Rethinking the Migration Effects of Natural Amenities: Part II

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Introduction

Migration is a demographic characteristic often found to be spatially clustered. This observed pattern of spatial inter-relation has been well explained by theories of regional economics and population geography, and the findings of residential preference studies. The growth pole theory applies spread and backwash notions to explain the mutual geographic dependence of economic growth and development, which in turn drives migration flows (Perroux 1955). Central place theory views migration within a hierarchy of urban places where the movement of population, firms and goods is determined by the associated costs and city sizes (Christaller 1966). Population geographers are interested in the spatial variation of population change with respect to distribution, growth, composition, and migration, and seek to explain population patterns caused by spatial regularities and processes (Jones 1990). Spatial diffusion theory argues that population growth will spread to surrounding areas and implies that population growth is spatially autocorrelated (Hudson 1972). In studies of residential preference, rural demographers find that migrants prefer locations somewhat rural or truly sub-urban within commutable distance of large cities (Brown et al 1997; Fuguitt and Brown

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1990; Fuguitt and Zuiches 1975). Migratory factors such as improved quality-of-living and increased employment opportunities in a place (city, village, or town) not only attract migrants who move into its territory, but also attract migrants who move into neighboring places because of the access to the benefits of the attractive place provided by transportation infrastructure. Overall, these factors and effects exhibit explicit spatial process elements, which need to be controlled in empirical regional models of migration.

Part II builds upon the results of Part I and develops a spatial approach to modeling migration effects of natural amenities. This spatial approach considers spatial lag and spatial error dependence simultaneously and selects an optimal spatial weights matrix for diagnosing spatial dependence in model residuals and specifying appropriate spatial regression models. Our central research questions are twofold. First, does this spatial approach improve the respective models' goodness-of-fit? Second, does this spatial approach provide a relatively more comprehensive view of the role natural amenities play in explaining socio-demographic change compared to the results of Part I?

Part II is organized into three additional sections. Following this introduction, we briefly recap the data used in Part I and outline our spatial approach. The subsequent results section uses the spatial approach to revisit the migration effects of natural amenities. Finally, we close this paper with a concluding summary of the work, identify several areas for further research, and discuss relevant policy implications.

Data and Methods Used

Part II extends concepts and data from Part I by adopting a spatial regression approach. Specifically, it empirically focuses on the state of Wisconsin as the research case, and examines in-migration from 1995 to 2000 (the dependent variable) at the MCD level. The analytical dataset consists of 1,837 MCDs with an average size of 29.56 square miles. Natural amenities are represented by the presence of forests, water, wetlands, public lands, lakeshore/riverbank/coastline, golf courses and viewshed. Explanatory controls include three demographics indices, three livability indices, two accessibility indices, and one developability index generated by principal factor analysis and spatial overlay methods.

The ordinary least squares (OLS) models developed in Part I are diagnosed for the existence of spatial dependence in model residuals which leads to the suggestion of appropriate spatial regression models for controlling for spatial dependence. Diagnostics include Moran's I statistic for residuals, Lagrange-Multiplier (LM) tests for the lag dependence, error dependence, and a combination (joint), and robust LM tests for the lag dependence and error dependence. Although Moran's I is often used in existing literature for detecting spatial dependence in regression residuals, it is affected by non-normality, heteroskedasticity, and spatial lag dependence (Anselin and Rey 1991). Moreover, it cannot identify the characteristic of the spatial dependence (e.g. spatial lag dependence, spatial error dependence, or a joint spatial lag and error dependence), and thus it cannot suggest what spatial regression models are most appropriate to account for spatial dependence. The Lagrange Multiplier (LM) test (Burridge 1980), which follows a chi-square distribution with one degree of freedom, can help detect the presence of spatial dependence in the form of an omitted spatially lagged dependent variable and/or spatial error dependence (Anselin 1988). The robust LM tests (Anselin et al 1996) further diagnose spatial lag dependence in the presence of spatial error dependence and spatial error dependence in the presence of a spatially lagged dependent variable. When the LM tests for both the lag and error dependence are significant, the robust LM tests can suggest the pertinence of the spatial dependence. Finally, based on the spatial dependence tests, we specify appropriate spatial regression models to further examine the effect of amenities on migration.

It is noted that a spatial weights matrix is needed for diagnosing the existence of spatial dependence in the OLS model residuals and specifying spatial regression models (Anselin 1988). A spatial weights matrix corresponds to a neighborhood structure for each location by specifying its neighboring locations on a lattice. The use of a spatial weights matrix allows the variance-covariance matrix of neighborhood structure to be expressed as a function of a small number of estimable parameters relative to the sample size (Anselin 2002). However, there exists little theory suggesting an appropriate spatial weights matrix for examining the effects of natural amenities on migration and many studies select one without strong justification or comparison to others. In this study, we adopt a data-driven approach to select the optimal spatial weights matrix (Chi 2010; Chi and Zhu 2008). We develop and compare 40 different spatial weights matrices and choose the one that achieves a high coefficient of spatial autocorrelation in combination with a high level of statistical significance. The considered spatial weights matrices include the rook's case and queen's case contiguity weights matrices with order 1 and order 2; the k-nearest neighbor weights matrices, with k ranging from 3 to 8 neighbors; and the general distance weights matrices and the inverse-distance weights matrices with power 1 or power 2, from 0 to 100 miles at 10-mile increments based on the distance between the centroids of MCDs.

Each of the 40 spatial weights matrices is used to calculate the spatial autocorrelation, measured by Moran's I statistic, of each of the variables and indices used in this study (Table 1). The rook contiguity weights matrix with Order 1 captures the maximum spatial dependence of most variables (indicated by Moran's I and its significance). The rook contiguity weights matrix appears to be better than the rest (with the highest Moran's I if significance is indicated) for proportions of forest, water, wetland, demographic index 1, demographic index 2, livability index 3, accessibility index 1, and developability index. The rook matrix also shows secondary highest or relatively high spatial dependence for the other variables (except livability index 2 whose spatial autocorrelation is very low by all weights matrices). Therefore, the rook contiguity weights matrix with Order 1 is selected for detecting spatial dependence in the OLS regression residuals as well as for accounting for spatial dependence in spatial regression models.

TABLE 1 Moran's I Statistics for All Variables by Forty Different Spatial Weights Matrices

Spatial weights matrix	In-mig. rate 1995-2000 at the MCD level	In-mig. rate 1985-90 at the county level	Proportion of forest	Proportion of water	Proportion of wetland
Rook Contiguity, Order 1	0.142***	0.320***	**0.798*** **	**0.315*** **	**0.637*** **
Rook Contiguity, Order 2	0.091***	0.193***	0.689***	0.151***	0.435***
Queen Contiguity, Order 1	0.129***	0.306***	0.785***	0.302***	0.614***
Queen Contiguity, Order 2	0.082***	0.173***	0.666***	0.130***	0.388***
3 nearest neighbors	0.145***	**0.334*** **	0.760***	0.280***	0.584***
4 nearest neighbors	0.146***	0.318***	0.760***	0.290***	0.584***
5 nearest neighbors	**0.148*** **	0.306***	0.753***	0.279***	0.581***
6 nearest neighbors	0.143***	0.297***	0.746***	0.267***	0.566***
7 nearest neighbors	0.141***	0.290***	0.739***	0.255***	0.553***
8 nearest neighbors	0.138***	0.281***	0.730***	0.249***	0.539***
General distance, 10 miles	0.130***	0.263***	0.728***	0.235***	0.548***
General distance, 20 miles	0.090***	0.172***	0.649***	0.127***	0.392***
General distance, 30 miles	0.068***	0.130***	0.589***	0.076***	0.303***
General distance, 40 miles	0.053***	0.101***	0.536***	0.046***	0.243***
General distance, 50 miles	0.038***	0.075***	0.490***	0.029***	0.202***
General distance, 60 miles	0.031***	0.057***	0.451***	0.017***	0.178***
General distance, 70 miles	0.025***	0.039***	0.409***	0.010***	0.161***
General distance, 80 miles	0.020***	0.026***	0.366***	0.007***	0.143***
General distance, 90 miles	0.014***	0.016***	0.324***	0.004***	0.125***
General distance, 100 miles	0.009***	0.007***	0.285***	2.51E-4	0.107***
Inverse distance, 10 miles, power 1	0.133***	0.280***	0.731***	0.246***	0.558***
Inverse distance, 10 miles, power 2	0.132***	0.296***	0.733***	0.257***	0.564***
Inverse distance, 20 miles, power 1	0.104***	0.203***	0.671***	0.160***	0.435***
Inverse distance, 20 miles, power 2	0.117***	0.246***	0.697***	0.202***	0.481***
Inverse distance, 30 miles, power 1	0.086***	0.166***	0.625***	0.115***	0.361***
Inverse distance, 30 miles, power 2	0.108***	0.223***	0.670***	0.174***	0.437***
Inverse distance, 40 miles, power 1	0.073***	0.140***	0.584***	0.086***	0.309***
Inverse distance, 40 miles, power 2	0.102***	0.208***	0.649***	0.156***	0.407***
Inverse distance, 50 miles, power 1	0.061***	0.119***	0.548***	0.069***	0.272***
Inverse distance, 50 miles, power 2	0.096***	0.196***	0.631***	0.145***	0.386***
Inverse distance, 60 miles, power 1	0.054***	0.102***	0.518***	0.057***	0.247***
Inverse distance, 60 miles, power 2	0.093***	0.188***	0.617***	0.137***	0.371***
Inverse distance, 70 miles, power 1	0.048***	0.087***	0.487***	0.048***	0.229***
Inverse distance, 70 miles, power 2	0.090***	0.180***	0.603***	0.132***	0.360***
Inverse distance, 80 miles, power 1	0.043***	0.075***	0.457***	0.043***	0.212***
Inverse distance, 80 miles, power 2	0.088***	0.174***	0.591***	0.128***	0.351***
Inverse distance, 90 miles, power 1	0.039***	0.066***	0.428***	0.038***	0.197***
Inverse distance, 90 miles, power 2	0.086***	0.170***	0.580***	0.124***	0.343***
Inverse distance, 100 miles, pow. 1	0.035***	0.058***	0.401***	0.033***	0.182***
Inverse distance, 100 miles, pow. 2	0.084***	0.166***	0.570***	0.121***	0.336***

TABLE 1 Continued

Spatial weights matrix	Proportion of public land	Lengths of riverbank /lakeshore /coastline	Golf courses	Slope	Demographic index 1	Demographic index 2
Rook Contiguity, Order 1	0.508***	0.212***	0.127***	0.800***	**0.105*** **	**0.323*** **
Rook Contiguity, Order 2	0.240***	0.120***	0.079***	0.657***	0.063***	0.152***
Queen Contiguity, Order 1	0.493***	**0.216*** **	**0.128*** **	**0.801*** **	0.102***	0.322***
Queen Contiguity, Order 2	0.210***	0.104***	0.078***	0.642***	0.066***	0.139***
3 nearest neighbors	0.527***	0.094***	0.114***	0.644***	0.055**	0.229***
4 nearest neighbors	0.516***	0.139***	0.112***	0.654***	0.086***	0.243***
5 nearest neighbors	0.484***	0.171***	0.111***	0.671***	0.100***	0.238***
6 nearest neighbors	0.458***	0.182***	0.111***	0.664***	0.102***	0.236***
7 nearest neighbors	0.438***	0.191***	0.117***	0.658***	0.100***	0.242***
8 nearest neighbors	0.423***	0.190***	0.109***	0.655***	0.099***	0.240***
General distance, 10 miles	0.546***	0.186***	0.111***	0.657***	0.097***	0.208***
General distance, 20 miles	0.312***	0.167***	0.081***	0.576***	0.082***	0.154***
General distance, 30 miles	0.215***	0.133***	0.061***	0.511***	0.050***	0.128***
General distance, 40 miles	0.156***	0.112***	0.050***	0.462***	0.036***	0.111***
General distance, 50 miles	0.125***	0.097***	0.043***	0.417***	0.026***	0.103***
General distance, 60 miles	0.105***	0.084***	0.038***	0.369***	0.017***	0.096***
General distance, 70 miles	0.087***	0.071***	0.033***	0.316***	0.010***	0.089***
General distance, 80 miles	0.070***	0.060***	0.028***	0.264***	0.004***	0.082***
General distance, 90 miles	0.056***	0.050***	0.024***	0.216***	0.001	0.073***
General distance, 100 miles	0.045***	0.040***	0.020***	0.174***	-0.001	0.065***
Inverse distance, 10 miles, power 1	0.553***	0.137***	0.103***	0.639***	0.076***	0.218***
Inverse distance, 10 miles, power 2	**0.560*** **	0.067***	0.087***	0.611***	0.044**	0.225***
Inverse distance, 20 miles, power 1	0.361***	0.148***	0.085***	0.590***	0.075***	0.181***
Inverse distance, 20 miles, power 2	0.420***	0.084***	0.078***	0.589***	0.048***	0.209***
Inverse distance, 30 miles, power 1	0.274***	0.132***	0.071***	0.545***	0.057***	0.158***
Inverse distance, 30 miles, power 2	0.357***	0.081***	0.072***	0.569***	0.041***	0.198***
Inverse distance, 40 miles, power 1	0.218***	0.120***	0.062***	0.508***	0.048***	0.143***
Inverse distance, 40 miles, power 2	0.318***	0.079***	0.068***	0.553***	0.038***	0.192***
Inverse distance, 50 miles, power 1	0.186***	0.110***	0.056***	0.475***	0.040***	0.135***
Inverse distance, 50 miles, power 2	0.294***	0.076***	0.065***	0.539***	0.035***	0.188***
Inverse distance, 60 miles, power 1	0.164***	0.101***	0.052***	0.441***	0.033***	0.128***
Inverse distance, 60 miles, power 2	0.279***	0.074***	0.063***	0.526***	0.032***	0.185***
Inverse distance, 70 miles, power 1	0.145***	0.092***	0.048***	0.406***	0.027***	0.122***
Inverse distance, 70 miles, power 2	0.265***	0.071***	0.061***	0.514***	0.030***	0.183***
Inverse distance, 80 miles, power 1	0.128***	0.084***	0.044***	0.371***	0.022***	0.116***
Inverse distance, 80 miles, power 2	0.254***	0.069***	0.060***	0.502***	0.028**	0.181***
Inverse distance, 90 miles, power 1	0.114***	0.077***	0.041***	0.339***	0.018***	0.110***
Inverse distance, 90 miles, power 2	0.244***	0.067***	0.058***	0.492***	0.026**	0.179***
Inverse distance, 100 miles, power 1	0.102***	0.070***	0.037***	0.310***	0.016***	0.104***
Inverse distance, 100 miles, power 2	0.236***	0.065***	0.057***	0.483***	0.025**	0.177***

TABLE 1 Continued

Spatial weights matrix	Livability index 1	Livability index 2	Livability index 3	Access index 1	Access index 2	Develop index
Rook Contiguity, Order 1	0.695***	0.022	**0.688*****	**0.550*****	0.561***	**0.435*****
Rook Contiguity, Order 2	0.609***	-0.065***	0.561***	0.342***	0.306***	0.241***
Queen Contiguity, Order 1	0.687***	0.044**	0.680***	0.535***	0.533***	**0.435*****
Queen Contiguity, Order 2	0.587***	-0.079***	0.538***	0.310***	0.249***	0.214***
3 nearest neighbors	**0.740*****	-0.097***	0.610***	0.459***	**0.589*****	0.380***
4 nearest neighbors	**0.740*****	-0.043**	0.623***	0.454***	0.574***	0.393***
5 nearest neighbors	0.730***	-0.011	0.618***	0.446***	0.549***	0.390***
6 nearest neighbors	0.724***	-0.002	0.610***	0.440***	0.531***	0.380***
7 nearest neighbors	0.710***	-0.003	0.603***	0.451***	0.514***	0.365***
8 nearest neighbors	0.696***	0.004	0.600***	0.449***	0.496***	0.357***
General distance, 10 miles	0.671***	0.009	0.602***	0.406***	0.482***	0.364***
General distance, 20 miles	0.547***	0.021***	0.507***	0.273***	0.206***	0.228***
General distance, 30 miles	0.457***	0.008*	0.432***	0.192***	0.109***	0.159***
General distance, 40 miles	0.380***	0.009***	0.368***	0.140***	0.076***	0.114***
General distance, 50 miles	0.327***	0.009***	0.312***	0.106***	0.046***	0.086***
General distance, 60 miles	0.290***	0.007***	0.262***	0.089***	0.026***	0.066***
General distance, 70 miles	0.261***	0.007***	0.215***	0.074***	0.017***	0.050***
General distance, 80 miles	0.238***	0.007***	0.175***	0.064***	0.017***	0.036***
General distance, 90 miles	0.216***	0.006***	0.141***	0.056***	0.016***	0.024***
General distance, 100 miles	0.195***	0.005***	0.116***	0.048***	0.014***	0.011***
Inverse distance, 10 miles, pow. 1	0.700***	-0.045***	0.596***	0.420***	0.519***	0.371***
Inverse distance, 10 miles, pow. 2	0.727***	**-0.125*****	0.585***	0.434***	0.560***	0.371***
Inverse distance, 20 miles, pow. 1	0.605***	-0.010	0.529***	0.327***	0.307***	0.269***
Inverse distance, 20 miles, pow. 2	0.677***	-0.093***	0.546***	0.387***	0.436***	0.311***
Inverse distance, 30 miles, pow. 1	0.534***	-0.009	0.473***	0.265***	0.213***	0.211***
Inverse distance, 30 miles, pow. 2	0.642***	-0.085***	0.514***	0.358***	0.381***	0.278***
Inverse distance, 40 miles, pow. 1	0.474***	-0.004	0.423***	0.223***	0.170***	0.172***
Inverse distance, 40 miles, pow. 2	0.616***	-0.079***	0.488***	0.340***	0.353***	0.256***
Inverse distance, 50 miles, pow. 1	0.431***	-0.002	0.380***	0.195***	0.139***	0.145***
Inverse distance, 50 miles, pow. 2	0.598***	-0.075***	0.466***	0.328***	0.334***	0.242***
Inverse distance, 60 miles, pow. 1	0.399***	-0.001	0.341***	0.177***	0.117***	0.126***
Inverse distance, 60 miles, pow. 2	0.585***	-0.072***	0.448***	0.321***	0.321***	0.231***
Inverse distance, 70 miles, pow. 1	0.374***	-3.87E-4	0.305***	0.163***	0.103***	0.110***
Inverse distance, 70 miles, pow. 2	0.574***	-0.071***	0.432***	0.314***	0.311***	0.223***
Inverse distance, 80 miles, pow. 1	0.353***	1.77E-4	0.274***	0.151***	0.095***	0.096***
Inverse distance, 80 miles, pow. 2	0.566***	-0.069***	0.418***	0.310***	0.305***	0.216***
Inverse distance, 90 miles, pow. 1	0.335***	-1.39E-4	0.246***	0.141***	0.089***	0.084***
Inverse distance, 90 miles, pow. 2	0.559***	-0.069***	0.406***	0.306***	0.300***	0.209***
Inverse distance, 100 miles, pow 1	0.318***	6.39E-5	0.224***	0.133***	0.083***	0.072***
Inverse distance, 100 miles, pow 2	0.553***	-0.068***	0.396***	0.302***	0.296***	0.203***

Note: 1. * significance at 0.05, ** significance at 0.01, ***significance at 0.001.

TABLE 2 Diagnostics of OLS Regression Models

	OLS 1	OLS 2	OLS 3
Measures of fit			
R^2	0.023	0.139	0.202
Log likelihood	2078.66	2195.24	2264.53
AIC	-4141.32	-4372.48	-4495.07
BIC	-4097.20	-4322.83	-4401.30
Tests for spatial dependence			
Moran's I (error)	0.120***	0.060***	0.053***
Lagrange Multiplier test (lag)	57.457***	26.421***	15.167***
Robust Lagrange Multiplier test (lag)	11.856***	27.055***	7.000**
Lagrange Multiplier test (error)	48.841***	12.424***	9.560**
Robust Lagrange Multiplier test (error)	3.240	13.057***	1.393
Lagrange Multiplier test (lag and error)	60.697***	39.479***	16.560***

Notes: 1. * significance at 0.05, ** significance at 0.01, ***significance at 0.001.

Results

In Part I, Model OLS 3 was the best among the three OLS models in terms of both goodness-of-fit and spatial independence (Table 2), and thus is used as a benchmark model for evaluating our spatial regression models. However, spatial dependence still remains in OLS 3; the LM tests for both the lag and error terms are significant (Table 2). The robust measure for lag dependence remains significant, suggesting spatial lag dependence in the presence of the spatial error term. But the robust LM test for error dependence becomes insignificant, indicating the lack of spatial error dependence in the presence of the spatial lag term. Overall, between a spatial lag model and a spatial error model, the former is more appropriate for minimizing the influence of spatial dependence. In addition, the LM test for the joint lag and error dependence (Anselin and Bera 1998) is significant, suggesting that considering spatial lag and error dependence simultaneously, through a Spatial Error Model with Lag Dependence (SEMLD) model, is also appropriate (Chi 2010). Therefore, Model OLS 3 is further expanded into a spatial lag model and a SEMLD model.

A spatial lag model is specified as:

$$Y = X\beta + \rho WY + \varepsilon \tag{1}$$

where W denotes the spatial weights matrix, WY denotes the spatially lagged dependent variable, and ε denotes the vector of error terms that are independent but not necessarily identically distributed. In the spatial lag model, the spatially lagged dependent variable was significant in explaining the in-migration rate

(Table 3). The coefficients and significance of other explanatory variables remained generally unchanged. The spatial lag model slightly improved Model OLS 3 based on the measures of fit, which include R^2, log likelihood, Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC).

A SEMLD specification combines a first-order spatial error model with spatial lag dependence and can be expressed as (Chi 2010):

$$Y = (WY + X)\beta + u, \quad u = \rho W u + \varepsilon \tag{2}$$

The SEMLD model dramatically outperformed the spatial lag model based on measures of goodness of fit (Table 3). Both the spatial lag and error terms were significant. However, none of the seven natural amenity variables was significant in explaining in-migration. The in-migration rate from 1985-90 still played a significance role in explaining in-migration. Four of the six controlled factors remained significant in influencing in-migration. They included demographic index 1 (age structure), demographic index 2 (minorities), livability index 3 (occupational structure and housing characteristics), and the developability index (land development potentials).

The SEMLD model is our preferred model because it examines the effects of natural amenities on in-migration by systematically controlling the temporal effect of in-migration, spatial lag and spatial error effects, demographic characteristics, socioeconomic conditions, transportation accessibility, and land developability. The preference is supported by the measures of fit. Thus, our final conclusions regarding the effects of natural amenities on in-migration are drawn from the results of the SEMLD model.

Conclusion and Discussion

In this study, we applied a spatial regression approach to model migration in the presence of natural amenities by revisiting the results of Part I. When combined with other control variables, the indices (demographics, livability, accessibility, and developability) were spatially modeled using alternative approaches which provided insights into the empirical methods used to assess the role of natural amenities in explaining migration. Our results did not suggest any significance of natural amenities in influencing in-migration. Natural amenities appear to be best thought of as only a catalyst, or one of many contextual forces that act to drive rural population change. Their migration attraction appears to exist only when other conditions are met.

From a methodological perspective, it is important to consider spatial lag and spatial error dependence simultaneously and select an optimal spatial weights matrix for examining the effects of natural amenities on migration. The model that jointly accounted for spatial lag and spatial error dependence appeared to improve the models' goodness-of-fit balanced with model parsimony. The selection of an optimal spatial weights matrix among forty matrices allowed capturing the maximum spatial lag and spatial error dependence in the model residuals.

TABLE 3 Spatial Regression Models and Diagnostics

	Spatial lag model	SEMLD model
Explanatory variables		
Constant	0.205*** (0.018)	-0.005 (0.014)
The proportion of forest area	-0.044*** (0.011)	-0.013 (0.007)
The proportion of water area	0.023 (0.030)	0.022 (0.022)
The proportion of wetland area	-0.020 (0.019)	0.002 (0.013)
The proportion of public land area	0.027 (0.016)	0.015 (0.011)
The length of riverbank/lakeshore/coastline	8.171e-5 (2.383e-4)	1.372e-4 (1.570e-4)
Golf courses	-1.716e-8 (1.363e-7)	-1.026e-7 (1.020e-7)
Slope	0.116*** (0.034)	0.038 (0.021)
The in-migration rate across county in 1985-90	0.312*** (0.027)	0.148*** (0.020)
Demographic index 1	0.006* (0.002)	0.005** (0.002)
Demographic index 2	0.012*** (0.003)	0.008*** (0.002)
Livability index 1	0.008*** (0.002)	0.001 (0.001)
Livability index 2	-0.002 (0.003)	-0.002 (0.002)
Livability index 3	-0.022*** (0.003)	-0.006** (0.002)
Accessibility index 1	-0.006* (0.002)	-0.002 (0.002)
Accessibility index 2	-1.432e-4 (0.003)	0.001 (0.002)
Developability index	0.048** (0.016)	0.024* (0.012)
Spatial lag term	0.116*** (0.028)	0.885*** (0.027)
Spatial error term	--	-0.793*** (0.025)
Measures of fit		
R^2	0.206	0.379
Log likelihood	2272.36	2351.96
AIC	-4508.72	-4667.93
BIC	-4409.44	-4568.64

Note: 1. * significance at 0.05, ** significance at 0.01, ***significance at 0.001; standard errors in brackets.

There is ample opportunity for further research along these thematic lines. Extending, refining, and adapting a more holistic examination of the effects of natural amenities on socio-demographic and economic change characteristics important to regional development will, no doubt, become increasingly important. This is particularly true for amenity-rich rural regions experiencing dramatic post-industrial developmental transitions. In addition, policy instruments that can affect this transition should be incorporated into modeling population dynamics considering their increasing importance in modern land use and development planning practice (Chi 2009). Planning tools such as legal regulations, restrictions, development incentives, and public process as embodied in comprehensive planning, zoning ordinances, and resource management programs act to directly limit and/or encourage land development and migration. Thus, these instruments are key explanatory policy variables that need more creative incorporation into both theoretical and empirical analysis.

Second, the temporal context in which natural amenities interact with other factors to drive socio-demographic change needs further research. As addressed in the introduction section of Part I, population distribution process has experienced various patterns throughout human history. In future research, extensions of time-series analysis can examine the effects of natural amenities on migration in multiple time periods. By comparing the effects across several time periods, a more comprehensive view can be obtained.

Third, the five sets of variables (demographic, socioeconomic, accessibility, amenity, and developability) were used as independent variables to explain migration. We recognize that complex relationships exist among these variables and migration. The change in transportation accessibility, natural amenities, and land development induces change in demographic and socioeconomic characteristics, and vice versa. Population redistribution can also induce change in these variables. For example, improved transportation accessibility stimulates economic growth and attracts migrants, while at the same time economic growth and in-migration create demand for yet higher levels of transportation infrastructure (Chi et al 2006). There is an opportunity to consider simultaneity and causality among these variables and migration to more systematically evaluate the effect of amenities on demographic change.

Finally, our empirical spatial analysis used the minor civil division level as the relevant geographic unit of analysis for Wisconsin, one of several U.S. Lake States and representative of a rather unique set of natural amenity types and rural development contexts. Given the rapid transformation in information technology and data availability, these types of fine-grained spatial analyses can extend into broader geographies, amenity types, and development contexts. Doing so would act to develop a broader, more robust, set of results aimed at helping us understand the role of natural amenities in the processes of regional socio-demographic and economic change.

Policy implications of this work reinforce a cautionary and integrative approach to community economic development that accounts for the complexity associated with rates of in-migration. Certainly, results of our work with natural amenities suggest that non-commodity uses of local natural resource assets serve as one of several attractants to new in-migrants. However, natural amenity values alone are insufficient in explaining in-migration. Other key elements behind regional in-migration include demographic, socioeconomic, accessibility, and developability indicators that are unique to local communities. These broader elements, when combined with locally available natural amenity assets, can serve as an appropriate set of integrative public policy instruments.

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