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Spatial analysis of rural land development

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Abstract

This article examines patterns of rural land development and density using spatial econometric models with the application of Geographical Information System (GIS). The cluster patterns of both development and high-density development indicate that the spatially continuous expansions of development and high-density development exist in relatively remote rural areas. The results also revealed that a closer distance to roads, a closer distance to cities, greater access to streams and rivers, higher elevations, and greater proportions of flat area are valued highly in rural land development.

Keywords: Spatial; Cluster; GIS; Development; Density; Rural

The population of non-metropolitan counties grew by 5.3 million, or 10.3% in the 1990s, compared with an increase of just 1.3 million, or 2.7% in the 1980s. Net migration also shifted from an average annual outmovement of 269,000 in the 1980s to an average inmovement of 348,000 in the 1990s (Economic Research Service, 2004). The non-metropolitan population growth has slowed down recently but there are still rapidly growing counties with amenities that attract retired people. The Blue Ridge Mountains area is among the fastest growing rural areas in the country and Macon County, North Carolina, situated at the southern end of the Blue Ridge Mountains, is an area specifically experiencing this rapid development.

Macon County is classified as rural by the Census Bureau and "non-metro" by White House's Office of Management and Budget (OMB).[1] The county grew from 20,178 people to 29,811 in the 1990s, an increase of nearly 48%. At the same time, the number of housing units increased from 13,358 to 20,746, a gain of 55%. The higher increase of housing units relative to population growth reflects the impact of recreational second home developments in the mountains. For instance, in 2002, 45% of all new residences

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[1] The Census Bureau classifies urban area as a central city and the surrounding densely settled territory that together have a population of 50,000 or more and a population density generally exceeding 1,000 people per square mile. All others are considered rural. OMB classifies a metro area as one city with 50,000 or more inhabitants or an urbanized area (defined by the Census Bureau) with at least 50,000 inhabitants and a total metropolitan statistical area (MSA) population of at least 100,000 (75,000 in New England). Any area not included in an MSA is considered "non-metro".

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built in the county were second homes. An increasing number of rural homeowners, interfacing with the unprecedented growth of the metropolitan Atlanta area's northern suburbs (e.g., the population of Cherokee County, Georgia grew 174% between 1980 and 2000), has expanded second home communities of the county at a rapid pace.

The rapid growth in Macon County has given rise to concerns over declining environmental quality. Scientific monitoring revealed that the water quality in some streams has declined significantly during the past two decades (N.C. Division of Water Quality, 2002). This rapid growth puts pressure on such public services as sewage treatment and overall water quality. Despite the common recognition of the consequences of the county's rapid growth, it has had difficulties adopting a land use plan. The county needs a systematic study to help decision makers propose land use development patterns that make the most efficient and feasible use of infrastructure and public services. Because development is tied to economic incentives, locational externalities, and geological features, spatial econometric models are needed to design development and conservation strategies that address specific environmental consequences. Macon County provides an excellent study site for testing our methodology because institutional factors such as land use regulations have only a minor influence on the area's development because the region contains no land use zoning or regulations.

While the process of urban growth and development has long been a focus of study, there has been increasing interest in non-metro and fringe area development (e.g., Irwin et al., 2003; Miller, 2003; Libby and Sharp, 2003; Irwin and Bockstael, 2002). The development of tests for spatial autocorrelation or dependence in linear regression models as well as the development of efficient and consistent estimators for these types of models have been an important part of the spatial econometric literature over the last few decades (e.g., McMillen, 2003; Tse, 2002; Leung et al., 2000; LeSage, 1997; McMillen, 1992; Anselin, 1988; Cliff and Ord, 1973). While land development models that account for spatial relationships have begun to emerge, such models have focused on development probability or stochastic processes (Dubin, 1988, 1992; Can, 1990, 1992; McMillen, 1992, 1995; Bockstael, 1996). Details of spatial pattern such as density or intensity have not been accommodated. To understand spatial processes and patterns, we must take both types into account (Cheng and Masser, 2003).

In this article, we examine the spatial patterns of land development and the density of land development of a rural county experiencing rapid change. It focuses on an empirical analysis that is useful in understanding rural growth in a spatial context. We also account for spatial dependence by using an integrated approach that combines Geographical Information System (GIS) and spatial econometric models. The spatial dependence with unknown disturbance error is diagnosed by creating spatial lagged variables that capture unobserved characters in regression models (Cliff and Ord, 1973). The GIS and spatial statistics allow for spatially explicit analysis by providing flexibility in specifying models and measuring variables (e.g., Ding, 2001; Lake et al., 2000; Geoghegan et al., 1997).

1. Empirical model

Land development decisions by a landowner at the parcel level have been modeled using discrete choice models. These models estimate the probability of land development as a function of parcel-level attributes (e.g., Bockstael and Bell, 1998; Bockstael, 1996). Because a priori returns from parcel development are unknown with certainty, Bockstael (1996) developed a hedonic model of land values to estimate predicted land values, which were then used as a proxy for the expected returns of development. Then, in a second stage, they modeled land development using a discrete choice model incorporating these predicted land values.

We extend Bockstael and Bell's two-stage model into a three-stage model to accommodate the density of development. We estimate a hedonic model of land value in the first stage, a development model in the second stage, and a density of development model in the third stage. The first-stage hedonic model utilizes attributes of land values. The predicted land value is estimated from the hedonic model and used as a proxy for the expected return of development in the second and third stage estimations. The second stage estimations of the development model identify character-