-0.00102844	-.00135394*	-.00130011*	-.0014336*	-0.00099057
County GINI	-0.0300872	-0.22477417	-.29491147*	-.42942826**	0.06176194
Adjusted R^2	0.3767039	0.36403998	0.36570381	0.34348651	0.3922094
Root MSE	0.19020596	0.19212852	0.19187702	0.19520851	0.18782522

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Rent_Non-metro	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-3.52E-07	-0.00006066	-0.0000632	-0.00003707	-0.00001142
PM 2.5	-0.00212867	-.00471516**	-.00391414*	-.00430398*	-0.00339457
County Population	2.127e-06***	2.104e-06***	2.240e-06***	2.073e-06***	2.047e-06***
Population Density	.00014491*	0.00009639	0.00009958	0.00009318	.00015029*
Population Growth	0.00340068	.00536749*	0.00447473	0.00423255	.00552954*
Heating Degree Days	.00002752***				.00004085***
Precipitation		.00178167***			.0032569***
Wind Speed			-0.00828835		-0.00763242
Sunshine				-.00286868**	.00444681**
County Poverty	.00296814***	.00245478**	.0024972**	.00269534***	.00279489***
County GINI	-.66149312***	-.98203092***	-.92484003***	-.88970762***	-.71958444***
Adjusted R^2	0.50360001	0.49441505	0.49223402	0.49324807	0.51209705
Root MSE	0.24132601	0.24354842	0.24407318	0.24382934	0.23925167

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

The following tables are based on the continental United States, using a metro dummy.

Wage_MetroDummy	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-5.10E-06	-0.00002872	-0.00002003	-0.00001047	-3.71E-06
PM 2.5	-.00372908***	-.00412367***	-.0029408**	-.00679929***	-0.00182251
County Population	2.932e-08**	2.00E-08	2.785e-08*	3.306e-08**	2.617e-08*
Population Density	3.40E-06	5.267e-06**	3.914e-06*	4.716e-06*	2.83E-06
Population Growth	.00813501***	.00786137***	.00849488***	.00717506***	.0083756***

Heating Degree Days	.00002306***				.00001276***
Precipitation		-.00224737***			-.00123771***
Wind Speed			.02832427***		.01898534***
Sunshine				-.00292066***	-.00148827*
County Poverty	-0.00080264	-.00105197*	-.00104608*	-0.00095759	-0.00085434
County GINI	0.13559806	-0.03508465	-0.05904711	-0.15628867	0.16228326
Metro	.04582779***	.03739212***	.03947934***	.03429989***	.04563277***
Adjusted R^2	0.50550897	0.4956043	0.5037845	0.48888483	0.51584525
Root MSE	0.17480481	0.17654681	0.17510935	0.17771888	0.1729682

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Rent_MetroDummy	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-.000061*	-.00009819***	-.00009958***	-.00006572**	-.00006299*
PM 2.5	-.00296122*	-.00706236***	-.00521746***	-.0061165***	-.00654529***
County Population	1.020e-07***	9.430e-08***	8.945e-08***	9.706e-08***	1.067e-07***
Population Density	.00001667***	.00001357***	.00001506***	.00001404***	.00001572***
Population Growth	.0100279***	.0100013***	.0091402***	.00923459***	.0119287***
Heating Degree Days	.00002137***				.00003104***
Precipitation		.00303971***			.00392834***
Wind Speed			-.00931381*		-.0088243*
Sunshine				-.00475052***	0.00124032
County Poverty	.00139697*	0.00086963	0.00094533	.00133573*	.00141023*
County GINI	0.25657636	-0.10409965	0.03273626	0.05973585	0.10888408
Metro	.10497063***	.08881788***	.09296019***	.09193134***	.10155419***
Adjusted R^2	0.59251726	0.59355595	0.58690047	0.59065144	0.60411087
Root MSE	0.2446258	0.24431382	0.24630601	0.24518522	0.24112067

Root MSE refers to the root mean square error. legend: * p<0.05; ** p<0.01; *** p<0.001

Then, I add spatial relationship to the models for the continental United States with a metro dummy (SEM-GS2SLS with heteroskedastic option).

Wage_Dummy_Spatial	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-0.00001804	-0.00002632	-0.0000231	-0.00001882	-0.00001875
PM 2.5	-.00318876*	-.00318726*	-0.00288182	-.00519268***	-0.00203533
County Population	1.802e-08*	1.426e-08*	1.700e-08*	1.946e-08**	1.693e-08*
Population Density	4.58E-06	5.33E-06	4.88E-06	5.17E-06	4.27E-06
Population Growth	.00902413***	.00874108***	.0088743***	.00860047***	.00891988***
Heating Degree Days	.00002022***				9.59E-06
Precipitation		-.00196075***			-.0013536*
Wind Speed			.02239464**		.01505536*
Sunshine				-.00254205*	-0.00183515
County Poverty	-0.00122789	-0.00134121	-0.00130324	-0.00128022	-0.00121813
County GINI	.44201245**	.35954319**	.34648281*	.33070777*	.42729704**
Metro	.04038208***	.03616111***	.03758163***	.03554789***	.03972646***

legend: * p<0.05; ** p<0.01; *** p<0.001

The coefficient on County GINI indicates that people prefer places with more equal distribution of income.

Rent_Dummy_Spatial	Model1	Model2	Model3	Model4	Model5
County Violent Crime	-.00006337**	-.00007398**	-.00007325**	-.00006238**	-.00006345**
PM 2.5	-0.00249656	-.00600582**	-0.00394245	-0.00407918	-.00562984**
County Population	5.800e-08***	5.592e-08***	5.392e-08***	5.883e-08***	6.041e-08***
Population Density	.00001476***	.00001279***	.00001332***	.00001289***	.00001512***
Population Growth	.01120659***	.01116237***	.01089922***	.01108177***	.01178586***
Heating Degree Days	0.00001106				.00002477***
Precipitation		.00370459***			.00437023***
Wind Speed			-0.01027231		-0.01051189
Sunshine				-.00408771*	0.00091857
County Poverty	0.00125352	0.0011343	0.00115579	0.00127948	0.00125996
County GINI	.67442432***	.51572654**	.59134543***	.61812444***	.617482***
Metro	.06238729***	.05834033***	.05901668***	.0597006***	.06247252***

legend: * p<0.05; ** p<0.01; *** p<0.001

Version 8:Climate Amenities Set 1 without PM 2.5

Section 4.2.2.2.4 Climate Amenities Set 1 without PM 2.5

Rent_Metro	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Violent Crime	-0.0002477	0.0000333	-7.44	0	-0.000313	-0.0001824
County Population	8.26E-08	1.41E-08	5.84	0	5.48E-08	1.10E-07
Population Density	3.46E-06	3.36E-06	1.03	0.303	-3.13E-06	0.00001
Population Growth	0.0183855	0.0034763	5.29	0	0.011565	0.025206
Heating Degree Days	7.61E-06	5.35E-06	1.42	0.155	-2.89E-06	0.0000181
Precipitation	0.0035857	0.0006277	5.71	0	0.002354	0.0048173
Wind Speed	0.0105063	0.005981	1.76	0.079	-0.0012287	0.0222414
Sunshine	0.0020711	0.0013106	1.58	0.114	-0.0005004	0.0046426
County GINI	1.401802	0.2097902	6.68	0	0.990185	1.813419
Housing Vacancy	0.0063661	0.0059246	1.07	0.283	-0.0052581	0.0179904
HSTRUCTURE2	0.0103571	0.0013261	7.81	0	0.0077552	0.0129589
HSTRUCTURE7	-0.0147376	0.001146	-12.86	0	-0.0169861	-0.0124891
HYEAR2	0.0129014	0.0008692	14.84	0	0.011196	0.0146068
HROOMS45	-0.0124258	0.0017481	-7.11	0	-0.0158557	-0.0089959
HBEDROOMS23	-0.0445283	0.0046806	-9.51	0	-0.0537119	-0.0353447
HBEDROOMS4	-0.0414148	0.0047668	-8.69	0	-0.0507674	-0.0320622
_cons	12.92043	0.5194026	24.88	0	11.90134	13.93951
Adjusted R^2	0.6585					
Root MSE	0.20448					

Rent_Non-metro	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Violent Crime	-0.0000149	0.0000345	-0.43	0.665	-0.0000826	0.0000527
County Population	1.99E-06	3.02E-07	6.6	0	1.40E-06	2.59E-06
Population Density	0.0001448	0.0000631	2.3	0.022	0.0000211	0.0002684
Population Growth	0.0054624	0.0026568	2.06	0.04	0.0002519	0.0106729
Heating Degree Days	0.0000418	4.90E-06	8.53	0	0.0000322	0.0000514
Precipitation	0.0032669	0.0006099	5.36	0	0.0020708	0.004463
Wind Speed	-0.0055222	0.0047368	-1.17	0.244	-0.0148119	0.0037675

Sunshine	0.0054537	0.0013452	4.05	0	0.0028156	0.0080919
County GINI	-0.6680523	0.1736394	-3.85	0	-1.008593	-0.3275119
Housing Vacancy	0.0298588	0.0036665	8.14	0	0.0226682	0.0370494
HSTRUCTURE2	0.0455274	0.0043145	10.55	0	0.0370659	0.0539889
HSTRUCTURE7	-0.0149368	0.0009674	-15.44	0	-0.016834	-0.0130396
HYEAR2	0.0214021	0.0008327	25.7	0	0.019769	0.0230352
HROOMS45	-0.0063626	0.001184	-5.37	0	-0.0086847	-0.0040404
HBEDROOMS23	-0.0174246	0.0029927	-5.82	0	-0.0232939	-0.0115554
HBEDROOMS4	-0.0166519	0.0030573	-5.45	0	-0.0226478	-0.0106559
_cons	10.25495	0.3455527	29.68	0	9.577255	10.93265
Adjusted R^2	0.5083					
Root MSE	0.24019					

Wage_Metro	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Population	2.75E-08	8.89E-09	3.1	0.002	1.01E-08	4.50E-08
Population Density	1.18E-06	1.51E-06	0.78	0.433	-1.78E-06	4.14E-06
Population Growth	-0.0000296	0.0023952	-0.01	0.99	-0.0047291	0.0046699
Heating Degree Days	4.18E-06	3.55E-06	1.18	0.239	-2.79E-06	0.0000111
Precipitation	-0.0012231	0.0003995	-3.06	0.002	-0.0020069	-0.0004392
Wind Speed	0.0191272	0.0037969	5.04	0	0.0116775	0.0265769
Sunshine	-0.002796	0.0008363	-3.34	0.001	-0.0044368	-0.0011552
County GINI	0.7580333	0.1529735	4.96	0	0.4578926	1.058174
White	-0.002196	0.0004323	-5.08	0	-0.0030442	-0.0013478
Private Employee	0.0087048	0.0008858	9.83	0	0.0069668	0.0104428
Occupation MBSA	0.0262724	0.0016533	15.89	0	0.0230286	0.0295163
Occupation Sales Office	0.0033529	0.0022581	1.48	0.138	-0.0010776	0.0077834
Occupation NCM	0.0066569	0.0023307	2.86	0.004	0.0020841	0.0112298
Occupation PTM	-0.0004354	0.0018282	-0.24	0.812	-0.0040224	0.0031515
Married	0.0035915	0.0010992	3.27	0.001	0.0014348	0.0057483
Veteran	-0.0073468	0.0032766	-2.24	0.025	-0.0137756	-0.000918
Mean Hour	0.047675	0.0039873	11.96	0	0.0398519	0.0554982
High School Labor Force	0.000223	0.001089	0.2	0.838	-0.0019136	0.0023596

_cons	7.088102	0.2160925	32.8	0	6.664119	7.512085
Adjusted R^2	0.6879					
Root MSE	0.12908					

Wage_Non-metro	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
County Population	5.66E-07	2.49E-07	2.27	0.023	7.71E-08	1.06E-06
Population Density	0.0000137	0.0000494	0.28	0.781	-0.0000832	0.0001106
Population Growth	0.0104343	0.0021006	4.97	0	0.0063146	0.0145539
Heating Degree Days	0.0000242	3.58E-06	6.77	0	0.0000172	0.0000313
Precipitation	-0.0014055	0.0004762	-2.95	0.003	-0.0023395	-0.0004716
Wind Speed	0.0205768	0.0036076	5.7	0	0.0135016	0.0276521
Sunshine	0.0018142	0.0010932	1.66	0.097	-0.0003297	0.0039581
County GINI	0.0622803	0.1479476	0.42	0.674	-0.2278736	0.3524343
White	-0.0012775	0.0003952	-3.23	0.001	-0.0020525	-0.0005025
Private Employee	0.0096604	0.0008498	11.37	0	0.0079938	0.011327
Occupation MBSA	0.0085119	0.0015432	5.52	0	0.0054855	0.0115383
Occupation Sales Office	-0.0003168	0.0018926	-0.17	0.867	-0.0040285	0.0033949
Occupation NCM	-0.0026953	0.0017397	-1.55	0.121	-0.0061071	0.0007165
Occupation PTM	-0.0024439	0.0014948	-1.63	0.102	-0.0053755	0.0004878
Married	0.000463	0.0010055	0.46	0.645	-0.0015089	0.002435
Veteran	0.0014055	0.0027649	0.51	0.611	-0.0040169	0.006828
Mean Hour	0.0483802	0.0028893	16.74	0	0.0427137	0.0540467
High School Labor Force	-0.0033502	0.0008181	-4.1	0	-0.0049547	-0.0017458
_cons	7.778045	0.1834235	42.4	0	7.418316	8.137774
Adjusted R^2	0.3914					
Root MSE	0.18796					

For non-metro counties, the full implicit price of population growth rate has negative value and sunshine's influence is insignificantly different from zero for the wage equation.

Appendix 4: Full Statistics for Selected Regressions

Table 4.2.2.2.1. Rent and Wage Equations' Results: Metro versus Non-metro

a. Rent Equation for Metro

	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
County Violent Crime	-0.000247	0.000033	-7.49	0	-0.0003117	-0.0001824
PM 2.5	-0.0103998	0.0021097	-4.93	0	-0.0145391	-0.0062605
County Population	8.68E-08	1.40E-08	6.19	0	5.93E-08	1.14E-07
Population Density	6.09E-06	3.37E-06	1.81	0.071	-5.12E-07	0.0000127
Population Growth	0.0167645	0.0034571	4.85	0	0.0099817	0.0235474
Heating Degree Days	4.62E-06	5.33E-06	0.87	0.386	-5.84E-06	0.0000151
Precipitation	0.0038145	0.0006232	6.12	0	0.0025918	0.0050371
Wind Speed	0.0019554	0.0061699	0.32	0.751	-0.0101502	0.014061
Sunshine	0.0013004	0.0013069	1	0.32	-0.0012637	0.0038645
County GINI	1.349257	0.2079592	6.49	0	0.9412326	1.757282
Housing Vacancy	0.0060759	0.0058654	1.04	0.3	-0.0054323	0.0175841
HSTRUCTURE2	0.0104311	0.0013129	7.95	0	0.0078552	0.013007
HSTRUCTURE7	-0.0150838	0.0011367	-13.27	0	-0.017314	-0.0128536
HYEAR2	0.0129022	0.0008605	14.99	0	0.0112139	0.0145905
HROOMS45	-0.0133435	0.0017406	-7.67	0	-0.0167586	-0.0099285
HBEDROOMS23	-0.0412354	0.0046816	-8.81	0	-0.0504209	-0.0320499
HBEDROOMS4	-0.0389811	0.0047447	-8.22	0	-0.0482904	-0.0296718
_cons	12.94104	0.5142096	25.17	0	11.93214	13.94994

b. Rent Equation for Non-metro

	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
County Violent Crime	-0.0000141	0.0000345	-0.41	0.682	-0.0000817	0.0000535
PM 2.5	-0.0035312	0.0018268	-1.93	0.053	-0.0071139	0.0000515
County Population	1.99E-06	3.02E-07	6.58	0	1.39E-06	2.58E-06
Population Density	0.0001487	0.000063	2.36	0.018	0.000025	0.0002723
Population Growth	0.0052285	0.0026577	1.97	0.049	0.0000163	0.0104407
Heating Degree Days	0.0000403	4.95E-06	8.14	0	0.0000306	0.00005

Precipitation	0.0033379	0.0006106	5.47	0	0.0021404	0.0045354
Wind Speed	-0.0074362	0.0048359	-1.54	0.124	-0.0169202	0.0020479
Sunshine	0.0047908	0.0013873	3.45	0.001	0.00207	0.0075116
County GINI	-0.6884588	0.1738374	-3.96	0	-1.029388	-0.34753
Housing Vacancy	0.029908	0.003664	8.16	0	0.0227223	0.0370937
HSTRUCTURE2	0.0452699	0.0043135	10.5	0	0.0368103	0.0537294
HSTRUCTURE7	-0.0149777	0.0009669	-15.49	0	-0.016874	-0.0130814
HYEAR2	0.0214713	0.0008329	25.78	0	0.0198378	0.0231047
HROOMS45	-0.0064846	0.0011849	-5.47	0	-0.0088084	-0.0041608
HBEDROOMS23	-0.0169567	0.0030003	-5.65	0	-0.022841	-0.0110725
HBEDROOMS4	-0.0163361	0.0030595	-5.34	0	-0.0223364	-0.0103358
_cons	10.33118	0.3475529	29.73	0	9.649566	11.0128

c. Wage Equation for Metro

	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
PM25	-0.0008704	0.0013767	-0.63	0.527	-0.0035716	0.0018308
County Population	2.78E-08	8.90E-09	3.12	0.002	1.03E-08	4.53E-08
Population Density	1.25E-06	1.51E-06	0.83	0.409	-1.72E-06	4.22E-06
Population Growth	-0.0000545	0.0023961	-0.02	0.982	-0.0047559	0.0046468
Heating Degree Days	4.06E-06	3.56E-06	1.14	0.254	-2.92E-06	0.000011
Precipitation	-0.0012066	0.0004005	-3.01	0.003	-0.0019924	-0.0004209
Wind Speed	0.0184542	0.0039443	4.68	0	0.0107153	0.0261931
Sunshine	-0.0028514	0.0008411	-3.39	0.001	-0.0045016	-0.0012011
County GINI	0.754707	0.1531042	4.93	0	0.4543097	1.055104
PopWhite12	-0.0022143	0.0004334	-5.11	0	-0.0030646	-0.001364
Private Employee	0.0087806	0.0008941	9.82	0	0.0070263	0.0105348
Occupation MBSA	0.0264084	0.0016677	15.84	0	0.0231364	0.0296805
Occupation SalesOffice	0.0033745	0.002259	1.49	0.135	-0.0010576	0.0078067
Occupation NCM	0.0066769	0.0023315	2.86	0.004	0.0021024	0.0112514
Occupation PTM	-0.0002793	0.0018453	-0.15	0.88	-0.0038998	0.0033412
Pop12_Married	0.0035783	0.0010997	3.25	0.001	0.0014206	0.005736
Veteran	-0.0072554	0.0032806	-2.21	0.027	-0.0136921	-0.0008186
Mean Hour	0.0476843	0.0039883	11.96	0	0.039859	0.0555096

High School Labor Force	0.0002919	0.0010947	0.27	0.79	-0.0018559	0.0024397
_cons	7.097719	0.2166839	32.76	0	6.672576	7.522863

d. Wage Equation for Non-metro

	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
PM 2.5	-0.0020565	0.0014699	-1.4	0.162	-0.0049394	0.0008263
County Population	5.65E-07	2.49E-07	2.27	0.023	7.64E-08	1.05E-06
Population Density	0.0000166	0.0000494	0.34	0.737	-0.0000803	0.0001136
Population Growth	0.0104218	0.0021001	4.96	0	0.0063032	0.0145405
Heating Degree Days	0.0000234	3.63E-06	6.44	0	0.0000163	0.0000305
Precipitation	-0.0013689	0.0004768	-2.87	0.004	-0.002304	-0.0004337
Wind Speed	0.0196452	0.0036677	5.36	0	0.0124522	0.0268382
Sunshine	0.0015442	0.0011098	1.39	0.164	-0.0006323	0.0037207
County GINI	0.0615067	0.1479119	0.42	0.678	-0.2285774	0.3515908
PopWhite12	-0.0012858	0.0003951	-3.25	0.001	-0.0020607	-0.0005109
Private Employee	0.0097455	0.0008518	11.44	0	0.0080751	0.011416
Occupation MBSA	0.0086029	0.0015441	5.57	0	0.0055746	0.0116313
Occupation Sales Office	-0.0003441	0.0018922	-0.18	0.856	-0.0040551	0.0033669
Occupation NCM	-0.0026909	0.0017392	-1.55	0.122	-0.0061019	0.0007201
Occupation PTM	-0.0022855	0.0014987	-1.52	0.127	-0.0052248	0.0006538
Pop12_Married	0.0005142	0.0010059	0.51	0.609	-0.0014586	0.002487
Veteran	0.0013496	0.0027645	0.49	0.625	-0.0040721	0.0067713
Mean Hour	0.0481544	0.0028931	16.64	0	0.0424804	0.0538283
High School Labor Force	-0.0031964	0.0008253	-3.87	0	-0.0048149	-0.0015779
_cons	7.824142	0.1863145	41.99	0	7.458743	8.189541

Table 4.2.2.3.1.1 Rent Equation: Direct and Indirect Effects from the Spatial Durbin Error Model

Log County Rent	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
County Violent Crime	-0.0000164	0.00002	-0.56	0.577	-0.000074	0.0000412
PM 2.5	-0.0032229	0.0021	-1.54	0.124	-0.0073304	0.0008846
County Population	1.41E-06	2.54E-07	5.54	0	9.10E-07	1.91E-06
Population Density	0.0000934	0.0001	1.84	0.066	-6.23E-06	0.0001931
Population Growth	0.0049717	0.0023	2.16	0.031	0.0004553	0.0094881
Heating Degree Days	0.000036	6.46E-06	5.58	0	0.0000234	0.0000487
Precipitation	0.0038943	0.0007	5.51	0	0.0025085	0.0052801
Wind Speed	-0.0075285	0.0059	-1.28	0.201	-0.0190771	0.0040201
Sunshine	0.0038839	0.0018	2.13	0.034	0.0003026	0.0074653
County GINI	0.0509199	0.1476	0.34	0.73	-0.2383729	0.3402127
Housing Vacancy	0.0211514	0.0030	7.09	0	0.0153056	0.0269971
HSTRUCTURE2	0.0362966	0.0037	9.9	0	0.0291101	0.0434831
HSTRUCTURE7	-0.0138253	0.0009	-15.28	0	-0.0155982	-0.0120525
HYEAR2	0.0189964	0.0008	24.77	0	0.0174935	0.0204993
HROOMS45	-0.0062041	0.0010	-6.09	0	-0.0082021	-0.0042062
HBEDROOMS23	-0.0106469	0.0027	-3.98	0	-0.0158912	-0.0054027
HBEDROOMS4	-0.0071029	0.0027	-2.61	0.009	-0.0124419	-0.0017639
Metro	2.417685	0.5767	4.19	0	1.287402	3.547968
Metro×County Violent Crime	-0.0002016	0.000041	-4.89	0	-0.0002825	-0.0001208
Metro×PM 2.5	-0.0041809	0.0027	-1.53	0.126	-0.0095348	0.001173
Metro×County Population	-1.35E-06	2.54E-07	-5.31	0	-1.85E-06	-8.53E-07
Metro×Population Density	-0.0000863	0.0001	-1.69	0.09	-0.0001861	0.0000135
Metro×Population Growth	0.0153246	0.0041	3.78	0	0.0073718	0.0232774
Metro×Heating Degree Days	-0.0000319	7.24E-06	-4.41	0	-0.0000461	-0.0000177
Metro×Precipitation	0.0002929	0.0009	0.34	0.731	-0.0013789	0.0019647
Metro×Wind Speed	0.004092	0.0086	0.47	0.636	-0.0128424	0.0210265
Metro×Sunshine	-0.0025303	0.0019	-1.34	0.18	-0.0062264	0.0011659
Metro×County GINI	1.316889	0.2442	5.39	0	0.8382661	1.795512
Metro×Housing Vacancy	-0.0161036	0.0064	-2.5	0.012	-0.028706	-0.0035012

Metro×HSTRUCTURE2	-0.0292609	0.0039	-7.58	0	-0.0368291	-0.0216928
Metro×HSTRUCTURE7	0.00229	0.0014	1.67	0.094	-0.0003927	0.0049726
Metro×HYEAR2	-0.0086853	0.0011	-7.83	0	-0.010859	-0.0065116
Metro×HROOMS45	-0.0075844	0.0019	-3.91	0	-0.0113832	-0.0037856
Metro×HBEDROOMS23	-0.0199628	0.0051	-3.88	0	-0.0300385	-0.0098871
Metro×HBEDROOMS4	-0.0209958	0.0052	-4.06	0	-0.0311354	-0.0108563
W County Violent Crime	0.0001065	0.0001	1.49	0.137	-0.000034	0.0002471
W PM 2.5	-0.0011479	0.0037	-0.31	0.758	-0.0084566	0.0061608
W County Population	7.92E-07	6.52E-07	1.22	0.224	-4.85E-07	2.07E-06
W Population Density	-0.0000216	0.0001	-0.16	0.871	-0.0002821	0.0002389
W Population Growth	-0.0030259	0.0056	-0.54	0.591	-0.0140575	0.0080058
W Heating Degree Days	0.0000186	8.63E-06	2.15	0.031	1.65E-06	0.0000355
W Precipitation	0.0001225	0.0012	0.1	0.919	-0.0022348	0.0024798
W Wind Speed	-0.0045704	0.0096	-0.47	0.636	-0.0234763	0.0143355
W Sunshine	0.0052984	0.0026	2.05	0.041	0.0002206	0.0103761
W County GINI	-0.327985	0.3519	-0.93	0.351	-1.017746	0.3617757
W Housing Vacancy	-0.0029617	0.0076	-0.39	0.698	-0.0179327	0.0120092
W HSTRUCTURE2	-0.0019071	0.0095	-0.2	0.841	-0.0205634	0.0167493
W HSTRUCTURE7	0.001913	0.0020	0.94	0.346	-0.0020629	0.0058888
W HYEAR2	0.000563	0.0018	0.31	0.755	-0.0029787	0.0041048
W HROOMS45	-0.0021773	0.0025	-0.88	0.379	-0.0070283	0.0026736
W HBEDROOMS23	-0.0017857	0.0028	-0.64	0.525	-0.0072862	0.0037147
W HBEDROOMS4	-0.004247	0.0035	-1.22	0.223	-0.0110746	0.0025805
W Metro	0.1642153	1.3218	0.12	0.901	-2.426465	2.754895
W Metro×ViolentCrime	-0.000242	0.0001	-2.2	0.028	-0.0004576	-0.0000264
W Metro×PM25	-0.0046789	0.0068	-0.69	0.492	-0.0180255	0.0086678
W Metro×Population	-7.14E-07	6.52E-07	-1.09	0.274	-1.99E-06	5.65E-07
W Metro×PopDen	0.0000295	0.0001	0.22	0.825	-0.0002317	0.0002907
W Metro×Growth	0.0168957	0.0110	1.53	0.125	-0.0046819	0.0384733
W Metro×Heating Degree Days	-0.0000136	0.0000166	-0.82	0.413	-0.0000462	0.000019
W Metro×Precipitation	0.0011206	0.0020	0.56	0.578	-0.0028243	0.0050656
W Metro×Wind	-0.0070897	0.0190	-0.37	0.709	-0.0443518	0.0301724
W Metro×Sunshine	-0.0054632	0.0044	-1.23	0.217	-0.0141444	0.003218

W Metro×County GINI	0.3931326	0.6525	0.6	0.547	-0.8857518	1.672017
W Metro×Housing Vacancy	-0.0197969	0.0169	-1.17	0.241	-0.0528547	0.013261
W Metro×HSTRUCTURE2	-0.0008015	0.0100	-0.08	0.936	-0.0205014	0.0188983
W Metro×HSTRUCTURE7	0.002718	0.0037	0.73	0.465	-0.0045764	0.0100124
W Metro×HYEAR2	-0.0021943	0.0029	-0.76	0.448	-0.0078594	0.0034708
W Metro×HROOMS45	-0.0092475	0.0053	-1.75	0.08	-0.019603	0.001108
W Metro×HBEDROOMS23	0.0070979	0.0124	0.57	0.567	-0.0171993	0.031395
W Metro×HBEDROOMS4	0.0034781	0.0130	0.27	0.789	-0.0220036	0.0289599
_cons	9.494044	0.3373	28.15	0	8.832929	10.15516
rho (ρ)	0.7113084	0.0185	38.47	0	0.6750643	0.7475525

W refers to a spatial lag.

Table 4.2.2.3.1.4 Wage Equation: Direct and Indirect Effects from the Spatial Durbin Error Model

Log County Income	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
PM 2.5	-0.0020394	0.0016	-1.3	0.194	-0.0051156	0.0010368
County Population	5.61E-07	2.06E-07	2.72	0.007	1.56E-07	9.65E-07
Population Density	0.0000178	0.0000391	0.46	0.648	-0.0000589	0.0000945
Population Growth	0.0109985	0.0018	6.14	0	0.0074873	0.0145097
Heating Degree Days	0.0000196	4.49E-06	4.36	0	0.0000108	0.0000284
Precipitation	-0.0014086	0.0005	-2.69	0.007	-0.0024341	-0.0003831
Wind Speed	0.0180855	0.0043	4.23	0	0.0097011	0.0264699
Sunshine	0.0022757	0.0014	1.68	0.093	-0.0003785	0.0049298
County GINI	0.2756734	0.1211	2.28	0.023	0.0382607	0.513086
White	-0.0007368	0.0004	-1.89	0.059	-0.0015006	0.0000269
Private Employee	0.0080449	0.0007	11.32	0	0.0066519	0.0094379
Occupation MBSA	0.0071611	0.0013	5.65	0	0.0046789	0.0096432
Occupation SalesOffice	-0.0001105	0.0015	-0.07	0.942	-0.0030762	0.0028551
Occupation NCM	-0.0018085	0.0014	-1.31	0.191	-0.0045203	0.0009032
Occupation PTM	-0.0027765	0.0013	-2.16	0.031	-0.0052945	-0.0002585
Married	0.0015691	0.0008	1.93	0.054	-0.0000265	0.0031648
Veteran	0.0042251	0.0023	1.86	0.062	-0.000216	0.0086663
Mean Hour	0.0373807	0.0025	14.74	0	0.0324099	0.0423515

High School Labor Force	-0.002302	0.0007	-3.17	0.002	-0.0037261	-0.0008778
Metro	-0.8634485	0.3022	-2.86	0.004	-1.455819	-0.2710779
Metro×PM 2.5	-0.0000538	0.0021	-0.03	0.98	-0.004248	0.0041405
Metro×County Population	-5.43E-07	2.07E-07	-2.63	0.009	-9.48E-07	-1.38E-07
Metro×Population Density	-0.0000148	0.0000392	-0.38	0.706	-0.0000916	0.000062
Metro×Population Growth	-0.0100053	0.0033	-3.02	0.002	-0.0164897	-0.0035209
Metro×Heating Degree Days	-0.0000192	5.44E-06	-3.54	0	-0.0000299	-8.58E-06
Metro×Precipitation	0.000019	0.0007	0.03	0.977	-0.0012613	0.0012994
MetroWind	-0.0090872	0.0064	-1.42	0.155	-0.0216185	0.0034441
Metro×Sunshine	-0.0048375	0.0015	-3.32	0.001	-0.0076893	-0.0019858
Metro×County GINI	0.6057368	0.2142	2.83	0.005	0.1859455	1.025528
Metro×White	-0.0007186	0.0006	-1.17	0.244	-0.0019274	0.0004902
Metro×Private Employee	0.000183	0.0013	0.14	0.886	-0.0023268	0.0026927
Metro×OccupationMBSA	0.0153046	0.0023	6.68	0	0.0108128	0.0197963
Metro×OccupationSalesOffice	0.0037391	0.0030	1.26	0.209	-0.0020919	0.0095701
Metro×OccupationNCM	0.0028669	0.0030	0.95	0.34	-0.0030196	0.0087534
Metro×OccupationPTM	0.002976	0.0025	1.2	0.229	-0.0018709	0.007823
Metro× Married	0.0046838	0.0015	3.14	0.002	0.0017617	0.0076059
Metro×Veteran	-0.005502	0.0044	-1.26	0.207	-0.014049	0.003045
Metro×Mean Hour	0.0069915	0.0052	1.33	0.182	-0.0032735	0.0172565
Metro×HighSchoolLaborforce	0.0018475	0.0015	1.24	0.214	-0.001068	0.0047629
W PM 2.5	0.0036553	0.0030	1.23	0.217	-0.0021508	0.0094614
W County Population	1.13E-07	5.17E-07	0.22	0.827	-9.01E-07	1.13E-06
W Population Density	0.0001562	0.0001	1.53	0.127	-0.0000443	0.0003568
W Population Growth	0.0006739	0.0044	0.15	0.879	-0.0079718	0.0093196
W Heating Degree Days	7.16E-06	6.12E-06	1.17	0.242	-4.84E-06	0.0000192
W Precipitation	-0.000476	0.0009	-0.54	0.591	-0.002211	0.001259
W Wind Speed	0.0093942	0.0071	1.32	0.185	-0.0045116	0.0233
W Sunshine	0.0014614	0.0019	0.78	0.437	-0.0022276	0.0051504
W County GINI	-0.0705374	0.2727	-0.26	0.796	-0.6050813	0.4640065
W White	0.0010433	0.0008	1.32	0.188	-0.0005105	0.0025972
W Private Employee	-0.0016465	0.0017	-0.95	0.342	-0.0050397	0.0017468
W Occupation MBSA	-0.0065143	0.0031	-2.1	0.036	-0.0125977	-0.000431

W Occupation Sales Office	-0.0018364	0.0037	-0.49	0.624	-0.0091685	0.0054957
W Occupation NCM	-0.0045151	0.0037	-1.23	0.217	-0.0116872	0.0026571
W Occupation PTM	-0.0010225	0.0031	-0.33	0.74	-0.0070726	0.0050277
W Married	-0.0018133	0.0022	-0.83	0.408	-0.0061113	0.0024847
W Veteran	-0.003795	0.0059	-0.65	0.518	-0.015297	0.007707
W Mean Hour	0.0062287	0.0057	1.09	0.275	-0.0049648	0.0174221
W High School Laborforce	-0.0014789	0.0016	-0.93	0.353	-0.0046001	0.0016424
W Metro	0.6590502	0.6807	0.97	0.333	-0.6750282	1.993129
W Metro×PM 2.5	-0.0057506	0.0053	-1.08	0.281	-0.0162129	0.0047117
W Metro×Population	-1.03E-07	5.18E-07	-0.2	0.842	-1.12E-06	9.11E-07
W Metro×Population Density	-0.0001502	0.0001	-1.46	0.143	-0.0003513	0.0000509
W Metro×Population Growth	-0.0010677	0.0091	-0.12	0.907	-0.0189048	0.0167695
W Metro×Heating Degree Days	-3.57E-06	0.0000131	-0.27	0.785	-0.0000292	0.000022
W Metro×Precipitation	-0.0000164	0.0015	-0.01	0.991	-0.0030238	0.002991
W Metro×Wind Speed	-0.0333493	0.0144	-2.31	0.021	-0.0615919	-0.0051066
W Metro×Sunshine	-0.0077709	0.0034	-2.32	0.021	-0.0143499	-0.0011919
W Metro×County GINI	-0.0305772	0.5579	-0.05	0.956	-1.124057	1.062903
W Metro×White	-0.0004534	0.0016	-0.29	0.773	-0.0035391	0.0026323
W Metro×Private Employee	0.0025081	0.0034	0.75	0.456	-0.0040805	0.0090967
W Metro×Occupation MBSA	-0.0026561	0.0057	-0.46	0.643	-0.0138932	0.008581
W Metro×Occupation Sales Office	-0.0030887	0.0076	-0.41	0.685	-0.0180363	0.0118589
W Metro×Occupation NCM	-0.0094126	0.0079	-1.19	0.235	-0.024933	0.0061078
W Metro×Occupation PTM	-0.0095918	0.0063	-1.51	0.13	-0.0220199	0.0028363
W Metro×Married	0.0027634	0.0041	0.68	0.498	-0.0052292	0.010756
W Metro×Veteran	0.014395	0.0121	1.19	0.232	-0.009226	0.0380161
W Metro×Mean Hour	0.0051767	0.0139	0.37	0.71	-0.0220742	0.0324276
W Metro×High School Laborforce	0.0041015	0.0038	1.07	0.282	-0.0033775	0.0115806
_cons	8.159486	0.1861	43.84	0	7.794727	8.524244
rho (ρ)	0.6465142	0.0193	33.51	0	0.6087047	0.6843238

W refers to a spatial lag.

Table 4.3.4.1.1 Second-stage Results for Rent Equation: Metro versus Non-metro

Metro Counties	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Log County Income	-0.265439	0.0413686	-6.42	0	-0.3465201	-0.184358
County Revenue	0.0170205	0.0025248	6.74	0	0.012072	0.021969
Land Share	6.034096	0.1549519	38.94	0	5.730396	6.337796
County Population	4.84E-08	8.53E-09	5.67	0	3.17E-08	6.51E-08
High School Graduation	0.0005723	0.0002115	2.71	0.007	0.0001577	0.0009869
Extreme Temp	-0.0000562	4.10E-06	-13.69	0	-0.0000642	-0.0000481
PM 2.5	-0.0079669	0.0012098	-6.59	0	-0.010338	-0.0055958
County Violent Crime	-0.0000427	0.0000213	-2	0.045	-0.0000844	-9.12E-07
County GINI	0.5872408	0.1586277	3.7	0	0.2763363	0.8981454
Mammography	0.0014122	0.000475	2.97	0.003	0.0004811	0.0023432
Physical Activity	0.0013948	0.0002332	5.98	0	0.0009377	0.0018518
Child Poverty	-0.0125513	0.0010818	-11.6	0	-0.0146717	-0.0104309
HSTRUCTURE2	0.0049319	0.0008207	6.01	0	0.0033233	0.0065405
HSTRUCTURE7	-0.0033135	0.000759	-4.37	0	-0.0048012	-0.0018258
HYEAR2	0.0017105	0.0005753	2.97	0.003	0.0005829	0.002838
HROOMS45	-0.0035695	0.0010082	-3.54	0	-0.0055456	-0.0015935
HBEDROOMS23	-0.0216298	0.0021452	-10.08	0	-0.0258343	-0.0174253
HBEDROOMS4	-0.018527	0.0021792	-8.5	0	-0.0227982	-0.0142559
_cons	14.09872	0.520698	27.08	0	13.07817	15.11927

Non-metro Counties	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Log County Income	-0.2603975	0.0436614	-5.96	0	-0.3459722	-0.1748228
County Revenue	0.0035919	0.0011548	3.11	0.002	0.0013286	0.0058552
Land Share	7.210997	0.137973	52.26	0	6.940575	7.481419
County Population	1.52E-06	1.78E-07	8.51	0	1.17E-06	1.87E-06
High School Graduation	0.0000328	0.0001125	0.29	0.771	-0.0001877	0.0002532
Extreme Temp	-0.0000169	3.53E-06	-4.8	0	-0.0000239	-0.00001
PM 2.5	-0.0048631	0.0010398	-4.68	0	-0.006901	-0.0028251
County Violent Crime	0.0000403	0.0000207	1.95	0.052	-2.70E-07	0.0000809
County GINI	-0.0474803	0.121753	-0.39	0.697	-0.2861119	0.1911513

Mammography	0.0010746	0.000257	4.18	0	0.000571	0.0015783
Physical Activity	0.0004978	0.0001553	3.21	0.001	0.0001934	0.0008021
Child Poverty	-0.0103407	0.0008176	-12.65	0	-0.0119433	-0.0087382
HSTRUCTURE2	-0.0020482	0.0026313	-0.78	0.436	-0.0072054	0.003109
HSTRUCTURE7	-0.0025786	0.000595	-4.33	0	-0.0037449	-0.0014123
HYEAR2	0.005272	0.0005548	9.5	0	0.0041846	0.0063594
HROOMS45	-0.0016501	0.0006954	-2.37	0.018	-0.003013	-0.0002871
HBEDROOMS23	-0.0082722	0.0018544	-4.46	0	-0.0119068	-0.0046376
HBEDROOMS4	-0.006319	0.0019448	-3.25	0.001	-0.0101307	-0.0025072
_cons	12.48417	0.4505226	27.71	0	11.60116	13.36718

Table 4.3.4.1.5 Second-stage Results for Wage Equation: Metro versus Non-metro

Metro Counties	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Log County Rent	0.4998518	0.0429727	11.63	0	0.4156269	0.5840767
County Revenue	0.004279	0.0024795	1.73	0.084	-0.0005807	0.0091388
Land Share	-3.165423	0.3270275	-9.68	0	-3.806385	-2.524461
County Unemployment	-0.0095253	0.0020934	-4.55	0	-0.0136283	-0.0054223
Population Growth	-0.0069144	0.0021215	-3.26	0.001	-0.0110725	-0.0027563
Private Public School	0.0020276	0.0006507	3.12	0.002	0.0007522	0.0033029
Sunshine	-0.0026549	0.0006427	-4.13	0	-0.0039145	-0.0013952
County GINI	0.8174566	0.1279875	6.39	0	0.5666057	1.068308
Poor Water Quality	0.0006263	0.0002964	2.11	0.035	0.0000453	0.0012072
Mammography	-0.0013874	0.0004789	-2.9	0.004	-0.002326	-0.0004487
Private Employee	0.0087003	0.0007314	11.9	0	0.0072668	0.0101338
Occupation MBSA	0.0175885	0.0010662	16.5	0	0.0154989	0.0196781
Veteran	-0.0133338	0.0030743	-4.34	0	-0.0193593	-0.0073083
Mean Hour	0.0617995	0.0029878	20.68	0	0.0559435	0.0676556
_cons	2.774974	0.4176988	6.64	0	1.9563	3.593649

Non-metro Counties	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
Log County Rent	0.4343153	0.0678981	6.4	0	0.3012374	0.5673931
County Revenue	0.0050827	0.001588	3.2	0.001	0.0019703	0.0081952

Land Share	-4.265939	0.582344	-7.33	0	-5.407312	-3.124565
County Unemployment	-0.0191105	0.0019555	-9.77	0	-0.0229432	-0.0152778
Population Growth	0.0101713	0.0022165	4.59	0	0.005827	0.0145157
Private Public School	0.0005659	0.0006377	0.89	0.375	-0.0006841	0.0018158
Sunshine	0.0002643	0.0008553	0.31	0.757	-0.001412	0.0019406
County GINI	0.4337871	0.1514457	2.86	0.004	0.136959	0.7306152
Poor Water Quality	-0.0002967	0.0002497	-1.19	0.235	-0.0007862	0.0001927
Mammography	0.0023381	0.0003733	6.26	0	0.0016065	0.0030697
Private Employee	0.0062181	0.000719	8.65	0	0.0048088	0.0076274
Occupation MBSA	0.0101399	0.0011856	8.55	0	0.0078162	0.0124635
Veteran	-0.0015608	0.0028622	-0.55	0.586	-0.0071706	0.0040491
Mean Hour	0.0442544	0.0029685	14.91	0	0.0384362	0.0500726
_cons	4.348673	0.6551993	6.64	0	3.064506	5.632841

Table 4.3.4.1.8 Reduced-form Results for Wage Equation Results: Metro versus Non-metro

Metro Counties	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Population	1.65E-08	8.03E-09	2.05	0.041	7.00E-10	3.22E-08
High School Graduation	0.0008028	0.0002056	3.9	0	0.0003994	0.0012062
Extreme Temp	-0.0000168	3.95E-06	-4.26	0	-0.0000246	-9.07E-06
PM 2.5	-0.0027732	0.0011902	-2.33	0.02	-0.0051085	-0.0004378
County Violent Crime	0.0000377	0.0000202	1.87	0.062	-1.91E-06	0.0000772
Physical Activity	-4.46E-06	0.0002286	-0.02	0.984	-0.000453	0.0004441
Child Poverty	-0.0117692	0.0008678	-13.56	0	-0.0134719	-0.0100664
HSTRUCTURE2	0.0008691	0.0007781	1.12	0.264	-0.0006577	0.0023958
HSTRUCTURE7	0.0014125	0.0007168	1.97	0.049	6.15E-06	0.0028189
HYEAR2	-0.0034645	0.0005286	-6.55	0	-0.0045016	-0.0024273
HROOMS45	0.0005025	0.0010245	0.49	0.624	-0.0015076	0.0025127
HBEDROOMS23	0.001185	0.0020789	0.57	0.569	-0.0028939	0.0052639
HBEDROOMS4	0.0063438	0.0021101	3.01	0.003	0.0022037	0.0104839
County Revenue	0.0083901	0.0023399	3.59	0	0.003799	0.0129811
Land Share	0.2544931	0.1492661	1.7	0.088	-0.0383758	0.5473619

County Unemployment	0.0066882	0.0021315	3.14	0.002	0.0025061	0.0108703
Population Growth	-0.0026618	0.0020378	-1.31	0.192	-0.0066602	0.0013365
Private Public School	0.0031644	0.0005913	5.35	0	0.0020043	0.0043245
Sunshine	-0.0019161	0.0006767	-2.83	0.005	-0.0032438	-0.0005884
County GINI	1.536807	0.1479381	10.39	0	1.246544	1.82707
Poor Water Quality	0.0006663	0.0002683	2.48	0.013	0.0001398	0.0011927
Mammography	-0.0012617	0.0004501	-2.8	0.005	-0.0021448	-0.0003785
Private Employee	0.0042014	0.0007609	5.52	0	0.0027084	0.0056943
Occupation MBSA	0.0127032	0.0011071	11.47	0	0.010531	0.0148754
Veteran	-0.0044967	0.0028227	-1.59	0.111	-0.0100351	0.0010417
Mean Hour	0.0593978	0.0028786	20.63	0	0.0537497	0.0650458
_cons	7.347085	0.2863741	25.66	0	6.785203	7.908968

Non-metro Counties	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
County Population	5.94E-07	2.29E-07	2.59	0.01	1.45E-07	1.04E-06
High School Graduation	0.0001403	0.0001464	0.96	0.338	-0.0001469	0.0004275
Extreme Temp	5.20E-06	4.82E-06	1.08	0.281	-4.26E-06	0.0000147
PM 2.5	-0.003253	0.001289	-2.52	0.012	-0.0057809	-0.0007251
County Violent Crime	0.0000841	0.0000249	3.37	0.001	0.0000352	0.000133
Physical Activity	0.0002178	0.0001895	1.15	0.25	-0.0001538	0.0005894
Child Poverty	-0.0098585	0.00079	-12.48	0	-0.0114079	-0.0083092
HSTRUCTURE2	0.0051395	0.0031927	1.61	0.108	-0.0011219	0.011401
HSTRUCTURE7	0.0000952	0.0007206	0.13	0.895	-0.001318	0.0015084
HYEAR2	-0.0019683	0.0006808	-2.89	0.004	-0.0033035	-0.0006332
HROOMS45	-0.0029917	0.0008749	-3.42	0.001	-0.0047075	-0.0012759
HBEDROOMS23	0.0083352	0.0022128	3.77	0	0.0039954	0.012675
HBEDROOMS4	0.0109281	0.0022158	4.93	0	0.0065824	0.0152738
County Revenue	0.0012136	0.0014018	0.87	0.387	-0.0015357	0.0039629
Land Share	-0.7769654	0.1592092	-4.88	0	-1.089206	-0.4647243
County Unemployment	0.0021424	0.0021265	1.01	0.314	-0.0020281	0.006313
Population Growth	0.0098881	0.0019537	5.06	0	0.0060565	0.0137198
Private Public School	0.0008934	0.0005485	1.63	0.104	-0.0001823	0.0019692

Sunshine	0.003145	0.0009032	3.48	0.001	0.0013737	0.0049163
County GINI	1.011394	0.1366138	7.4	0	0.7434672	1.279321
Poor Water Quality	0.0000208	0.0002178	0.1	0.924	-0.0004062	0.0004479
Mammography	0.0013234	0.0003219	4.11	0	0.000692	0.0019547
Private Employee	0.0023998	0.0007605	3.16	0.002	0.0009082	0.0038914
Occupation MBSA	0.0027706	0.0011197	2.47	0.013	0.0005747	0.0049665
Veteran	0.0020003	0.0025171	0.79	0.427	-0.0029362	0.0069367
Mean Hour	0.0404393	0.0025251	16.01	0	0.0354871	0.0453916
_cons	7.655389	0.2572509	29.76	0	7.150869	8.15991

Table 4.3.4.2.3 Reduced-form Estimates for Rent Equation with a Metro Dummy and Cross Products for the Continental United States

Non-spatial	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Revenue	0.0035127	0.0010461	3.36	0.001	0.0014615	0.0055639
Metro×County Revenue	0.0084246	0.0028242	2.98	0.003	0.0028871	0.0139622
Land Share	7.367103	0.1188101	62.01	0	7.134148	7.600059
Metro×Land Share	-1.32966	0.2052327	-6.48	0	-1.732069	-0.9272523
County Violent Crime	0.0000149	0.0000186	0.8	0.422	-0.0000216	0.0000514
Metro×Violent Crime	-0.0000543	0.0000293	-1.85	0.064	-0.0001117	3.17E-06
Private Public School	0.0013049	0.0004093	3.19	0.001	0.0005023	0.0021075
Metro×Private Public School	-0.0000241	0.0007791	-0.03	0.975	-0.0015516	0.0015035
County GINI	-0.4422089	0.1019483	-4.34	0	-0.642103	-0.2423148
Metro×County GINI	0.5393811	0.1946843	2.77	0.006	0.1576557	0.9211065
Child Poverty	-0.0082256	0.0005895	-13.95	0	-0.0093815	-0.0070696
Metro×Child Poverty	-0.0028175	0.0011376	-2.48	0.013	-0.0050481	-0.0005869
Physical Activity	0.0004491	0.0001414	3.18	0.002	0.0001719	0.0007264
Metro×Physical Activity	0.0009601	0.0002927	3.28	0.001	0.0003861	0.001534
High School Graduation	0.0002385	0.0001093	2.18	0.029	0.0000242	0.0004527
Metro×High School Graduation	0.0003973	0.0002551	1.56	0.119	-0.0001029	0.0008975
Poor Water Quality	0.0000309	0.0001625	0.19	0.849	-0.0002877	0.0003495
Metro×Poor Water	-0.0000826	0.0003419	-0.24	0.809	-0.0007529	0.0005878
Mammography	0.0010422	0.0002402	4.34	0	0.0005712	0.0015133

Metro×Mammography	0.0002109	0.0005589	0.38	0.706	-0.000885	0.0013067
Extreme Temp	-0.0000177	3.60E-06	-4.92	0	-0.0000248	-0.0000107
Metro×Extreme Temp	-0.0000284	5.70E-06	-4.97	0	-0.0000395	-0.0000172
Sunshine	0.0011743	0.000674	1.74	0.082	-0.0001473	0.0024958
Metro×Sunshine	-0.0011725	0.0010148	-1.16	0.248	-0.0031622	0.0008173
PM2 .5	-0.0018293	0.0009619	-1.9	0.057	-0.0037153	0.0000567
MetroPM25	-0.0052618	0.001645	-3.2	0.001	-0.0084871	-0.0020365
County Unemployment	0.0009225	0.0015869	0.58	0.561	-0.002189	0.0040341
Metro×Unemployment	0.009527	0.0028686	3.32	0.001	0.0039024	0.0151515
County Population	1.46E-06	1.71E-07	8.53	0	1.12E-06	1.79E-06
Metro×Population	-1.41E-06	1.71E-07	-8.22	0	-1.74E-06	-1.07E-06
Population Growth	0.001403	0.001458	0.96	0.336	-0.0014558	0.0042617
Metro×Population Growth	0.0008921	0.0027102	0.33	0.742	-0.004422	0.0062062
Private Employee	-0.0036534	0.0005676	-6.44	0	-0.0047663	-0.0025406
Metro×Private Employee	-0.0017011	0.0010246	-1.66	0.097	-0.0037101	0.000308
Occupation MBSA	-0.0004975	0.0008356	-0.6	0.552	-0.0021358	0.0011409
Metro×Occupation MBSA	-0.0024443	0.0014963	-1.63	0.102	-0.0053781	0.0004895
Veteran	0.0034618	0.0018784	1.84	0.065	-0.0002212	0.0071447
Metro×Veteran	0.0035279	0.0036801	0.96	0.338	-0.0036878	0.0107436
Mean Hour	-0.0121991	0.0018844	-6.47	0	-0.0158938	-0.0085043
Metro×Mean Hour	-0.0004278	0.0037371	-0.11	0.909	-0.0077554	0.0068998
HSTRUCTURE2	-0.0045733	0.0023825	-1.92	0.055	-0.0092448	0.0000983
Metro×HSTRUCTURE2	0.0084604	0.0025372	3.33	0.001	0.0034856	0.0134353
HSTRUCTURE7	-0.0025025	0.0005377	-4.65	0	-0.0035568	-0.0014481
Metro×HSTRUCTURE7	-0.0012323	0.0009669	-1.27	0.203	-0.0031282	0.0006636
HYEAR2	0.0053689	0.000508	10.57	0	0.0043728	0.0063651
Metro×HYEAR2	-0.0032857	0.0007806	-4.21	0	-0.0048162	-0.0017552
HROOMS45	-0.001205	0.0006529	-1.85	0.065	-0.0024851	0.0000751
Metro×HROOMS45	-0.0011084	0.0013212	-0.84	0.402	-0.0036989	0.0014822
HBEDROOMS23	-0.0067809	0.0016513	-4.11	0	-0.0100187	-0.0035431
Metro×HBEDROOMS23	-0.0109057	0.0028564	-3.82	0	-0.0165064	-0.0053051
HBEDROOMS4	-0.0068501	0.0016536	-4.14	0	-0.0100923	-0.0036078
Metro×HBEDROOMS4	-0.0089089	0.0028863	-3.09	0.002	-0.0145681	-0.0032496

Metro	1.502842	0.3740775	4.02	0	0.7693734	2.236311
_cons	10.27957	0.1919738	53.55	0	9.903162	10.65598

Spatial	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Revenue	0.0033814	0.0021787	1.55	0.121	-0.0008887	0.0076515
Metro×County Revenue	0.0057414	0.0029584	1.94	0.052	-0.0000569	0.0115397
Land Share	7.354414	0.5676921	12.95	0	6.241758	8.46707
Metro×Land Share	-0.7286073	0.5001501	-1.46	0.145	-1.708883	0.2516689
County Violent Crime	0.0000199	0.0000175	1.14	0.256	-0.0000144	0.0000542
Metro×Violent Crime	-0.0000327	0.000023	-1.43	0.154	-0.0000777	0.0000123
Private Public School	0.0006937	0.0003811	1.82	0.069	-0.0000533	0.0014406
Metro×Private Public School	0.0005475	0.0006237	0.88	0.38	-0.000675	0.0017699
County GINI	-0.3850137	0.1206338	-3.19	0.001	-0.6214516	-0.1485757
Metro×County GINI	0.3789252	0.1841071	2.06	0.04	0.018082	0.7397685
Child Poverty	-0.0062349	0.0006758	-9.23	0	-0.0075594	-0.0049104
Metro×Child Poverty	-0.0009595	0.0009785	-0.98	0.327	-0.0028774	0.0009585
Physical Activity	0.0004692	0.0001697	2.77	0.006	0.0001367	0.0008017
Metro×Physical Activity	0.0003305	0.0002591	1.28	0.202	-0.0001774	0.0008384
High School Graduation	0.0002864	0.0001145	2.5	0.012	0.000062	0.0005108
Metro×High School Graduation	0.0001197	0.0002202	0.54	0.587	-0.0003118	0.0005512
Poor Water Quality	0.000032	0.0001827	0.17	0.861	-0.000326	0.00039
Metro×Poor Water	-0.0003432	0.000276	-1.24	0.214	-0.0008841	0.0001977
Mammography	0.0005693	0.0002867	1.99	0.047	7.43E-06	0.0011311
Metro×Mammography	0.0005146	0.0005243	0.98	0.326	-0.0005129	0.0015422
Extreme Temp	-0.000013	6.15E-06	-2.12	0.034	-0.0000251	-9.68E-07
Metro×Extreme Temp	-0.0000202	6.29E-06	-3.22	0.001	-0.0000325	-7.90E-06
Sunshine	0.0012797	0.0013522	0.95	0.344	-0.0013707	0.00393
Metro×Sunshine	-0.0005063	0.001114	-0.45	0.649	-0.0026898	0.0016772
PM2 .5	-0.0008237	0.0012843	-0.64	0.521	-0.0033408	0.0016935
MetroPM25	-0.0034553	0.001353	-2.55	0.011	-0.0061071	-0.0008035
County Unemployment	0.0009886	0.0017311	0.57	0.568	-0.0024043	0.0043815
Metro×Unemployment	0.003579	0.0029652	1.21	0.227	-0.0022326	0.0093906

County Population	1.19E-06	1.94E-07	6.11	0	8.06E-07	1.57E-06
Metro×Population	-1.15E-06	1.95E-07	-5.89	0	-1.53E-06	-7.66E-07
Population Growth	-0.001045	0.0018963	-0.55	0.582	-0.0047617	0.0026718
Metro×Population Growth	0.0051504	0.0027073	1.9	0.057	-0.0001558	0.0104566
Private Employee	-0.0018514	0.0005993	-3.09	0.002	-0.003026	-0.0006769
Metro×Private Employee	-0.0006582	0.0009502	-0.69	0.489	-0.0025205	0.0012042
Occupation MBSA	-0.0003041	0.0008782	-0.35	0.729	-0.0020253	0.0014172
Metro×Occupation MBSA	-0.001124	0.0013216	-0.85	0.395	-0.0037143	0.0014662
Veteran	0.0009169	0.0022536	0.41	0.684	-0.0035	0.0053339
Metro×Veteran	0.004275	0.0031632	1.35	0.177	-0.0019247	0.0104747
Mean Hour	-0.0105504	0.0024628	-4.28	0	-0.0153774	-0.0057235
Metro×Mean Hour	-0.001338	0.0035309	-0.38	0.705	-0.0082585	0.0055825
HSTRUCTURE2	-0.0073167	0.0050156	-1.46	0.145	-0.0171472	0.0025137
Metro×HSTRUCTURE2	0.0107216	0.0049783	2.15	0.031	0.0009643	0.0204789
HSTRUCTURE7	-0.0019293	0.0007982	-2.42	0.016	-0.0034939	-0.0003648
Metro×HSTRUCTURE7	-0.0007156	0.0008916	-0.8	0.422	-0.0024632	0.001032
HYEAR2	0.0042572	0.0010208	4.17	0	0.0022565	0.0062579
Metro×HYEAR2	-0.0032645	0.001122	-2.91	0.004	-0.0054635	-0.0010654
HROOMS45	-0.0021152	0.0008035	-2.63	0.008	-0.0036899	-0.0005404
Metro×HROOMS45	0.0000217	0.0011941	0.02	0.985	-0.0023187	0.0023622
HBEDROOMS23	-0.0033986	0.0021535	-1.58	0.115	-0.0076193	0.0008222
Metro×HBEDROOMS23	-0.0047333	0.0048888	-0.97	0.333	-0.0143151	0.0048486
HBEDROOMS4	-0.0029528	0.0020956	-1.41	0.159	-0.0070602	0.0011545
Metro×HBEDROOMS4	-0.0047719	0.0048761	-0.98	0.328	-0.014329	0.0047851
Metro	0.751749	0.5232897	1.44	0.151	-0.27388	1.777378
_cons	9.745162	0.311769	31.26	0	9.134106	10.35622
rho	0.7878894	0.0211249	37.3	0	0.7464854	0.8292935

Table 4.3.4.2.7 Reduced-Form Estimates: Wage Equation with a Metro Dummy and Cross Products for the Continental United States

Non-spatial	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Revenue	0.0012136	0.0012486	0.97	0.331	-0.0012345	0.0036617
Metro×County Revenue	0.0071765	0.0033707	2.13	0.033	0.0005674	0.0137856
Land Share	-0.7769654	0.1418005	-5.48	0	-1.055	-0.4989313
Metro×Land Share	1.031459	0.2449464	4.21	0	0.551182	1.511735
County Violent Crime	0.0000841	0.0000222	3.79	0	0.0000406	0.0001277
Metro×Violent Crime	-0.0000464	0.000035	-1.33	0.184	-0.000115	0.0000221
Private Public School	0.0008934	0.0004885	1.83	0.068	-0.0000645	0.0018513
Metro×Private Public School	0.002271	0.0009298	2.44	0.015	0.0004479	0.0040942
County GINI	1.011394	0.1216758	8.31	0	0.7728194	1.249969
Metro×County GINI	0.5254129	0.2323568	2.26	0.024	0.0698214	0.9810045
Child Poverty	-0.0098585	0.0007036	-14.01	0	-0.0112381	-0.0084789
Metro×Child Poverty	-0.0019107	0.0013578	-1.41	0.159	-0.0045729	0.0007516
Physical Activity	0.0002178	0.0001687	1.29	0.197	-0.0001131	0.0005487
Metro×Physical Activity	-0.0002222	0.0003494	-0.64	0.525	-0.0009073	0.0004628
High School Graduation	0.0001403	0.0001304	1.08	0.282	-0.0001154	0.0003961
Metro×High School Graduation	0.0006624	0.0003045	2.18	0.03	0.0000654	0.0012595
Poor Water Quality	0.0000208	0.000194	0.11	0.914	-0.0003595	0.0004011
Metro×Poor Water	0.0006454	0.0004081	1.58	0.114	-0.0001547	0.0014455
Mammography	0.0013234	0.0002867	4.62	0	0.0007611	0.0018856
Metro×Mammography	-0.002585	0.0006671	-3.88	0	-0.003893	-0.0012771
Extreme Temp	5.20E-06	4.29E-06	1.21	0.226	-3.22E-06	0.0000136
Metro×Extreme Temp	-0.000022	6.81E-06	-3.23	0.001	-0.0000354	-8.66E-06
Sunshine	0.003145	0.0008044	3.91	0	0.0015677	0.0047223
Metro×Sunshine	-0.0050611	0.0012112	-4.18	0	-0.0074359	-0.0026864
PM 2.5	-0.003253	0.001148	-2.83	0.005	-0.005504	-0.0010021
Metro×PM 2.5	0.0004799	0.0019633	0.24	0.807	-0.0033696	0.0043293
County Unemployment	0.0021424	0.001894	1.13	0.258	-0.0015712	0.0058561
Metro×Unemployment	0.0045458	0.0034237	1.33	0.184	-0.0021672	0.0112588
County Population	5.94E-07	2.04E-07	2.91	0.004	1.94E-07	9.94E-07

Metro×Population	-5.78E-07	2.04E-07	-2.83	0.005	-9.78E-07	-1.77E-07
Population Growth	0.0098881	0.0017401	5.68	0	0.0064762	0.0133001
Metro×Population Growth	-0.01255	0.0032347	-3.88	0	-0.0188924	-0.0062076
Private Employee	0.0023998	0.0006774	3.54	0	0.0010716	0.003728
Metro×PrivateEmployee	0.0018015	0.0012229	1.47	0.141	-0.0005963	0.0041993
Occupation MBSA	0.0027706	0.0009973	2.78	0.005	0.0008152	0.004726
Metro×Occupation MBSA	0.0099326	0.0017858	5.56	0	0.0064311	0.0134341
Veteran	0.0020003	0.0022418	0.89	0.372	-0.0023954	0.0063959
Metro×Veteran	-0.006497	0.0043922	-1.48	0.139	-0.015109	0.002115
Mean Hour	0.0404393	0.002249	17.98	0	0.0360296	0.044849
Metro×Mean Hour	0.0189584	0.0044603	4.25	0	0.0102129	0.0277039
HSTRUCTURE2	0.0051395	0.0028436	1.81	0.071	-0.000436	0.010715
Metro×HSTRUCTURE2	-0.0042705	0.0030282	-1.41	0.159	-0.010208	0.001667
HSTRUCTURE7	0.0000952	0.0006418	0.15	0.882	-0.0011632	0.0013536
Metro×HSTRUCTURE7	0.0013173	0.001154	1.14	0.254	-0.0009454	0.0035801
HYEAR2	-0.0019683	0.0006064	-3.25	0.001	-0.0031573	-0.0007794
Metro×HYEAR2	-0.0014961	0.0009316	-1.61	0.108	-0.0033228	0.0003306
HROOMS45	-0.0029917	0.0007792	-3.84	0	-0.0045195	-0.0014639
Metro×HROOMS45	0.0034942	0.0015769	2.22	0.027	0.0004024	0.006586
HBEDROOMS23	0.0083352	0.0019709	4.23	0	0.0044709	0.0121995
Metro×HBEDROOMS23	-0.0071502	0.0034091	-2.1	0.036	-0.0138346	-0.0004658
HBEDROOMS4	0.0109281	0.0019735	5.54	0	0.0070585	0.0147977
Metro×HBEDROOMS4	-0.0045843	0.0034448	-1.33	0.183	-0.0113387	0.00217
Metro	-0.3083042	0.4464637	-0.69	0.49	-1.183704	0.5670954
_cons	7.655389	0.2291219	33.41	0	7.206141	8.104638

Spatial	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
County Revenue	-0.0003254	0.0027726	-0.12	0.907	-0.0057596	0.0051088
Metro×County Revenue	0.0078386	0.0034354	2.28	0.023	0.0011053	0.0145719
Land Share	-0.4240033	0.2028979	-2.09	0.037	-0.8216759	-0.0263306
Metro×Land Share	1.095554	0.2406391	4.55	0	0.6239104	1.567198
County Violent Crime	0.000068	0.0000253	2.69	0.007	0.0000184	0.0001176
Metro×Violent Crime	-0.0000474	0.0000298	-1.59	0.112	-0.0001059	0.000011

Private Public School	0.0004981	0.0006293	0.79	0.429	-0.0007353	0.0017315
Metro×Private Public School	0.0021952	0.0009866	2.22	0.026	0.0002614	0.0041289
County GINI	0.7801015	0.1557047	5.01	0	0.474926	1.085277
Metro×County GINI	0.5017759	0.2319451	2.16	0.031	0.0471719	0.95638
Child Poverty	-0.0085606	0.0009365	-9.14	0	-0.010396	-0.0067252
Metro×Child Poverty	-0.0015515	0.0012248	-1.27	0.205	-0.0039519	0.000849
Physical Activity	0.0001348	0.0002066	0.65	0.514	-0.0002701	0.0005397
Metro×Physical Activity	-0.0000842	0.0003142	-0.27	0.789	-0.0006999	0.0005316
High School Graduation	0.0000396	0.0001599	0.25	0.804	-0.0002738	0.0003531
Metro×High School Graduation	0.0005026	0.0002862	1.76	0.079	-0.0000584	0.0010636
Poor Water Quality	-0.0001591	0.0002308	-0.69	0.491	-0.0006115	0.0002933
Metro×Poor Water	0.0005274	0.0004196	1.26	0.209	-0.0002949	0.0013498
Mammography	0.0012396	0.0004523	2.74	0.006	0.0003531	0.002126
Metro×Mammography	-0.0021625	0.000784	-2.76	0.006	-0.003699	-0.000626
Extreme Temp	7.85E-06	6.40E-06	1.23	0.22	-4.70E-06	0.0000204
Metro×Extreme Temp	-0.0000256	7.38E-06	-3.47	0.001	-0.0000401	-0.0000111
Sunshine	0.0032593	0.0011861	2.75	0.006	0.0009345	0.005584
Metro×Sunshine	-0.0051648	0.0013127	-3.93	0	-0.0077376	-0.002592
PM 2.5	-0.0035721	0.0015896	-2.25	0.025	-0.0066876	-0.0004566
Metro×PM 2.5	0.0009113	0.001823	0.5	0.617	-0.0026617	0.0044844
County Unemployment	0.0008578	0.0025801	0.33	0.74	-0.0041991	0.0059148
Metro×Unemployment	0.0020523	0.0031745	0.65	0.518	-0.0041697	0.0082742
County Population	3.90E-07	1.98E-07	1.97	0.049	1.55E-09	7.79E-07
Metro×Population	-3.78E-07	1.98E-07	-1.91	0.056	-7.67E-07	1.02E-08
Population Growth	0.0098174	0.0029499	3.33	0.001	0.0040357	0.0155992
Metro×Population Growth	-0.0131532	0.0038536	-3.41	0.001	-0.020706	-0.0056003
Private Employee	0.0025058	0.0009539	2.63	0.009	0.0006362	0.0043753
Metro×PrivateEmployee	0.0022147	0.0012476	1.78	0.076	-0.0002306	0.0046599
Occupation MBSA	0.0032815	0.0013773	2.38	0.017	0.0005821	0.0059808
Metro×Occupation MBSA	0.0078412	0.0017051	4.6	0	0.0044993	0.011183
Veteran	0.0036044	0.0031714	1.14	0.256	-0.0026114	0.0098202
Metro×Veteran	-0.0053316	0.0042479	-1.26	0.209	-0.0136574	0.0029942
Mean Hour	0.035794	0.0034298	10.44	0	0.0290717	0.0425163

Metro×Mean Hour	0.0172533	0.0051516	3.35	0.001	0.0071564	0.0273502
HSTRUCTURE2	0.0054453	0.0035828	1.52	0.129	-0.0015768	0.0124675
Metro×HSTRUCTURE2	-0.0043909	0.003628	-1.21	0.226	-0.0115017	0.00272
HSTRUCTURE7	-0.0006106	0.0008442	-0.72	0.469	-0.0022651	0.0010439
Metro×HSTRUCTURE7	0.001955	0.0010579	1.85	0.065	-0.0001184	0.0040285
HYEAR2	-0.0013171	0.000828	-1.59	0.112	-0.0029399	0.0003057
Metro×HYEAR2	-0.0014495	0.0009787	-1.48	0.139	-0.0033678	0.0004687
HROOMS45	-0.0026053	0.0011239	-2.32	0.02	-0.0048081	-0.0004024
Metro×HROOMS45	0.0020519	0.0014902	1.38	0.169	-0.0008688	0.0049727
HBEDROOMS23	0.0076539	0.0026808	2.86	0.004	0.0023996	0.0129081
Metro×HBEDROOMS23	-0.0087535	0.0045115	-1.94	0.052	-0.0175958	0.0000888
HBEDROOMS4	0.0097335	0.0027564	3.53	0	0.0043311	0.0151359
Metro×HBEDROOMS4	-0.0061635	0.0045378	-1.36	0.174	-0.0150575	0.0027304
Metro	-0.0104483	0.5204891	-0.02	0.984	-1.030588	1.009692
_cons	7.935796	0.3320438	23.9	0	7.285002	8.58659
rho	0.5668707	0.0293257	19.33	0	0.5093933	0.6243481

VITA

Jinhyoung Kim earned a doctorate in applied economics and a Master of Public Affairs majoring in public policy at the University of Missouri-Columbia from 2010 to 2017. His research and educational backgrounds include a diversity of disciplines, such as cultural studies, economics, law, political science, and public administration.

Jinhyoung focused on Indian studies, Hindi (one of the Indian languages of India), and law as his undergraduate studies and on economics as his graduate studies at the Hankuk University of Foreign Studies (HUFS), South Korea.

After received master's degree in South Korea, Jinhyoung worked for the Korean Ministry of Commerce, Industry, and Energy as an alternative military service from 2005 to 2007.

As a lecturer, Jinhyoung taught several classes related to the field of political economy in the Department of Brazil, Russia, India, and China (BRICs) at HUFS from 2008 to 2010.

Currently, his research interests lie in comprehensive wealth, spatial economics, non-market valuation, social amenities, and social capital.

He loves traveling as well as reading philosophy books.