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Urban encroachment, forest regrowth and land-use institutions: Does zoning matter?

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ABSTRACT

As concern grows regarding urban sprawl and forest and agricultural land preservation, the effectiveness of land-use policies in shaping land-use change warrants further study. We evaluate the impact of county-level zoning laws, the most predominant land use policy in the USA, and land rents on the relative amounts of forest, agricultural, and developed land, while controlling for demographic information and taxation rates. Over the past decades, southern Indiana has experienced forest regrowth on private lands, but this regrowth has declined in recent years with increased conversion of open space for urban residential development. We develop a model of land-use shares in 40 southern Indiana counties based on the net benefits to agriculture, forestland, and urban uses using a maximum likelihood estimation of a Dirichlet distribution. We find agricultural land rent and indicators of land productivity are the most important predictors of the proportion of agriculture and urban uses. Forest use is better explained by shifting regional economic structure and hilly terrain. Counties with a greater proportion of their work force in the service sectors have a greater proportion of land forested. Finally, to some extent zoning may protect agricultural land in the region, although land rents, land characteristics, and population are strong predictors of the ratio of agriculture to urban use.

Introduction

Subdivisions, strip malls, and office complexes spring up amid cornfields and trees creating concern about loss of rural life, landscapes, and communities. Decentralization of cities during recent decades due to the relocation of households and firms to outlying areas and the increasing polycentricity of urban regions has significantly impacted formerly rural landscapes. Urban-regional systems influence this process of decentralization through industrial specialization, transportation, and the resulting residential settlement patterns (Partridge et al., 2008). These trends are referred to as counterurbanization (Deller et al., 2001), whereby cities experience population decline or stabilization while nearby rural and peri-urban areas face population growth and changing settlement patterns. At the same time, primary production (including agriculture, forestry and fishing) is declining in many industries, particularly as less suitable areas fall out of production and/or real product prices decline. Primary production is often conceptualized as the opportunity cost of urban expansion; economists generally postulate a bidding processes at the outer extent of an urban region between urban rents and anticipated future returns in agriculture (cf. Johnston and Mellor, 1961; Brueckner and Fansler, 1983).

Interestingly, the impacts of agricultural and urban change on forests may be difficult to determine a priori. On the one hand, if agricultural production declines or halts on more marginal lands, forests can regrow. On the other, clearing of forest for new urban development is also common. Thus, the amount of urban development that occurs within a particular locality and its impacts on forests will depend on how the various land-use processes come together, mediated by land-use policies. Institutional constraints such as growth management policies or urban growth boundaries are a means to protect agricultural and forestland, yet traditional zoning remains the most prevalent land-use control in the USA, especially in rural regions (Diamond and Noonan, 1996).

In this paper, we argue that regional-level land-use policies, such as county zoning, can play an important role in this process of urban encroachment into proximate rural areas. Zoning can directly influence the rate of urbanization by limiting urban growth through increased transaction costs and loss of use rights, though this is often not the original intent of zoning policy. Zoning can also directly target resources when resource restrictions are part of the

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county plan; open space, agricultural, and forest reserve zones are sometimes used to protect these land-uses, yet the efficacy of such zones is hampered in areas where urban growth pressure is high (Munore et al., 2005). Overall the empirical evidence of the effectiveness of zoning in the mitigation of urban sprawl and protection of forest and farmland is mixed (Bengston et al., 2004; Erickson, 1995) perhaps due to the fact that zoning is implemented to reduce conflicts between land uses, maintain or increase property values for preferred land uses, and promote orderly development not to slow urbanization.

What is particularly interesting in Indiana is the interplay between the replacement of agriculture by urban land, versus urban encroachment into forest. We anticipate that variations in land rent are a better predictor of the loss of agricultural land, as this use is more directly tied to agricultural profits (though transfer payments to farmers are significant). On the other hand, smaller plots of forest land may be subjected to periodic selective harvesting, depending on the value of tree species. However, there is a literature that suggests that the non-timber value of forest, particularly in regions with a significant presence of private, small-scale landowners, may be very significant (Hardie and Parks, 1997).

Because land-use changes, such as urban conversion of natural lands occur at a regional level, scholars characterize local-level zoning as ineffective in the absence of a comprehensive regional approach (Carruthers, 2003; Daniels, 1999; Diamond and Noonan, 1996; Dowall, 1989; Platt, 1996). Carruthers (2003) has clearly articulated the issue of leapfrogging onto unzoned or inconsistently zoned land in rural regions. Most studies assessing zoning's impact on forest and farmland conversion have focused on isolated plots, parcels, or individual cities (Brabec and Smith, 2002; Kline and Alig, 1999; Stone, 2004), but do not evaluate the broader impact of zoning on land-use conversion in a regional context. We investigate the impact of county-level zoning using a land-use shares model addressing two main questions: (1) does zoning restrict urban encroachment and the conversion of open space, both agricultural and forest? (2) Are the impacts of zoning distinct for urban conversion from forest or agriculture?

We explore these questions using a multivariate Dirichlet land rent model creating a system of agriculture and forest land-use shares relative to urbanization incorporating the effects of local land-use controls in the context of regional economic structural shifts. Many land-use share studies only focus on two land classes, such as agriculture versus forestry land-use decisions (for example Plantinga, 1996) or have used two models for the comparison of forestry, agriculture, and urbanized land (i.e. Munroe and York, 2003). When creating separate comparative models of land-use shares for urban, forestry, and agriculture the sum of land-use shares are not constrained to the unit simplex. We select a Dirichlet specification, which models proportional data simultaneously, allows for different effects of variables on choice sets, i.e. median household income on urban to agriculture and urban to forestry, and constrains the shares to a sum of one. We model a broad set of economic and institutional determinants on land-use patterns at the county level over three decades, from 1970 to 2000, in 40 southern Indiana counties, a region that has experienced great variation in urbanization, agricultural abandonment, and reforestation and deforestation. In the following sections we introduce our study site, explore the theoretical foundation for the model, construct the multivariate Dirichlet land-use shares model, and conclude with discussion and directions for future research.

Study site

Southern Indiana presents a unique study area that has experienced significant forest regrowth, continued agricultural production, and increased conversion of forest and agricultural land due to urban encroachment. In response to urbanization, many states pass legislation requiring land-use planning or growth management; in comparison Indiana has not passed legislation requiring county level zoning, as can be seen by the variation in zoning adoption in Fig. 1. Indiana's enabling legislation allows county-level zoning, passed in 1935 (Snider, 1940), but the state has never adopted any requirements for zoning and planning. Similar to many regions throughout the United States, southern Indiana has experienced urbanization in exurban areas, or those rural areas proximate to metropolitan centers (Erickson et al., 2002; Deller et al., 2001). Within Indiana, urban encroachment threatens agricultural land and perhaps most concerning, extremely productive hardwood forests, primarily nonindustrial private forests (NIPFs). These forests provide valuable timber, especially hardwoods such as oak and walnut, as well as ecological services, recreation opportunities, and aesthetic benefits (Alig et al., 2004). In some regions, including Indiana, NIPFs are the primary source for wood products such as pulp, lumber, plywood, and other wood productions (Rickenbach, 2002).

The land-use trends in southern Indiana reflect changes in the nation, but are most similar to other regions in the Upland South. The southern Indiana region was originally settled by farmers from Virginia, North Carolina, and Tennessee, predominately of Scotch-Irish ancestry, who brought a subsistence-based agricultural economy with them in the early 19th century (Nation, 2005). The land was heavily deforested for agriculture and then during the late 1800s and early 1900s timber harvesting supported furniture and automobile manufacturers (Sieber and Munson, 1992). Land-use decision-making about forested land became more complex in recent decades with urbanization pressures; from 1968 to 1998 counties in Indiana have both gained and lost NIPF land (Munroe and York, 2003). Some lands reforested due to agricultural abandonment processes that began in the early 20th century (Sieber and Munson, 1992). While in other areas, increased agricultural intensification post-World War II continued to cause deforestation via conversion to agricultural land. Most importantly in recent decades both agricultural and forest land have been converted to residential uses.

Our 40-county study area includes three United States Forest Service (USFS) forestry units with similar ecological and topographic features, hilly land and relatively poor soils, which were not glaciated by the Wisconsin glacier,[1] and with variation in adoption of county level zoning (Fig. 1). Two of the five counties that gain forest cover over the 1968–1998 period, Crawford and Sullivan County, do not have county level zoning controls. Three counties, Franklin, Perry, and Union, gain forest cover and are zoned at the county level since at least 1970. The southern Indiana region has experienced agricultural expansion, reduction, deforestation, reforestation, and urbanization providing an interesting case for understanding urban encroachment onto rural lands. How are these land-use change processes impacted by local land-use controls and economic structure? Next we discuss the theoretical foundation for the land-use shares model, which enables us to evaluate the relationship between zoning and conversion of rural lands to urban uses.

Theoretical foundation

The theoretical foundation of our land-use shares model stems from work by Parks and Murray (1994), Hardie and Parks (1997), and Ahn et al. (2000) who postulate that land-use shares at the

[1] This 40 county study area stands in stark contrast to the flat, glaciated areas of Northern Indiana, which have extremely good soils for crop production.