Growth and Convergence in the Space Economy: Evidence from the United States

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Abstract. This paper investigates geographic relationships in a land use based regional adjustment model containing equations for population density, employment density, and wages in the continental United States during the 1980s and 1990s. The results of the analysis suggest that (1) accounting for spatial interdependencies appreciably enhances the estimates; (2) with this correction, the viability of the three-equation framework used here seems strong; and (3) even as the nation's post-industrial economy continues along its path of decentralization, equilibrating forces work to maintain an uneven pattern of development characteristic of the well-known, hierarchical system of regional economies described by traditional forms of location and central place theory.

1. Introduction

The object of this paper is to investigate geographic relationships in a dynamic growth model — namely, a land use based regional adjustment model containing equations for population density, employment density, and the average annual wage — in the United States during the 1980s and 1990s. Regional adjustment models are ideal for studying growth and settlement patterns because they account for the roles of both opportunity and preference in the growth process and extend in a natural way to describe the spatial configuration of development. The theoretical framework underpinning the models originates from Borts and Stein's (1964) study *Economic Growth in a Free Market*, which was apparently the first to suggest that population growth may drive employment growth as jobs follow people into and/or within regions in addition to the other way around. The core concept was succinctly framed in the title of Muth's (1971) paper, *Migration: Chicken or Egg?* and then fully operationalized by Steinnes and Fisher (1974) in an analysis of the interaction between population growth and employment growth in the Chicago metropolitan area. Finally, regional adjustment models were popularized by Carlino and Mills (1987) and Boarnet (1994a, 1994b) and have since emerged as an increasingly common method of analyzing the process and outcome of development within various spatial frames of reference (see, for example, Clark and Murphy 1996; Henry et al 1997, 1999, 2001; Glavac et al 1999; Mulligan et al 1999; Vias and Mulligan 1999; Deller et al 2001; Bao et al 2004; Rey and Boarnet 2004; Boarnet et al 2005; Carruthers and Vias 2005; Carruthers and Mulligan 2006, 2007, 2008; Mulligan and Vias 2006).

This paper extends the existing body of research involving regional adjustment models in several key ways. First, building on work done by Carruthers and Mulligan (2008) it expands the traditional two-equation specification by adding a third equation, for wages, so that population density, employment density, and the average annual wage are modeled as a function of contemporaneous values of one another, plus their own time-lagged values and a set of other predetermined factors. Second, each equation is specified with a spatially lagged dependent variable and then estimated via Kelejian and Prucha's (1998) spatial two stage least squares (S2SLS) procedure, which accommodates the endogenous relationship among the three dependent variables and their own spatial lags. Two alternative spatial weighting schemes are considered and, for comparison, an aspatial specification is also presented. Third, the densities used in the analysis are measured with land use data, so the spatial units reflect the area actually occupied by socioeconomic activity. In addition, all of the interdependent variables and most of the independent variables are expressed as location quotients. This transformation ensures that each observation is pegged to the system as a whole and enables direct comparison of the relative importance of population, employment, and the average annual wage in shaping the growth process at equilibrium. Fourth, the model is applied to the entire continental United States using county-level data representing the three 5-year periods that comprise the 1982 – 1997 timeframe: 1982 – 1987, 1987 – 1992, and 1992 – 1997. And, because the estimation results represent what, for all practical purposes, is the entirety of a more-or-less closed labor market, they can reliably be used to evaluate and compare projected steady state scenarios for three points in time. Finally, as an extension, the estimates are used to produce a detailed portrait of how equilibrating tendencies influence the geographic distribution and spatial configuration of American growth and land use patterns.

The remainder of the paper is organized into three main sections. The background discussion briefly explains the purpose of regional adjustment models and outlines the particulars of the modeling framework used in this study. The empirical analysis then estimates a series of three-equation systems and evaluates their results. Last, the paper closes with a summary of its findings and some general conclusions and recommendations for future research.

2. Background

The innovation of regional adjustment models is that they simultaneously capture demand- (employment) and supply- (population) induced growth that occurs as labor moves from place-to-place and the space economy as a whole searches for an optimal arrangement of activity. It is common for people to relocate for opportunity, or work, related reasons — for example, to the Puget Sound region of Washington State to fill jobs created by Boeing, Microsoft, Starbucks, or any other of the region's many high-performing companies — but also for preference, or quality of life, related reasons. Whether moves resulting from the latter motivation are made with complete disregard for work or not, it is often the case that employment is generated in their wake, especially in the finance, insurance and real estate (FIRE) and service sectors. Regional adjustment models emulate both of these mechanisms and the give-and-take between them by describing population (employment) change between two points in time as a function of employment (population) at the end of the time period, population (employment) at the beginning of the time period, and a set of other initial, or predetermined, conditions. The result is normally a system of two simultaneous equations wherein population and employment dynamically adjust via an equilibrating process that eventually produces a steady state in which the relative levels of population and employment remain fixed, even if some zero-sum-movement still occurs. The process of getting to this point is explicitly spatial because all actors end up being located in such a way that there is no incentive for further movement — in other words, at equilibrium, they are indifferent among locations.

The logic of the three-equation regional adjustment model used in this paper is analogous to DiPasquale and Wheaton's (1996) three-sector model of metropolitan growth, which connects the local export, labor, and real estate markets. As explained, demand-induced growth occurs as a result of firms needing additional labor, and supply-induced growth occurs as a result of households making moves for quality of life related reasons. Only the first of these two mechanisms is precipitated by gains in the export market but both place pressure on the real estate market, raising rents and, at the same time, densities due to more intense competition over space. Expressing population and employment in terms of the density of land use ties the regional adjustment model framework directly to land rent and gives rise to the wage equation. Specifically, land use density measures the spatial intensity of activity, which is influenced by the average annual wage because of its relationship to land consumption: For households, land is a normal good, so, the more they earn in wages, the more space they are able to consume, leading to a lower population density; conversely, for profit-maximizing firms, land is a factor of production, so, the more they pay in wages, the less space they are able consume, leading to a higher employment density. Meanwhile, population density, which measures how concentrated the supply of labor is, and employment density, which measures how concentrated the demand for labor is, simultaneously drive the average annual wage. Working off of Roback's (1982) model of compensating differentials, Mueser and Graves (1995) show how labor demand, labor supply, and wages combine to form a kind of "moving equilibrium" that calls for more-or-less continuous migration as the space economy wobbles along a path of constant, interactive growth and change, searching for an optimal organization of activity. See Mulligan et al. (1999) and Carruthers and Mulligan (2006, 2007, 2008) for detailed expositions of the material presented in this and the following several paragraphs.

Turning to the model itself, a regional adjustment model is an application of the partial adjustment model — which was originally used for analyzing business cycles (see, for example, Litner 1956; Lev 1969) — where population density and employment density are simultaneously determined. The present approach expands on the traditional two-equation framework by adding a third endogenous variable, the average annual wage (y), to the system:

$$\begin{aligned} \dot{p} = (p_t / p_{t\text{-}}) &= \delta_p(\tilde{p} / p_{t\text{-}}) \\ \dot{e} = (e_t / e_{t\text{-}}) &= \delta_e(\tilde{e} / e_{t\text{-}}) \\ \dot{y} = (y_t / y_{t\text{-}}) &= \delta_y(\tilde{y} / y_{t\text{-}}) \end{aligned} \quad (1)$$

In these equations, t- and t represent two successive points in time; $\dot{p}$, $\dot{e}$, and $\dot{y}$ represent rates of change in population density, employment density, and the average annual wage; $\tilde{p}$, $\tilde{e}$, and $\tilde{y}$ represent the (mobile, in the sense described by Mueser and Graves 1995) equilibrium levels of those three variables; and δ_p, δ_e, δ_y represent fractional adjustment parameters that are less than zero and greater than negative one, implying a process of convergence toward a state of spatial equilibrium.

The core of the system of relationships in the three-equation regional adjustment model is created by expressing each variable's observed rate of change toward spatial equilibrium as a function of the observed level of the other two at time t, its own level at time t-, and a set of other predetermined variables:

$$\dot{p} = \alpha_0 + \alpha_1 p_{t-} + \alpha_2 e_t + \alpha_3 y_t + \boldsymbol{\alpha}_4 \boldsymbol{x}_{pt-} + \varepsilon_{pt}$$
$$\dot{e} = \beta_0 + \beta_1 p_t + \beta_2 e_{t-} + \beta_3 y_t + \boldsymbol{\beta}_4 \boldsymbol{x}_{et-} + \varepsilon_{et} \qquad (2)$$
$$\dot{y} = \gamma_0 + \gamma_1 p_t + \gamma_2 e_t + \gamma_3 y_{t-} + \boldsymbol{\gamma}_4 \boldsymbol{x}_{yt-} + \varepsilon_{yt}$$

Here, the αs, βs, and γs represent various estimable parameters (α_1, β_2, and γ_3 replace δ_p, δ_e, and δ_y, respectively) or vectors of estimable parameters; the $\boldsymbol{x}$s represent vectors of predetermined variables; and ε_{pt}, ε_{et}, and ε_{yt} represent stochastic error terms.

Note that, once estimated, the model's formulation (see Mulligan et al 1999) allows the equilibrium levels of population density, employment density, and the average annual wage — which are used in the following empirical analysis to examine steady state scenarios — to be derived the following equivalencies:

$$\tilde{p} = \frac{p_t}{\delta_p} - \frac{(1-\delta_p)p_{t\text{-}1}}{\delta_p}$$
$$\tilde{e} = \frac{e_t}{\delta_e} - \frac{(1-\delta_e)e_{t\text{-}1}}{\delta_e} \qquad (3)$$
$$\tilde{y} = \frac{y_t}{\delta_y} - \frac{(1-\delta_y)y_{t\text{-}1}}{\delta_y}$$

If rates of change, rather than levels, are used as dependent variables, as they are in this study, the same set of circumstances applies except that, in equation sets (3) and (4), δ_p, δ_e, and δ_y are instead equivalent to $1+\alpha_1$, $1+\beta_2$, and $1+\gamma_3$.

Within the framework just described, population density, employment density, and the average annual wage are characterized as pushing one another toward equilibrium values in the growth process, meaning that the system is expected upfront to register a particular pattern of feedback among all three. Specifically: (1) population density is expected to be positively influenced by employment density and negatively influenced by the average annual wage; (2) employment density is expected to be positively influenced by population density and the average annual wage; and (3) the average annual wage is expected to be negatively influenced by population density and positively influenced by employment density. The opposite effects expected of population density (–) and employment density (+) in the wage equation relate to the difference between supply- and demand-induced growth: Both mechanisms increase densities by raising rents, but only the latter is accompanied by a corresponding increase in wages (DiPasquale and Wheaton 1996).

Finally, testing for dynamic stability in the system requires solving for the characteristic roots, or eigenvalues, of a 3 × 3 matrix composed of reduced form parameters; within these solutions, the dominant root must be less than one in order for the system to converge on an equilibrium outcome. Further, because there is feedback among population density, employment density, and the average annual wage, the resulting unit vector, or eigenvector, describing the equilibrium outcome is composed of all three influences. Evidence of the expected forms of feedback and an equilibrium solution that is empirically reasonable may be interpreted as an affirmation of the three-equation regional adjustment model. The following sections investigate the viability of the framework — and the importance of geographic relationships within it — by estimating a series of three-equation systems involving all counties in the continental United States and evaluating the results.

3. Empirical Analysis

3.1 Model Specification

The operational model shown in equation set (2) is specified with data from all 3,073 counties and county equivalents that make up the continental United States for the time periods 1982 – 1987, 1987 – 1992, and 1992 – 1997. In order to account for spatial dependence among counties, each equation is expanded to contain a spatial lag of the dependent variable, resulting in the following operational specification (see Anselin 1988):

$$\begin{aligned} \dot{p}' &= \alpha_0 + \rho_{pt} W p'_t + \alpha_1 p'_{t\text{-}5} + \alpha_2 e'_t + \alpha_3 y'_t + \boldsymbol{\alpha}_4 \boldsymbol{x}_{pt\text{-}5} + \varepsilon_{pt} \\ \dot{e}' &= \beta_0 + \rho_{et} W e'_t + \beta_1 p'_t + \beta_2 e'_{t\text{-}5} + \beta_3 y'_t + \boldsymbol{\beta}_4 \boldsymbol{x}_{et\text{-}5} + \varepsilon_{et} \\ \dot{y}' &= \gamma_0 + \rho_{yt} W y'_t + \gamma_1 p'_t + \gamma_2 e'_t + \gamma_3 y'_{t\text{-}5} + \boldsymbol{\gamma}_4 \boldsymbol{x}_{yt\text{-}5} + \varepsilon_{yt} \end{aligned} \tag{4}$$

Here, all notation is the same as above expect that the ′s indicate that the core variables are expressed in natural logarithmic form; the W is a 3,073 × 3,073 ($n \times n$) row-standardized weights matrix that describes the spatial arrangement of the data set; and the ρs are estimable parameters measuring the influence of the spatially lagged variables. Several weighting schemes were constructed and tested for the purposes of this analysis. In the first step, the population weighted center — that is, a mean point identifying where people are concentrated, rather than the geographic center — was calculated for each county in the country using tract-level data from the 1990 Census of Population. The centers, mapped in Figure 1, were then used to construct weights matrices based on 25-, 50-, and 100-mile spatial lags, plus a weights matrix based on a single nearest neighbor; in the distance-based matrices, the single nearest neighbor was used in the event that there was no population center within the specified range. As illustrated in Figure 2, all counties have a nearest neighbor, but not all counties also *are* a nearest neighbor. For example, the most "remote" county in the country is Aroostook County, in Maine; Aroostook's nearest neighbor, located 111 miles away, is Piscataquis County, which is, in turn, just 31 miles from its nearest neighbor, Penobscot County. In this way, the weighting schemes account for the actual pattern of settlement, not just arbitrary space.

Note that because each dependent variable depends on its value in neighboring counties, Wp_t, We_t, and Wy_t, are endogenous to $\dot{p}'$, $\dot{e}'$, and $\dot{y}'$, respectively. That is, rates of change in population density, employment density, and the average wage in county i depend on the contemporaneous levels of these variables in surrounding counties, creating yet another "chicken-or-egg" problem that must be resolved by choosing an appropriate procedure for estimating the system. The approach used here is a spatial two-stage least squares (S2SLS) strategy developed by Kelejian and Prucha (1998). The first stage involves regressing Wp_t, We_t, *and* Wy_t, on instruments developed using the "three-group" method — where the instrumental variable is assigned a –1, 0, or 1 depending on whether the value of the original variables is in the bottom, top, or middle third of its ordinal ranking (Kennedy 2003) — plus $\boldsymbol{x}$ and $W\boldsymbol{x}$, to produce predicted values of the spatial lags (see, for example, Fingleton et al 2005). The second stage then uses the predicted values in place of the observed values to arrive at the parameter estimates. In practice, the system shown in equation set (4) already requires an estimation strategy that handles endogeneity, so all of the interdependent variables end up being regressed on $\boldsymbol{x}$, $W\boldsymbol{x}$, and a set of additional instruments specific to each in a single S2SLS estimation process. See Rey and Boarnet (2004) for an extended discussion of various spatial econometric specifications of regional adjustment models.

The data used to estimate the models comes from a number of United States government sources. First, densities were calculated using population and employment measures from the Bureau of Economic Analysis' (BEA) Regional Economic Information System (REIS), plus land use measures from the Department of Agriculture's (USDA) National Resources Inventory. Second, average annual wages, based on employment location, were also obtained from the BEA. Third, the vector $\boldsymbol{x}$ in each equation contains: (1) the percentage of total earnings in the FIRE, manufacturing, and service sectors in the base year, obtained from the REIS database; (2) initial size, measured as total population, total employment, or total annual wages, depending on the equation, in the base year, obtained from the REIS; (3) a composite natural amenity index (excluded from the employment equation) measuring the attractiveness of the local climate and landscape, obtained from the USDA's Economic Research Service (see McGranahan 1999);[1] (4) a composite export price index (excluded from the population equation) measuring local economic performance in the base year developed using data from the Bureau of Labor Statistics (see Pennington-Cross 1997);[2] and (5) each county's longitude and latitude. All of the variables involved in the analysis except for longitude and latitude are expressed as location quotients, or the ratio of the local value to the mean value nationally for the relevant year in the data set. This transformation ensures that each observation is pegged to the system as a whole and, because the result is unit free, enables direct comparison of population density, employment density, and the average annual wage at equilibrium. Descriptive statistics for all of the underlying data — that is, for the variables themselves, not their transformed values — involved in the analysis are provided in Table 1.

3.2 Estimation Results

As already noted, equation set (4) was estimated for each of the three time periods with a spatial lag representing a single nearest neighbor, with 25-, 50-, and 100-mile spatial lags, and with no spatial lag; in all, a total of 15 systems were estimated. The differences between models estimated with the three distance-based spatial lags were minor — perhaps due to the large size of the units of observation — so only the results for the 50-mile spatial lag are reported here. This distance is the most reasonable given commuting tendencies in the United States, and, maybe for that reason, equation-for-equation the 50-mile lag produced higher adjusted R^2 values than either the 25- or 100-mile lag. It is worth noting, too, that applying the 100-mile lag to the 3,073 counties in the data set yields a grand total of over 135,000 spatial relationships! This compares to the 25- and 50-mile lag operations, which produce about 6,500 and 34,000 spatial relationships, respectively. In other words, within a 50-mile radius, the average county in the dataset has about 11 neighbors, based on the location of the population centers shown in Figures 1 and 2. The following paragraphs discuss some diagnostics for each of the three sets of results then describe the findings from the group as a whole.

First, estimation results for the models specified with a nearest neighbor spatial lag are presented in Tables 2a – 2c. Only the 1992 – 1997 panel registers the expected pattern of

[1] The natural amenity index measures January sunshine, January temperature, July humidity, July sunshine, topography, and water area.
[2] The export price index measures output price changes in the export market.

feedback in all three-equations: Population density (a measure of labor supply) is not significant and carries the wrong sign (+) in the 1982 – 1987 panel's wage equation and is not quite significant in the 1987 – 1992 panel's wage equation. In all three panels, the dominant characteristic root, λ, which is derived from reduced form estimates (see Carlino and Mills 1987), is less than one. The unit vectors — which measure the ratio, or relative importance, of population, employment, and wages, respectively, at the projected equilibrium scenarios (see Carruthers and Mulligan 2008) — are (p = 0.5587 : e = 0.2168 : y = 02245) for the 1982 – 1987 panel; (p = 0.5287 : e = 0.2572 : y = 0.2141) for the 1987 – 1992 panel; and (p = 0.2848 : e = 0.5156 : y = 0.1996) for the 1992 – 1997 panel. The spatial lag itself is always significant except for in the 1982 – 1987 panel's employment density equation; note that the negative sign on the spatial lag in this equation and that of the subsequent panels is logical because it most likely registers the presence of employment density gradients. The adjusted-R^2s, though small, are all in the vicinity of the expected size (say, ~0.20) for rate of change oriented regional adjustment models. When levels, rather than rates of change, are used, the results remain essentially the same, except that the own-lagged coefficients are inverted and the adjusted-R^2s, soar to nearly one, reflecting the tautological fact that the single biggest predictor of each of the three dependent variables today is what their value was "yesterday."

Next, estimation results for the models specified with a 50-mile spatial lag — or the nearest neighbor if no population center is within range — are presented in Tables 3a – 3c. This specification exhibits a distinct improvement: All of the panels register the expected pattern of feedback among the interdependent variables and, in each case, the dominant characteristic root remains less than one, indicating that the models predict a stable equilibrium outcome (see Rogers 1971). Here, the unit vectors are (p = 0.5504 : e = 0.2261 : y = 0.2245) for the 1982 – 1987 panel; (p = 0.5056 : e = 0.3016 : y = 0.1928) for the 1987 – 1992 panel; and (p = 0.2915 : e = 0.5012 : y = 0.2073) for the 1992 – 1997 panel. Like before, the spatial lag is always significant except for in the 1982 – 1987 panel's employment density equation and it carries its expected sign pattern. Again, this sign pattern is positive in the population and wage equations, but negative in the employment equation — with the latter effect likely being due to the very steep employment density gradients found in most American regions. Overall, the adjusted-R^2s are somewhat improved from the nearest neighbor spatial lag, reflecting the more accurate representation of the spatial relationships expressed by this model. As noted, shifting to the 25-mile or 100-mile spatial lag does not improve the models' performance and, in fact, it takes away from it, at least in terms of explanatory power as measured by the adjusted R^2s. Still, the differences among the spatial specifications suggests that, even at this relatively high (county) level of aggregation, regional adjustment models are sensitive to the spatial dependencies that mediate the growth processes they emulate. Future work in this vein should focus on developing weighting schemes — perhaps based on travel costs, rather than distances — that more precisely reflect the nature of regional connectivity.

For comparison, estimation results for aspatial models are presented in Tables 4a – 4c. Not surprisingly, this version of the model is ineffective compared to the other two: Many of the interrelated variables are not statistically significant; they do not always carry their expected signs; and the dominant characteristic root is less than one only in the 1992 – 1997 panel. Further, the adjusted-R^2s reflect the fact that this version of the model explains less of the variation in the system's dependent variables than either of the two spatial lag models. Even based on the simplest of regression diagnostics, the aspatial models fall short of their spatial counterparts — a finding that reinforces the need to account for the interconnectedness of growth and change across geographic space.

Moving on, the estimation results reported for the 50-mile spatial lag model in Table 3a – 3c tell a straightforward story. In the population density equation, over the 1982 – 1997 timeframe, the negative effect of initial population density becomes progressively stronger reflecting the kind of broad shifts — especially to the West and South of the United States — that have occurred over the past three decades. As a result, by the end of the study period, regions with high concentrations of population relative to the nation as a whole experienced substantially lower rates of change in density than they did just 15 years before. Meanwhile, the role of natural amenities in driving this process (as documented by McGranahan 1999, among others) also grew more powerful. The natural amenity index is not significant in the 1982 – 1987 panel, is a bit closer to being significant in the 1987 – 1992 panel, and is highly significant in the 1992 – 1997 panel. The rise of this variable is brought into relief by the decline of the longitude and latitude variables: Both are highly significant in the 1982 – 1987 panel and indicate that counties located in the East and South of the United States experienced gains in population density, but these fall out of significance as the amenity index transitions into significance during the 1987 – 1992 and 1992 – 1997 panels. In the employment equation, the effect of initial employment density gets progressively weaker and smaller over the 15-year timeframe. At the same time, the role of manufacturing declines but, in an experience known, for better or for worse, in many parts of the country, manufacturing is ultimately replaced by the FIRE and service sectors. Likewise, in the average wage equation the effect initial wage concentration grows both weaker and smaller and so too does the influence of initial employment density. Additionally, over the course of the three panels, the influence of the natural amenity index reverses itself from a strong positive effect in the 1982 – 1987 panel to a strong negative effect in the 1992 – 1997 panel; the negative effect is the expected effect within the kind of compensating differentials framework that regional adjustment models emulate. The fact that each of these findings follows a logical progression over the study period is encouraging because it suggests that the models are, in fact, registering the kind of broad structural shifts in the space economy that they were designed to characterize. If so, they also reinforce the notion that an equilibrating process is responsible for mediating growth and land use patterns throughout the nation.

Coming back, for a moment, to the unit vectors from the models specified with a 50-mile spatial lag, note how the weight of the population and employment components shifts from the first two panels to the third panel. Past evidence suggests that the ratio between the two normally is in the range between 1.5 : 1 and 2.2 : 1 when employment includes full-time, part-time, and seasonal workers (Carruthers and Mulligan 2007). By this benchmark, the 1982 – 1987 and 1987 – 1992 panels seem to almost perfectly capture the balance between people and jobs in the equilibrating process — but this is at odds with previous findings (Carruthers and Mulligan 2008) that suggesting that the 1987 – 1992 panel, which is centered squarely on a recession,[3] is the outlier. That analysis, however, dealt with metropolitan areas only, so it did not capture the complete system, plus most of its models had dominant characteristic roots greater than one, meaning that they failed to settle on stable equilibrium growth paths. The present finding is interesting because it raises the possibility that the employment effect grows, maybe just temporarily, in the wake of a recession. Whatever the case may be, further work on this diagnostic is clearly required before the characteristic vectors can be used to either accept or reject a particular regional adjustment model. But given the models' strong and consistent performance overall, they in general, and the three-equation variant especially, continue to stand up as an excellent lens through with to view the processes of regional growth and land use change.

Last, it is worth acknowledging here that the models just discussed are "sparse" in the sense that each equation contains only a small number of predetermined explanatory variables. In order to be used the kind of policy analysis they are intended for, the specification of the three-equation system needs to be extended — and, along the way, experimented with — to speak directly to the kinds of issues that practitioners are faced with. For example, Carruthers and Vias (2005) developed a (two-equation) land use based regional adjustment model to examine patterns and processes of sprawl in the Mountain West region of the United States and were able to come

[3] According to the National Bureau of Economic Research's dating procedure, this recession ran from July 1990 to March 1991.

to the very tangible conclusion that the long-term prosperity of the region depends, crucially, on the preservation of the high quality of life it offers. Toward that end, they suggest that policymakers in the region should pursue several specific actions aimed at achieving broader environmental and economic development goals. But, arriving at these kinds of conclusions requires positing specific policy questions that can be addressed via hypothesis testing and, ultimately, measurement. Although this paper stops far short of doing that, it offers up the three-equation regional adjustment model with the belief that it will be an effective tool for conducting consequential policy analysis.

3.3 Spatial Outcomes

A deeper look into the spatial outcomes of the adjustment process is provided in Figures 2 and 3, which are based on the 50-mile spatial lag reported in Tables 3a – 3c. Using the equivalencies given in equation set (3), Figure 2 shows projected equilibrium scenarios for 1987 (Figures 2a – 2c), 1992 (Figures 2d – 2f), and 1997 (Figures 2g – 2i). In these maps, the white areas denote a projected location quotient of less than one, or below the average densities or annual wage; grey areas denote a location quotient of one to one-and-a-half, or from 100% up to 150% of the national averages; and black areas denote a location quotient of greater than one and a half, or more than 150% of the national averages. Inspection of the density maps reveals a transition away from the built-up areas of the Northeast and a gradual densification of the West and South. A similar pattern is observed in the wage maps, which seem to show a slight evening out of wages, except in the Great Plains, where the gulf remains as wide as ever.

Figure 3 documents whether these scenarios call for an increase or a decrease in the relative concentration of people and wages compared to initial (1982, 1987, and 1992) conditions — in other words, the direction in which the equilibrating process was pushing the space economy. In particular, the white areas on the maps denote projected decreases ($\tilde{p} < p_{t-5}$, $\tilde{e} < e_{t-5}$, $\tilde{y} < y_{t-5}$) and the black areas denote projected increases ($\tilde{p} > p_{t-5}$, $\tilde{e} > e_{t-5}$, $\tilde{y} > y_{t-5}$) as the system moves toward a state of spatial equilibrium. Interestingly, the maps pertaining to population density and employment density indicate a tendency toward gains in many comparatively disadvantaged, rural areas of the United States, especially at the interior. The wage maps show a similar pattern that gets stronger over the 15-year timeframe: By 1997, the equilibrating scenario calls for higher wages throughout much of the interior, and lower wages in the rapidly growing West and Southwest — likely due to the large part played by supply-induced growth in these parts of the country. Going back to the discussion above, these patterns may well be the product of the rise in the importance of natural amenities during the study period, which, of course, are key drivers of supply-induced growth. Even with an overall pattern of spatial convergence, however, the two sets of maps also document the clear persistence of a hierarchical system of regional economies described by traditional forms of location theory (see, for example, Lösch 1954; Isard 1956; Beckmann 1968; Mulligan 1984; Fujita et al 1998), suggesting that the longstanding pattern of central places is not easily broken.

4. Conclusion

The study documented in this paper highlights the importance of geographic relationships in a land use based regional adjustment model containing equations for population density, employment density, and the average annual wage. There are key findings are three: (1) accounting for spatial interdependencies substantially enhances the performance of land use based regional adjustment models; (2) with this correction, the viability of the three-equation framework used here (an extension of the traditional two equation framework) seems very strong; and (3) even as the nation's post-industrial economy continues along its path of decentralization, it retains an uneven pattern of development characteristic of the well-known, hierarchical system of regional economies described by traditional forms of location theory. The latter of these findings is especially interesting because it indicates that the longstanding patterns of central places are not easily broken.

Having further established the three-equation approach, the work presented here could be profitably extended in a number of ways. To begin with, more formal diagnostic work, particularly involving the unit vectors, is needed in order to discriminate among various spatial models — and, as important, processes — with any real confidence. Geography clearly matters and it should be taken seriously, which means going beyond simple econometric corrections like the spatial lags experimented with here and delving more deeply into the nature of the relationships themselves. Once this is accomplished, the three-equation regional adjustment model will be an excellent tool for urban and regional policy analysis aimed at, among other things, qualitative questions concerning the role of natural amenities and the export price index. Exploring these relationships in detail may involve developing the kind of spatial multipliers described by Anselin (2003) in order to observe how place-specific effects play out through the national system. Further, there is merit to evaluating how regional adjustment models compare to the kind of convergence models developed by Barro and Sala-i-Martin (2004). Broad avenues of research have recently opened up in this area of spatial analysis (see, for example, Rey and Montouri 1999; Fingleton 2003; Rey and Boarnet 2004; Rey and Janikas 2005; Arbia 2006) and the models presented here stand to make substantive contributions. Last, additional work also needs to be done to fully connect the results of the three-equation regional adjustment model to patterns described by location and central place theory. Each of these steps holds considerable promise for expanding the existing body of theory and evidence on the nature of growth and land use change in the contemporary space economy.

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Table 1. Descriptive Statistics

	Min.	Max.	Mean	Med.	Std. Dev.
Population Density					
1982	0.03	41.05	2.12	1.78	1.81
1987	0.03	41.96	1.97	1.67	1.75
1992	0.04	42.07	1.88	1.61	1.70
1997	0.02	43.84	1.76	1.51	1.64
Employment Density					
1982	0.02	25.96	0.74	0.52	1.04
1987	0.01	26.26	0.75	0.51	1.10
1992	0.01	24.89	0.74	0.52	1.03
1997	0.01	24.27	0.73	0.51	1.02
Average Annual Wage					
1982	12,721.46	57,558.05	25,975.78	25,053.12	5,663.14
1987	14,171.62	55,795.06	26,601.45	25,777.54	5,649.12
1992	13,628.04	59,960.52	26,111.51	25,062.19	5,690.93
1997	14,483.42	61,410.40	27,524.93	26,438.92	5,843.56
% Earnings in FIRE					
1982	0.00	0.24	0.04	0.03	0.02
1987	0.00	0.25	0.03	0.03	0.02
1992	0.00	0.26	0.04	0.03	0.02
% Earnings in Manufacturing					
1982	0.00	0.84	0.21	0.19	0.16
1987	0.00	0.82	0.21	0.19	0.15
1992	0.00	0.82	0.21	0.18	0.15
% Earnings in Services					
1982	0.00	0.74	0.15	0.15	0.07
1987	0.00	0.70	0.16	0.16	0.07
1992	0.00	0.86	0.18	0.17	0.08
Total Population					
1982	84.00	7,767,422.00	74,917.36	22,279.00	268,382.42
1987	94.00	8,553,844.00	78,321.42	22,405.00	283,627.16
1992	127.00	9,055,424.00	82,904.94	22,967.00	297,383.37
Total Employment					
1982	119.00	3,765,482.00	31,405.33	6,653.00	132,265.73
1987	43.00	4,339,073.00	35,616.70	7,077.00	147,812.17
1992	29.00	4,117,311.00	37,663.41	7,668.00	145,837.88
Total Annual Wages					
1982	2,209.88	146,538,599.22	1,032,848.27	165,425.88	5,079,612.87
1987	1,577.24	187,994,118.32	1,255,784.60	182,289.04	6,306,909.60
1992	885.43	191,568,382.20	1,333,137.11	191,964.56	6,408,673.20
Natural Amenity Index	3.60	21.17	10.06	9.86	2.29
Export Price Index					
1982	38.17	1,270.62	68.52	65.26	31.75
1987	49.35	603.95	73.72	72.00	15.22
1992	66.79	394.66	86.06	84.98	9.29
Longitude	–124.20	–67.48	–91.79	–90.36	11.46
Latitude	24.74	48.85	38.28	38.35	4.86

Table 2a. S2SLS Estimates of Nearest Neighbor Regional Adjustment Model, 1982 – 1987

	ln ($\dot{p}$)		ln ($\dot{e}$)		ln ($\dot{y}$)	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	6.40E-02 ★★★	2.74	–5.55E-02 ★★	–1.96	2.75E-02 ★	1.74
Spatial Lag	4.53E-02 ★★★	11.28	–5.24E-03 n/s	–1.21	7.84E-02 ★★★	9.80
Adjustment Variables						
ln Population Density	–1.83E-01 ★★★	–14.39	3.04E-01 ★★★	13.35	6.95E-04 n/s	0.09
ln Employment Density	1.42E-01 ★★★	12.40	–2.69E-01 ★★★	–14.24	5.14E-02 ★★★	8.47
ln Average Wage	–1.27E-01 ★★★	–7.06	1.31E-01 ★★★	5.54	–2.88E-01 ★★★	–26.47
Industrial Composition						
% Earnings in FIRE	1.31E-03 n/s	0.41	3.05E-02 ★★★	6.32	–2.84E-03 n/s	–0.99
% Earnings in Manufacturing	–6.31E-03 ★★★	–2.28	4.44E-02 ★★★	10.21	2.44E-02 ★★★	10.18
% Earnings in Services	5.43E-03 n/s	0.91	9.45E-02 ★★★	14.29	7.27E-04 n/s	0.17
Size and Comparative Advantage						
Population/Employment/Wages	1.54E-03 ★★★	4.11	1.70E-03 n/s	1.41	7.00E-04 ★★★	3.33
Natural Amenity Index	1.95E-02 ★★★	2.54	-	-	1.83E-02 ★★★	3.53
Export Price Index	-	-	2.19E-04 n/s	0.07	4.50E-03 ★★	2.16
Location						
Longitude	3.45E-04 ★★★	2.52	–3.22E-04 n/s	–1.64	–1.05E-04 n/s	–0.97
Latitude	–7.98E-04 n/s	–2.06	–5.12E-03 ★★★	–9.10	–1.69E-03 ★★★	–5.82
Adjusted R^2		0.19		0.33		0.39
Dominant λ						0.96

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; n/s denotes not significant.

Table 2b. S2SLS Estimates of Nearest Neighbor Regional Adjustment Model, 1987 – 1992

	ln ($\dot{p}$)		ln ($\dot{e}$)		ln ($\dot{y}$)	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	1.38E-02 n/s	0.70	–1.96E-01 ★★★	–6.55	5.28E-03 n/s	0.37
Spatial Lag	4.16E-02 ★★★	11.67	–1.69E-02 ★★★	–4.55	5.57E-02 ★★★	7.54
Adjustment Variables						
ln Population Density	–1.63E-01 ★★★	–12.83	1.48E-01 ★★★	8.57	–9.93E-03 n/s	–1.57
ln Employment Density	1.37E-01 ★★★	11.53	–1.38E-01 ★★★	–9.40	3.73E-02 ★★★	7.14
ln Average Wage	–9.97E-02 ★★★	–6.23	4.44E-02 ★★	2.27	–1.61E-01 ★★★	–15.07
Industrial Composition						
% Earnings in FIRE	–9.50E-03 ★★★	–2.74	6.14E-03 n/s	0.93	–2.48E-03 n/s	–1.27
% Earnings in Manufacturing	–7.71E-03 ★★★	–2.38	8.08E-03 ★	1.65	–8.26E-04 n/s	–0.39
% Earnings in Services	7.42E-03 n/s	1.32	5.49E-02 ★★★	6.44	4.32E-03 n/s	1.37
Size and Comparative Advantage						
Population/Employment/Wages	4.35E-04 n/s	1.24	–1.29E-03 ★★★	–3.28	8.58E-04 ★★★	3.04
Natural Amenity Index	2.31E-02 ★★★	2.83	-	-	–3.58E-03 n/s	–0.73
Export Price Index	-	-	5.57E-02 ★★★	8.04	2.26E-02 ★★★	4.70
Location						
Longitude	–7.20E-05 n/s	–0.59	–6.05E-04 ★★★	–3.41	–7.23E-05 n/s	–0.81
Latitude	–3.73E-04 n/s	–1.14	1.35E-04 n/s	0.28	–6.05E-04 ★★★	–2.76
Adjusted R^2		0.14		0.15		0.17
Dominant λ						0.98

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; n/s denotes not significant.

Table 2c. S2SLS Estimates of Nearest Neighbor Regional Adjustment Model, 1992 – 1997

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	–1.35E-02 n/s	–0.69	–2.57E-01 ★★★	–6.14	–4.36E-02 ★★★	–2.48
Spatial Lag	4.39E-02 ★★★	10.23	–7.27E-03 ★	–1.88	4.33E-02 ★★★	6.64
Adjustment Variables						
ln Population Density	–2.25E-01 ★★★	–16.92	6.24E-02 ★★★	2.88	–1.13E-02 ★★	–2.12
ln Employment Density	1.69E-01 ★★★	13.37	–9.61E-02 ★★★	–5.54	1.03E-02 ★★	2.14
ln Average Wage	–1.68E-01 ★★★	–10.10	5.06E-02 ★★	2.11	–1.35E-01 ★★★	–11.17
Industrial Composition						
% Earnings in FIRE	5.76E-03 ★	1.71	2.95E-02 ★★★	5.54	7.17E-03 ★★★	2.55
% Earnings in Manufacturing	–1.01E-02 ★★★	–3.54	–3.98E-03 n/s	–0.88	1.36E-02 ★★★	6.65
% Earnings in Services	–1.37E-02 ★	–1.89	5.50E-02 ★★★	5.61	7.14E-03 n/s	1.70
Size and Comparative Advantage						
Population/Employment/Wages	1.49E-03 ★★★	2.83	1.03E-04 n/s	0.29	1.08E-03 ★★★	2.57
Natural Amenity Index	5.07E-02 ★★★	7.14	-	-	–1.38E-02 ★★★	–2.93
Export Price Index	-	-	1.13E-01 ★★★	3.68	5.31E-02 ★★★	5.07
Location						
Longitude	1.05E-04 n/s	0.79	–4.15E-04 ★★	–2.11	2.08E-05 n/s	0.24
Latitude	4.71E-04 n/s	1.23	2.99E-04 n/s	0.65	–5.74E-04 ★★★	–2.82
Adjusted R^2		0.23		0.14		0.16
Dominant λ						0.98

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; n/s denotes not significant.

Table 3a. S2SLS Estimates of 50-mile Spatial Lag Regional Adjustment Model, 1982 – 1987

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	7.47E-02 ★★★	3.10	–5.31E-02 ★	–1.88	3.69E-02 ★★	2.34
Spatial Lag	6.88E-02 ★★★	9.22	–4.99E-03 n/s	–0.59	2.00E-01 ★★★	14.62
Adjustment Variables						
ln Population Density	–1.98E-01 ★★★	–14.33	3.00E-01 ★★★	11.38	–1.62E-02 ★★	–2.23
ln Employment Density	1.50E-01 ★★★	13.20	–2.65E-01 ★★★	–12.85	6.01E-02 ★★★	10.10
ln Average Wage	–1.30E-01 ★★★	–7.34	1.28E-01 ★★★	5.19	–3.17E-01 ★★★	–27.56
Industrial Composition						
% Earnings in FIRE	4.19E-03 n/s	1.33	3.01E-02 ★★★	6.43	–8.86E-04 n/s	–0.31
% Earnings in Manufacturing	–1.09E-02 ★★★	–3.59	4.46E-02 ★★★	9.73	2.34E-02 ★★★	9.86
% Earnings in Services	2.81E-03 n/s	0.47	9.44E-02 ★★★	14.09	–1.19E-03 n/s	–0.28
Size and Comparative Advantage						
Population/Employment/Wages	1.64E-03 ★★★	4.18	1.68E-03 n/s	1.41	5.68E-04 ★★★	3.10
Natural Amenity Index	1.14E-02 n/s	1.45	-	-	9.99E-03 ★	1.87
Export Price Index	-	-	5.84E-05 n/s	0.02	5.06E-03 ★★	2.23
Location						
Longitude	3.44E-04 ★★★	2.53	–3.23E-04 ★	–1.64	–1.33E-04 n/s	–1.23
Latitude	–8.27E-04 ★★	–2.09	–5.13E-03 ★★★	–9.13	–1.81E-03 ★★★	–6.33
Adjusted R^2		0.20		0.33		0.42
Dominant λ						0.96

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; n/s denotes not significant.

Table 3b. S2SLS Estimates of 50-mile Spatial Lag Regional Adjustment Model, 1987 – 1992

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	4.25E-02 **	2.25	–2.06E-01 ***	–6.89	1.13E-02 n/s	0.80
Spatial Lag	8.06E-02 ***	13.70	–4.66E-02 ***	–4.76	1.52E-01 ***	14.41
Adjustment Variables						
ln Population Density	–1.97E-01 ***	–13.73	1.95E-01 ***	8.43	–2.67E-02 ***	–3.91
ln Employment Density	1.57E-01 ***	12.42	–1.70E-01 ***	–9.34	4.75E-02 ***	8.46
ln Average Wage	–1.24E-01 ***	–7.62	7.83E-02 ***	3.52	–1.92E-01 ***	–17.86
Industrial Composition						
% Earnings in FIRE	–8.35E-03 ***	–2.37	6.79E-03 n/s	1.05	–1.43E-03 n/s	–0.73
% Earnings in Manufacturing	–1.48E-02 ***	–4.66	1.26E-02 **	2.36	–1.07E-03 n/s	–0.51
% Earnings in Services	3.28E-03 n/s	0.58	5.70E-02 ***	6.89	3.11E-03 n/s	0.99
Size and Comparative Advantage						
Population/Employment/Wages	5.99E-04 n/s	1.41	–1.47E-03 ***	–3.64	7.72E-04 ***	2.94
Natural Amenity Index	1.21E-02 n/s	1.55	-	-	–9.09E-03 **	–1.93
Export Price Index	-	-	5.55E-02 ***	8.09	2.31E-02 ***	5.45
Location						
Longitude	–3.61E-05 n/s	–0.29	–6.67E-04 ***	–3.84	–8.09E-05 n/s	–0.86
Latitude	–4.92E-04 n/s	–1.59	3.04E-05 n/s	0.06	–6.53E-04 ***	–3.06
Adjusted R^2		0.16		0.16		0.20
Dominant λ						0.98

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; *** denotes significant at $p < 0.01$; ** denotes significant at $p < 0.05$; * denotes significant at $p < 0.10$; n/s denotes not significant.

Table 3c. S2SLS Estimates of 50-mile Spatial Lag Regional Adjustment Model, 1992 – 1997

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	1.04E-02 n/s	0.53	–2.61E-01 ***	–6.20	–4.31E-02 ***	–2.54
Spatial Lag	7.47E-02 ***	10.87	–1.78E-02 **	–2.08	9.63E-02 ***	9.64
Adjustment Variables						
ln Population Density	–2.50E-01 ***	–16.88	7.68E-02 ***	3.09	–2.01E-02 ***	–3.82
ln Employment Density	1.85E-01 ***	13.81	–1.05E-01 ***	–5.51	1.59E-02 ***	3.51
ln Average Wage	–1.87E-01 ***	–10.58	6.11E-02 **	2.33	–1.52E-01 ***	–12.82
Industrial Composition						
% Earnings in FIRE	5.88E-03 *	1.84	2.95E-02 ***	5.52	7.65E-03 ***	2.80
% Earnings in Manufacturing	–1.52E-02 ***	–5.64	–2.52E-03 n/s	–0.53	1.32E-02 ***	6.58
% Earnings in Services	–1.78E-02 ***	–2.40	5.62E-02 ***	5.68	6.22E-03 *	1.51
Size and Comparative Advantage						
Population/Employment/Wages	1.75E-03 ***	2.70	–1.12E-05 n/s	–0.03	1.08E-03 ***	2.52
Natural Amenity Index	4.04E-02 ***	6.04	-	-	–1.53E-02 ***	–3.28
Export Price Index	-	-	1.13E-01 ***	3.70	5.44E-02 ***	5.66
Location						
Longitude	1.27E-04 n/s	0.92	–4.38E-04 **	–2.24	2.29E-05 n/s	0.26
Latitude	3.65E-04 n/s	0.96	2.79E-04 n/s	0.61	–5.59E-04 ***	–2.76
Adjusted R^2		0.24		0.14		0.17
Dominant λ						0.98

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; *** denotes significant at $p < 0.01$; ** denotes significant at $p < 0.05$; * denotes significant at $p < 0.10$; n/s denotes not significant.

Table 4a. 2SLS Estimates of Aspatial Regional Adjustment Model, 1982 – 1987

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	2.97E-02 $^{n/s}$	1.25	–5.00E-02 ★	–1.81	2.41E-02 $^{n/s}$	1.52
Spatial Lag	-	-	-	-	-	-
Adjustment Variables						
ln Population Density	–1.50E-01 ★★★	–12.82	3.05E-01 ★★★	15.40	1.87E-02 ★★★	2.53
ln Employment Density	1.34E-01 ★★★	11.69	–2.71E-01 ★★★	–15.71	4.05E-02 ★★★	6.56
ln Average Wage	–1.14E-01 ★★★	–6.37	1.28E-01 ★★★	5.77	–2.55E-01 ★★★	–25.09
Industrial Composition						
% Earnings in FIRE	–4.59E-04 $^{n/s}$	–0.15	3.09E-02 ★★★	6.36	–2.99E-03 $^{n/s}$	–0.99
% Earnings in Manufacturing	–1.07E-03 $^{n/s}$	–0.40	4.34E-02 ★★★	9.89	2.53E-02 ★★★	10.40
% Earnings in Services	8.46E-03 $^{n/s}$	1.30	9.36E-02 ★★★	14.08	4.38E-03 $^{n/s}$	1.02
Size and Comparative Advantage						
Population/Employment/Wages	2.25E-03 ★★★	4.36	1.54E-03 $^{n/s}$	1.31	8.49E-04 ★★★	3.28
Natural Amenity Index	2.59E-02 ★★★	3.36	-	-	2.25E-02 ★★★	4.33
Export Price Index	-	-	1.73E-04 $^{n/s}$	0.06	4.43E-03 ★	1.92
Location						
Longitude	3.20E-04 ★★	2.29	–3.20E-04 ★	–1.64	–5.42E-05 $^{n/s}$	–0.50
Latitude	–5.11E-04 $^{n/s}$	–1.26	–5.17E-03 ★★★	–9.15	–1.74E-03 ★★★	–5.86
Adjusted R^2		0.15		0.33		0.35
Dominant λ						1.01

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; $^{n/s}$ denotes not significant.

Table 4b. 2SLS Estimates of Aspatial Regional Adjustment Model, 1987 – 1992

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	–2.35E-02 $^{n/s}$	–1.19	–1.78E-01 ★★★	–5.85	3.95E-03 $^{n/s}$	0.28
Spatial Lag	-	-	-	-	-	-
Adjustment Variables						
ln Population Density	–1.19E-01 ★★★	–11.31	1.20E-01 ★★★	8.16	2.76E-03 $^{n/s}$	0.44
ln Employment Density	1.15E-01 ★★★	10.42	–1.20E-01 ★★★	–8.70	2.92E-02 ★★★	5.72
ln Average Wage	–6.65E-02 ★★★	–4.23	1.97E-02 $^{n/s}$	1.07	–1.34E-01 ★★★	–13.56
Industrial Composition						
% Earnings in FIRE	–1.03E-02 ★★★	–2.97	5.70E-03 $^{n/s}$	0.86	–2.20E-03 $^{n/s}$	–1.04
% Earnings in Manufacturing	–2.53E-03 $^{n/s}$	–0.79	5.58E-03 $^{n/s}$	1.14	–1.18E-03 $^{n/s}$	–0.55
% Earnings in Services	1.26E-02 ★★	2.10	5.25E-02 ★★★	5.99	6.53E-03 ★★	2.10
Size and Comparative Advantage						
Population/Employment/Wages	9.08E-04 ★★	2.35	–1.45E-03 ★★★	–3.47	9.58E-04 ★★★	2.94
Natural Amenity Index	2.82E-02 ★★★	3.42	-	-	–2.15E-03 $^{n/s}$	–0.42
Export Price Index	-	-	5.41E-02 ★★★	7.57	2.31E-02 ★★★	4.91
Location						
Longitude	–1.34E-04 $^{n/s}$	–1.10	–5.79E-04 ★★★	–3.29	–3.45E-05 $^{n/s}$	–0.38
Latitude	–1.68E-04 $^{n/s}$	–0.50	1.25E-04 $^{n/s}$	0.26	–6.07E-04 ★★★	–2.74
Adjusted R^2		0.09		0.14		0.14
Dominant λ						1.00

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; $^{n/s}$ denotes not significant.

Table 4c. 2SLS Estimates of Aspatial Regional Adjustment Model, 1992 – 1997

	$\ln(\dot{p})$		$\ln(\dot{e})$		$\ln(\dot{y})$	
	Est. Parameter	t-value	Est. Parameter	t-value	Est. Parameter	t-value
Constant	–5.61E-02 ★★★	–3.06	–2.49E-01 ★★★	–5.98	–4.89E-02 ★★★	–3.00
Spatial Lag	-	-	-	-	-	-
Adjustment Variables						
ln Population Density	–1.84E-01 ★★★	–17.11	4.91E-02 ★★★	2.55	–3.14E-03 n/s	–0.72
ln Employment Density	1.49E-01 ★★★	12.82	–8.73E-02 ★★★	–5.44	2.93E-03 n/s	0.68
ln Average Wage	–1.31E-01 ★★★	–8.20	3.78E-02 ★	1.71	–1.09E-01 ★★★	–11.12
Industrial Composition						
% Earnings in FIRE	7.72E-03 ★★★	2.55	2.90E-02 ★★★	5.46	8.33E-03 ★★★	2.96
% Earnings in Manufacturing	–5.73E-03 ★★	–2.06	–4.83E-03 n/s	–1.09	1.42E-02 ★★★	7.24
% Earnings in Services	–9.81E-03 n/s	–1.40	5.40E-02 ★★★	5.56	1.02E-02 ★★★	2.81
Size and Comparative Advantage						
Population/Employment/Wages	1.87E-03 ★★★	3.28	9.06E-05 n/s	0.26	1.16E-03 ★★★	2.54
Natural Amenity Index	5.78E-02 ★★★	8.37	-	-	–1.41E-02 ★★★	–3.08
Export Price Index	-	-	1.12E-01 ★★★	3.62	5.47E-02 ★★★	5.66
Location						
Longitude	5.06E-05 n/s	0.38	–4.03E-04 ★	–2.05	4.79E-05 n/s	0.54
Latitude	7.77E-04 ★★	2.02	2.87E-04 n/s	0.62	–5.67E-04 ★★★	–2.72
Adjusted R^2		0.20		0.13		0.15
Dominant λ						0.97

Notes: The number of observations in all cases is 3,073; all equations were estimated using White-adjusted standard errors clustered by state; all hypothesis tests are two-tailed; ★★★ denotes significant at $p < 0.01$; ★★ denotes significant at $p < 0.05$; ★ denotes significant at $p < 0.10$; n/s denotes not significant.

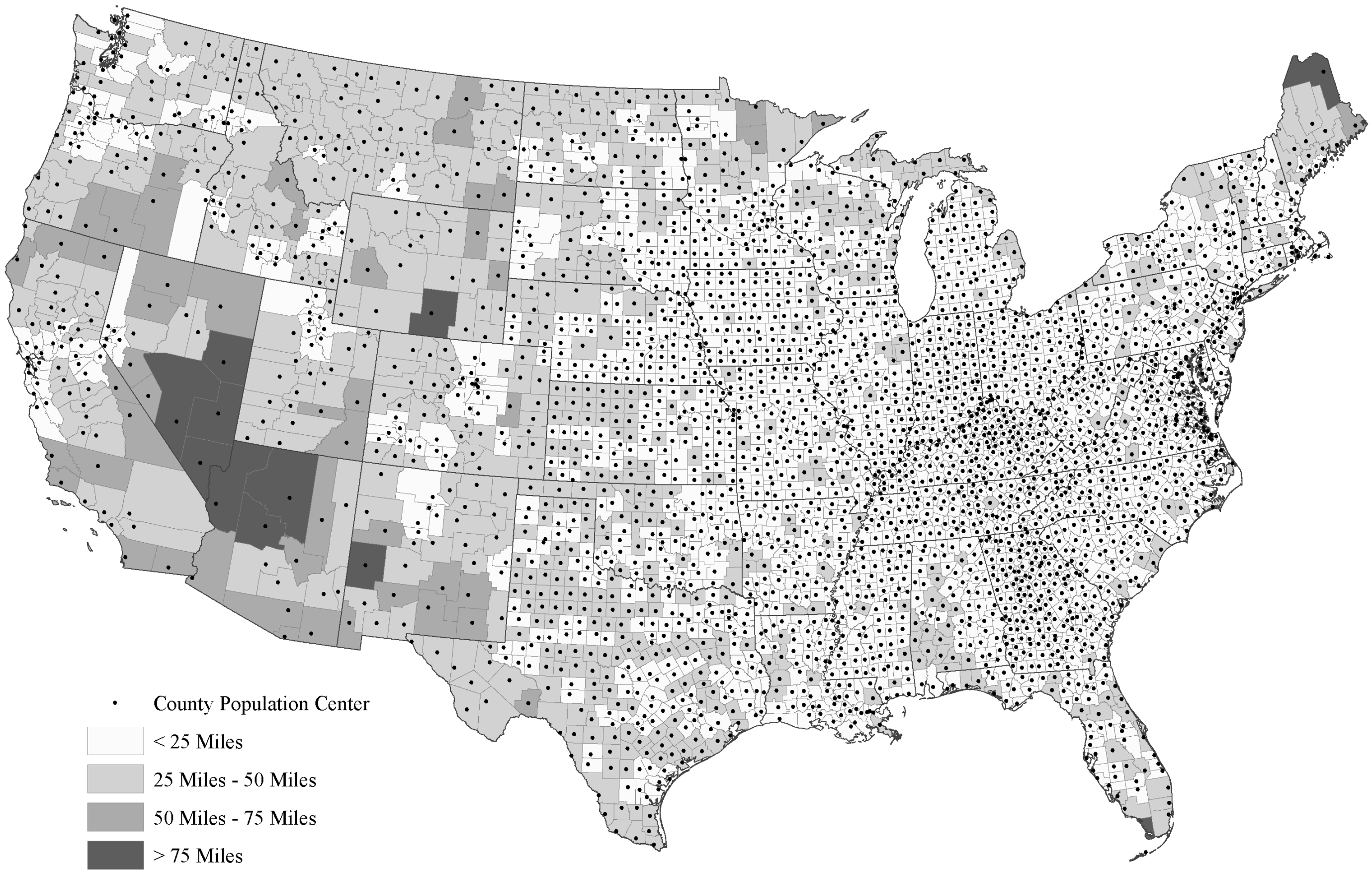
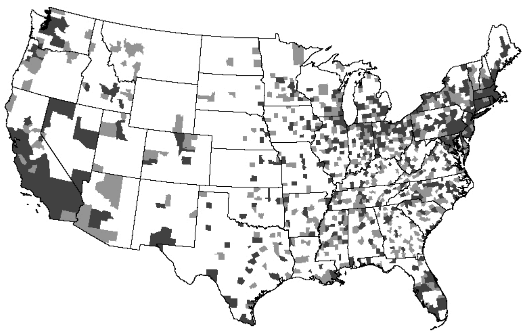
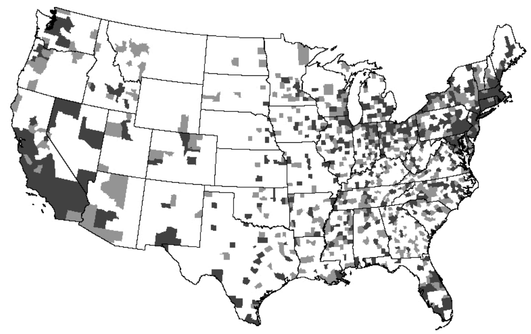


Figure 1. County Population Centers — Shading is by Distance to Nearest Neighbor

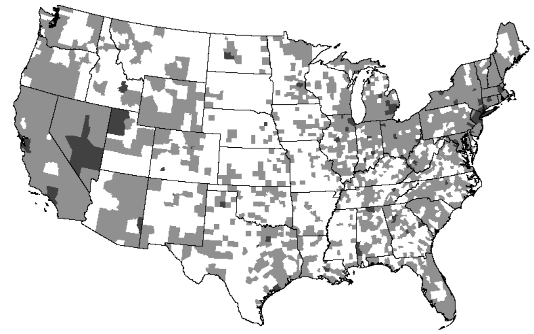
Figure 2. Connections to Nearest Neighbors



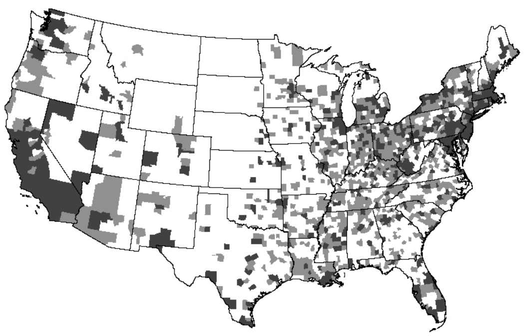
3a. Equilibrium Population Density, 1987



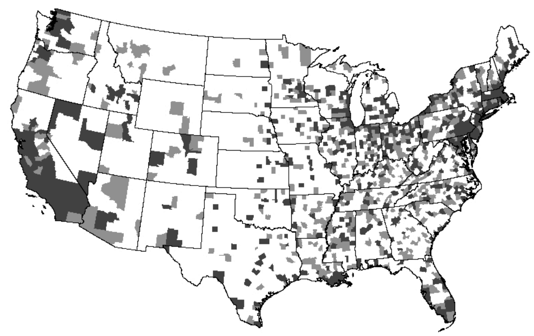
3b. Equilibrium Employment Density, 1987



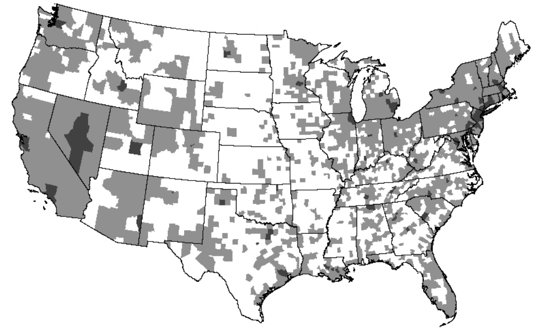
3c. Equilibrium Average Wage, 1987



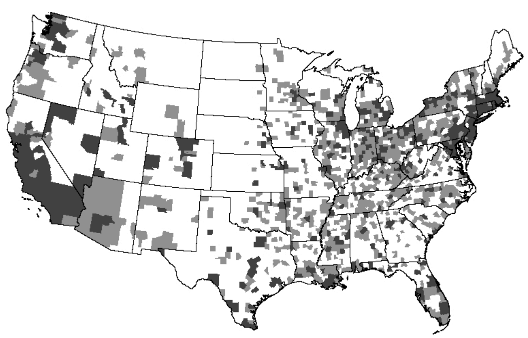
3d. Equilibrium Population Density, 1992



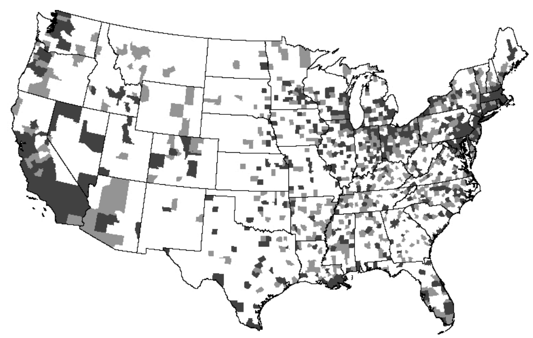
3e. Equilibrium Employment Density, 1992



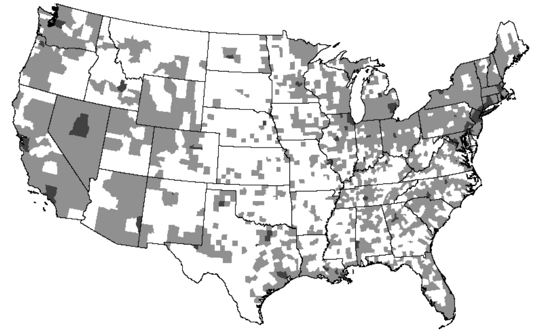
3f. Equilibrium Average Wage, 1992



3g. Equilibrium Population Density, 1997

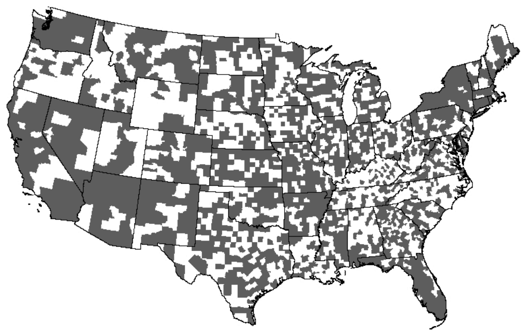


3h. Equilibrium Employment Density, 1997

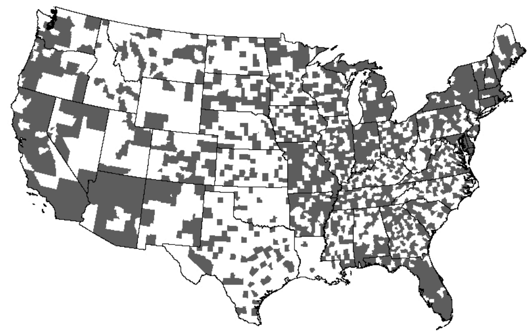


3i. Equilibrium Average Wage, 1997

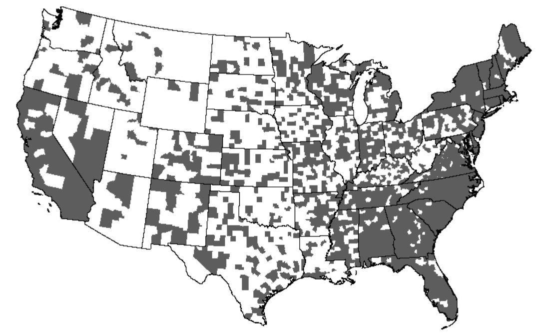
(Note: White areas denote LQ < 1; grey areas denote LQ 1 – 1.5; dark grey areas denote LQ > 1.5)



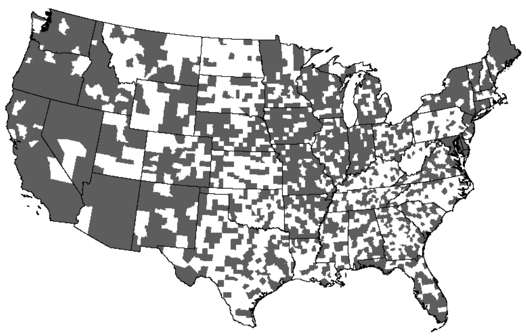
4a. Equilibrium Trend for Population Density, 1987



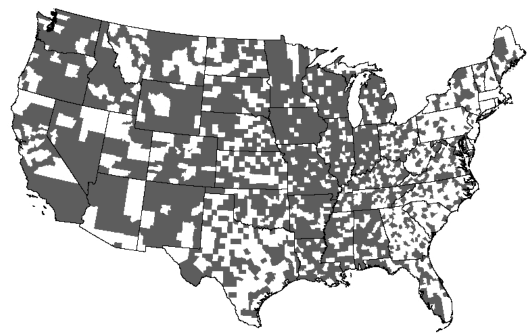
4b. Equilibrium Trend for Employment Density, 1987



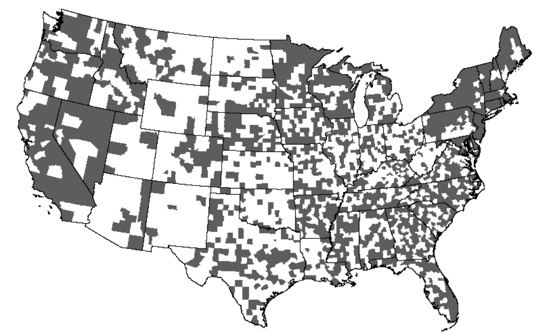
4c. Equilibrium Trend for Average Wage, 1987



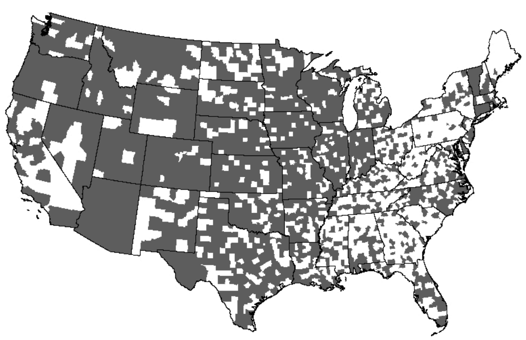
4d. Equilibrium Trend for Population Density, 1992



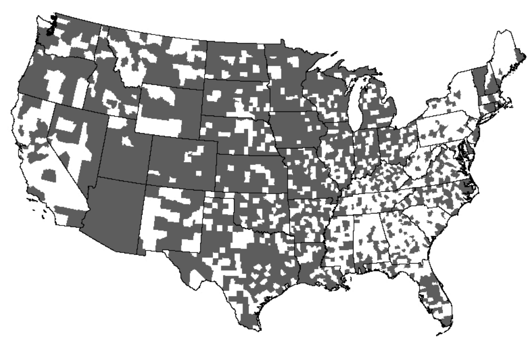
4e. Equilibrium Trend for Employment Density, 1992



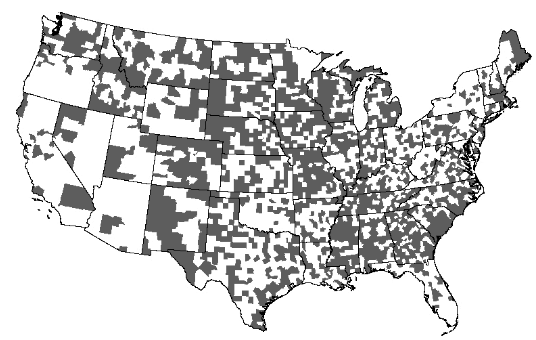
4f. Equilibrium Trend for Average Wage, 1992



4g. Equilibrium Trend for Population Density, 1997



4h. Equilibrium Trend for Employment Density, 1997



4i. Equilibrium Trend for Average Wage, 1997

(Note: White areas denote trend toward lower LQ; dark grey areas denote trend toward higher LQ)