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Rezoning Decisions Associated with Housing Price, Land Use Plan, and Urban Sprawl: Empirical Estimations

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To the Graduate Council:

I am submitting herewith a thesis written by Ji young Kim entitled "Rezoning Decisions Associated with Housing Price, Land Use Plan, and Urban Sprawl: Empirical Estimations." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Seong-Hoon Cho, Major Professor

We have read this thesis and recommend its acceptance:

Roland K. Roberts, Daton M. Lambert

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Rezoning Decisions Associated with Housing Price, Land Use Plan, and Urban Sprawl: Empirical Estimations

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Ji young Kim
December 2009

Abstract

Under the theme of “Rezoning Decisions Associated with Housing Price, Land Use Plan, and Urban Sprawl: Empirical Estimations”, this thesis consists of two research with two related topics. The first part analyzes the dynamics of zoning structure and accommodates the neighborhood spillover effects associated with the real estate market, focusing particularly neighborhood spillover effects between rezoning of vacant parcels and housing price. It is found that the price of a house is positively influenced by the prices of other houses in its neighborhood but the rezoning status of a vacant parcel in a neighboring location plays an insignificant role in explaining the price of a house. The contrasting results of neighborhood spillover effects between rezoning and housing price clarify the direction of association between rezoning and housing price. The second part examines whether the manipulation of land use plan influences spatial development patterns in Knoxville area. It is hypothesized that rezoning approvals from undevelopable land classifications to developable land classifications are affected by the area currently designated for agricultural-rural residential use. The results show that the average distances between the closest parcels identified as preexisting development and parcels predicted to be approved for developable land classification drop under the hypothetical land use plan scenarios with expanded area designated for agricultural-rural residential use. The drops of the average distances are due to the increases in the frequency of denials of rezoning petitions for development in the area expanded for agricultural-rural residential uses. These results indicate that a manipulation of agricultural-rural residential use areas encourages rezoning for development closer to the area of preexisting development, and thereby reduces urban sprawl.

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Part 1. Introduction

Introduction

Neighborhood Spillover Effects between Rezoning and Housing Price

Zoning is a common form of land use control that separates one set of land uses from another to minimize the potential for inconsistent uses of neighboring land (Lewis and Kutter 1978). Numerous studies related to zoning have focused on estimating its external effects on land development and property values (Lin and Hwang 2004; Jud 1980; Ohls et al 1974; Maser et al. 1977; Quigley and Rosenthal 2004). One complication with estimating the external effects of zoning is the endogenous nature of zoning. The endogeneity issue associated with zoning has been explored in only a handful of studies (e.g., Epple et al. 1988; McMillen and McDonald 1991a, 1991b; Munneke 2005; Pogodzinski and Sass 1994; Wallace 1988).

Employing the standard two-stage procedure outlined in Lee (1983), a multinomial logit model, with the dependent variable representing land use classifications for vacant land, is estimated in the first stage to generate the selection variables used to estimate a land price equation in the second stage (McMillen and McDonald 1991a, 1991b; Wallace 1988). Land prices are estimated treating zoning as endogenous and considering the potential for selection bias. The relationship between endogenized zoning and land value is empirically examined using a price equation for vacant parcels under the existing zoning classification.

Unlike studies that treat zoning classification as static and current, Munneke (2005) acknowledges that the allocation of land differs from the market allocation and then examines if the allocation of land will be reallocated or rezoned toward the market allocation. He analyzes the dynamics of an urban zoning structure by examining the role of land prices in the decision to rezone vacant land from one land use to another. Munneke (2005) uses the two-stage procedure to address the potential for sample selection bias in the estimation of the land price equation.

Based on the information from the two-stage procedure, a zoning-change equation is developed to test whether the probability of a zoning change increases as the price of a parcel in an alternative use increases relative to its price in its current use. He shows that the land price is determined by current zoning, and zoning changes are sought and approved that lead to a higher expected return for the parcel. While he correctly highlights the need for analyzing the dynamics of zoning structure, the neighborhood effects associated with the housing market are not evaluated.

The need to control for neighborhood effects arises because the price of a house is strongly influenced by the price and quality of houses in its immediate neighborhood, and proximity to amenities and disamenities. Quantitative estimates of the spillover effects of rezoning on housing price and spillover effects of housing price on rezoning are essential to making informed zoning policy decisions. Information from this research will be useful to county planners and officers in developing guidelines for rezoning decisions.

Land Use Plan and Urban Sprawl

During the two decades between 1982 and 2003, the nonfederal developed areas, largely development of cultivated cropland and forests, increased by 74% from 1.5 to 2.6 million acre in Tennessee (NRCS 2003). The rate of increase was greater than 48%, the average increase in the United States. Responding to this rapid land development of Tennessee, the Growth Policy Act was introduced by initiating Public Chapter 1101, in 1998. The act required all counties and the cities within them to collaborate on a 20-year Growth Plan (MPC 2001a). Subsequently, in 2001, Knox County, located in East Tennessee, classified its land to three types based on the Growth Plan: areas within an urban growth boundary (UGB), planned growth areas (PGAs), and rural areas (MPC 2001a). The UBG is a regional boundary designed to control urban sprawl by encouraging a pattern of compact and contiguous development. The PGAs are designed to be large enough to accommodate expected growth in unincorporated areas over the planning horizon (MPC 2001a). Rural areas include land preserved for farming, recreation, and other non-urban uses.

The Growth Plan for Knox County also requires that rezoning approval for new developments must be consistent with the Sector Plan, which is a 15-year comprehensive development plan initiated by the Knoxville-Knox County Metropolitan Planning Commission (MPC) in 1996. The MPC divided the County into eleven planning sectors based on census tract boundaries. Each Sector Plan includes a background report about the sector containing basic planning information on its environmental resources, population, transportation, community facilities, utilities, and land use plans (MPC 2001b).

Numerous studies have attempted to investigate the effectiveness of the delineation of growth areas such as urban growth boundaries (Carlson and Dierwechter 2007; Cho et al. 2008; Cho et al. 2006, 2007; Downs 2002; Knaap 1985; Nelson and Moore 1993; Phillips and Goodstein 2000). Among these studies, Cho et al. (2008) evaluated the impacts of UBG on spatial development patterns in Knox County and found that the UGB in Knox County does not differentiate requirements from one region to another based on anecdotal evidence including interviews with planners engaged in the UGB planning process.

Conversely, the land use plan can be assumed to have significant effects on the spatial direction of land use because the Growth Plan states that rezoning that triggers new development must be consistent with the Sector Plan. There are 20 different types of land use and each type of land use stipulates the permitted zoning classifications and the density levels consistent with the

Growth Plan. Among the 20 land uses, the areas designated for agricultural-rural residential use allows open space, agricultural, and planned residential zoning and prohibits residential development at a density exceeding 1 dwelling unit per acre, commercial and industrial rezoning to protect natural, historic, and scenic resources from the sprawling development in agricultural-rural residential uses (MPC 2001b). The areas currently designated for agricultural-rural residential use tend to be located in rural area where land is preserved for farming, recreation, and other non-urban uses (MPC 2009). Thus, the land use plan, by designating greater areas for the agricultural-rural residential uses, implies restriction on developable areas. This study evaluates the land use plan identifying future land use changes with regards to urban sprawl management.

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Part 2. Neighborhood Spillover Effects between Rezoning and Housing Price

Abstract

The objective of this research was to investigate neighborhood spillover effects between rezoning of vacant parcels and housing price. The study is unique in that it correctly highlights the need to analyze the dynamics of zoning structure and accommodates the neighborhood spillover effects associated with the real estate market. Results indicate that real estate housing market conditions affect the likelihood of rezoning but the rezoning of a vacant parcel in the neighborhood of a house does not influence the price of that house. Findings also indicate that rezoning is initiated to meet greater demand for residential and commercial development. The finding that different degrees of rezoning pressure are influenced differently by rising housing prices can be used to help update guidelines for rezoning decisions.

Introduction

Zoning is a common form of land use control that separates one set of land uses from another to minimize the potential for inconsistent uses of neighboring land (Lewis and Kutter 1978). Numerous studies related to zoning have focused on estimating its external effects on land development and property values (Quigley and Rosenthal 2004; Lin and Hwang 2004; Jud 1980; Ohls et al 1974; Maser et al. 1977). One complication with estimating the external effects of zoning is the endogenous nature of zoning. The endogeneity issue associated with zoning has been explored in only a handful of studies (e.g., Epple et al. 1988; McMillen and McDonald 1991a, 1991b; Munneke 2005; Pogodzinski and Sass 1994; Wallace 1988).

Employing the standard two-stage procedure outlined in Lee (1983), a multinomial logit model, with the dependent variable representing land use classifications for vacant land, is estimated in the first stage to generate the selection variables used to estimate a land price equation in the second stage (McMillen and McDonald 1991a, 1991b; Wallace 1988). Land prices are estimated treating zoning as endogenous and considering the potential for selection bias. The relationship between endogenized zoning and land value is empirically examined using a price equation for vacant parcels under the existing zoning classification.

Unlike studies that treat zoning classification as static and current, Munneke (2005) acknowledges that the allocation of land differs from the market allocation and then examines if the allocation of land will be reallocated or rezoned toward the market allocation. He analyzes the dynamics of an urban zoning structure by examining the role of land prices in the decision to rezone vacant land from one land use to another. Munneke (2005) uses the two-stage procedure to address the potential for sample selection bias in the estimation of the land price equation. Based on the information from the two-stage procedure, a zoning-change equation is developed to test whether the probability of a zoning change increases as the price of a parcel in an alternative use increases relative to its price in its current use. He shows that the land price is determined by current zoning, and zoning changes are sought and approved that lead to a higher expected return for the parcel. While he correctly highlights the need for analyzing the dynamics of zoning structure, the neighborhood effects associated with the housing market are not evaluated. The need to control for neighborhood effects arises because the price of a house is strongly influenced by the price and quality of houses in its immediate neighborhood, and proximity to amenities and disamenities.

The objective of this research was to investigate neighborhood spillover effects between rezoning and housing prices. We hypothesize that rezoning leads to changes in the housing price within neighborhoods, while at the same time the housing price within neighborhoods determines rezoning. The endogeneity of rezoning and the neighborhood housing price is addressed using a simultaneous-equations model modified to accommodate the discrete (and endogenous) nature of rezoning.

Quantitative estimates of the spillover effects of rezoning on housing price and spillover effects of housing price on rezoning are essential to making informed zoning policy decisions. Information from this research will be useful to county planners and officers in developing guidelines for rezoning decisions. The next section discusses the econometric details of the procedure used to estimate the neighborhood spillover effects of rezoning and housing price. Results and discussion follow, and the last section draws conclusions.

Methods and Procedures

A two-stage model for current land-use classification and land price

The land use classification equation is estimated with annual data for vacant parcels sold within the City of Knoxville from January 1997 through December 2006 using a multinomial logit model with the dependent variable representing the three land use classifications for vacant land zoned—residential (j = 1), commercial (j = 2), and industrial (j = 3)—in the first stage of the two-stage approach outlined in Lee (1983). Land use classification at the time of sale is specified as[1]:

$$(1) \qquad \Pr(d_i = j) = \frac{\exp(\mathbf{x_i}\boldsymbol{\beta}_\mathbf{j})}{1 + \sum_{j=1}^{3} \exp(\mathbf{x_i}\boldsymbol{\beta}_\mathbf{j})}$$

where $\mathbf{x_i}$ is a vector of exogenous variables explaining land use classification j, including variables representing the characteristics that influence the use of parcel i; $\boldsymbol{\beta}_\mathbf{j}$ is a vector of unknown parameters for land use classification j; and $\Pr(d_i = j)$ is the probability that parcel i will take land use classification j.

The current level of zoning near a parcel may impact the probability of the parcel being zoned to a particular land use (Rolleston 1987; McMillen and McDonald 1991b; Munneke 2005). To account for the level of a particular land use near a vacant parcel, the percentages of land allocated to residential, commercial, and industrial zoning classifications within a 1–mile radius buffer around the parcel in 1997 were included as exogenous variables. These zoning allocation variables serve as proxies for past levels of zoning restrictions in a land parcel's neighborhood (Munneke 2005).

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[1] For simplicity, time subscripts are suppressed.

The second stage calls for the introduction of a selection variable into the land price equation as an explanatory variable. The land price equation is estimated as:

(2) $y_1^j = \rho_1^j \mathbf{W}_1^j y_1^j + \boldsymbol{\beta}_1^j \mathbf{X}_1^j - \delta_1^j \hat{\lambda}_1^j + u_1^j$, j = 1, 2, 3

where y_1 is the sale price of vacant land parcel, given its current land use *j* at the time of sale for a parcel sold between 1997 and 2006; $\mathbf{W}_1^j$ is a row-standardized spatial weight matrix; $\mathbf{X}_1^j$ is a vector of explanatory variables containing site-specific characteristics for the vacant parcel , i.e., lot size and distances to CBD, interstate, railroad, and local park; ρ_1^j**,** β_1^j **,** and δ_1^j are parameter to be estimated; and u_1^j are error terms. The "Inverse-Mill's ratios", $\hat{\lambda}_1^j = \phi[\Phi^{-1}(\hat{\Pr}(d_i = j))] / \hat{\Pr}(d_i = j)$, are calculated using the predicted values of the probabilities from the multinomial logit model, $\hat{\Pr}(d_i = j)$, where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density and cumulative distribution functions of the standard normal distribution, and ρ_j is a vector of estimated parameters for the inverse-Mill's ratios for land use *j*.

The spatial lag $\mathbf{W}_1^j y_1^j$ is correlated with the error term (Anselin 1998). To correct for endogeneity of spatially lagged price in the land price equation, we employed the two-stage least squares method (Kelejian and Prucha 1998). Spatial lag $\mathbf{W}_1^j y_1^j$ is replaced by an instrumental variables, which is the predicted value from a regression of spatial lag $\mathbf{W}_1^j y_1^j$ on a set of instruments $\mathbf{X}_1^j, \mathbf{W}_1^j \mathbf{X}_1^j$, and $\mathbf{W}_1^j \mathbf{W}_1^j \mathbf{X}_1^j$.

Mixed-use zoning allows a combination of compatible land uses, providing opportunities to live and work within compact areas and thereby decreasing travel distances between activities (Parker 1994). A mixed-use dummy variable was included as an exogenous variable to serve as a proxy for the effect on land price of past mixed-use classification. The mixed-use dummy variable was set to 1 if the vacant parcel was located within an area zoned for mixed use at the time of sale for a parcel sold between 1997 and 2006, and 0 otherwise.

Thiessen polygons were used to identify neighborhood contiguity through the row-standardized spatial weight matrix $\mathbf{W}_1^j$. This effectively turns the spatial representation of the sample from points into polygons, which are related to notions of spatial market areas (Anselin 1988). The average numbers of neighboring parcels identified by the spatial weight matrix $\mathbf{W}_1^j$ for the residential (j = 1), commercial (j = 2), and industrial (j = 3) classifications were respectively 5.9, 5.7, and 5.6.

Simultaneous-equations model for rezoning and housing price

A simultaneous equations model is hypothesized to include an endogenous continuous variable denoting housing price y_1 for single family houses sold in 2006 that are closest to the vacant land sold between 1997 and 2006 and an endogenous binary variable representing the rezoning of the vacant land sold between 1997 and 2006 y_2. A binary variable representing rezoning in any of the ten years prior to the house sale is used to capture the effect of the average time lag of rezoned vacant parcels in the house's neighborhood on the price of that house. The structural equations of the model are:

$$y_2 = \rho_2 \mathbf{W_2} y_2 + \gamma_2 y_3 + \boldsymbol{\beta}_2 \mathbf{X}_2 + u_2, \quad (3)$$

$$y_3^* = \gamma_3 y_2 + \boldsymbol{\beta}_3 \mathbf{X}_3 + \gamma_4 P_{diff} + u_3, \quad (4)$$

where y_3^* is a latent variable corresponding to y_3; β_2, β_3,are parameter vectors for $\mathbf{X}_2, \mathbf{X}_3$, respectively ;$\gamma_2$ and γ_3 are scalar parameters; γ_4 is parameter for price difference variable; $\mathbf{X}_2$ is a vector of exogenous variables that affect housing price such as structural variables (e.g., lot size and number of bedroom), census-block group variables (e.g., vacancy rate and housing density), distance variables (e.g., distances to central business district (CBD) and park), and other variables (e.g., American College Test (ACT) score); $\mathbf{X}_3$ is a vector of exogenous variables that affect rezoning; P_{diff} is the price difference between under alternative land use zoning classifications and under its current zoning classification based on *A two-stage model for current land-use classification and land price*; $\mathbf{W_2}$ is a row-standardized spatial weight matrix; and u_2 and u_3 are the error terms. Inverse distances were combined with the contiguity matrix to give closer contiguous neighbors more influence through row-standardized spatial weight matrix $\mathbf{W_2}$. Spatially lagged housing price $\mathbf{W}_2 y_2$ is replaced by an instrumental variables, which is the predicted value from a regression of $\mathbf{W}_2 y_2$ on a set of instruments $(\mathbf{X}_2, \mathbf{X}_3), \mathbf{W}_2(\mathbf{X}_2, \mathbf{X}_3),$ and $\mathbf{W}_2\mathbf{W}_2(\mathbf{X}_2, \mathbf{X}_3)$.

The rezoning equation includes variables for the differences between the expected value of a parcel in alternative land use zoning classifications and the value of the parcel in its current zoning classification at the time of sale for a parcel sold between 1997 and 2006. The land value difference P_{diff} is included in the rezoning equation based on the hypothesis that the probability of rezoning should increase if the price of a parcel in an alternative zoning classification rises relative to the price in its current zoning classification.

The land value difference is calculated as:

$$(5) \qquad P_{diff} = E[\hat{y}_1^{oi}] - \ln(\hat{y}_1^{si}) = \frac{\sum_{j=1, j\neq s}^{3} \mathrm{Pr}_{ji} \ln(\hat{y}_1^{ji})}{1 - \mathrm{Pr}_{si}} - \ln(\hat{y}_1^{si})$$

where $\hat{y}_1^{si}$ is the predicted land price of parcel *i* in its current zoning classification *s* at the time of sale, and the expected value of the price of a parcel in a use other than the current zoning classification, $E[\hat{y}_1^{oi}]$ are calculated based on *A two-stage model for current land-use classification and land price*. The probability of the *i*th parcel being zoned *j*, $\Pr_{ji}$ are generated based on the first-stage estimation of the multinomial logit model and the expected values $\hat{y}_1^{ji}$ are based on the second-stage land price estimates from the '*two-stage model for current land-use classification and land price*'. The use of the expected values should reflect the potential return under alternative zoning classifications. The price differential is expected to have a positive effect on the probability of rezoning indicating that the probability of zoning change should increase as the expected return for alternative feasible uses increases. This hypothesis is based on assumption that the land owners of the parcels are profit maximizers.

The vector $\mathbf{X}_3$ also includes the percentages of land allocated to residential, commercial, and industrial zoning classifications within a 1–mile radius buffer around a vacant parcel in 1997, which serve as proxies for past levels of zoning restrictions in a land parcel's neighborhood (Munneke 2005). Additional interaction variables are included to define the price differential interacted with a dummy variable representing the land use at the time of sale. This specification allows price differential effects to be varied by each type of land use change.

A variable meant to serve as a measure of the propensity for zoning changes in an area (referred to as 'Restrict') is included in $\mathbf{X}_3$. The variable Restrict is assigned the value of 1 if the parcel sold between 1997 and 2006 falls into the 1–mile radius buffer around another vacant parcel that has had more than 15% of its buffer's land rezoned at the time of sale, and assigned the value of zero otherwise. The variable ‘Restrict’ is used as a proxy for the past actions of the zoning authority in a land parcel’s neighborhood (Munneke 2005).

These procedures imply that the error distribution of latent variable equation in equation 4 is standard normal distributed (Maddala 1983). A Bootstrap procedure would be an alternative approach to estimate the covariance matrix of each stage for correction of standard error. We need to focus on the reduced for system for equation 2-4 because the parameters in these equation do not appear in the first stage multinomial logit selection model. Reduced form system is;

(6) $$\begin{pmatrix} \mathrm{I}\text{-}\rho_1 \mathrm{W}_1 & 0 & 0 \\ 0 & \mathrm{I}\text{-}\rho_2 \mathrm{W}_2 & -\Gamma_2 \\ -\overline{\Gamma_4} & -\Gamma_3 & \mathrm{I} \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ y_3 \end{pmatrix} = \begin{pmatrix} \mathrm{X}_1 & 0 & 0 \\ 0 & \mathrm{X}_2 & 0 \\ 0 & 0 & \mathrm{X}_3 \end{pmatrix} \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix} + \begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix},$$

$$\overline{\Gamma_4} = diag\left(\gamma_4 \left[\frac{\sum_{j=1,\, j\neq s}^{3} \mathrm{Pr}_{ji}}{1 - \mathrm{Pr}_{si}} - 1 \right] \right),$$

$$\mathrm{I}\text{-}\rho_1 \mathrm{W}_1 = \begin{pmatrix} \mathrm{I}_1^{j=1} & 0 & 0 \\ 0 & \mathrm{I}_1^{j=2} & 0 \\ 0 & 0 & \mathrm{I}_1^{j=2} \end{pmatrix} - \begin{pmatrix} \rho_1^{j=1} \mathrm{X}_1^{j=1} & 0 & 0 \\ 0 & \rho_1^{j=2} \mathrm{X}_1^{j=2} & 0 \\ 0 & 0 & \rho_1^{j=3} \mathrm{X}_1^{j=3} \end{pmatrix}.$$

Setting the matrix of coefficients associated with the endogenous variables as Π, the reduced form system can be expressed compactly as;

(7) $$\mathrm{Y} = \Pi^{-1} \mathrm{XB} + \Pi^{-1} \mathrm{U}.$$

We use a nonparamatric, paired bootstrap procedure to estimate var(B). As a refinement to nonparametric bootstrap, we also simulate the probability distribution associated with the bootstrap samples. Cameron and Trivedi (2005) outlined the detail of these procedures, and Fingleton (2000) provides the steps to bootstrap the SAR(1) process model. In this research, given consistent estimates of the parameters in equation 2-4, we generated a new set of residual by randomly drawing triplets with the replacement from the original distribution to create the bootstrap sample which is used to generate the vector of psedudo-responses. Given the vector of pseudo responses, equation 2-4 are reestimated, and the associated vector of parameters is collected. Because equation 4 is specified as probit regression we resample the matrix of exogenous variables corresponding with the equation, transformed by Π^{-1}. This process is repeated (m=999) times. The bootstrap covariance matrix is;

(8) $$\operatorname{cov}(B) = \frac{1}{M-1}\sum_{m=1}^{M}(\hat{B}_m^* - \bar{\hat{B}}^*)(\hat{B}_m^* - \bar{\hat{B}}^*)', \;\; \bar{\hat{B}}^* = M^{-1}\sum_{m=1}^{M}\hat{B}_m^* .$$

Bootstrap standard errors are the square roots of the diagonal vector of the covariance. Bootstrap *p*-values are estimated by comparing the original *t* statistic associated with each parameter vector with the ordered empirical distribution of bootstrap *t* tests. For *p*-value associated with a symmetrical *t* test, we set the Type I error rate to α =5%. The absolute value of the original *t* statistic is matched with the bootstrap empirical distribution of the bootstrap replicate *t* tests.

Study Area and Data Description

This research uses two sets of transaction-level data: vacant parcels sold within the City of Knoxville from January 1997 through December 2006 and single family houses sold during January 2006 through December 2006 that are closest to the vacant land sold from January 1997 through December 2006. The zoning and tax assessment data were collected from Knoxville Utilities Board Geographic Information System (KGIS) and Knox County Tax Assessor's Office. These data provided information about sales transactions and locations of vacant parcels and single family houses, along with structural information about single family houses. The Knoxville, Knox County Metropolitan Planning Commission (MPC) provided rezoning information during 1997-2006.

Rezoning information between 1997 and 2006 and the zoning shape file that was updated on December 2004 were used to identify each vacant parcel's zoning classification at the time of sale for parcels sold during 1997-2006. The 1997 zoning map was recreated using the same information. The percentages of land allocated to residential, commercial, and industrial zoning classifications within a 1–mile radius buffer around a vacant parcel in 1997 were estimated by superimposing a 1-mile radius buffer around each vacant parcel sold during 1997-2006 on the 1997 zoning map. The calculation was done using the Patch Analyst (v3.12) extension for ArcView 3.3 (Rempel 2006).

There were 1,447 sales of vacant land during the 1997-2006 period in the City of Knoxville. Of those vacant parcels sold during the period, 1,080 were zoned residential, 169 were zoned commercial, 103 were zoned industrial, 18 were zoned agricultural, 56 were zoned for office, 8 were zoned for floodway, 6 were zoned for mixed use, 6 were zoned town center, and 1 zoned for open space at the time of sales transactions. Among the 1,447 vacant parcels, 1,352 vacant parcels classified as major categories of residential, commercial, and industrial zoning and their sales prices were used in the *two-stage model for current land-use classification and land price*. Among the 1,352 vacant parcels, 218 had undergone zoning changes during the 1997-2006 period and were assigned a value of 1 for the endogenous binary variable representing rezoning in the "*simultaneous-equations model for rezoning and housing price*" while the remaining 1,134 vacant parcels were assigned a value of zero. Of the 2,697 single-family houses sold within the City of Knoxville in 2006, 729 single-family houses were identified as being the closest ones to the 1,352 vacant parcels. The discrepancy between the numbers of vacant parcels and their closest single-family houses results from 623 vacant parcels sharing common closest single-family houses. Housing prices for the 729 single-family houses were used as an endogenous continuous variable in the "s*imultaneous-equations model for rezoning and housing price*".

Shape files for railroads, interstates, sidewalks, parks, golf courses, greenways, and water bodies that were used to create distance variables were acquired from KGIS (2004) and Environmental Systems Research Institute Data and Maps 2004 (ESRI 2004). The timing of these land-feature data (2004) and sales records for vacant parcels (1997-2006) and single-family houses (2006) did not match. Because land features such as railroads, interstates, sidewalks, parks, golf courses, greenways, and water bodies were not expected to change appreciably, these variables for 2004 were used as proxies for distance variables in the models for land-use classification (1997-2006), land price (1997-2006) and housing price (2006).

Additional information not available from the parcel data (e.g., income and travel time to work) was collected from the 2000 US census long-form dataset. The study area consists of 196 census-block groups. All houses and lots located within the boundaries of a census-block group were assigned the data for that census-block group. Although the timing of the census and sales records did not match, given the timing of census taking, the 2000 census data were used as proxies in the housing price equation.

The natural logarithms of vacant-parcel size, distance, and land price data were used as variables in the model, as the log transformation captures the declining effects of these variables (Bin and Polasky 2004; Iwata et al 2000; Mahan et al 2000). A statistical summary of the data for each major zoning classification is presented in Table 2-1. Detailed statistics for individual variables for single-family houses sold are reported in Table 2-2. Parcels in the residential zoning classification constitute a large portion (79.9%) of the full sample compared with the parcels in the commercial (12.5%) and industrial (7.6%) classifications.

Empirical Results

Two-stage model

Tables 2-3 and 2-4 present results from the two-stage model. The results from estimation of the current land use equations using a multinomial logit model for residential, commercial, and industrial vacant parcels are reported in Table 2-3. The current land use equations are normalized with respect to industrial zoning. Table 2-4 presents the results from estimation of the land price equation after controlling for potential selection bias.

Land surrounded by a greater percentage of residential zoning in the past is more likely to be zoned residential relative to industrial (Table 2-3). Land surrounded by a greater percentage of commercial zoning in the past is more likely to be zoned commercial relative to industrial. These results show that a parcel is more likely to be zoned the same as it was zoned in the past than to be rezoned for another use. Results also show that land surrounded by a greater percentage of residential land is more likely to be zoned commercial relative to industrial. This finding suggests that the incorporation of commercial zones within residentially zoned neighborhoods is more likely than finding industrially zoned property within residential zones.

Results show that lot size and distances to CBD, railroad, water body, and greenway are statistically significant at the 5% level for both zoning classifications. Larger vacant lots are more likely to be zoned for industrial relative to residential or commercial uses. While land located near the CBD, a railroad, or a greenway is more likely to be zoned industrial relative to residential or commercial, land located near a water body is more likely to be zoned residential or commercial relative to industrial. Vacant lots sold in 2003 or 2005 are more likely to be zoned residential or commercial relative to industrial than lots sold in 1997.

Estimates of the land price equation in the 2SLS model are presented in Table 2-4. The spatially lagged land price is statistically not significant at the 10% level for all three land use classifications. This result indicates that the values of vacant land zoned for residential, commercial, are industrial uses are not significantly influenced by neighborhood land prices for each land use classification. This result is rather unexpected and it requires more scrutiny. The statistical significances of the coefficients for the natural logarithm of lot size for all three types of land uses show the concave relationship between the price of vacant land and lot size regardless of land classifications. The negative coefficient for distance to a greenway suggests a premium for land closer to greenway for land zoned for commercial and industrial use. Results indicate that residential land prices in 1998, 2004, 2005, and 2006 were significantly greater than the residential land price in 1997. This indicates significantly greater appreciation in the price of residential land than the prices of land zoned for other uses and also point to the housing boom of the four years.

The coefficient for the selectivity variable ($\hat{\lambda}_{ji}$) for commercial use is positive and statistically significant at the 5% level. The coefficient on the selection variable provides evidence of the impact of the zoning authority (Munneke 2005). The result indicates that the zoning classifications influence differently on land prices depending the zoning types, implying a distinctive heterogeneity in the characteristics found in the zoning types.

Simultaneous-equations model

The elasticities from the simultaneously estimated housing price and rezoning equations are presented in Tables 2-5 and 2-6, respectively. Results in Table 2-5 show that the spatially lagged housing price is significant at the 1% level while the rezoning endogenous variable is not statistically significant. Thus, the price of a house is positively influenced by the prices of other houses in its neighborhood but the rezoning status of a vacant parcel in a neighboring location plays an insignificant role in explaining the price of a house. On average, a 1% increase in the prices of neighboring houses increases the price of a house by 0.096%.

All significant variables for housing characteristics in the housing price equation have their expected signs (Table 2-5). More finished area, stories, and a larger lot size add value to a house, as do higher quality construction, better condition, or lower age of the structure and the presence of brick siding, a garage, or a swimming pool. Two census-block group variables—vacancy rate and housing density—are significant at the 1% level (Table 2-5). Neighborhoods with lower vacancy rates and higher housing densities have higher housing prices. Two distance variables—greenway and water body—are significant at the 1% level. Closer proximity to a greenway or a water body increases the price of a house.

Results in Table 2-6 show that the endogenized house price within a neighborhood has a positive and significant effect on the likelihood of rezoning. More specifically, the probability of rezoning for a vacant parcel increases by 1.003% on average, given a 1% increase in a neighboring house price. We hypothesized that the rezoning occurs if its value in an alternative use is greater than its value in the current zoning classification. The insignificant effect of the price differential on the likelihood of rezoning rejects the null hypothesis. Contrast to the previous finding, land values in alternative uses do not explain rezoning occurrences in

Knoxville, Tennessee. The negative and significant elasticity for residential variables on the rezoning equation implies that land surrounded by a greater percentage of residential zoning in the past is less likely to be rezoned. The elasticity of the restrict dummy, representing the restrictiveness of rezoning within a 1-mile radius buffer, is positive and statistically significant at 1% level. This finding implies that, if more than 15% of vacant land within a one mile radius is rezoned, the probability of the land being rezoned increases, implying its spillover effect.

Conclusions

The principal objective of this research was to determine neighborhood spillover effects between rezoning and housing price. This objective was addressed through estimation of a simultaneous-equations model with an endogenous housing price variable and an endogenous binary variable reflecting the rezoning of a parcel in neighboring locations. The contrasting results of neighborhood spillover effects between rezoning and housing price clarify the direction of association between the two. Results indicate that real estate housing market conditions affect the likelihood of rezoning but the rezoning status of vacant parcel in a neighboring location plays an insignificant role in explaining house price.

The probability of rezoning vacant land is expected to increase as housing price in a neighboring location increases. The rise in the housing price in a neighboring location implies increasing pressure on housing demand. This increased pressure on housing demand likely contributes to greater demands for residential development and commercial development that complements residential use. Greater demand for residential and commercial development set in motion zoning changes for residential and commercial uses. Of the 218 vacant parcels that have undergone zoning changes during the study period, 70% (or 153 parcels) were rezoned for residential use and 20% (or 43 parcels) were rezoned for commercial use.

Rezoning approval is a key element of land use management in the Knoxville, TN area because (1) zoning is the most direct way to control location and density of development among the various types of land use policies and (2) other land use policies such as development guidelines, incentive-based policies, and property acquisitions are used infrequently in the area. The finding that different degrees of rezoning pressure are influenced differently by rising housing prices can be used to help update guidelines for rezoning decisions.

Currently, the major guidelines for the approval of rezoning petitions, according to the planners in the Knoxville area, are consistency with long-and short-range land use plans adopted by state, municipality, and county governments, and consistency with surrounding land use and environmental constraints, e.g., slope, flooding, and drainage. Local planning authorities can modify and update consistency measures in the current guidelines by accounting for varying degrees of housing demand pressure. For example, consistency measures can be strengthened in areas with greater housing-price increases, if preservation is desirable because these areas are likely to experience greater rezoning pressure.

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Appendix

Table 2-1. Statistical summary of vacant land sold during 1997-2006 in the models of land-use classification, land price, and rezoning (N=1,352)

Variable	Description	Unit	Full sample (N=1,352)	Residential (N=1,080)	Commercial (N=169)	Industrial (N=103)
			Mean (St. Dev)	Mean (St. Dev)	Mean (St. Dev)	Mean (St. Dev)
Endogenous Variables						
Land price	Vacant land sale price	$	100,662 (288,627)	72,446 (196,662)	280,256 (585,917)	101,839 (258,761)
Price differential	The difference between the expected value of a parcel in alternative zoning classifications and the value of the parcel in its current zoning classification	$	-1.079 (2.463)	0.031 (0.935)	-5.982 (1.501)	-4.667 (1.247)
Rezoning	1 if parcel was rezoned between 1997 and 2006, 0 otherwise		0.161 (0.368)	0.163 (0.370)	0.189 (0.393)	0.097 (0.298)
Parcel and Neighborhood Variables						
Lot size	Total square footage of parcel	feet^2	59,542 (189,719)	53,455 (174,260)	88,181 (278,082)	76,379 (161,551)
Residential	Ratio of total area zoned for residential to total area of a 1–mile radius buffer around parcel in 1997	ratio	0.609 (0.182)	0.642 (0.165)	0.474 (0.218)	0.483 (0.127)
Commercial	Ratio of total area zoned for commercial to total area of a 1–mile radius buffer around parcel in 1997	ratio	0.102 (0.084)	0.085 (0.057)	0.201 (0.141)	0.119 (0.080)
Industrial	Ratio of total area zoned for industrial to total area of a 1–mile radius buffer around parcel in 1997	ratio	0.112 (0.110)	0.103 (0.107)	0.106 (0.107)	0.218 (0.097)
Mixed use	1 if parcel was within an area classified for mixed land use at the time of sale for a parcel sold between 1997 and 2006, 0 otherwise		0.003 (0.054)	0.002 (0.043)	0.012 (0.108)	0.000 (0.000)

Table 2-1. (cont'd)

Variable	Description	Unit	Full sample (N=1,352) Mean (St. Dev)	Residential (N=1,080) Mean (St. Dev)	Commercial (N=169) Mean (St. Dev)	Industrial (N=103) Mean (St. Dev)
Restrict	1 if more than 15% of vacant land within a 1–mile radius buffer around parcel was rezoned at the time of sale for a parcel sold between 1997 and 2006, 0 otherwise		0.109 (0.311)	0.109 (0.312)	0.101 (0.302)	0.117 (0.322)
Distance Variables						
Dist. CBD	Euclidean distance from the centroid of a parcel to the centroid of the central business district	mile	4.098 (2.374)	4.087 (2.079)	5.126 (3.624)	2.520 (1.730)
Dist. railroad	Euclidean distance from the centroid of a parcel to the nearest railroad	mile	0.657 (0.573)	0.673 (0.520)	0.855 (0.817)	0.165 (0.281)
Dist. interstate	Euclidean distance from the centroid of a parcel to the nearest interstate highway	mile	0.921 (0.858)	1.016 (0.884)	0.527 (0.659)	0.567 (0.522)
Dist. park	Euclidean distance from the centroid of a parcel to the centrioid of the nearest park among 42 municipal parks in Knox County	mile	0.725 (0.405)	0.719 (0.399)	0.826 (0.472)	0.620 (0.312)
Dist. water body	Euclidean distance from the centroid of a parcel to the nearest stream, lake, river, or other water body	mile	1.320 (0.838)	1.321 (0.832)	1.432 (0.937)	1.126 (0.682)
Dist. greenway	Euclidean distance from the centroid of a parcel to the nearest greenway (a mostly contiguous vegetated pathway developed for recreation, pedestrian, and bicycle uses)	mile	0.901 (0.638)	0.917 (0.625)	0.989 (0.768)	0.588 (0.415)
Time Variables						
Y97	1 if parcel was sold in 1997, 0 otherwise		0.077 (0.267)	0.069 (253)	0.095 (0.294)	0.136 (0.344)
Y98	1 if parcel was sold in 1998, 0 otherwise		0.074 (0.262)	0.073 (0.261)	0.089 (0.285)	0.058 (0.235)

Table 2-1. (cont'd)

Variable	Description	Unit	Full sample (N=1,352) Mean (St. Dev)	Residential (N=1,080) Mean (St. Dev)	Commercial (N=169) Mean (St. Dev)	Industrial (N=103) Mean (St. Dev)
Y99	1 if parcel was sold in 1999, 0 otherwise		0.072	0.067	0.077	0.117
			(0.258)	(0.250)	(0.267)	(0.322)
Y00	1 if parcel was sold in 2000, 0 otherwise		0.075	0.058	0.107	0.194
			(0.263)	(0.234)	(0.309)	(0.397)
Y01	1 if parcel was sold in 2001, 0 otherwise		0.088	0.096	0.036	0.087
			(0.283)	(0.295)	(0.186)	(0.284)
Y02	1 if parcel was sold in 2002, 0 otherwise		0.098	0.101	0.095	0.078
			(0.298)	(0.301)	(0.294)	(0.269)
Y03	1 if parcel was sold in 2003, 0 otherwise		0.080	0.080	0.101	0.049
			(0.271)	(0.271)	(0.302)	(0.216)
Y04	1 if parcel was sold in 2004, 0 otherwise		0.097	0.095	0.118	0.078
			(0.296)	(0.294)	(0.324)	(0.269)
Y05	1 if parcel was sold in 2005, 0 otherwise		0.140	0.141	0.183	0.058
			(0.347)	(0.348)	(0.388)	(0.235)
Y06	1 if parcel was sold in 2006, 0 otherwise		0.200	0.220	0.101	0.146
			(0.400)	(0.415)	(0.302)	(0.345)

Table 2-2. Statistical summary of single-family houses sold in 2006 that are closest to the vacant land sold during 1997-2006, in the model of housing price (N=729)

Variable	Description	Unit	Mean (St. Dev)
Endogenous Variable			
House price	Housing sale price in 2006	$	163,518 (170,734)
Structure Variables			
Lot size	Total square footage of parcel	feet^2	34,616 (132,040)
Brick	1 if brick, 0 otherwise		0.209 (0.406)
Age	Year house was built subtracted from 2006		31.373 (26.668)
Pool	1 if pool, 0 otherwise		0.038 (0.191)
Garage	1 if garage, 0 otherwise		0.524 (0.500)
Bedroom	Number of bedrooms in house		2.953 (0.630)
Stories	Height of house in number of stories		1.274 (0.446)
Fireplace	Number of fireplaces in house		0.587 (0.581)
Quality	1 if quality of construction is excellent, very good or good, 0 if average, fair, or poor, as rated by the tax assessors' office		0.277 (0.447)
Condition	1 if condition of structure is excellent, very good or good, 0 if average, fair, or poor, as rated by the tax assessors' office		0.653 (0.476)
Finished area	Total finished square footage of house	feet^2	1665.859 (763.621)
Census block group Variables			
Vacancy rate	Ratio of vacant houses to total houses for census-block group in 2000	ratio	0.071 (0.037)

Table 2-2. (cont'd)

Variable	Description	Unit	Mean (St. Dev)
Unemployment rate	Ratio of unemployed to the labor force for census-block group in 2000	ratio	0.043 (0.037)
Travel time to work	Average travel time to work for census-block group in 2000	minutes	20.867 (3.553)
Income	Per capita income for census-block group in 2000	$	19,218 (10,750)
Housing density	Housing density for census-block group in 2000	houses /acre	1.192 (1.120)
Distance Variables			
Dist. CBD	Euclidean distance from the centroid of a parcel to the centroid of the central business district	mile	7.053 (3.166)
Dist. railroad	Euclidean distance from the centroid of a parcel to the nearest railroad	mile	1.223 (1.050)
Dist. sidewalk	Euclidean distance from the centroid of a parcel to the nearest interstate highway	mile	1.030 (1.418)
Dist. park	Euclidean distance from the centroid of a parcel to the centrioid of the nearest park among 42 municipal parks	mile	2.014 (1.337)
Dist. golf course	Euclidean distance from the centroid of a parcel to the centrioid of the nearest golf course	mile	2.299 (1.062)
Dist. greenway	Euclidean distance from the centroid of a parcel to the nearest greenway (a mostly contiguous vegetated pathway developed for recreation, pedestrian, and bicycle uses)	mile	1.751 (1.350)
Dist. water body	Euclidean distance from the centroid of a parcel to the nearest stream, lake, river, or other water body	mile	1.783 (1.103)
Other Variables			
Act	Average American College Test (ACT) in 2006 for the high school district where the house is located		20.442 (1.756)
Flood	1 if in 500-year floodplain area, 0 otherwise		0.016 (0.127)

Table 2-3. Multinomial logit model for current land use classification, the existing classification at the time of sale during 1997-2006

Variable	Residential	Commercial
	Coefficient (Std. Err.)	Coefficient (Std. Err.)
Intercept	7.067***	2.594
	(1.419)	(1.587)
Parcel and Neighborhood Variables		
ln (Lot size)	-0.681***	-0.453***
	(0.114)	(0.128)
Residential	4.172***	2.391**
	(1.038)	(1.158)
Commercial	3.575	16.486***
	(2.790)	(3.034)
Distance Variables		
ln (Dist. CBD)	1.323***	1.127***
	(0.314)	(0.344)
ln (Dist. railroad)	1.426***	1.432***
	(0.146)	(0.174)
ln (Dist. interstate)	0.492***	0.190
	(0.131)	(0.150)
ln (Dist. park)	-0.238	-0.327
	(0.254)	(0.292)
ln (Dist. water body)	-0.421**	-0.522***
	(0.170)	(0.196)
ln (Dist. Greenway)	0.432***	0.631***
	(0.151)	(0.184)
Time Variables		
Y98	0.721	0.653
	(0.626)	(0.072)
Y99	0.134	0.296
	(0.547)	(0.640)
Y00	-0.741	-0.108
	(0.509)	(0.600)
Y01	1.000*	0.013
	(0.591)	(0.763)
Y02	1.122*	0.848
	(0.595)	(0.672)
Y03	2.300***	2.300***
	(0.796)	(0.866)
Y04	0.917	0.817
	(0.562)	(0.641)
Y05	1.554**	1.595**
	(0.623)	(0.690)
Y06	1.252**	0.392
	(0.524)	(0.623)
Log likelihood	-561.161	

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2-4. The land price equation for each classification

Variable	Residential			Commercial			Industrial		
	Coefficient	Boot strapped SE	Elasticity	Coefficient	Boot strapped SE	Elasticity	Coefficient	Boot strapped SE	Elasticity
Intercept	-1.505	0.249		1.554	1.665		-4.969	1.282	
Spatial lag Variable									
$\mathbf{W}_1$[a] × ln (Land price)	0.646	0.015	0.646	0.223	0.030	0.223	0.267	0.071	0.267
Parcel and Neighborhood Variable									
ln (Lot size)	0.435***	0.090	0.435	0.736***	0.120	0.736	1.029***	0.084	1.004
Mixed use	0.529	0.362	0.528	-0.240	0.000	-0.239	0.000	0.000	0.000
Distance Variable									
ln (Dist. CBD)	0.084	0.032	0.084	0.055	0.121	0.055	-0.748	0.356	-0.748
ln (Dist. railroad)	-0.013	0.045	-0.013	-0.036	0.062	-0.036	-0.414	0.272	-0.414
ln (Dist. interstate)	-0.020	0.035	-0.020	-0.036	0.062	-0.036	-0.269	0.072	-0.269
ln (Dist. park)	0.140	0.044	0.140	0.133	0.146	0.133	0.163	0.198	0.163
ln (Dist. water body)	-0.127	0.032	-0.127	-0.182	0.061	-0.182	0.379	0.107	0.379
ln (Dist. Greenway)	-0.071	0.028	-0.071	-0.452***	0.080	-0.452	-0.872***	0.171	-0.872
Time Variable									
Y98	-0.071**	0.028	-0.071	0.136	0.340	0.135	-1.015*	0.556	-1.015
Y99	0.468	0.114	0.468	0.456	0.326	0.456	0.114	0.599	0.114
Y00	0.258	0.118	0.258	0.117	0.344	0.117	-0.197	0.528	-0.197

Table 2-4. (cont'd)

Variable	Residential			Commercial			Industrial		
	Coefficient	Boot strapped SE	Elasticity	Coefficient	Boot strapped SE	Elasticity	Coefficient	Boot strapped SE	Elasticity
Y01	0.205	0.130	0.205	-1.351*	0.339	-1.351	-0.833	0.685	-0.833
Y02	-0.025	0.113	-0.025	0.508	0.344	0.508	-0.414	0.538	-0.414
Y03	0.390	0.120	0.120	0.327	0.303	0.327	-1.027	0.635	-1.027
Y04	0.546**	0.118	0.118	-0.148	0.325	-0.148	-0.658	0.499	-0.658
Y05	0.640**	0.107	0.107	0.195	0.293	0.195	-0.982	0.533	-0.982
Y06	1.303***	0.103	0.103	1.125	0.321	1.125	-0.077	0.512	-0.077
$\hat{\lambda}_{ji}$	-0.380	0.265	-0.046	0.409**	0.451	0.037	-1.210	0.321	-0.119
Adjusted R-sq	0.525			0.531			0.570		

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

[a] $\mathbf{W_1}$: Row-standardized spatial weight matrix for vacant parcels.

Table 2-5. Elasticity of housing price equation

Variable	Coefficient	Bootstrapped SE	Elasticity
Intercept	5.014***	0.459	
Endogenous Variable			
Rezoning	0.025	0.025	0.002
$\mathbf{W_2}^{a}$ × ln (House price)	0.096***	0.032	0.096
Structural Variables			
ln (Lot size)	0.136***	0.012	0.136
Brick	0.140***	0.025	0.140
Age	-0.004***	0.001	0.001
Pool	0.166***	0.042	0.166
Garage	0.054**	0.025	0.054
Bedroom	0.006	0.016	0.001
Stories	0.166**	0.025	0.014
Fireplace	0.017	0.017	0.001
Quality	0.157***	0.022	0.157
Condition	0.100***	0.023	0.100
ln (Finished area)	0.540***	0.034	0.540
Census block group variables			
Vacancy rate	-0.899***	0.253	-0.761
Unemployment rate	-0.388	0.269	-0.329
Travel time to work	-0.004	0.002	0.003
Housing density	0.034***	0.011	0.001
ln (Income)	0.010	0.020	0.010
Distance variables			
ln (Dist. CBD)	0.046	0.029	0.046
ln (Dist. railroad)	0.015*	0.009	0.015
ln (Dist. sidewalk)	-0.007	0.009	-0.007
ln (Dist. park)	0.026	0.016	0.026
ln (Dist. golf course)	0.014	0.020	0.014

Table 2-5. (cont'd)

Variable	Coefficient	Bootstrapped SE	Elasticity
ln (Dist. greenway)	-0.037***	0.012	-0.037
ln (Dist. water body)	-0.047***	0.011	-0.047
Other variables			
ACT	0.002	0.007	0.000
Flood	0.114*	0.064	0.010
Adjusted R-sq	0.531		

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

[a] $\mathbf{W_2}$: Row-standardized spatial weight matrix for single family housings.

Table 2-6. Elasticity of rezoning equation

Variable	Coefficient	Bootstrapped SE	Elasticity
Intercept	-4.519***	1.141	
Endogenous Variables			
ln (Housing price)	0.391***	0.094	1.003
Land Price Variables			
Price differential	0.152	0.014	0.033
{ Price difference }*Res* [b]	-0.248	0.028	-0.054
{ Price difference }*Com* [c]	-0.120	0.053	-0.026
Neighborhood Variables			
Residential	-1.416***	0.271	-0.308
Commercial	-1.059	0.617	-0.230
Restrict	0.924***	0.122	0.201
Log likelihood			

[a] The elasticity was calculated at 0.702; the average of the price differential where the expected value of a parcel in alternative zoning classifications is greater than its value in its current use.

[b] *Res* =1 if parcel was zoned residential at time of sale, 0 otherwise.

[c] *Com*=1 if parcel was zoned commercial at time of sale, 0 otherwise.

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Part 3. Land Use Plan and Urban Sprawl

Abstract**:** The objective of this research was to examine whether the agricultural-rural residential land use plan influence spatial development patterns in the Knoxville, Tennessee area. It is hypothesized that rezoning approvals from undevelopable land classifications to developable land classifications are affected by the land use plan for agricultural-rural residential use. The results show that average distances between parcels predicted to be approved for developable land classification and its closest parcels identified as preexisting development drop under hypothetical land use plan scenarios with expanded area designated for agricultural-rural residential use. The drop of the average distances is due to increases in the frequency of denials of rezoning petitions for development in the areas of expanded agricultural-rural residential use. These results indicate that a manipulation of the area designated for agricultural-rural residential use can encourage rezoning for development closer to preexisting development, and thereby reduces urban sprawl

Introduction

During the two decades between 1982 and 2003, the nonfederal developed areas, largely development of cultivated cropland and forests, increased by 74% from 1.5 to 2.6 million acre in Tennessee (NRCS 2003). The rate of increase was greater than 48%, the average increase in the United States during the same period of time. Responding to this rapid land development of Tennessee, Growth Policy Act was introduced by initiating Public Chapter 1101, in 1998. The act required all counties and the cities within them to collaborate on a 20-year Growth Plan (MPC 2001a). Subsequently, in 2001, Knox County, located in East Tennessee, classified its land to three types based on the Growth Plan: areas within an urban growth boundary (UGB), planned growth areas (PGAs), and rural areas (MPC 2001a). The UBG is a regional boundary designed to control urban sprawl by encouraging a pattern of compact and contiguous development. The PGAs are designed to be large enough to accommodate expected growth in unincorporated areas over the planning horizon. Rural areas include land preserved for farming, recreation, and other non-urban uses (MPC 2001a).

The Growth Plan for Knox County also requires that rezoning approval for new developments must be consistent with the Sector Plan, which is a 15-year comprehensive development plan initiated by the Knoxville-Knox County Metropolitan Planning Commission (MPC) in 1996. The MPC divided the County into eleven planning sectors–central city, east county, east city, northeast county, north city, northwest county, northwest city, south county, south city, south west, and west city sectors–based on census tract boundaries. Each Sector Plan includes a background report about the sector containing basic planning information on its environmental resources, population, transportation, community facilities, utilities, and land use plans (MPC 2001b).

Numerous studies have attempted to investigate the effectiveness of the delineation of growth areas such as urban growth boundaries (Carlson and Dierwechter 2007; Cho et al. 2008; Cho et al. 2006, 2007; Downs 2002; Knaap 1985; Nelson and Moore 1993; Phillips and Goodstein 2000). Among these studies, Cho et al. (2008) evaluated the impacts of UBG on spatial development patterns in Knox County and found that the UGB in Knox County does not differentiate requirements from one region to another based on anecdotal evidence including interviews with planners engaged in the UGB planning process.

Conversely, the proposed land use plans ("land use plan" from here) are assumed to have significant effects on the spatial direction of land use because the Growth Plan states that rezoning that trigger new development must be consistent with the Sector Plan. There are 20 different types of land uses in the land use plan and the plan for each type of land use stipulates the permitted zoning classifications and the density levels consistent with the Growth Plan.[1] Among the 20 land uses, the areas designated for agricultural-rural residential use allow open space, agricultural, and planned residential zoning and prohibit residential development at a density exceeding 1 dwelling unit per acre, commercial and industrial rezoning to protect natural, historic, and scenic resources from the sprawling development in agricultural-rural residential use (MPC 2001b). The areas designated for agricultural-rural residential use tend to be located in rural area where land is preserved for farming, recreation, and other non-urban uses (MPC 2009). Thus, the land use plan that designates greater areas for the agricultural-rural residential use is

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[1] The 20 different types of land use are agricultural and rural residential, business park, commercial, neighborhood commercial, light industrial, heavy industrial, low density residential, low-medium density residential, medium density residential, high density residential, medium density residential and office, mixed use, office, park and open space, public institute, slope protection area, stream protection area, technology park, transportation, and other open space.

assumed to convey more restriction on developable areas. This study evaluates the effect of land use plan on spatial development patterns with regards to the roles in sprawl management.

Previous studies have investigated land development at the parcel level to examine the effects of planning policies on the spatial pattern of land development (e.g., Bell and Irwin 2002; Bockstael 1996; Bockstael and Bell 1998; Cho and Newman 2005; Cho et al. 2008; Irwin et al. 2003; Irwin and Bockstael 2002, 2004). Land development decision by a landowner at the parcel level has been modeled using a discrete choice model. These models estimate the probability of land development as a function of parcel-level attributes. The biggest drawback to this type of a parcel-based land development model originates from the fact that most residential development has occurred in subdivision setting, thus individual parcels developed within a subdivision are clustered. This may cause biased information of the location and the scope of development. For example, when a series of developed parcel is observed in a subdivision the parcels of development are counted individually in a parcel-based land development model (see Figure 3-1). This may be perceived as redundant counting since each parcel development reflects the same land development decision by a landowner or a group of landowners. Instead, each tightly clustered parcel should represent one big chunk of land development (see Figure 3-2).

Modeling rezoning approval, i.e., the decision of local governments to rezone a land from undevelopable land classifications (e.g., agricultural uses) to developable land classifications (e.g., residential and commercial uses), using a discrete choice model is a potential alternative to the parcel-based land development model. The grouping of parcels identified for rezoning is a more appropriate land use scale than using individual developed parcels observed in a subdivision because rezoning is often a precondition for land development and rezoning of a parcel represents development of a whole chunk of land before it is fragmented for a subdivision development. Thus, modeling rezoning approval using a discrete choice model prevents redundant counting of each developed parcel within a subdivision under a parcel-based land development model.

Rezoning is a legislative and comprehensive action by local governments. When an application for rezoning is filed by the property owner, the planning staff in Knoxville-Knox County Metropolitan Planning Commission (MPC) provides an evaluation report regarding the request. After the public hearings which allow the petitioner and any opponents opportunities to address their points of views, the Planning Commissioners vote on the rezoning request. Finally, to determine rezoning approval, the staffs in MPC and the Planning Commissioners consider the physical or economic situation and also the land use plan based on the Sector Plan, neighborhood compatibility, and environmental effects.

If the land use plan based on the Sector Plan plays significant roles in rezoning approval processes, manipulations of the area that restrict land-use conversions for developable land, e.g., agricultural-rural residential land use, should affect the spatial development patterns. Thus, the objective of this research is to examine whether manipulations of the land use plan for agricultural-rural residential use influence spatial development patterns in the Knoxville, Tennessee area. It is hypothesized that rezoning approval from undevelopable land classifications to developable land classifications is affected by the area designated for agricultural-rural residential land use. To achieve this objective, we compared 1) the overall distance between parcels predicted to be approved for developable land classification and its closest parcels identified as preexisting development under the current land use plan and 2) the overall distance between parcels predicted to be approved for developable land classification and its closest parcels identified as preexisting development under hypothetical land use plan scenarios for agricultural-rural residential use. By comparing those overall distances, we empirically tested the hypothesis that rezoning approvals from undevelopable land classifications to developable land classifications are affected by the land use plan for agricultural-rural residential use.

Empirical Model

The probability of rezoning approval decision as a function of individual parcel-level attributes is estimated using a probit model:

(1) $$\mathbf{y}^{*} = \mathbf{X}\boldsymbol{\beta} + \varepsilon$$

where $\mathbf{y}^{*}$ is a latent variable that links to the observed binary outcome (1 if rezoning request from undevelopable land classification to developable land classification is approved, 0 otherwise); $\mathbf{X}$ is an $n \times (k+1)$ matrix representing exogenous variables explaining rezoning approval decision, a dummy variable identifying whether the rezoning petition is consistent with land use, variables of parcel characteristics (e.g., assessed land value, lot size, and access to public sewer), distance variables (e.g., distances to central business district (CBD), park, major road, and water bodies), boundary variables (e.g., Knoxville and the Town of Farragut), geophysical variables (e.g., slope and elevation), census variables (e.g., income), and a dummy variable identifying whether the rezoning request is consistent with the land use plan, and the percentage of zoning classification that is consistent with requested rezoning in the surrounding area, i.e., the area within a 0.2-mile radius buffer around the petitioned parcel; $\boldsymbol{\beta}$ is a vector of parameter; and ε is disturbance term.

Moran’s index (I-value) is used to detect spatial autocorrelation of the residuals of the probit model. As the spatial autocorrelations are detected in the residuals, spatial-probit model commonly used for the modeling of spatial qualitative-dependent variables is applied (e.g., Holloway et al. 2002; Beron et al. 2003; Coughlin et al. 2003; Murdoch et al. 2003; Novo 2003; Schofield et al. 2003; Garrett et al. 2005; Lacombe and Shaughnessy 2005; Autant-Bernard 2006; Rathbun and Fei 2006; Mukherjee and Singer 2007). In this case, we hypothesize neighborhood spillover effects in the rezoning approval decision because rezoning approval decisions may be codetermined. The rezoning approval equation is respecified as:

(2) $$\mathbf{y}^* = \rho \mathbf{W} \mathbf{y}^* + \mathbf{X} \boldsymbol{\beta} + \varepsilon$$

where **W** is a row-standardized spatial weight matrix and ρ is coefficient of the spatially lagged dependent variable. The spatial weight matrix is normalized so the rows sum to unity. Point data of centroids of parcels were converted to thiessen polygon data to build the queen binary continuity matrix.

Because assessed land value is largely determined by forces in the housing market that affect the rezoning decision, which in turn is a function of assessed land value, a system of simultaneous equations to represent the relationship between assessed land value and rezoning approval decisions may need to be considered. The Durbin-Wu-Hausman test was conducted to test hypothesis that the assessed land value would be statistically exogenous. Failure to reject the null hypothesis suggested that the assessed land value is statistically exogenous.

There are several alternative estimation techniques such as general linear model for limited dependent variables (LDV’s) (Rasmussen 2004; Schabenberger and Gotway 2005), conditional autoregressive specifications of LDV’s (Schabenberger and Pierce 2002), and general moment approaches (Pinske and Slade 1998; Klier and McMillen 2008). The Bayesian strategy of Markov Chain Monte Carlo (MCMC) introduced by LeSage (2000) is an alternative method. Bayesian statistics treats parameters as unknown random variables, and it makes inferences based on the posterior distributions of the parameters. In this analysis I used Bayesian analysis because several advantages such as its ability to use prior information and to directly answer specific scientific questions that can be easily understood (Berry 2006). In this analysis, 500 of draws and 100 of initial draws omitted for burn-in were used. The MCMC method is a simulation technique that generates a sample from the target distribution by specifying the transition probability of a Markov process (Vieira et al. 1998). The Markov chain is then iterated a large number of times in computer-generated Monte Carlo simulation (Chib and Greenberg 1995). It is useful method because the joint distribution of the spatial-probit model is not expressible directly and sufficiently complex to prohibit direct sampling. The Gibbs sampler introduced by Geman and Geman (1984) is possibly the MCMC sampling technique which is used most frequently (Gelfand 2000; Verdinelli and Wasserman 1991). Gibb sampling was used to implement the MCMC method in this research.

Identifying areas of preexisting development is not straightforward. One alternative is to identify areas of parcels that were developed prior to rezoning request, but these areas may include areas with sprawl development patterns. Measuring the distance between an area with preexisting sprawl development prior to rezoning request and the parcels predicted to be approved for developable land classification may not be appropriate for testing the hypothesis that the manipulations of the land use plan for agricultural-rural residential use influence spatial development patterns with regards to the roles in sprawl management. Under this definition, the areas of preexisting development are not free from sprawl, thus the distance measure does not reflect the degree of sprawl. Another alternative is to identify CBD as a center of preexisting development. The CBD may not be appropriate for the purpose, either because there may be multiple preexisting development areas other than that centered in CBD.

Alternatively, in this study, the areas of preexisting development were defined as the areas of clustered development prior to the emergence of sprawling development. Because the areas of preexisting development did not include sprawling areas, their distance measures were used to reflect the degree of sprawl. To identify clustered development prior to the emergence of sprawling development, local indicators of spatial association (LISA) for years when the parcel was developed were estimated for years 1800 through 2006 (Anselin 1995). Spatial clusters of old-built parcels were identified as clustered development existing prior to current sprawling development, i.e. preexisting development. The distance between preexisting development prior to the emergence of sprawling development and rezoning for development were used to an alternative to estimate the degree of sprawl because a decrease in distance between them imply compact development closer to preexisting development. The LISA values of years when the parcels were developed serve well for the purpose of separating preexisting development from sprawling development because the LISA values identify spatial breaks for the years when the parcels were developed.

The predicted approval for developable land classification for the MCMC method of the spatial-probit model facilitates comparisons between predicted probabilities generated under the current land use plan and hypothetical land use scenarios for the expansion of agricultural-rural residential use by 1 mile and plus and minus 50% of the 1mile expansion, i.e., 1.5 mile and 0.5 mile. To investigate the changes in the spatial patterns of rezoning approvals under hypothetical land use plan scenarios, we divided the entire area of Knox County into the five sections: area currently designated for agricultural-rural residential use, a series of buffers from the inner boundary of area currently designated for agricultural-rural residential use by an interval of 0.5

mile, i.e., 0 – 0.5 mile, 0.5 – 1 mile, and 1 – 1.5 mile buffers, and areas inside of the inner boundary of 1 – 1.5 mile buffer (see Figure 3-3).

Study Area and Data Description

The rezoning approval equation was estimated using rezoning request information between January 1997 and December 2006 in Knox County, Tennessee that was collected from the Knoxville, Knox County Metropolitan Planning Commission (MPC). The rezoning information includes date of the denial or approval decision, parcel location and size, access to public sewer, existing zoning classification, requested zoning change, and whether the requested rezoning change is consistent with current land use plan. The shape file for the current land use plan was obtained from MPC. Boundary data, including the boundary of the City of Knoxville and the Town of Farragut were obtained from Knoxville Utilities Board Geographic Information System (KGIS 2004).

The individual parcel data including market assessed land value and parcel size were collected from Knox County Tax Assessor’s Office. The Knox County Tax Assessor’s Office conducts assessment of the structure and land separately once every four years and the data we obtained were in 2006. The reason for the use of market assessed land value instead of reported sale price of land is that transaction prices for the lots petitioned for rezoning during the study period were only available for the total value of both structure and land.

The original zoning shape file that was lastly updated on December 2004 was used to identify zoning classification consistent with the requested zoning changes in surrounding area of each rezoning at the time of rezoning occurred during 1997-2006. The zoning map during the period of 1997-2006 was recreated using the original zoning shape file and rezoning shape file.

The percentages of zoning classification consistent with the requested rezoning within a 0.2-mile radius buffer around the petitioned parcel were estimated. The size of buffer, 0.2-mile radius was determined based on a series of interviews with planners in the areas. The percentage estimation was done by superimposing a 0.2-mile radius buffer around each parcel of rezoning petition during the period of 1997-2006 using the Patch Analyst (v3.12) extension for ArcView 3.3 (Rempel 2006).

The rezoning committee composed of Knoxville City Council, Knox County Commission, and Farragut Municipal Planning Commission approved 2,048 of 2,221 parcels petitioned for rezoning during the period of 1997-2006 in Knox County.[2] Among the rezoning requests, 724 cases were petitions for rezoning from undevelopable land classifications (e. g., agricultural and open space zonings) to developable land classifications (e.g., residential, commercial, office, and industrial zonings). These 724 cases were the focus of this article (see Figure 3-4 for the spatial distribution of the approvals/denials of the petitions).[3] Among the 724 petitions for rezoning, 651 were approved and 73 were denied during the study period. The areas identified as preexisting development by LISA were shown in Figure 3-4. The areas of preexisting development were located mostly near downtown Knoxville and were developed during the 1800-1969 period. Considering the rise of suburban shopping malls in the 1970s that drew retail revenues away from Knoxville's Downtown area (Wheeler 2006), the 1969 cutoff seems to reflect changes in development patterns before and after the rise of suburban shopping

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[2] Among the 2048 rezoning, 996 were rezoned to residential, 620 were rezoned to commercial, 226 were rezoned to office, 71 were rezoned to agricultural, 62 were rezoned to industrial, 43 were rezoned to open space, 13 were rezoned to mixed or town center, 5 were rezoned to traditional neighborhood, 4 were rezoned to business and technology, 3 were rezoned to floodway, 3 were rezoned to transition, and 2 were rezoned historical overlay zoning. The transition zoning is intended to insure the development of land adjacent to residential areas into a transition zone between other types of commercial and residential classifications.

[3] Among the 724 petitions for rezoning, 448, 194, 52, 21, 6, and 3 were requested to rezone to residential, commercial, office, industrial, mixed or town center, and transition zonings, respectively.

malls. Figure 3-5 shows the shrinkage of areas zoned for agricultural and open space during 1997-2006. It illustrates that scattered land developments involving rezoning from undevelopable to developable land uses have been occurred mostly in the western area of Knox County, reflecting sprawling development in West Knox County during the period.

The shape files for railroads, major roads, parks, greenways, and water bodies that were used to create distance variables were acquired from KGIS (2004) and Environmental Systems Research Institute Data and Maps 2004 (ESRI 2004). The timing of these land-feature data (2004) and the rezoning information (1997-2006) did not match. Because land features such as railroads, major road, parks, greenways, and water bodies were not expected to change appreciably, these variables for 2004 were used as proxies for distance variables in the model of rezoning during 1997-2006.

The slope and elevation were obtained from U.S. Geological Survey (USGS 2004) and were calculated at a resolution of a 1/3 arc-second (approximately 100 square meters). This scale is sufficiently small to account for the smallest rezoning occurrence (600 square meters). Additional information not available from the parcel data, i.e., per capita income, was collected at the census-block group level from the 2000 US census long-form dataset. The study area consists of 234 census-block groups. All the parcels of rezoning petitions within the boundaries of a census-block group were assigned the per capita income for that census-block group. Although the timing of the census and rezoning did not match, given the timing of census taking, the 2000 census per capita income was used as a proxy in the rezoning approval equation. A statistical summary of the variables used in the rezoning equation is presented in Table 3-1.

Empirical Results

The Durbin-Wu-Hausman test indicated failure to reject the null hypothesis that the assessed land value was statistically exogenous (5% level). Thus, the assessed land value was not considered as an endogenous variable in this rezoning approval model. For the spatial-probit model, the Akaike Information Criterion (AIC) was -1.23, while the AIC from the probit model was 278.36. The percentage of correct predictions for the rezoning approval using probit model and spatial-probit model were 91% and 92%, respectively. The lower AIC and the higher prediction accuracy of the spatial-probit model suggests that this model produced a better fit than the probit model. The residuals from the probit model were spatially autocorrelated at the 5% significance level with I-value of 0.02 and Z-score of 2.31. Re-estimation with the spatial-probit model reduced the magnitude of the Z-score by 7%. However, spatial error autocorrelation remained in the residuals from the spatial -probit model at the 5% (I-value of 0.02). This result implies that although the spatial-probit model mitigates spatial autocorrelation slightly, it does not adequately address it and, thus, the statistical results must be interpreted with caution.

As the effects of explanatory variables are not trivial for the spatial-probit model, more insight can be gained by discussing elasticities. Parameter estimates of the rezoning decision model and the elasticities based on these parameter estimates using spatial-probit model are presented in Table 3-2. Hereafter, elasticities of variables of the spatial-probit model are considered statistically significant if their p-values are ≤ 0.05. Only statistically significant elasticities are discussed in the remainder of this section.

The elasticities of assessed land value, lot size, distance from land requested for rezoning to central business district (CBD), and a Knoxville dummy variable were significant in the rezoning approval equation. These four variables capture attributes of the individual parcel. The probability of rezoning approval for development increases by 0.43% given a 1% increase in assessed land value. A 1% increase in lot size increases the probability of rezoning approval for development by 0.43%. A 1% decrease in distance to the CBD increases the probability of rezoning approval for development by 1.84%. Rezoning inside of the city boundary is about 0.35% less likely to be approved for development than rezoning outside of the boundary. The findings indicate that rezoning petitions for development are more likely approved if the petitioned parcels are more highly valued, larger, closer to the CBD, and outside of the city boundary.

Also found to be significant factors for rezoning approval were 1) the dummy variable indicating whether the rezoning petition was consistent with the current land use plan (the “land use plan”) and 2) the ratio of zoning classification that is consistent with the type of rezoning request within a 0.2-mile radius buffer around the petitioned parcel (the “surrounding land use”). A rezoning petition that is consistent with the current land use plan is 23.13% more likely to be approved for development than a petition that is not consistent with the land use plan. A 1% increase in the ratio of zoning classifications that are consistent with the type of rezoning request increases the probability of rezoning approval for development by 2.41%. This result implies that the efforts made by local government to sustain spatially consistent land use patterns to reduce incompatibility with neighborhood areas have been largely successful. These findings of land use plan and surrounding land use variables imply that the land use plan plays a significant role regarding rezoning approval for development.

The rezoning approval rates including numbers of petitions and approvals for the entire area and the five divided areas under both the current land use plan and the three hypothetical land use plan scenarios of expanded areas for agricultural-rural residential use by 0.5, 1, and 1.5

miles are reported in Table 3-3. Under the current land use plan, 77% of rezoning petitions (or 59 of 77 cases) were predicted to be approved in area currently designated for agricultural-rural residential use. In contrast, 94% of rezoning petitions (or 610 of 647 cases) were predicted to be approved areas outside of the area designated for agricultural-rural residential use. The considerably lower approval rate in the area currently designated for agricultural-rural residential use implies that the area designated for agricultural-rural residential use contribute substantially to confining rezoning attempts for development.

The predicted approval rate for development within the 0 – 0.5 mile buffer drops from 91% (or 165 of 182 cases) under the current land use plan to 62% (or 113 of 182 cases) under the hypothetical land use scenario with 0.5 mile expansion of agricultural-rural residential use. The predicted approval rate for development within 0.5 – 1 mile buffer drops from 96% (or 96 of 100 cases) under the current land use plan to 80% (or 80 of 100 cases) under the hypothetical land use scenario with 1 mile expansion of agricultural-rural residential use. The predicted approval rate for development within 1 – 1.5 mile buffer drops from 97% (or 103 of 106 cases) under the current land use plan to 81% (or 86 of 106 cases) under the hypothetical land use scenario with 1.5 mile expansion of agricultural-rural residential use.

The hypothetical expansions of the areas for agricultural-rural residential use increase the frequency of denials of rezoning petitions for development by 52, 16, and 17 cases within the areas of 0 – 0.5 mile, 0.5 – 1 mile, and 1 – 1.5 mile buffers, respectively. The average distances between parcels predicted to be approved for developable land classification and its closest parcels identified as preexisting development drop from 2,849 feet under the current land use plan to 2,775, 2,758, and 2,746 feet under the hypothetical land use scenario with 0.5, 1, and 1.5 mile expansions of agricultural-rural residential use, respectively. These declines in the average distances are due to declines in the approval rates of rezoning for developments by the expansion of the area designated for agricultural-rural residential use. These findings fail to reject the hypothesis that rezoning approvals from undevelopable land classifications to developable land classifications are affected by the land use plan for agricultural-rural residential use. Thus, a manipulation of the area designated for agricultural-rural residential use can encourage rezoning for development closer to preexisting development, and thereby reduces urban sprawl.

Conclusions

The principal objective of this research was to examine whether a manipulation of the area currently designated for agricultural-rural residential use influences spatial development patterns associated with urban sprawl in the Knoxville area. The results show that the average distances between parcels predicted to be approved for developable land classification and its closest parcel identified as preexisting development drop under hypothetical land use scenarios with expanded agricultural-rural residential use. The drops of the average distances are due to declines in the approval rates of rezoning for developments by the expansion of the area designated for agricultural-rural residential use. These results indicate that a manipulation of the area designated for agricultural-rural residential use can encourage rezoning for development closer to preexisting development, and thereby reduces urban sprawl.

This research is unique in that rezoning approval for development, instead of land development, is modeled to examine whether government land use plan affects spatial patterns of development associated with urban sprawl. Modeling rezoning approvals prevents bias that may be caused by redundant counting of each parcel development in one subdivision under the land development model. In addition, the spatial-probit model applied for modeling rezoning approval produces a better goodness of fit and significantly mitigates spatial autocorrelation of the residuals of the probit model.

The predicted changes in spatial patterns due to the manipulations of land use plan under the Sector Plan provides a guideline for local government to improve the land use plan to be consistent with the Growth Plan in Knox County. For example, there is a need to redraw more effective classifications of the three types of land based on the Growth Plan (i.e., areas within urban growth boundary, planned growth areas, and rural areas) because the current classifications do not differentiate requirements from one region to another (Cho et al. 2008). The boundaries for the three types of land may be redrawn by referencing the projections of rezoning approvals based on the current land use plan as well as the hypothetical land use plans from this study. Thus, a need exists to focus future research on developing models that can provide more meaningful insights associated with land use plan under the Sector Plan and the three types of land classifications under the Growth Plan.

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Appendix

Table 3-1. Statistical summary of the variables used in the rezoning approval equation

Variables	Description	Unit	Mean (St. Dev)
Endogenous Variables			
Rezoning	1 if land requested rezoning was approved between 1997 and 2006, 0 otherwise		0.90 (0.30)
Parcel Variables			
Assessed Land value	Average of assessed land value per acre of parcels within land for rezoning	$	23,213.34 (38,009.11)
Lot size	Total square footage of land for rezoning	feet^2	710,387.50 (1,490,030.00)
Sewer	Access to public sewer		0.82 (0.39)
Census Variables			
Income	Per capita income in 2000 census	feet^2	24,036.10 (9,045.72)
Distance Variables			
Dist. CBD	Euclidean distance from the centroid of a parcel to the centroid of the central business district	feet	52,251.77 (17,024.13)
Dist. railroad	Euclidean distance from the centroid of a parcel to the nearest railroad	feet	9,262.97 (6,839.38)
Dist. Major road	Euclidean distance from the centroid of a parcel to the nearest major road	feet	1,849.91 (2,398.44)
Dist. park	Euclidean distance from the centroid of a parcel to the centrioid of the nearest park	feet	11,913.74 (6,593.89)
Dist. water body	Euclidean distance from the centroid of a parcel to the nearest stream, lake, river, or other water body	feet	10,288.03 (6694.06)
Boundary Variables			
Knoxville	1 if within Knoxville, 0 otherwise		0.10 (0.30)
Farragut	1 if within the Town of Farragut, 0 otherwise		0.02
Plan variables			
land use plan	1 if rezoning request is consistent with land use plan in the Sector Plan		0.76 (0.43)
Surrounding land use	Ratio of zoning classification consistent with the type of rezoning request within a 0.2-mile radius buffer around the petitioned parcel	ratio	0.22 (0.21)

Table 3-1. (cont'd)

Variables	Description	Unit	Mean (St. Dev)
Geographical variables			
Slope	Average slope of land for rezoning	%	6.13 (3.17)
Elevation	Average elevation of land for rezoning	ft	1,020.80 (100.39)
Rezoning type Variables			
To Residential	1 if rezoning to residential uses, 0 otherwise		0.62 (0.49)
To Commercial	1 if rezoning to commercial uses, 0 otherwise		0.27 (0.44)

Table 3-2. Estimated coefficients and elasticities of the rezoning approval model

Variables	Coefficient (Std. Err)	Variables	Elasticity (Std. Err)
Intercept	6.257 (8.227)		
ln (Assessed Land value)	0.165* (0.088)	Assessed Land value	0.433* (0.231)
ln (Lot size)	0.149* (0.079)	Lot size	0.433* (0.230)
In (Income)	-0.555 (0.332)	Income	-1.623 (0.971)
ln (Dist. CBD)	-0.628* (0.276)	Dist. CBD	-1.840* (0.809)
ln (Dist. Railroad)	0.113 (0.094)	Dist. Railroad	0.325 (0.270)
ln (Dist. Major road)	-0.120 (0.094)	Dist. Major road	-0.003 (0.254)
ln (Dist. Park)	0.016 (0.141)	Dist. Park	0.000 (0.000)
ln (Dist. Water body)	-0.008 (0.095)	Dist. Water body	0.000 (0.000)
Slope	-0.026 (0.026)	Slope	-0.664 (0.664)
ln (Elevation)	0.410 (1.210)	Elevation	1.190 (3.513)
Sewer	-0.047 (0.232)	Sewer	-0.088 (0.436)
Knoxville	-0.649* (0.319)	Knoxville	-0.353* (0.174)
Farragut	-0.101 (0.707)	Farragut	-0.006 (0.043)
Land use plan	2.315* (0.262)	Land use plan	23.133* (2.618)
Surrounding land use	3.766* (0.619)	Surrounding land use	2.413* (0.397)
To Residential	-0.546 (0.348)	To Residential	-0.871 (0.555)
To Commercial	-0.262 (0.279)	To Commercial	-0.232 (0.247)
ρ	-0.006 (0.086)		
N		724	
Overall % of correct prediction		90.94	

* = .05 level (5%)

Table 3-3. The changes in the spatial pattern of rezoning approval rates between under the current land use plan and under hypothetical land use plan scenarios

	Number of rezoning predicted to be approved / Total number of rezoning petition (Rezoning approval rates)			
	Current land use plan	Hypothetical land use plan scenarios of expansions of agricultural-rural residential uses		
		0.5 mile expansion	1mile expansion	1.5 mile expansion
The entire area	669/724 (92.4%)	617/724 (85.2%)	601/724 (83.0%)	584/724 (80.7%)
Area currently designated for agricultural-rural residential use	59/77 (76.6%)	59/77 (76.6%)	59/77 (76.6%)	59/77 (76.6%)
0 - 0.5 mile buffer	165/182 (90.7%)	113/182 (62.1%)	113/182 (62.1%)	113/182 (62.1%)
0.5 – 1 mile buffer	96/100 (96.0%)	96/100 (96.0%)	80/100 (80.0%)	80/100 (80.0%)
1 – 1.5 mile buffer	103/106 (97.2%)	103/106 (97.2%)	103/106 (97.2%)	86/106 (81.1%)
Area inside of the inner boundary of 1-1.5 buffer	246/259 (95.0%)	246/259 (95.0%)	246/259 (95.0%)	246/259 (95.0%)

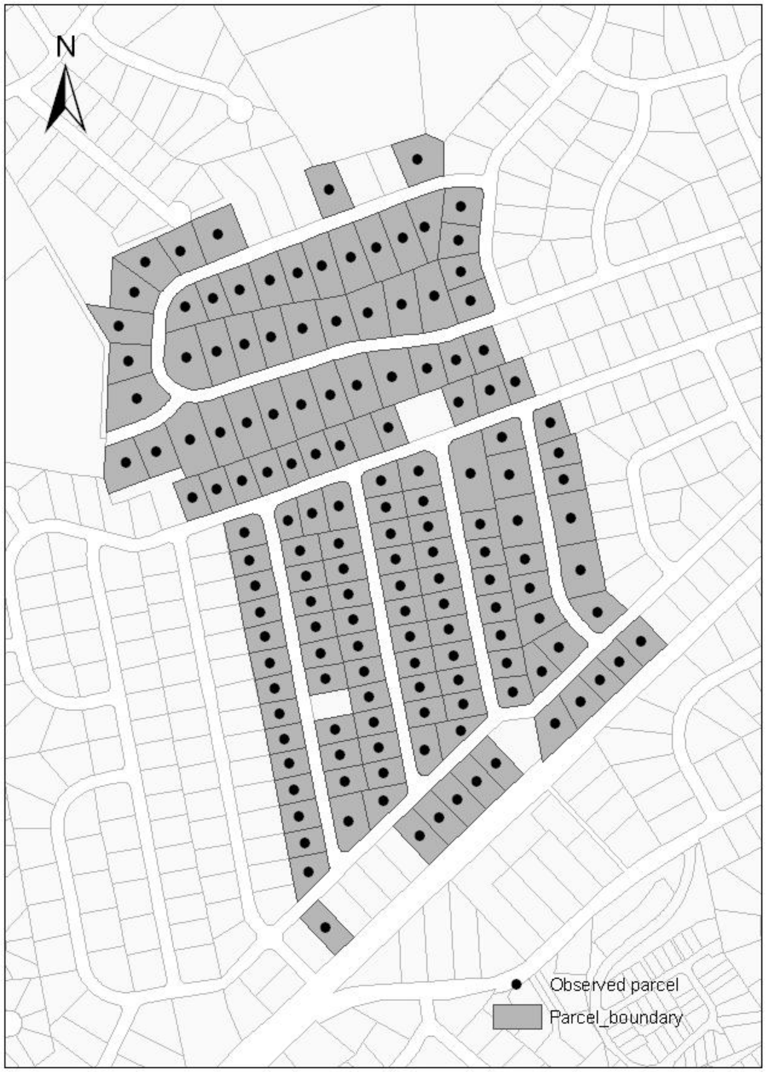

Figure 3-1. A series of observed parcels as developments in a subdivision.

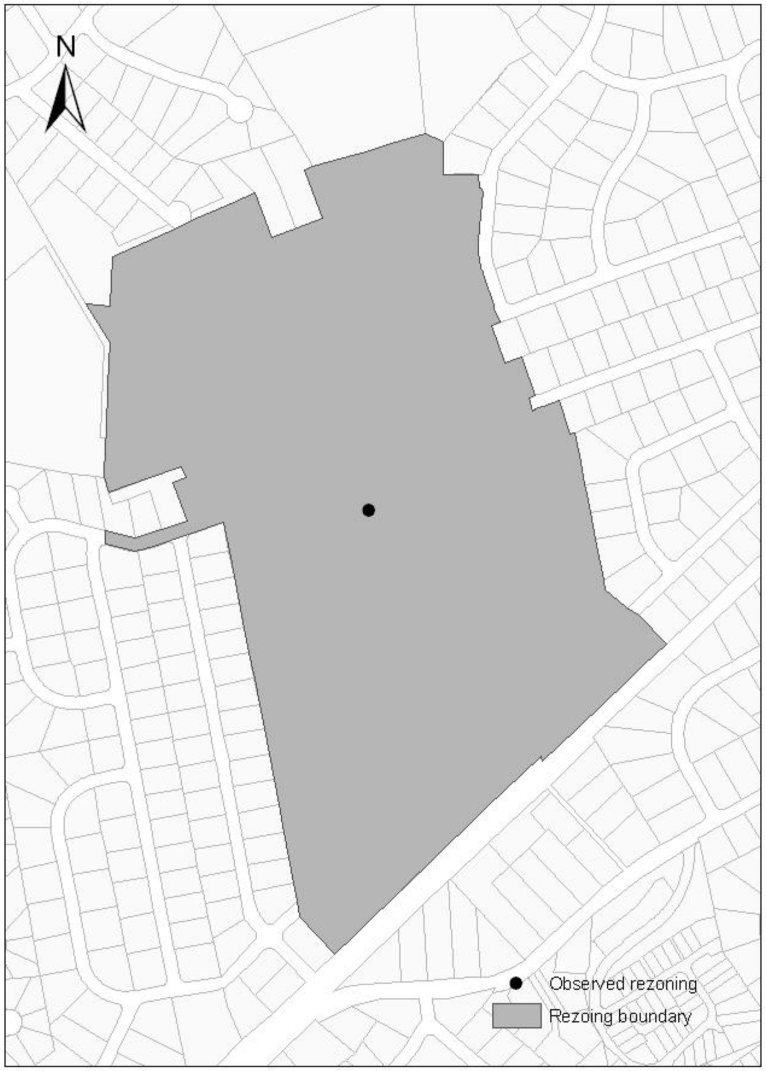

Figure 3-2. A rezoning of a parcel before it is fragmented for a subdivision development as shown in Figure 3-1

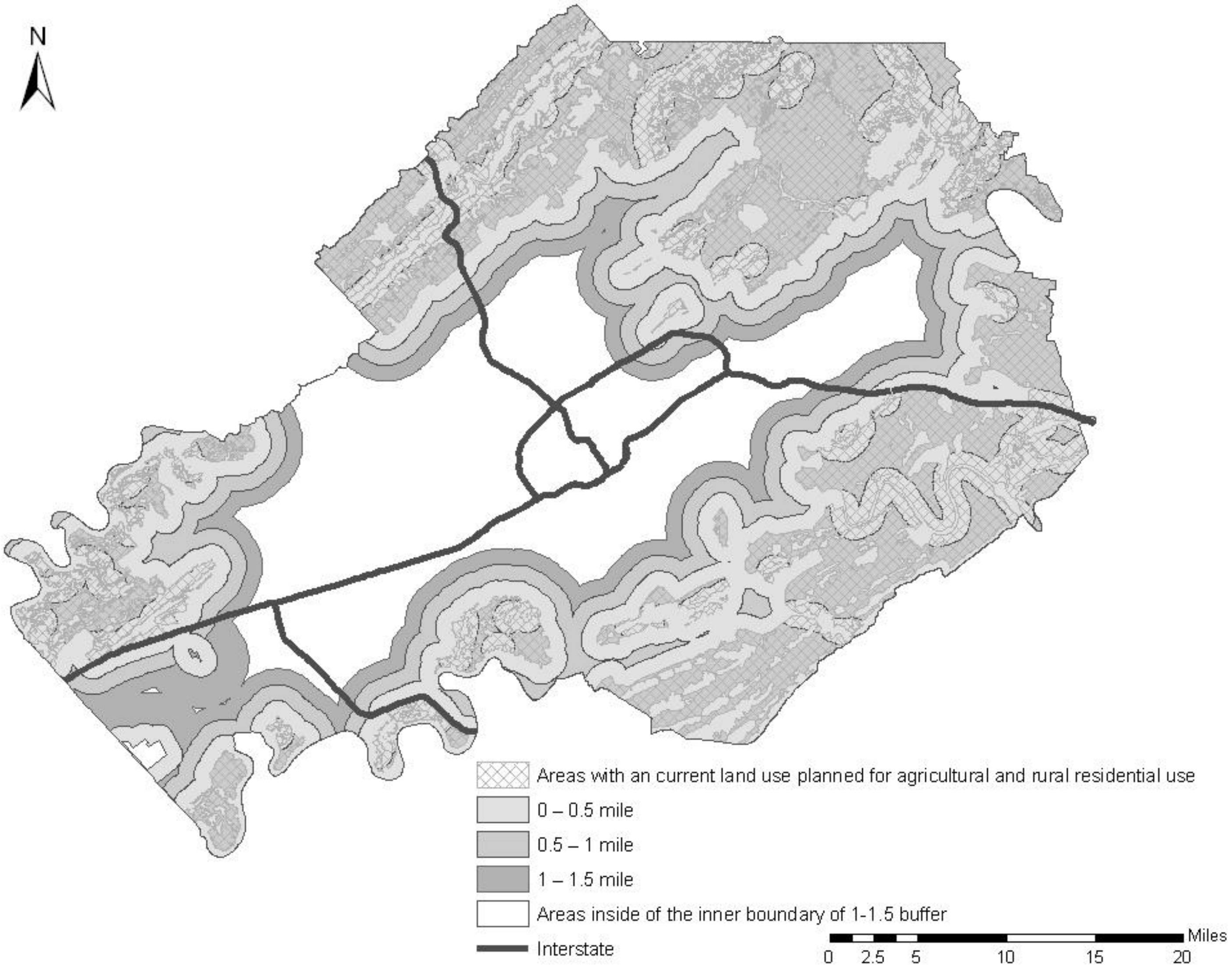

Figure 3-3. Five sections to investigate the changes in the spatial patterns of rezoning approvals under hypothetical land use plan scenarios

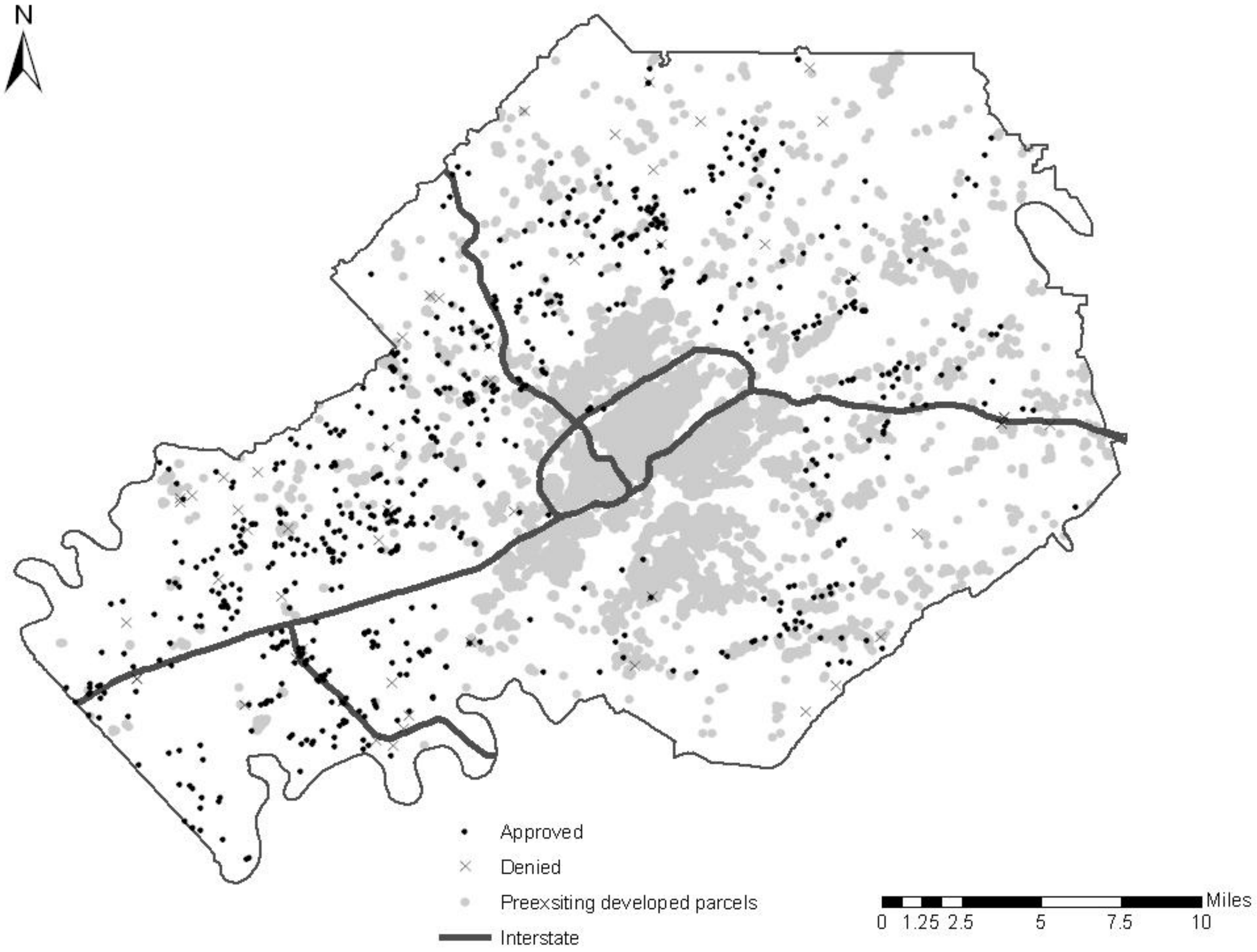

Figure 3-4. Spatial distribution of rezoning approval/denial from undevelopable land classification, i.e., agricultural zoning and open space zoning, to developable land classification, e.g., residential, commercial, office, and industrial, and the parcel identified as preexisting developed parcels.

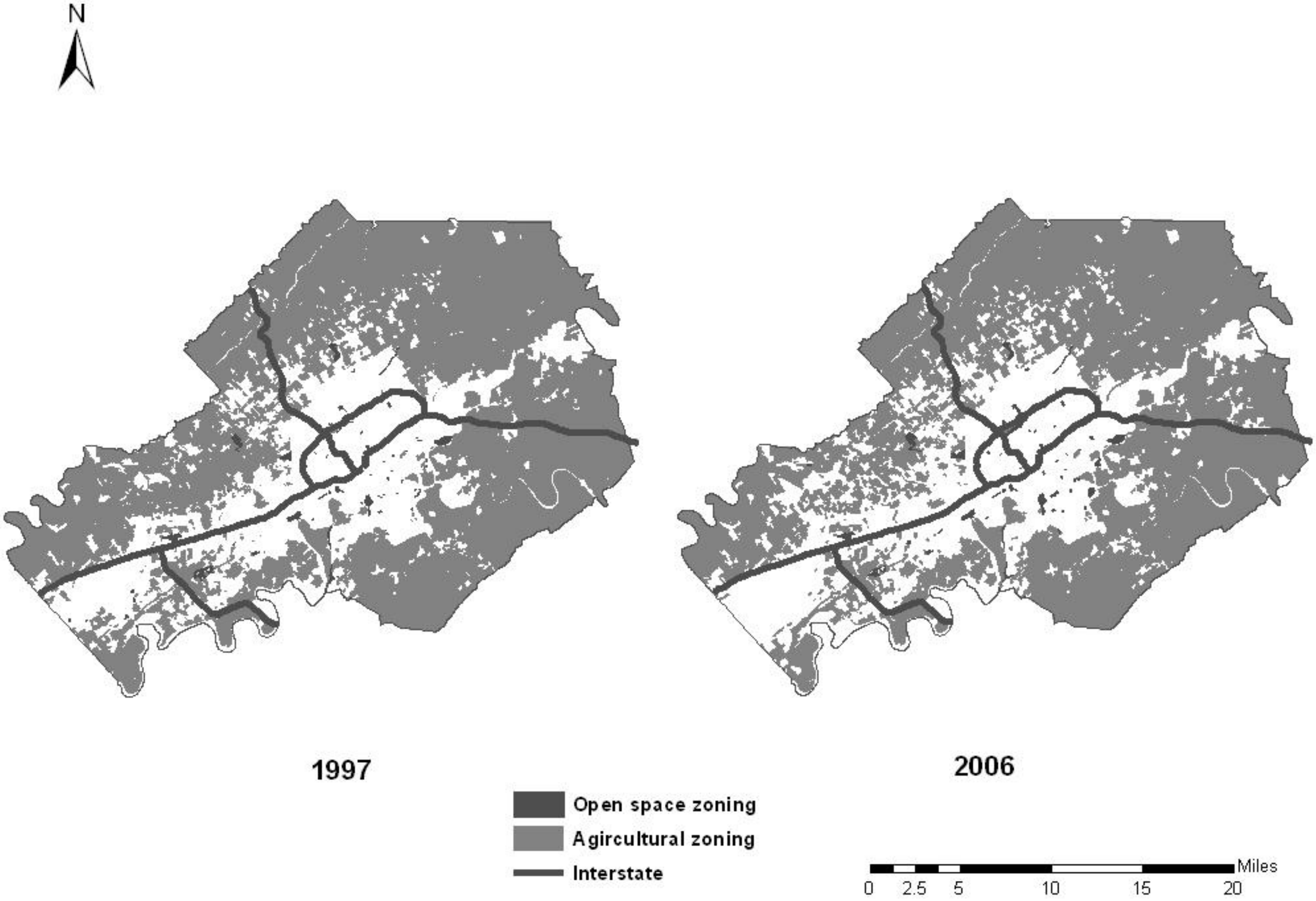

Figure 3-5. Changes in agricultural and open space zonings between 1997 and 2006 in the Knox County

Part 4. Summary

This thesis deals with two related topics under the theme of “Rezoning Decisions Associated with Housing Price, Land Use Plan, and Urban Sprawl: Empirical Estimations.” The first part investigated neighborhood spillover effects between rezoning and housing price using a simultaneous-equations model with an endogenous housing price variable and an endogenous binary variable reflecting the rezoning of a parcel in neighboring locations. The contrasting results of neighborhood spillover effects between rezoning and housing price clarify the direction of association between the two. Results indicate that real estate housing market conditions affect the likelihood of rezoning but the rezoning status of vacant parcel in a neighboring location plays an insignificant role in explaining house price.

The probability of rezoning vacant land is expected to increase as housing price in a neighboring location increases. The rise in the housing price in a neighboring location implies increasing pressure on housing demand. This increased pressure on housing demand likely contributes to greater demands for residential development and commercial development that complements residential use. Greater demand for residential and commercial development set in motion zoning changes for residential and commercial uses. Of the 218 vacant parcels that have undergone zoning changes during the study period, 70% (or 153 parcels) were rezoned for residential use and 20% (or 43 parcels) were rezoned for commercial use.

Rezoning approval is a key element of land use management in the Knoxville, TN area because (1) zoning is the most direct way to control location and density of development among the various types of land use policies and (2) other land use policies such as development guidelines, incentive-based policies, and property acquisitions are used infrequently in the area. The finding that different degrees of rezoning pressure are influenced differently by rising housing prices can be used to help update guidelines for rezoning decisions.

Currently, the major guidelines for the approval of rezoning petitions, according to the planners in the Knoxville area, are consistency with long-and short-range land use plans adopted by state, municipality, and county governments, and consistency with surrounding land use and environmental constraints, e.g., slope, flooding, and drainage. Local planning authorities can modify and update consistency measures in the current guidelines by accounting for varying degrees of housing demand pressure. For example, consistency measures can be strengthened in areas with greater housing-price increases, if preservation is desirable because these areas are likely to experience greater rezoning pressure.

Second part examines whether manipulation of land use plan adopted by Knox County influences spatial development patterns using rezoning approval model. The principal objective of this research was to examine whether the manipulation of land use plan for agricultural-rural residential use influences spatial development patterns in the Knoxville, TN area using rezoning approval model. The results show that the average distances between parcels predicted to be approved for developable land classification and its closest parcel identified as preexisting development drop under hypothetical land use scenarios with expanded agricultural-rural residential use. The drops of the average distances are due to increases in the frequency of denials of rezoning petitions for development in the area of expanded agricultural-rural residential use. These results indicate that the manipulation of land use plan, particularly a manipulation of the area designated for agricultural-rural residential use, encourages the rezoning for development closer to preexisting development.

This research is unique in that rezoning approval for development, instead of land development, is modeled, to examine whether government land use plan affects spatial patterns of development associated with urban sprawl. Modeling rezoning approvals prevents bias that may be caused by redundant counting of each developed parcel within a subdivision under the land development model. In addition, the spatial-probit model applied for modeling rezoning approval produces a better goodness of fit and significantly mitigates spatial autocorrelation of the residuals of the probit model.

The predicted changes in spatial patterns due to the manipulations of land use area under the Sector Plan provides a guideline for local government to improve the current land use plan to be consistent with the Growth Plan in Knox County. For example, the UGB, a core of the three types of land classification identified by the Growth Plan in Knox County, does not differentiate requirements from one region to another. Thus, there is a need to redraw more effective classifications of the three types of land. The boundaries for the three types of land may be redrawn by referencing the projections of rezoning approvals based on the current land use plan as well as the hypothetical land use plans. A need exists to focus future research on developing models that can provide more meaningful insights associated with land use plans under the Sector Plan and the three types of land classifications under the Growth Plan.

Vita

Ji young Kim was born in Pusan, Korea on December 11, 1979, to Eulbin Kim and Okgun Jung. She graduated from Busan National University in February, 2003, where she obtained a B.S. degree in Urban Engineering. Later, she attended the University of Tennessee, Knoxville, where she earned a M.S. degree in Agricultural Economics in August, 2009.