Amenities, Infrastructure, and Spatial Variations in Economic Development in the United States

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Abstract

This paper examines the causes of spatial inequalities in economic development across counties in the United States. A theoretical model is developed to analyze the interaction between location decisions of firms and households as they are affected by natural amenities, accumulated human and physical capital, and economic geography. An empirical model is then estimated to quantify the contribution of these factors to spatial variations in economic development across counties in the United States. Results show that amenities, infrastructure and economic geography all affect the level of income, employment, housing prices, and land development. However, infrastructure is the primary cause of the differences in income, employment, and development density between the top and bottom 20% counties in the United States. This result arises because the differences in amenities and location advantages between the two groups of counties are small on average. Infrastructure investments lead to more jobs, higher income, higher housing prices, and more land development; but they are not equally effective everywhere. In rural areas with higher natural amenities, infrastructure investments are more effective in promoting land development than in raising income and employment. Infrastructure investments are less effective in raising income and employment in rural communities than in urban areas. Amenities make a large contribution to spatial variations in housing prices than in income, employment, and development density.

Key words: amenities, economic development, economic geography, employment, housing price, income, infrastructure, land development.

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The authors thank Haixia Lin for her assistance with data collection and Bruce Weber and Emery Castle for their comments and suggestions. This project was supported by the National Research Initiative of the U.S. Department of Agriculture, Grant # 2005-01406.

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I. Introduction

It is striking to note that the two most stressed groups of communities in the United States have such opposite geographic characteristics. One group is located in the most isolated rural areas, and the other group is located in the most populated urban centers. Both groups, however, have experienced dramatic socioeconomic changes in the last 50 years. Job losses, crimes, and urban decay have made some inner cities the most distressed communities in the United States. Dwindling economies, declining education and health services, and the weakening community structures have caused some once-viable rural communities to become ghost towns (National Research Council, 2001). Globalization, technological change, and increasing demand for recreational and environmental services from land and water resources have also changed the global environment within which local economies operate. These changes have created opportunities for some communities, but raised new barriers for others. In 2000, the median household income varies from below $18,000 to over $91,000 across counties in the United States, and the variation of median housing prices is even large, from below $10,000 to over $640,000. Much of the spatial variations in income and housing prices can be seen in Figure 1, which displays the ratio of median housing price to median household income across counties in the United States in 2000.

Why do the spatial inequalities in economic development exist in the United States? Why are the spatial differences in wages and housing prices not bid away by households and firms in search of high income and low production costs? Understanding these issues is central for understanding many aspects of economic underdevelopment in distressed communities and for developing policies to stimulate economic growth in those areas (Henderson et al., 2001). Given the importance of these issues, it is not surprising that they have been explored in the economics literature. However, most previous analyses are conducted in the international context and cross-country studies (see Henderson et al., 2001 for an extensive review). These studies have identified three major causes of spatial inequalities in economic development: a) natural endowments (e.g., environmental amenities), b) accumulated human and physical capital (e.g., educational level of labor force, infrastructure), and c) economic geography (e.g., remoteness, proximity to input and output markets). These theories, however, have rarely been tested in the context of economic development in the United States; and no study, to our knowledge, has evaluated the relative contribution of these factors to spatial inequalities in economic development.

The objective of this article is to evaluate the relative contributions of natural amenities, accumulated capital, and economic geography to spatial inequalities in economic development in the United States. To this end, a theoretical model is developed to analyze the interaction between location decisions of firms and households as they are affected by natural endowments, accumulated capital, and economic geography. Understanding the interaction is important because it determines the spatial distribution of economic activity. For example, if a household requires a compensating wage differential to live in a low-amenity location, the firms in that location must have some productivity advantage to be able to pay the higher wage. Based on the theoretical analysis, an empirical model is estimated to quantify the effect of natural endowments, accumulated capital, and economic geography on labor and land markets using county-level data from the United States. Implications of the results for policies to promote economic development in distressed communities are discussed.

Much research has focused on location decisions of households and firms, but relatively few studies have analyzed their interactions. According to the classic theory, households choose residential locations that provide the best tradeoff between land costs and commuting costs. High-income households live in suburbs if and only if the income elasticity of demand for housing is larger than the income elasticity of commuting cost. Wheaton (1977) provides empirical evidence that questions the validity of this theory. In searching for alternative explanations, many economists have turned to factors excluded from the classic urban economics model. For example, Brueckner et al. (1999), Wu (2002), and Wu and Plantinga (2003), show that the location pattern of different income groups can be explained by the spatial distribution of amenities. However, these studies do not consider the location decisions of firms and, thus sources of household income.

Firms' location decisions have also been at the center of economic research (Giannias and Liargovas 2002). According to Fujita et al. (1999), firms' location decisions are based on both input price considerations and proximity to markets. Firms want to locate close to input and output markets to save transportation costs. So a location with a lot of firms will have a high demand for intermediate goods, making it an attractive location for intermediate producers. This in turn makes it an attractive location for firms that use intermediate goods. Thus, there is a positive feedback between location decisions of upstream and downstream firms in the chain of economic activity (Henderson et al., 2001). Resource abundance and scale effects are also key determinants of firms' location and economic growth (Romer 1996). As a disproportionate share of manufacturing is attracted to a location, either the wage rate is bid up or labor is attracted to the location, both of which will tend to increase this location's share of total expenditure still further. This cluster or agglomeration effect has been explored in Krugman (1991) and other studies.

Although many studies have analyzed the location decisions of firms and households, only a few have examined spatial variations in economic development as a result of firm and household location decisions in the United States.[1] In a seminal paper, Roback (1982) develops an equilibrium model of firm and household location decisions to examine the role of wage and rents in allocating workers to locations with different level of amenities. She applies the model to explain wage differences in major U.S. cities and finds that amenities have a significant effect on wages and rents. Rappaport and Sachs (2002) analyze the effect of coastal proximity on the concentration of economic activity in the United States and find that the coastal concentration derives primarily from a productivity effect but also, increasingly, from a “quality-of-life” effect. Deller et al. (2001) examine the role of amenity and quality of life attributes in regional economic growth in the United States and find that there exist predictable relationships between amenities, quality of life and local economic performance. Halstead and Deller (1997), Rudzitis (1999) and Gottlieb (1994) find that quality of life plays an increasingly important role in community economic growth in the United States.[2] However, no previous study, to our knowledge, has examined the relative contribution of alternative factors to spatial inequalities in economic development.[3]

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[1] Several studies have examined spatial variations in economic development in cross-country studies. For example, Giannias and Liargovas (2002) develop a model to analyze the location decisions of firms and households and apply it to examine spatial variations in economic development in 17 Arab countries. Redding and Venables (2000) examine the relationships between geographic characteristics, wage, and per capita income in a cross-country study. Gallup and Sachs (1999) regress national per capita income on four variables (a measure of hydro-carbons per capita, a dummy variable for incidence of malaria, the proportion of population who live within 100 km of the coast, international transportation costs) and find that these four variables alone account for an astonishing 69% of the per capita income variations across their sample of 83 countries.

[2] See Castle (1995) for a comprehensive review and analysis of changing American countryside.

[3] A few studies have examined the impact of geography on land development patterns. See, e.g., Irwin and Bockstael (2002), Wu (2001), Wu et al. (2004)..

This paper is organized as follows. The next section presents a simple theoretical model to analyze the interaction between location decisions of firms and households. An empirical model, based on the theoretical analysis, is then specified to assess the relative contribution of amenities, accumulated capital and economic geography to spatial variations in economic development in the United States. This is followed by a discussion of data and estimation results. The last section presents the main results and policy implications.

II. The Model

This section presents a model to analyze the interaction between location decisions of firms and households and its effect on spatial variations in economic development. The model assumes that locations differ by natural endowments, accumulated human and physical capital, and economic geography. Some of these factors directly affect households' utility, others directly affect firms' productivity and/or transportation costs. Those directly affecting households' utility and residential location decisions are referred to as amenities and are indexed by ε, and those directly affecting firms' location decisions are referred to as capital and are indexed by κ. Amenities and capital may not be mutually exclusive because some variables may affect both households' utility and firms' productivity.

Households have preferences defined over residential space (*h*), a numeraire non-housing good (*z*), and environmental amenities (ε). Each household supplies one unit of time and receives wage *w* in return.[4] At each location, a household solves the following utility maximization problem:

(1) $$V(w, p; \varepsilon) \equiv \max_{h,z} \; U(h, z; \varepsilon) \text{ s.t. } \gamma ph + z = w + I,$$

[4] This assumption can be easily relaxed without changing the main results of the model.

where p is the housing price per unit of residential space, γ is a factor converting housing prices to annual rental or mortgage payments (real interest rate), and I is the non-labor income. Both γ and I are assumed to be independent of location and will be suppressed from the model henceforth. The solution of (1) yields the demand functions for residential space and the non-housing good:

(2) $$h^d = h(w, p; \varepsilon),$$

(3) $$z^d = z(w, p; \varepsilon),$$

The indirect utility function $V(w, p; \varepsilon)$ gives the maximum utility achievable given the wage, the housing price, and the level of amenity.

Households choose residential locations to maximize utility $V(w, p; \varepsilon)$ by considering the tradeoffs between wage (w), housing price (p), and amenities (ε). Households are completely mobile, and migration is costless, equilibrium for households requires that wages and housing prices adjust to equalize utility in all locations:

(4) $$V(w, p; \varepsilon) = \bar{V},$$

where $\bar{V}$ is the national utility level, exogenous to individual counties. Graphically, iso-utility curves are upward sloping in the (w, p)-plane as shown in figure 2. For a given level of amenity, counties that offer higher wages must have high housing prices to equalize utility in all locations.

Firms choose production locations to minimize total cost by considering the tradeoff between input prices, accumulated human and physical capital, and transportation costs. At any given location, a firm chooses the best combination of labor, capital, and factory space to minimize the total production cost:

(5) $$C(w, p; \kappa) \equiv \min_{l,k,s} \; wl + rk + \phi ps, \quad \text{subject to } f(l, k, s; \kappa) = y,$$

where *l, k,* and *s* are labor, capital, and factory space, respectively, *r* is the unit cost of capital, *f*(.) is the production function, *y* is the total output, and ϕ is a factor that converts factory-space prices to annual rental payments.[5] *y*, ϕ, and *r* all are assumed to be independent of location and thus is suppressed from the model henceforth. The solution to (5) gives the firm's demand for labor and factory space:[6]

(6) $$l^d = l^d(w, p; \kappa)$$

(7) $$s^d = s^d(w, p; \kappa)$$

Equilibrium for firms requires that wages and rents adjust to equalize cost in all counties:

(8) $$C(w, p; \kappa) = \overline{C},$$

where $\overline{C}$ is a constant determined by the existing production technologies. Graphically, iso-cost curves are downward sloping in the (*w, p*)-plane, as shown in figure 2. Given the level of accumulated capital, counties with higher labor cost must have lower rental cost to equalize total cost across counties.

The equilibrium conditions for firms and households, (4) and (8), together determine the equilibrium level of wage and housing price, $y^* = y(\varepsilon, \kappa)$ and $p^* = p(\varepsilon, \kappa)$. That is, it is the interaction between the two sides of the markets that determines the equilibrium level of wage and housing prices. This simple framework, illustrated in figure 2 can be used to examine the effect of amenities, accumulated capital, and geography on wages and housing prices.

Consider two counties that have the same level of capital, but county 2 has a higher level of amenities (see figure 3). The iso-utility curve is higher for households living in county 2 because for a given wage, housing prices in county 2 must be higher to equalize utility across the

[5] The price of factory space is assumed to be the same as the price of residential space. The assumption can be easily relaxed without changing the basic results from the model.
[6] The solution to (6) also gives the firm's demand for capital, which is not specified here because our empirical analysis does not consider capital markets.

two counties. In equilibrium, the housing price is higher and the wage is lower in county 2, where households are trading better amenities for lower wage and higher housing prices, and firms are trading lower labor costs for higher rental costs. This basic results can be obtained by differentiating (4) and (8) with respect to ε and solving for $dw/d\varepsilon$ and $dp/d\varepsilon$:

(9)
$$\frac{dw}{d\varepsilon} = -\frac{V_\varepsilon C_p}{\Delta} < 0, \quad \frac{dp}{d\varepsilon} = \frac{V_\varepsilon C_w}{\Delta} > 0,$$

where $\Delta = V_w C_p - V_p C_w > 0$.

Figure 3 is generated under the assumption that amenities do not affect productivity directly. But some amenities may also affect productivity. For example, lack of severe snow storms is an amenity, but it may also increase productivity because blizzards may be costly to firms (Roback 1982). In this case, both the iso-utility and iso-cost curves are higher for the county with better amenity (see figure 4). The equilibrium housing price is still higher in the county with better amenity, but the equilibrium income can be higher or lower, depending on the relative magnitude of the effects of amenity on productivity and utility.

The level of accumulated capital on wage rates and housing prices are illustrated in figure 5, where the two counties are assumed to have the same level of amenities, but county 2 has a higher level of accumulated capital. The iso-cost curve is higher for firms located in county 2 because firms located in county 2 must pay a higher labor and/or rental cost to offset the productivity advantage offered by the higher level of capital. In equilibrium, both the wage and the housing price are higher in county 2. Households trade higher wages for higher housing prices, and firms trade higher labor and rental costs for higher productivity. This basic result can be obtained by differentiating (4) and (8) with respect to κ and solving for $dw/d\kappa$ and $dp/d\kappa$:

(10)
$$\frac{dw}{d\kappa} = \frac{V_p C_\kappa}{\Delta} > 0, \quad \frac{dp}{d\kappa} = -\frac{V_w C_k}{\Delta} > 0.$$

A high concentration of capital may be a "disamenity" because of more traffic and pollution. Accumulated capital's disamenity effect reinforces that on wages, but offsets that on housing prices. If the disamenity effect dominates, a county with higher accumulated capital may have lower housing prices, which can be illustrated in a way similar to that of figure 4.

The effect of geography on economic development can be similarly analyzed as the effect of accumulated capital. Consider two counties that are identical except that county 1 is located in a more remote area than county 2. The iso-cost curve for county 1 is lower than the iso-cost curve for county 2. This may occur for two reasons. First, firms located in county 1 are far from input and output markets and thus may have a higher transportation cost. These firms must be compensated with lower labor and rental costs. Otherwise they will have incentive to move. Second, firms located in county 1 may also have a productivity disadvantage because of lack of access to larger economies—centers of information, communication, trade, finance, and markets. So, in equilibrium counties located in remote areas have both lower wages and lower housing prices.

The above results are summarized in figure 6. In equilibrium, counties with a high level of accumulated capital and a low level of amenity (i.e., some metro counties) have high wages, whereas counties with a low level of accumulated capital and a high level of amenity (i.e., some rural counties) have lower wages. Housing prices in those two types of counties can be high or low, depending on the relative magnitude of the amenity and capital effects. If the capital effect dominates, counties with a high level of accumulated capital and a low level of amenity can have high housing prices. In contrast, counties with both a high level of capital and a high level of amenity (e.g., some suburban counties) have high housing prices, whereas counties with both a low level of capital and a low level of amenity (rural counties) have low housing prices. Income in those types of counties can be high or low, depending on the relative magnitude of the amenity and capital effects.

The model presented in this section provides a theoretical foundation for our empirical analysis. In the following sections, we first specify the empirical model based on the theory and then discuss data and estimation results.

III. The Empirical Model

There are two approaches to the empirical analysis. One is to estimate the reduced form equations of wage and housing price $w^* = w(\varepsilon, \kappa)$ and $p^* = p(\varepsilon, \kappa)$ directly as Roback (1982). The other is to estimate the structural equations of demand and supply of labor and land development and derive the reduced forms from the structural equations. While the first approach is simpler, it does not provide information about whether the effects of amenity and capital on wage and housing prices are driven by the demand or supply side of the labor and land markets. This study adopts the second approach and estimates the demand and supply functions of labor and land development using county-level data. County is the smallest geographic unit at which most economic data are reported at the national level. County is also the basic political unit (jurisdiction) in which many local regulations and policies are developed.

To specify the demand and supply functions in labor and land development markets, note that households choose residential locations to maximize utility $V(w, p; \varepsilon)$ by considering the tradeoffs between wage (*w*), housing price (*p*), and amenities (ε). Thus, the total supply of labor (L^s) in a county is a function of *w*, *p*, and ε in the county:

(11) $$L^s = L^s(w, p; \varepsilon)$$

This equation, together with individual households' demand for residential space (2), determines the total demand for residential development (H^d) in a county:

$$H^d = \alpha L^s h^d \equiv H^d(w, p; \varepsilon), \tag{12}$$

where α is the amount of land needed to build one unit of residential space.

Likewise, firms choose production locations by considering the tradeoffs between labor, rental and transport costs and the level of accumulated human and physical capital. Thus, the total number of firms located in a county is a function of *w*, *p*, and κ: $F = F(w, p; \kappa)$. This equation, together with individual firms' demand for labor and land development (6) and (7), determines the total demand for labor (L^d) and non-residential development (S^d) in a county:

$$L^d = Fl^d \equiv L^d(w, p; \kappa), \tag{13}$$

$$S^d = \beta F s^d \equiv S^d(w, p; \kappa), \tag{14}$$

where β is the amount of land needed to build one unit of factory space. From equations (12) and (14), a county's demand for land development equals

$$A^d \equiv H^d(w, p; \varepsilon) + S^d(w, p; \kappa). \tag{15}$$

The total supply of land development, A^s, is a function of housing price (*p*), construction cost (*x*), and the level of accumulated capital (κ):

$$A^s \equiv A^s(p, w, x; \kappa). \tag{16}$$

The construction cost includes the opportunity cost of land and non-land costs (e.g., labor, materials, and capital costs). The opportunity cost of land is measured using agricultural land prices in this study.

In the theoretical model, all variables affecting productivity are referred to as capital and denoted by κ. However, human and physical capital may play different roles in economic development. To fully capture the effect of human and physical capital, κ is represented by three variables in the empirical analysis : human capital, physical capital/infrastructure, and location characteristics affecting firms' productivity and transportation costs. Although physical capital and location characteristics take time to change, human capital such as the education level of work force can change with migration in a relative short period. Thus, the supply of human capital (E^s)is treated as an endogenous variable and is specified as a function of income, housing price, and amenities:

$$E^s = E^s(w, p; \varepsilon). \quad (17)$$

Equations (11), (13), (15), (16), and (17) constitute the simultaneous equation system estimated in this study. This system is estimated using the county level data and three-stage least squares. All the left-hand side variables are normalized by the total land area in the county to account for differences in county size. Alternative functional forms (e.g., linear vs. log-log) and different measures of amenities and capital (see discussion in the next section) are used to test the robustness of empirical results.

IV. Data

Cross-sectional, county-level data for the year 2000 are used to estimate the simultaneous equation system. These data are taken from a variety of sources, and the final sample contains 2635 U.S. counties. The endogenous variables in the equation system include employment, wage, housing price, developed area, and human capital. Data on employment are taken from the *County Business Patterns* (CBP, 2000), a publication of the Census Bureau, U.S. Department of Commerce. Median household income (including both wage and nonwage income) is used to represent wages in the empirical analysis. Data on median household income and median price of vacant housing units for sale are obtained from the *Census Summary File 3* (SF3, 2000).

While total developed area in each county in 1997 can be directly calculated using data from the 1997 *National Resources Inventory* (NRI) conducted by the Natural Resources Conservation Service, U.S. Department of Agriculture (USDA), the same data are unavailable for 2000. The average annual growth rate of total developed area in each county is calculated using data from the 1992 and 1997 NRIs.[7] The total developed area in each county in 2000 is then extrapolated by applying the annual rate to the total developed area in 1997.[8] Both total employment and total developed area are normalized by the total land area in the county. Human capital represents embodied knowledge and skills and is a measure of the accumulated effect of activities such as formal education. In this study, human capital is measured using the share of bachelor-degree holders in a county's labor force, which is calculated using data from the SF3.

The exogenous variables are broadly grouped into three categories: amenities (ε), accumulated physical capital (ϕ), and location characteristics (θ). Amenities are measured using the natural amenity index developed by the USDA's Economic Research Service (McGranahan, 1999). The index is constructed based on six factors: warm winter (average January temperature), winter sun (average number of sunny days in January), temperate summer (low winter-summer temperature gap), summer humidity (low average July humidity), topographic variation (topography scale), and water area (water area proportion of total county area). To test the robustness of empirical results, amenities are also measured using three indexes that we constructed based on data from National Outdoor Recreation Supply Information System (NORSIS) developed by USDA Forest Service's Wilderness Assessment Unit, Southern Research Station, Athens, Georgia. The three indexes measures the level of amenities provided by climate, water resources, and recreational facilities (e.g., parks, swimming pools),

[7] The county-level developed land data are unavailable from the 2003 NRI at the time of this study.
[8] For 30 counties (less than 1.5% of the sample), the estimated developed area is greater than the total land area. In those counties, the developed area is set to equal to the total land area.

respectively. These indexes are constructed using the principal component analysis based on 22 variables measuring climate conditions (e.g., July temperatures, January sunny days), recreational water resource abundance (e.g., white water miles), and the number of recreational facilities in a county.[9] Farmland prices are taken from Lobowski, Plantinga, and Stavings (2003).

Both public infrastructure and private establishments may affect firms' productivity and thus, should be accounted for when measuring the level of accumulated physical capital. Public infrastructure is represented by road density in the empirical model. Road density is defined as the number of paved road miles per unit of land and is constructed using data from the Bureau of Transportation Statistics, U.S. Department of Commerce. Road density is a good indicator of public infrastructure because it is correlated with other types of public infrastructure. Private establishments are measured using the size-adjusted establishment density, which is defined as the number of establishments (weighted by the size of firms) per unit of land and is calculated using data from the CBP. The CBP data divide establishment into nine categories based on the number of employees: <4, 5-9, 10-19, 20-49, 50-99, 100-249, 250-499, 500-999, and >1000. The size-adjusted establishment density is lagged two years (1998) in the empirical model to avoid potential endogeneity problems.

Location characteristics are described using the urban influence code developed by the USDA's Economic Research Service (2003). The ERS divides counties into 12 groups based on urban influence. Metro counties are divided into two groups by the size of the metro area—those in large areas with at least 1 million residents and those in areas with fewer than 1 million residents. Nonmetro, micropolitan counties are divided into three groups by their adjacency to

[9] The principal component analysis is an approach to compress higher dimension variables into a single scalar. The single scalar is called score which is, in essence, the linear combination of the original variables where the weights are the eigenvectors of the correlation matrix for the factor variables. Because the principal component is very sensitive to scale, all variables used in the principal component analysis are standardized to zero mean and unit variance.

metro areas—adjacent to a large metro area, adjacent to a small metro area, and not adjacent to a metro area. Nonmetro, noncore counties are divided into seven groups by their adjacency to metro or micro areas and whether or not they have their own town of at least 2,500 residents. Table 1 presents summary statistics of all variables used in the empirical analysis.

V. Results

The simultaneous equation system is estimated using the data described in the previous section. Results are reported in table 2 for four alternative specifications of functional form and/or different measures of amenities and physical capital. Model 1 uses the linear functional form and serves as the base model. It uses the natural amenity score developed by USDA's Economic Research Service to measure the level of amenity, and uses road density to measure the level of infrastructure. Model 2 includes the same variables but uses the log-log functional form instead of the linear functional form. Model 3 is the same as model 1 except that it uses both the road density and the establishment density to measure the level of accumulated physical capital. Accumulated physical capital may include both public infrastructure and private establishments. However, because the establishment density is positively correlated with the road density and is potentially endogenous, the base model only includes road density as a measure of accumulated physical capital. Model 4 differs from model 1 in that it uses three separate indexes to measure amenities provided by climate, water resources, and recreational facilities instead of using a single index from USDA. In each model, almost all coefficients are statistically significant at the 1% level and have signs consistent with economic theory. The coefficients are also robust to changes in functional forms and measures of amenities and physical capital.

As expected, income has a positive effect on labor supply, and the effect is statistically significant at the 1% level in every model. All amenity measures have positive and statistically significant coefficients in the labor supply equations regardless of the choice of amenity measures or functional form. This result is consistent with those from Rappaport and Sachs (2002) and Deller et al. (2001), which find that amenities have a positive effect on employment. Unlike previous studies, which estimate reduced form equations, this study estimates the structural equations, which allow us to identifies the effect of amenity as a supply-side phenomenon. High housing prices reduce the supply of labor because, given the level of income and amenities, households prefer to live in places with lower housing prices.

Consistent with the theory, income has a significant negative effect on firms' demand for labor, while the stocks of human and physical capital have a significant positive effect. Counties with more accumulated human capital and better infrastructure attract more firms and thus, have more demand for labor.[10] Using the percentage of high-school graduates in a county's population, Deller et al. (2001) find that human capital is positively associated with employment. High housing prices reduce the demand for labor. Firms prefer locations with lower housing prices because of potential saving in labor cost (as a result of workers' willingness to accept lower wages in those locations). The urban influence code has a negative and highly significant coefficient in each specification of labor demand. Counties located in remote areas (i.e., counties with a large urban influence code) are less attractive to firms and thus, have lower demand for labor. While previous studies (e.g., Rappaport and Sachs, 2002) have attempted to quantify the effect of distance on population density and trade, this study examines the effect of remoteness on income and employment.

The supply of developed land increases with housing prices, but decreases with farmland

[10] However, the density of establishment has a negative sign in the labor demand equation in model 3. A high density of establishments may have two effects on the demand for labor. First, the agglomeration or cluster effect from a high density of establishments may attract more firms to a location, which increases the demand for labor. Second, the agglomeration effect may also change the relative productivity of alternative inputs, which may increase or decrease firms' demand for labor. The negative coefficient on the density of establishments indicates that the second effect is negative and larger than the first one.

prices. Given that land is a major component of development cost, development is more likely to occur in areas with lower land costs, *ceteris paribus*. Road density and remoteness affect the supply of developed land because developers prefer to develop in areas with more roads and easy access, anticipating higher demand for development in those areas.

Income has a significant positive effect on the demand for developed land, whereas housing price has the opposite effect. Counties with higher amenities also face a larger demand for developed land, and the effect of amenities is enhanced by roads as indicated by the positive coefficient on the interaction term between amenities and road density. This positive interaction may indicate that households prefer residential locations with high amenities and easy access. Road density itself, however, has a negative effect on the demand for the developed area. A high road density may indicate traffic and pollution, which reduce amenities. Remote areas have low demand for developed land because there are few households and firms located in those places. However, increasing access to remote areas increases demand for developed land in those places as indicated by the positive coefficient on the interaction term between UIC and road density.

As shown by the human capital equation in the base model, high income and high amenity attract human capital (highly educated labor). However, the result on the effect of amenities on human capital are sensitive to the choice of amenity measures. Although the recreation index has a significant positive coefficient in model 4, climate and water have significant negative coefficients in the human capital equation. The coefficient on housing price in the human capital equation is also sensitive to the choice of functional form.

Table 3 presents elasticities estimated based on the base model and sample means of the variables. Both the demand and supply of labor are highly responsive to income changes. A 1% increase in income increases the supply of labor by 9.50%, but reduces the demand for labor by

5.18%. Both the demand and supply of labor are also affected by housing prices. A 1% increase in housing prices reduce the demand for labor by 1.56%, but reduces the supply of labor by only 0.82%.

The supply of developed land is more responsive to housing prices than to farmland prices. A 1% increase in housing price increases the supply of developed land by 1.03%, whereas a 1% increase in farmland prices reduces the supply of developed land by only 0.08%. The demand for developed land is more responsive to income than to housing prices. A 1% increase in income increases demand for developed land by 4.81%, while a 1% increase in housing price reduces demand for developed land by 2.43%. Nevertheless, the demand for developed land is still more responsive to changes in housing prices than the supply of developed land, which has an elasticity of 1.03.

Causes of Spatial Variations in Economic Development

The interaction between the location decisions of firms and households shapes the markets of labor and land development and determines the spatial distribution of economic activity. Because amenities, infrastructure, and economic geography affect both the firm and household decisions, either directly or indirectly, their net effects on income, employment, housing price and developed land depend on the relative magnitudes of their effects on the two sides of labor and land development markets. These net effects can be evaluated using the reduced-form equations of income, employment, housing prices, and development density derived from the structural equations. The estimated parameters for the reduced-form equations based on the base model are reported in table 4.

The coefficients of amenities are positive in each of the five reduced-form equations. This implies that natural amenities have a positive net effect on every indicator of economic development considered in this study, including income, employment, housing prices, developed density, and human capital. This result is consistent with Deller et al.'s (2001) result on the effect of amenities on employment, but is opposite to Roback's (1982) result on the effect of amenities on wage in American cities. Roback (1982) finds that amenities (disamenities) have a negative (positive) effect on wages. Roback's study is limited to 98 cities in the United States and does not estimate the structural linkages among human capital, amenities, and income. Although our results show that households are willing to accept lower wage for better amenities (as indicated by the positive coefficient of amenities in the labor supply equation), amenities have a positive net effect on income because they attract human capital, which increases total demand for labor. Table 4 also shows that counties with better amenity have higher housing prices and higher development density. This positive link between amenities and housing price is also found in Roback (2002).

Remoteness, as measured by the urban influence code, has a negative effect on every indicator of economic development considered in this study. It reduces income, employment density, housing prices, and development density. The primary driver of this result is labor demand, which is lower in remote areas. Because of lower demand for labor, income is lower in remote areas, which leads to lower housing prices and lower demand for land development.

Better infrastructure as measured by road density contributes to economic development as measured by income, employment, housing prices, and development density. Improving roads increases demand for labor, which leads to higher income and higher housing prices. Despite the direct negative effect of roads on demand for developed land, the income effect dominates, resulting in a positive net effect of road density on land development. However, the interaction between amenities and road density has a negative effect on income and employment and a positive effect on housing prices and development density. This result arises because road construction is more effective in raising demand for developed land in higher amenity locations and, consequently, causes development density and housing prices to go up by a larger amount in those locations. Because higher housing prices reduce labor demand more than they reduce labor supply, the interaction between roads and amenities offsets the effect of roads on employment and income. However, the interaction effects are relatively small compared with the direct effects of amenities and road density on income and employment.

The coefficient on the interaction term between road density and the urban influence code indicates that building roads is less effective in raising income and employment in remote areas (i.e., places with larger urban influence code). This is because building roads will increase the demand for developed land in remote areas, which leads to higher housing prices. Because higher housing prices reduce the demand for labor more than the supply of labor, the interaction between roads and remoteness offsets the direct effect of roads on employment and income. If high-income households prefer large ranches in remote areas, remoteness with increased road access favors housing markets over labor markets.

To assess the relative contribution of amenities, infrastructure, and geography to spatial variations in economic development, the contribution of these factors to the income difference between the top 20% high-income county and the bottom 20% low-income counties in the United States is estimated using the following procedure. First, by substituting the sample means of exogenous variables for the top and bottom 20% counties into the reduced-form equation of income, average median income is estimated for each of the two income groups:

$$w_k = \alpha_0 + \alpha_1 A_k + \alpha_2 R_k + \alpha_3 U_k + \alpha_4 A_k * R_k + \alpha_5 U_k * R_k , \quad (18)$$

where $k = T, B$ indicates the top and bottom 20% counties, and A_k, R_k, U_k represents the sample means of amenities, road density, and the urban influence code for group *k*, respectively. Second, dividing the difference between the two equations in (18) by $(w_T - w_B)$ gives

$$(19) \qquad 1 = \frac{\alpha_1(A_T - A_B)}{(w_T - w_B)} + \frac{\alpha_2(R_T - R_B)}{(w_T - w_B)} + \frac{\alpha_3(U_T - U_B)}{(w_T - w_B)} + \frac{\alpha_4(A_T R_T - A_T R)_B}{(w_T - w_B)} + \frac{\alpha_5(U_T R_T - U_T R)_B}{(w_T - w_B)}.$$

The five terms on the right-hand side of (19) represent the shares of the difference in the median income between the two income groups that can be attributed to amenities, road density, geography, and the interactions between roads and amenities, and roads and geography. The contributions of these factors to employment density, housing prices and development density are similarly calculated, and the results are reported in tables 5.

The difference in the average median income between the top and bottom 20% counties is $12,364. Seventy-four percent of the difference can be attributed to road density, 16% to geography, -3% to amenities, and 14% to the interaction between road density and geography. Amenities make a negative contribution to the income difference because the average level of amenities is higher in the bottom 20% low-income counties than in the top 20% high-income counties. Amenities' contribution to spatial income inequality is lower due to relatively small differences in the average level of amenities between the two income gropus. However, this does not mean that amenity is unimportant in determining the level of income. Consider two counties that have same (average) level of capital and remoteness, but one has higher level of amenity than the other. If one county has the lowest level of amenity ($\varepsilon = 0$) and the other has the highest level of amenity ($\varepsilon = 1$), their income would differ by $ 15,235 or 42 %.

The negative coefficients on the two interaction terms in the reduced form equations of income and employment density indicates that investments in roads are less effective in raising income and employment in remote areas with high amenities. Road construction is more effective in raising demand for developed land and housing prices in remote areas with high amenities than in urban communities with low amenities. However, because the interaction effects are small, they can never completely offset the direct effect of road density on income and employment.

The difference in the average median price between the top 20 % high housing-price counties and the bottom 20 % low housing-price counties is $59,403. About 29 % of the difference can be attributed to amenities, 36 % to road density, 52 % to geography, 5 % to the interaction between roads and amenities, -25 % to the interactions between roads and geography, and 3 % to farmland prices. In contrast to the top 20% high-income (or high-employment, high-development density) counties, which have a lower level of amenities that the bottom 20% counties on average, the top 20% high-housing-price counties have a higher level of amenities than the bottom 20% low-housing-price counties on average. Thus, amenities make a positive contribution to the difference in housing prices. Amenities also make a much larger contribution to variations in housing price than to variations in income, employment density, and development density. If road density had been the same in the two groups of counties (with road density equal the national average), the difference in the average median housing prices between the two groups of counties would have been $38,211. Fifty-three percent of the difference would be attributed to amenities, 42 % to the difference to remoteness, and 5 % to farmland prices.

Infrastructure is the primary cause of the difference in employment and development densities between top and bottom 20% counties in the United States. However, amenities and remoteness reduce the effect of infrastructure on income and employment, and increase the effect of infrastructure on land development and housing prices. Consequently, investments in infrastructure such as roads are more effective in promoting land development in rural communities with high amenities than in urban areas with low amenities. However, those investments are less effective in raising income and employment in rural communities with high amenities than in urban areas with low amenities.

VI. Summary and Conclusions

This article evaluates the contributions of amenities, infrastructure, and economic geography to spatial inequalities in economic development across counties in the United States. A theoretical model is developed to analyze the interaction between location decisions of firms and households as they are affected by amenities, accumulated capital, and economic geography. An empirical model is then estimated to quantify the contribution of these factors to spatial variations in economic development across counties in the United States.

Results show that amenities, infrastructure and economic geography all affect the level of income, employment, housing prices, and land development; however, infrastructure is the primary cause of the difference in income, employment, and development density (percent of land developed) between the top and bottom 20% counties in the United States. These apparent counter intuitive results arise because the differences in amenities and location advantages between the two groups of counties are small on average. Investments in infrastructure and amenity enhancements lead to more jobs, higher income, higher housing prices, and more land development; but they are not equally effective everywhere. In rural areas with higher amenities, improving infrastructure is more effective in promoting land development than in raising income and employment. Amenities contribute more to spatial variations in housing prices than in income, employment, and development density. About 30% of the difference in median housing prices between the top 20% high housing-price counties and the bottom 20% low housing-price counties can be directly attributed to amenities. Amenities also play an important role in determining the level of income, employment and development density. They could make a 40% difference in income between two counties with the average level infrastructure and remoteness.

Although both the theoretical and empirical models omit any direct representation of public policies, they have implications for the design of policies to promote economic development in distressed communities. Most of the bottom 20 % low income counties are located in remote rural areas. Although those counties have a slightly higher level of natural amenity on average than the top 20% high-income counties, they generally have a much lower level of infrastructure. Investments in infrastructure in rural communities will contribute to economic development in those areas. However, these investments are more effective in promoting land development than in raising income and employment. In addition, infrastructure investments are less effective in raising income and employment in rural communities than in urban areas.

This study shows that infrastructure is the primary cause of spatial variations in economic development across counties in the United States. Although the methods developed in this study can be applied to geographic units smaller than counties, data are unavailable at the sub-county level for the United States. However, we anticipate that infrastructure may play even a greater role in determining intra-county variations in economic development because differences in amenities and remoteness are likely to be smaller within a county than across counties. A more comprehensive study would include a direct representation of development policies and take into account socio-demographic characteristics of communities.

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Table 1: Descriptive Statistics of U.S. County Data (2635 Counties)

Name of Variable	Unit	Mean	Standard Deviation	Minimum	Maximum
Employment density	Number/Acre	77.77	169.91	0.15	3896.06
Median income	$	36254	8434	17062	91210
Development density	Acre/Acre	0.1055	0.1639	0.0001	1.0000
Housing price	$	64494	42583	9999	639700
Amenities	Index	0.3456	0.1206	0.0006	1.0000
Recreation	Index	0.6323	0.4944	0.0065	4.5444
Water	Index	0.6162	0.9623	0.0019	10.1759
Climate	Index	2.2550	0.9592	0.0003	4.5859
Road density	Miles/Acre	2.8145	1.4858	0.2607	20.8504
Human capital	Share of BS degree holders	0.0964	0.0411	0.0278	0.3356
Establishment density	Number/Acre	0.8524	1.1694	0.0001	17.2336
Farmland price	1000$/acre	1.57	2.18	0.087	80.85
Construction wages	$/year	5601	1702	500	34950
Urban influence code (UIC)	Index	5.353	3.351	1.0000	12.0000

Table 2: Parameter Estimates of the Structural Model (4 Specifications)

	Model 1 (Base)		Model 2, Log-log		Model 3, with firm density		Model 4, with climate/water/recreation	
	Parameter	t value	Parameter	t value	Parameter	t value	Parameter	t value
Labor Supply (Employment/Total Area)								
Intercept	-659.175	-8.10	-78.962	-14.37	-689.351	-8.48	-732.714	-17.19
Income	0.020	8.17	8.043	10.65	0.021	8.54	0.023	15.10
Housing price	-0.001	-1.78	-0.128	-0.57	-0.001	-2.15	-0.004	-9.57
Amenities	175.373	2.26	0.440	2.81	206.011	2.66		
Climate							36.055	9.22
Recreation							180.785	18.51
Water							18.916	4.06
Labor Demand (Employment/Total Area)								
Intercept	-275.311	-8.70	-6.574	-3.40	-306.252	-9.53	84.837	2.23
Income	-0.011	-9.52	-0.565	-2.64	-0.011	-9.53	-0.021	-14.74
Housing price	-0.002	-8.53	1.082	21.24	-0.002	-9.25	-0.001	-3.34
Human capital	77.980	37.08	1.462	15.61	86.192	41.63	69.837	23.87
Road density	53.117	36.40	1.292	58.23	51.636	37.71	80.097	37.38
UIC	-4.455	-4.52	-0.042	-7.25	-5.959	-6.30	-13.334	-9.41
Establishment density					-17.815	-10.91		
Developed Area Supply (Developed Area/Total Area)								
Intercept	-0.144700	-11.70	-16.544	-24.02	-0.143570	-11.32	-0.213170	-14.46
Housing price	0.000002	14.39	1.503	18.06	0.000002	14.30	0.000002	14.10
Road density	0.058644	30.77	1.309	28.67	0.058451	30.71	0.067036	33.41
UIC	-0.002870	-3.02	-0.541	-10.03	-0.002920	-3.07	0.001359	1.28
Farmland price	-0.005000	-3.98	-26.000	-3.20	-0.005000	-3.74	-0.005000	-3.38

Table 2 (continued): Parameter Estimates of the Structural Model (4 Specifications)

	Model 1 (Base)		Model 2, Log-log		Model 3, with firm density		Model 4, with climate/water/recreation	
	Parameter	t value	Parameter	t value	Parameter	t value	Parameter	t value
Developed Area Demand (Developed Area/Total Area)								
Intercept	-0.759570	-7.22	-146.370	-4.17	-0.919030	-9.18	-1.193070	-16.88
Income	0.000014	4.37	16.258	3.74	0.000018	5.82	0.000026	11.23
Housing price	-0.000004	-6.96	-2.443	-2.78	-0.000005	-8.69	-0.000005	-11.34
Amenities	0.342064	3.64	1.463	2.15	0.523670	5.67		
Human capital	0.053225	13.27	1.128	2.74	0.054804	14.44	0.040365	11.94
Road density	-0.019060	-2.98	-1.763	-4.47	-0.014500	-2.45	-0.000150	-0.05
UIC	-0.022230	-7.79	-0.041	-1.71	-0.021310	-7.99	0.004838	2.79
Amenities × Road density	0.026261	1.72	-0.031	-0.16	0.018294	1.28		
UIC × Road density	0.008947	8.90	0.136	2.31	0.008968	9.62		
Establishment density					0.006891	2.84		
Climate							0.082798	14.70
Recreation							0.059138	3.57
Water							0.030800	6.66
Road density × Recreation							0.001448	0.88
UIC × Recreation							0.006959	2.95
Human Capital Supply (Share of BS/BA holders)								
Intercept	-3.02199	-3.02	-12.72870	-12.03	-0.35135	-0.36	4.29939	6.39
Income	0.00029	9.19	1.64366	11.34	0.00021	6.79	0.00009	3.76
Housing price	0.00001	1.43	-0.18799	-4.39	0.00003	4.12	0.00004	7.55
Amenities	4.30971	4.84	0.23176	7.84	1.59852	1.84		
Climate							-0.55934	-9.27
Recreation							0.94752	6.34
Water							-0.15801	-2.61
System Weighted R-square	0.44		0.58		0.43		0.47	

Table 3. Estimates of Elasticities

	Supply of Labor	Supply of Human Capital	Demand for Labor	Supply of Developed Land	Demand for Developed Land
Income	9.50	1.09	-5.18		4.81
Housing price	-0.82	0.07	-1.56	1.03	-2.43
Amenities	0.78	0.15			1.12
Human capital			9.67		4.86
Road density			1.92	1.56	-0.51
UIC			-0.31	-0.15	-1.13
Farmland price				-0.08	
Amenities × Road density					0.24
UIC × Road density					1.11

Table 4: Parameter Estimates of the Reduced Form Equations

Independent Variable	Income	Housing Price	Employment Density	Development Density	Human Capital
Intercept	17,365	-50,605	-255	-0.23	1.51
Amenities	15,235	199,353	289	0.34	10.69
Road density	5,714	17,915	99	0.09	1.83
UIC	-413	-6,159	-2	-0.01	-0.18
Farmland price	-13	949	-1	0.003	-0.01
Amenities × Road density	-67	4,726	-6	0.01	0.03
UIC × Road density	-223	1,610	-2	0.003	0.01

Table 5: The Contribution of Alternative Factors to Difference in Income, Housing Price, Employment Density, and Development Density between the Top and Bottom 20% of U.S. Counties

	Income ($)		Housing Price ($)		Employment Density (Person/Acre)		Development Density (Share of Land Developed)	
	Percent	Value	Percent	Value	Percent	Value	Percent	Value
Difference		12,364		59,403		311		0.30
Amenities	-3	-381	29	17,344	-2	-6	-2	-0.01
Road density	74	9,126	36	21,192	97	302	81	0.25
UIC	16	1,990	52	30,865	5	15	24	0.07
Amenities× Road density	0	-30	5	2,689	-2	-7	3	0.01
UIC× Road density	14	1,685	-25	-14,679	3	9	-3	-0.01
Farmland prices	0	-25	3	1,992	-1	-3	-2	-0.01

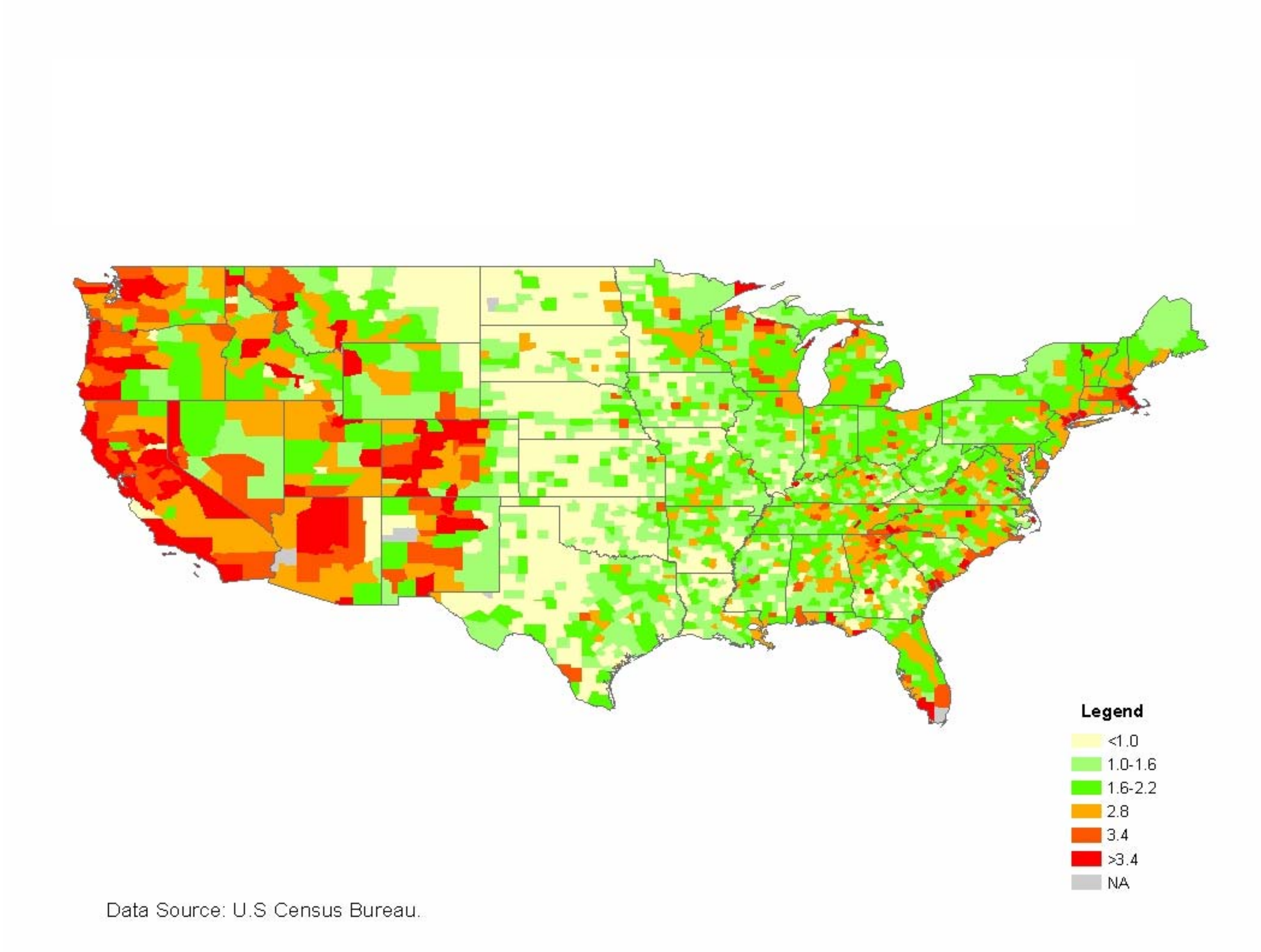

Fig. 1. The ratio of median housing price to median household income across counties in the United States

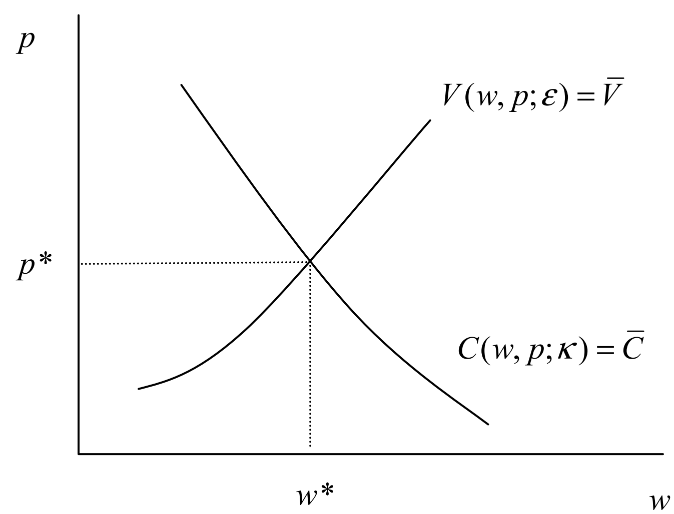

Fig. 2. The equilibrium level of wage and housing price

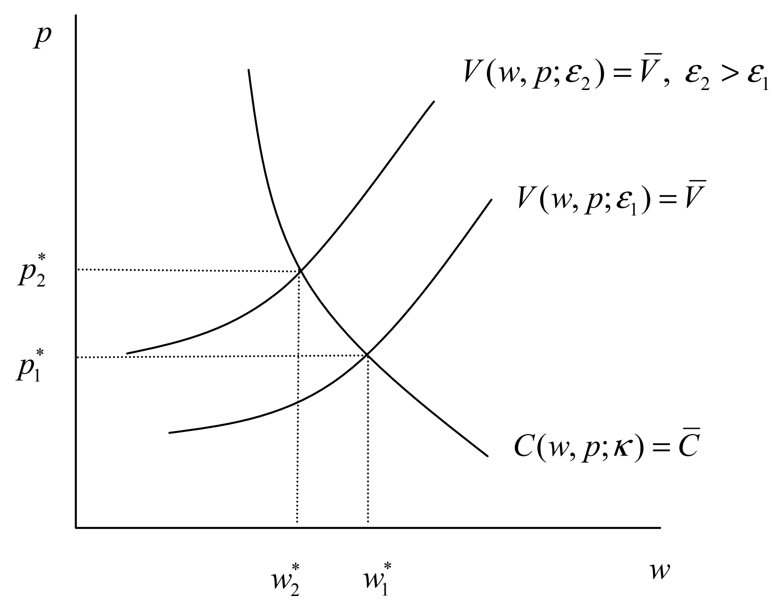

Fig. 3. The equilibrium level of wage and housing price in two counties with the same level of accumulated capital but different levels of amenities

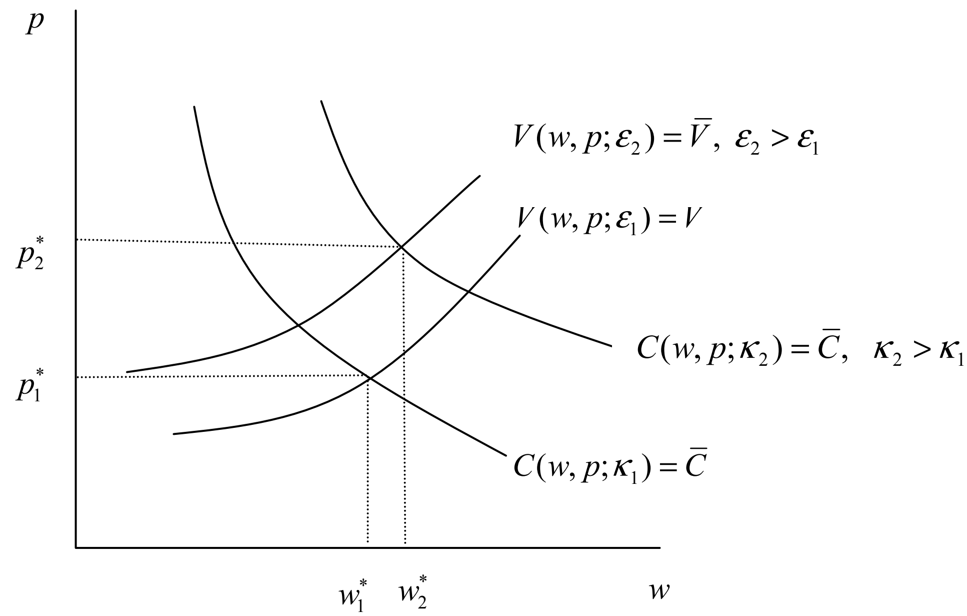

Fig. 4. The equilibrium levels of income and housing prices in the presence of productive amenities (e.g., lack of severe snow storms)

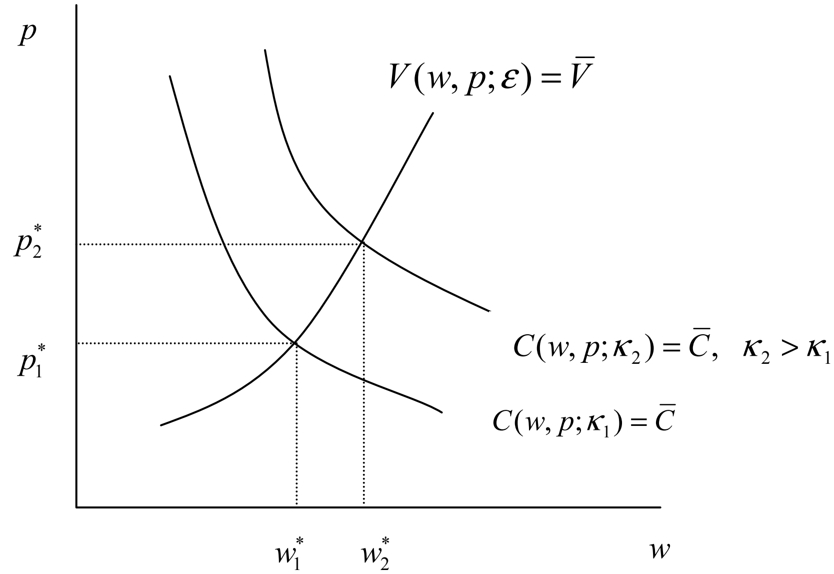

Fig. 5. The equilibrium level of wage and housing price in two counties with the same level of amenities but different levels of accumulated capital

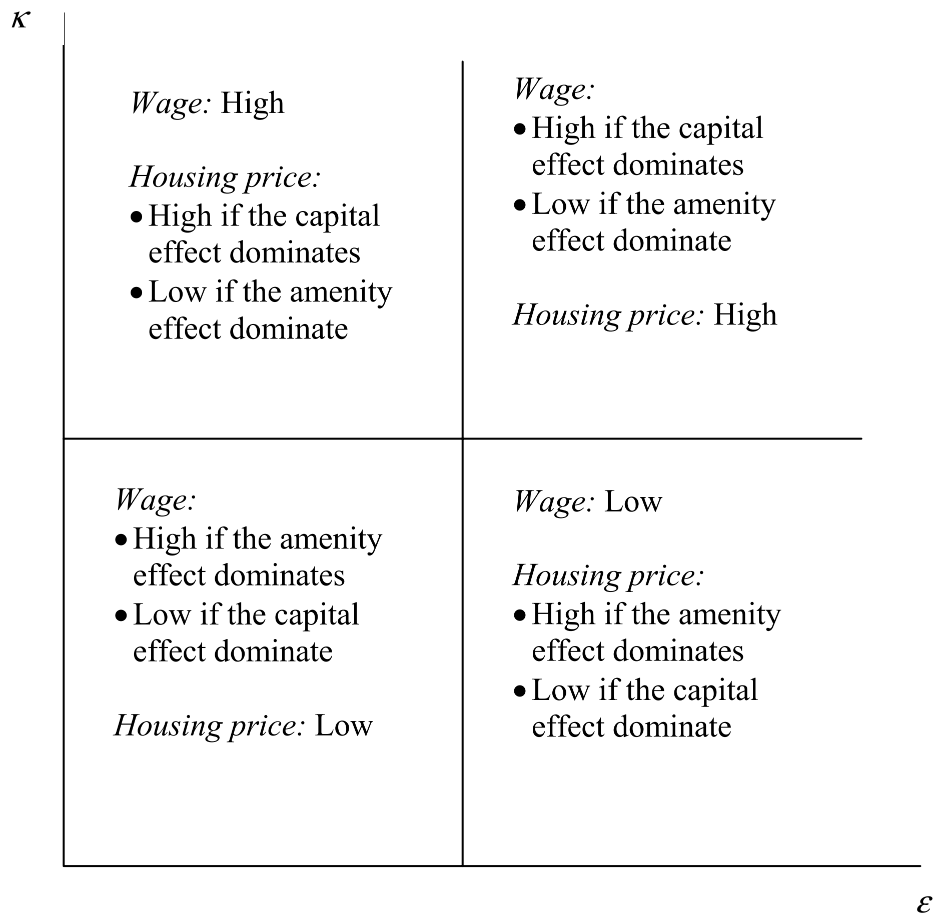

Fig. 6. Amenities, accumulated capital, remoteness, and the spatial variation in wage and housing price