DRAFT

Using Regression Discontinuity Design to Identify the Effect of Zoning on Rural Land Conversion

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I. Introduction

The purpose of this paper is to extend the research on modeling land use using spatial models. This study takes the same approach as some spatially-explicit models at the parcel level using discrete choice models, which allow the simulation of land use change based on parameter estimates of land use conversion models (Bockstael, 1996; Bockstael and Bell, 1998; McMillen, 1989; Kline and Alig, 1999; Landis and Zang, 1998). The model in Carrión-Flores and Irwin, 2002 identified how economic, policy, and environmental factors influence changes in the land use patterns. This paper introduces a regression discontinuity design to shed light on how current zoning policies are affecting land use pattern. The regression discontinuity has recently become a commonly applied framework for empirical work in economics. This is a feasible extension to the model and opens new areas of research. The main reason is that it is believed that zoning creates a "cut-off" point in treatment assignment or in the probability of treatment assignment. It has been noted in the literature that the use of treatment effects has made a substantial contribution to answering specific public policy questions.

Therefore, this methodology will focus on estimating the likelihood of conversion of parcels located on zoning boundaries. The reason for this is that zoning creates a "cut-off" point in the indicator treatment variable or in the probability of treatment assignment. The purpose is to estimate causation between the likelihood of conversion and growth control measure such as, zoning. This estimation procedure may be complicated by the fact that it is more likely for a parcel to be converted in those areas where zoning changes and it may also depend on the township the zoning is located in. As a result, estimates that do no control for township characteristics may underestimate the likelihood of conversion.

In general, causation is notoriously difficult to establish using statistical analysis and causation questions set in the context of land use and growth controls present difficult challenges (Geoghegan and Bockstael, 2003). This paper presents the regression discontinuity design modeling land use following two previous papers. This will be used as a building block for future estimation. The expected results are that not to control for township characteristics may underestimate the likelihood of conversion. I will employ a matching strategy to provide as much evidence as is possible for causation, rather than just association, in the statistical analysis of "treatment" effects.

The structure of the paper is as follows: Section two develops a brief overview of the theory of land use conversion following Irwin and Bockstael (2002). Section three depicts the details of area of study and describes zoning policies. Section four introduces the regression discontinuity design, how it applies to this case. Finally, some very preliminary results are presented as well as conclusions and implications.

II. Theoretical model of an individual's land use conversion decision.

In developing a model of residential land conversion, there is a large literature in economics in which land use change is treated explicitly and is the direct object of the modeling approach (Bockstael, 1996; Bockstael and Bell, 1998; Chomitz and Gray, 1995; Hardie and Parks, 1997; Irwin and Bockstael, 2002; Landis and Zhang, 1998; McMillen, 1989; Parks, 1991). The underlying behavior is assumed to be consistent with an optimal timing of development model. The landowner's decision of land use change is the selection of the optimal land use that maximizes his expected utility. The optimal time for a parcel to be developed is when the following two conditions are met: (1) the one time return form selling residential lots developed from the parcel, net of conversion costs, exceeds the present value of returns from the current (undeveloped) land use; and (2) the rate of increase in net returns is less than the interest rate (i.e. the present value of the net gains from postponing are less than zero).

Consider the following model of land use, where land can be in an undeveloped state (*U*) or a developed state (*D*). The functions that relate returns from an undeveloped state, (R_U), to the characteristics of a given property in an undeveloped state (X_U), are given by

(1) $R_U = f_U\left(X_U\right) + e_U$

where e_u is a random term that represents unobservable factors.

Hence, land parcels are viewed as bundles of heterogeneous characteristics and the returns from land in a particular use are functions of a subset of these characteristics. Land will be allocated to use *D* if the returns from an undeveloped use $R_U(X_U)$ are less than the maximized profits. These are defined as the returns from land in a developed use $R_D(X_D)$ net the costs $C_D(Z_D)$ of converting the parcel from an undeveloped use to a developed use:

(2) $R_U\left(X_U\right) < \max_{U \neq D}\left(R_D\left(X_D\right) - C_D\left(Z_D\right)\right)$.

Several assumptions are made in developing this land use change model. First, each person is viewed as making an inter-temporal, profit-maximizing choice regarding the conversion of the parcel to a developed land use. The landowner is assumed to choose a land use in each time period such that the present discounted sum of all future expected returns from land are maximized. Second, not all the factors influencing the land use conversion are observable. Thus, the returns from land in residential or non-urban uses are treated as stochastic and the land use decision is defined as the probability that the net present discounted value of the expected returns from development minus the conversion costs is at its maximum. In this case, land conversion is treated as a discrete outcome and represents a latent variable that depends on the different characteristics of the parcel X and the error term e.

III. Area of study

The area of study is one county on the exurban areas on the fringes of the Cleveland, Ohio metropolitan area. The "exurban" portion of the landscape, is defined by the literature as those areas that fall beyond the outer belt of a major metropolitan area but within its commutershed[i]. The rural-urban interface begins where suburbs end and extend into rural areas. Changes in these areas are interesting because of the link between individual choices of land use change under different local policies and their impacts at the aggregate level. Individual owners and farmers seek to maximize their expected profits and ignore the impacts of their actions on their surroundings. Medina County fits this definition and it will be the area of study for this paper. Medina County lies just south of Cleveland, Ohio and some portions of it are considered to be part of the Cleveland/Akron metropolitan area. The total area of Medina County is 270,000 acres, and, according to the Medina's Auditors Office, 61% of the total land area was in agriculture in 1996. The population growth rate for Medina County has increased 23% from 1990 to 2000, making Medina County one of the fastest growing counties in Ohio. Medina County was originally a rural county, but interstate highways have created easy access to it from neighboring urban area within Cuyahoga and Summit Counties. For example, interstate 71 and 76 run through the eastern part of the County.

The parcel database is comprised of data from the Medina County Auditor's office records and was compiled by the Northern Ohio Data and Information Service (NODIS) and the Urban Center at Cleveland Sate University. The auditor's code was used to classify each parcel to its respective land use. The auditor's code is divided in different types of land use. The code defines as an agricultural use, those parcels that have croplands, pasture or a dairy farm.

Residential development is defined as single-family homes, multifamily dwelling units, including condominiums, townhouses, and apartment buildings, that are built on a parcel. Commercial use includes those parcels that have all types of stores and malls as well as office buildings. Industrial use is defined as those parcels with light and heavy industries. Finally, exempt parcels include all buildings that do not pay property taxes, such as schools, churches, and cemeteries. Medina County has experienced urban development across the entire county and a dramatic change of the landscape is evident (Carrión-Flores and Irwin, 2003). For example, when comparing the development pattern from 1956 with that from 1996, the change is significant[ii]. In 1956, Medina County was a rural area with only 5% of the land in a developed land use. However, by 1996, Carrión Flores and Irwin indicate that 77% of the area of the County was still undeveloped, 18% was in residential use, and the remaining 5% in other urban uses.

Zoning Policies in Medina County, Ohio.

The motivations for introducing different types of zoning regulation, such as allowable use, heights, and lot sizes, in models of land use change have been extensively studied. A large literature body indicates that zoning ordinances are one of the most visible growth related local government policies and have played a central role in determining land use pattern. Moreover, zoning is considered as one of the most important factors in determining the likelihood of development. The minimum lot requirement, water and sewage system, location of wetlands and flood plains, and school district boundaries capture some of the major factors that are likely to affect the value of the parcel in residential use[iii]. Zoning laws regulate the type of activity or land use permitted on each site, the minimum lot size, and the basic use of each lot that can be specified in greater or lesser detail (Bockstael and Bell, 1998). In this paper I am interested in a minimum lot size ordinance.

Zoning ordinances recognize that residential development next to either agricultural or industrial land uses often leads to conflicts, and try to create zoning designations that preclude such conflict from happening. However, zoning is often changeable, with developers applying for, and often receiving, re-zoning on land they wish to develop. This changes the initially authorized uses to conform to the desires of the developer. For example, zoning decisions can create discontinuities in the land use pattern when restricting the amount of land available for residential, commercial, agricultural or industrial use. Mills and Hamilton (1994) argue that zoning is a potentially valuable tool for dealing with incompatible land uses. On the other hand, Anas *et. al*. (1998) argue that one of the negative consequences of having a complete separation of retail and residential land uses is unnecessary auto travel. Another argument against zoning is the effect of zoning on socioeconomic groups. When a minimum lot size is established then some people cannot afford to move to certain parts of the city. This effect of zoning adds considerably to the decentralization of cities as well as to social segregation since it forces the poor to live in central cities. Pasha (1996) uses a general equilibrium model of the residential economy to study the effects of zoning and concludes that, while suburban minimum lot size zoning raises the utility level of people living in the central city by decreasing land values, it increases the size of the metropolitan area.

Medina County has 28 local jurisdictions, with three cities, six villages, seventeen townships, and part of one city and one village. All jurisdictions in the county have adopted zoning codes. Table 1 summarizes the Coding of Medina Ordinances. Medina County regulation states:

> " No building shall be erected, converted, enlarged, reconstructed or structurally altered, nor shall any building or land be used in a manner which does not comply with all the district provisions established by this Zoning Ordinance for the districts in which the building or land is located. Uses which are omitted from this Ordinance, not being specifically permitted, shall be considered prohibited until, by amendment, such uses are written into this Ordinance."

Furthermore, several townships (excluding Hinckley and Spencer) in Medina County have zoning codes that designate all or some of their residentially zoned areas with two allowable densities: a lower one (i.e. 3-acre minimum lot size) if there are no centralized sewers available and another more dense zone if centralized sewers are in place. For the purpose of this paper I will look into the implications of this minimum lot requirement.

IV. Regression Discontinuity Design

This section will introduce an alternative estimation strategy based on the regression discontinuity design (Hahn et al, 2001). It focuses on estimating the likelihood of conversion of parcels located on zoning boundaries. Zoning boundaries are defined as a geographical line where on one side of the boundary we will have parcels that have a minimum lot size of 3 acres and on the other side are those parcels which are not subject to this requirement.

Zoning creates a "cut-off" point in the indicator treatment assignment or in the probability of treatment assignment. Importantly, the fact that zoning creates a discrete jump at the zoning boundaries while neighborhoods continue to change in a smooth manner allows me to isolate the relationship between zoning and land use change.

Analyses of the effect of land use policy instruments that are based on the aggregated observations often have drawbacks (Geoghegan and Bockstael, 2003). Even though we have access to micro level data to evaluate the effects of these instruments, it is plagued with difficulties. The reason is simply that it is difficult to separate out confounding influences; in other words, it is difficult to identify the effect of the growth control instrument.

A complication is the fact that correlation is not causation nor does correlation prove causation. Geoghegan and Bockstael (2003), indicate that it is quite difficult to provide evidence for causation, because we can never observe the outcome of both treatment and control on the same unit of observation at the same moment of time. Yet, regression and related statistical techniques, which are fundamentally tools of associational inference, are repeatedly used by economists to provide evidence of causation. The problem is that regression analysis cannot guarantee independence between the varying characteristics of the observational units and the treatment status. Simply including an indicator treatment variable together with whatever finite set of additional regressors might be on hand is an inadequate strategy if one wants some confidence in the results.

Causation is difficult to demonstrate. It is even more difficult in spatial analyses because many variables tend to correlate over space. Moreover, previous land use research on the relationship between zoning and land use change has estimated versions of equation (3). Unfortunately, a drawback to these approaches is that all relevant neighborhood characteristics cannot be observed; hence the results are biased because of omitted variables. To make this point consider the basic relation of interest:

$$(3)\ Y_i^* = \alpha + X_i'\beta + W_i'\delta + Z_i'\theta + \sum_{j=1}^{16} \phi_j D_{ij}$$

$$y_i = 1\ if\ \varepsilon_i \geq -X_i'\beta$$
$$y_i = 0,\ otherwise$$

where $Yi*$ is the unobserved latent version of the observed dependent variable, y_i. The vector X_i includes characteristics of the parcel such as parcel size, distance to nearest city, soil quality, W_i is a vector of neighborhood characteristics such as population density, house density, and D_{ij} are dummy variables that indicate which township the parcel is located in. ε_i is assumed to be normally distributed with mean zero and constant variance. Zoning (Z_i) is the regressor of primary interest. Zoning is defined as dummy variable that takes the value of one if the parcel is subject to a minimum lot size of 3 acres and zero otherwise.

Recognizing the problem of providing evidence of causation with respect to public policies, recent literature has used the regression discontinuity design. However, as Geoghegan and Bockstael (2003), we need to account for the discrete nature of the response. The goal of an evaluation is to determine the effect that some binary treatment variable z_i has on an outcome y_i. The regression discontinuity design tries to isolate the effects of zoning in the land use conversion decision. The purpose is to estimate causation between of the likelihood of conversion and zoning. This estimation procedure may be complicated by the fact that it is more likely for a parcel to be converted in those areas where zoning changes and it may also depend on the township the zoning is located in. As a result, estimates that do not control for township characteristics may underestimate the likelihood of conversion.

To avoid this problem, we will compare the likelihood of conversion on opposite sides of zoning boundaries. By looking within townships, we can control for variation in local policies, such as property tax rates, public services. By limiting my sample to parcels that lie within close proximity to zoning boundaries – parcels that lie very close to each other but are subject to different zoning ordinances – we can also control for zoning differences. Therefore, to eliminate such problems, the methodology explored here replaces the vector of observed characteristics (W_i) with a full set of boundary dummies that indicate parcels that share a zoning boundary:

$$(4)\ Y_i^* = \alpha + X_i'\beta + K_i'\lambda + Z_i'\theta + \sum_{j=1}^{16}\phi_j D_{ij}$$

where K_i is a vector of boundary dummies. Conceptually, this methodology is equivalent to calculating differences in likelihood of conversion on opposite sides of the zoning boundary. The matching strategy as in Black (1999) incorporates localized dummy variables that attempt to control for omitted variables. Parcels that share the same boundary are likely to share similar characteristics, this approach will help control for unobserved but spatially correlated factors as indicated by Geoghegan and Bockstael (2003).

There are two main types of discontinuity designs considered in the literature (Hahn, et al. 2001) the sharp design and the so-called fuzzy design. With the sharp design, treatment is known to depend in a deterministic way on some observable variable, where it takes on a continuum of values and the point, where the function is discontinuous, is assumed to be known. With a fuzzy design, the treatment is a random variable, but the conditional probability is known to be discontinuous. The fuzzy design differs from the sharp design in that the treatment assignment is not a deterministic function. Hahn et al. (2001) has recently demonstrated how discontinuities in the treatment assignment mechanism (i.e., in natural experiments) can be exploited to identify and estimate the effects of those treatments. With a regression discontinuities design the probability of receiving the treatment can be assumed to change discontinuously as a function of one or more underlying variables.

The model estimated here is similar to the approach used by Black (1999), where she imposed limits on the number of elementary schools with overlapping grade levels in a district, required absence of intra-district choice programs, and dropped cases where the attendance districts were poorly defined or unavailable. All of these choices seem motivated by assuring a sharp regression discontinuity design.

V. Estimation

The sample includes all undeveloped parcels (i.e. agricultural uses or open space parcels) and developed parcels that were converted to residential land use in the period from1990 to 1996. However, this sample does not observe variables that can change over space, both within and across zoning boundaries, such as township quality. To eliminate this problem, a sub-sample is created. This sub-sample includes parcels in the full sample that share (on either side) a zoning boundary. Conceptually, this sub-sample is equivalent to calculating differences in likelihood of conversion on opposite sides of zoning boundaries and relating this to differences in township quality. This sub-sample will account for unobserved characteristics shared on either side of the boundary by assuming that other features of treatment (in this case zoning is considered the treatment variable) and control samples change smoothly, so the only reason for a change in land use conversion can be attributed to the effect of the zoning minimum lot requirement policy.

A concern with using zoning boundaries is that they may not be exogenous to the residential development process. Indeed, a well-established literature has provided evidence of the endogeneity of zoning to residential land values (e.g., Pogodizinski and Sass, 1991). To avoid potential problems with endogeneity, we identify zoning boundaries that are drawn based on exogenous characteristics of the land. Specifically, county health departments in Ohio mandate minimum lot sizes for residential land parcels that are not serviced by public sewer, but instead have septic tanks. While the minimum lot size varies for these parcels, depending on soil characteristics, they range from a three acres minimum lot size up to five or more acres minimum lot sizes. Thus, we use the zoning boundaries that delineate a change in the three acre minimum lot size requirement as the policy boundary.

The success of our approach depends critically on the sample that is drawn and the similarity of parcels on either side of the zoning boundary. However, precisely because some of these characteristics are unobserved, it is an empirical question as to how close to the zoning boundary parcels should be to ensure similarity in all respects other than the zoning attribute. To examine the sensitivity of the results to different sub-sample sizes, we estimate the model using parcels located within 250, 500, 1000, 1500 and 2500 feet of the nearest zoning boundary. Map I illustrates the parcels that are selected vs. excluded for each of these buffer areas. The zoning variable will distinguish those parcels that lie on one side of the boundary and have a 3-acre min lot zoning and those parcels on the other side where there is not.

Summary Statistics and Characteristics of the Sub-samples

The full sample consists of 16,114 parcels within Medina County. Out of the 17 Townships in Medina County, 15 have adopted a minimum 3-acre lot size zoning. The sub-samples range from 3,133 parcels for the sample drawn with a 250 foot buffer to 10,536 parcels for the sample drawn with a 2500 foot buffer. Table 2 summarizes the data. While many of the means are similar across the full and sub-samples, others are not. This is true for an obvious reason. Because we have selected sub-samples based on a division between higher density vs. lower density development, we omit large agricultural tracts that are not within close proximity of these more densely zoned areas.

Results

Column 1 of Table 3 presents the estimation results from the estimation of the probit model on the full sample (i.e. 16,114 observations) and column 1 in Table 4 presents the marginal effects. These results do not control for unobserved characteristics shared on either side of the boundary. The regression includes the following variables: parcel size in acres; distance to nearest city in miles[iv]; soil quality, which is a dummy variable that takes the value of one if the parcel has prime agricultural soil and zero otherwise; population density and house density, calculated as number of persons and houses respectively per square mile; the percentage of the parcels surrounding a parcel in agricultural uses and residential uses respectively. A boundary dummy is included to control for parcels that either intersect a zoning boundary or that are adjacent to it. Lastly, the minimum lot zoning requirement is included, which takes the value of one if the parcel is subject to a minimum lot size of three acres or greater and a value of zero otherwise.

Many of the results are as expected. Distance from Cleveland is negative and significant, which is consistent with the basic urban bid rent model of land values. Soil quality, a proxy for the farmer's opportunity of converting the parcel, is negative and significant, implying that all else equal, land with higher quality soil is less likely to be converted. The size of a parcel is negative and highly significant, implying that smaller parcels are more likely to be converted. Because we do not control for the subdivision process, by which a larger parcel is first subdivided into smaller parcels, which are then developed, this result is not surprising. Neighborhood density and land use variables are also significant. Higher population density in the neighborhood discourages development, suggesting that congestion effects are associated with higher densities. On the other hand, a parcel's probability of development is increasing in the amount of surrounding residential land and decreasing in the amount of agricultural land, suggesting that surrounding residential development is an attractor of new residential development. Finally, neither the zoning boundary fixed effect nor the minimum lot size zoning difference are statistically significant.

Because of the problems associated with estimating the full sample, we focus the attention on the results from estimating the same model using the sub-samples, which include zoning boundaries effects. When estimating the model using the sub-samples, we systematically restrict my sample to parcels that have a maximum distance from the zoning boundary. As the sample is restricted to parcels that lie closer to the boundary, it becomes less likely that there are differences other than the minimum lot size zoning on either side of the boundary.

The results for the six sub-samples are presented in columns 2-5 in Tables 3 and 4. In comparing the estimates across the sub-samples, some estimates appear robust while others do not. For example, lot size and the amount of surround agriculture remain negative and significant throughout whereas the proportion of residential development remains positive and significant throughout. Other estimates are significant in some samples, but not others. For example, distance to Cleveland is negative and significant across all samples with the exception of the smallest, that drawn with the 250 foot buffer. Population density remains negative and significant in the larger samples, but drops in significance level with the smaller samples. The boundary fixed effect is insignificant with the full sample, but positive and significant with the 250, 1000 and 2500 samples, implying that parcels that intersect or are adjacent to the zoning boundary are more likely to be converted. Finally, the minimum lot size zoning restriction, which is insignificant with the full sample, is negative and significant for the smaller samples, including the 250, 500, 1000 and 1500 samples, but insignificant with the larger 2500 sample and the full sample. In comparing the magnitude of the marginal effect across these samples, we find that the marginal effect increases slightly as the sample increases, but then decreases and is insignificant with the full sample model. This result is consistent with the intuition that smaller samples drawn tightly on either side of the policy discontinuity are more homogeneous with respect to unobserved variation and therefore the effect of the policy is more discernable in these cases. Given this, we find that the effect of minimum lot zoning has a modest, but significant effect on land conversion. Depending on the sample, our estimates suggest that a small marginal increase in the minimum lot size restriction will decrease a parcel's conversion probability by anywhere from 0.02 to 0.4 percent.

Limitations

A concern with this estimation is that areas being compared, on opposite sides of zoning boundaries may not have the same characteristics. One way to test for this is to include more sub samples and make a statistical comparison among them (using matching estimations). Another concern in this estimation is that zoning boundaries could actually represent township division or neighborhood effects. A hint to this problem comes from the significant estimates of population and housing density in the model. A third issue arises if the zoning boundaries are endogenous to the land development process. If this is so, then our estimates will be biased since parcels in areas with higher growth pressures are more likely to be zoned for higher density (lower minimum lot size).

Conclusion and Implications

Using an approach that compares parcels that are close to each other but are associated with different lot requirement, we find that the effect of zoning on the likelihood conversion changes, as the parcel gets closer to zoning boundaries. Yet to be conducted are the tests of the robustness of the results to misspecification of boundaries and omitted variables.

Nevertheless, the key implications of this preliminary study are that although the preferences of the sub-sample may not be representative of the county as a whole, this approach could help to evaluate more effectively zoning policies. One implication is that more attention should be devoted to zoning boundaries because they have a different pattern of conversion than parcels further away. Another implication is the if landowners make efficient ex ante decisions and then the policymaker acts ex-post to affect the value of their land uses, efficiency issues arise. Efficiency requires that the policy maker face the full cost of his/her actions[v].

Another implication from this paper is that in practice it is often difficult to be confident that a temporal or spatial distinction isolates the desired policy effects. While we might observe land use conversion before and after some policy has been implemented, we rarely know the information that was available to landowners and farmers at the time of their decisions. Under these circumstances, there is the prospect for endogeneity between zoning and the decision to convert an undeveloped parcel to some other developed land use. Equally important, sometimes a land use such as a public park conveys benefits to some (i.e. not having houses around) and losses (congestion during weekends around the park) to other. Distinguishing these separate effects for individual land parcels can be a difficult identification problem.

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TABLE 1

CODIFIED ORDINANCES FOR MEDINA COUNTY

0-C [vi]	OPEN SPACE – CONSERVATION LANDS, PUBLIC PARKS
R-S [vii]	SUBURBAN RESIDENTIAL DISTRICT
R-1	LOW-DENSITY URBAN RESIDENTIAL DISTRICT
R-2	MEDIUM-DENSITY URBAN RESIDENTIAL DISTRICT
R-3	HIGH-DENSITY URBAN RESIDENTIAL DISTRICT
R-4	MULTI-FAMILY URBAN RESIDENTIAL DISTRICT
M-U [viii]	MULTI-USE DISTRICT
C-B [ix]	COMMERCIAL-BUSINESS DISTRICT
C-1	LOCAL COMMERCIAL DISTRICT
C-2	RETAIL COMMERCIAL DISTRICT
C-3	COMMERCIAL DISTRICT
C-4	PLANNED COMMERCIAL DISTRICT
I-1 [x]	INDUSTRIAL DISTRICT
SPP[xi]	SPECIAL PLANNING DISTRICT

TABLE I

SUMMARY STATISTICS

Distance from Boundary:	Full sample		250 feet		500 feet		1000 feet		2500 feet	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
% Parcels Developed	0.5806	0.4935								
Lot Size (Acres)	11.4323	23.5695								
Distance to Cleveland	30.7011	7.2510								
Distance to nearest City	3.2221	1.6259								
Soil Quality	0.8283	0.3771								
Population Density	3.1665	4.3384								
Work Density	0.4988	0.0997								
% Neighboring parcels in Agriculture	0.5927	0.2183								
% Neighboring parcels in Residential	0.9264	2.7130								
Zoning Requirement										
Zoning Boundary										
N	16,114									

TABLE II
Differences in Means

TABLE III

REGRESSION RESULTS: BOUNDARY FIXED EFFECTS

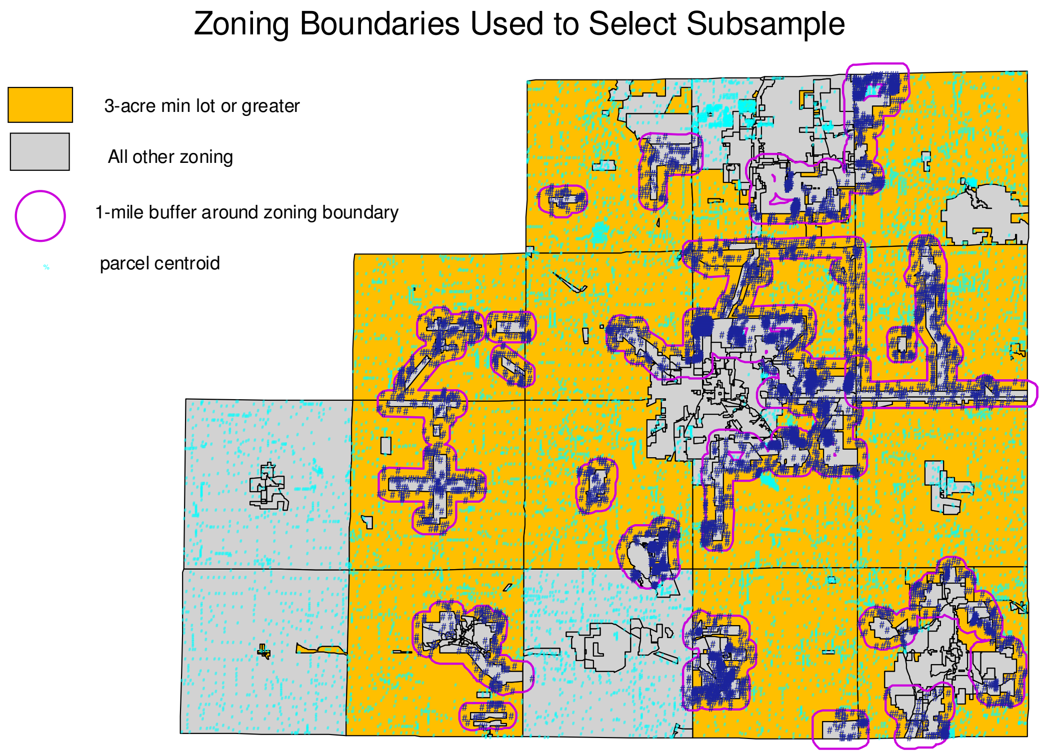
Distance from Boundary:	Full Sample		250 feet		500 feet		1000 feet		1500 feet		2500 feet	
	Coeff	Std Err	Coeff	Std Err	Coeff	Std Err	Coeff	Std Err	Coeff	Std Err	Coeff	Std Err
Zoning Requirement	0.0158	0.0477	-0.5728	0.1332	-0.4447	0.1107	-0.2475	0.0910	-0.1747	0.0801	-0.0503	0.0666
Lot Size (Acres)	-0.3172	0.0065	-0.3451	0.0153	-0.3046	0.0126	-0.3093	0.0108	-0.3048	0.0096	-0.3141	0.0085
Distance to Cleveland	-0.0088	0.0039	-0.0401	0.0111	-0.0418	0.0093	-0.0437	0.0078	-0.0322	0.0068	-0.0144	0.0055
Soil Quality	-0.2295	0.0694	0.0118	0.1727	-0.2441	0.1448	-0.3131	0.1194	-0.3528	0.1082	-0.2964	0.0909
Population Density	-0.0325	0.0082	0.0090	0.0265	-0.0158	0.0219	-0.0293	0.0178	-0.0496	0.0151	-0.0506	0.0128
Work Density	-0.0335	0.2431	0.3701	0.6186	0.6640	0.5221	0.5927	0.4264	0.3214	0.3799	0.3279	0.3297
%Ag in neighborhood	-3.4853	0.1641	-3.4165	0.4809	-3.3809	0.4022	-3.3833	0.3287	-3.5131	0.2845	-3.6446	0.2304
%Res in neighborhood	0.1586	0.0148	0.2019	0.0424	0.1724	0.0306	0.1551	0.0224	0.1545	0.0212	0.1493	0.0184
Boundary fixed effect	0.0964	0.0762	0.3536	0.1378	0.1696	0.1111	0.2013	0.0952	0.0519	0.0878	0.1599	0.0818
Constant	4.6338	0.1772	5.3475	0.4785	5.4025	0.4014	5.4554	0.3324	5.4691	0.2971	4.8046	0.2523
Log likelihood	-6142.4		-926.3		-1289.6		-1861.3		-2348.8		-3290.3	
N	16,114		3,792		4,895		6,658		8,260		10,831	

TABLE IV

REGRESSION RESULTS: MARGINAL EFFECTS WITH BOUNDARY FIXED EFFECTS

	Full Sample		250 feet		500 feet		1000 feet		1500 feet		2500 feet	
	Marg Eff	Std Err	Marg Eff	Std Err	Marg Eff	Std Err	Marg Eff	Std Err	Marg Eff	Std Err	Marg Eff	Std Err
Zoning Requirement	0.0007	0.0022	-0.0002	0.0001	-0.0013	0.0005	-0.0022	0.0010	-0.0035	0.0018	-0.0014	0.0018
Lot Size (Acres)	-0.0147	0.0008	-0.0001	0.0000	-0.0008	0.0002	-0.0027	0.0005	-0.0061	0.0008	-0.0086	0.0008
Distance to Cleveland	-0.0004	0.0002	0.0000	0.0000	-0.0001	0.0000	-0.0004	0.0001	-0.0006	0.0002	-0.0004	0.0002
Soil Quality	-0.0114	0.0040	0.0000	0.0001	-0.0007	0.0005	-0.0030	0.0015	-0.0079	0.0032	-0.0088	0.0033
Population Density	-0.0015	0.0004	0.0000	0.0000	0.0000	0.0001	-0.0003	0.0002	-0.0010	0.0003	-0.0014	0.0004
Work Density	-0.0016	0.0113	0.0001	0.0002	0.0018	0.0015	0.0052	0.0039	0.0064	0.0077	0.0089	0.0091
%Ag in neighborhood	-0.1615	0.0138	-0.0009	0.0004	-0.0092	0.0027	-0.0297	0.0064	-0.0705	0.0119	-0.0994	0.0131
%Res in neighborhood	0.0073	0.0009	0.0001	0.0000	0.0005	0.0002	0.0014	0.0003	0.0031	0.0007	0.0041	0.0007
Boundary fixed effect	0.0046	0.0038	0.0001	0.0001	0.0005	0.0003	0.0018	0.0009	0.0011	0.0018	0.0045	0.0024
Log likelihood	-6142.4		-926.3		-1289.6		-1861.3		-2348.8		-3290.3	
N	16,114		3,792		4,895		6,658		8,260		10,831	

FIGURE 1: EXAMPLE OF ZONING BOUNDARY SUB-SAMPLE



Endnotes

[i] Nelson, 1992 Provides diverse operational definitions of exurban.
[ii] For details, see Carrión-Flores (2002)
[iii] These include number of lost and lot size, open space in development, distance to employment centers, school quality, and congestion in surrounding area. It also includes some proxies for the value the owner may place on the property in its undeveloped use, such as agricultural rental value, forest cover, soil quality. Finally it includes a number of factors that affect the costs of conversion. These include whether public utilities are available, proximity to major road access, environmental regulations, etc.

[iv] Distance to nearest city is the linear distance from the centroid of the parcel to downtown of the city.
[v] Miceli and Segerson (1996) demonstrate that a policy design can be efficient under certain conditions, such as the transparency of the policy design and there should exist a compensation for the unanticipated change in the landowner's properties.
[vi] The 0-C District will preserve and protect areas of distinctive geologic, topographic, botanic, historic or scenic areas.
[vii] The R-S District is established to accommodate single-family residential dwellings in areas that are or may reasonably be expected to be provided with central sewer and water facilities.
[viii] The M-U District allows a combination of limited commercial uses and residential uses in areas of the City located adjacent to commercial areas that indicate a changing trend.
[ix] The C-B District is established to create an environment conducive to well located and designed office building sites to accommodate professional offices, nonprofit organizations and limited business service activities.
[x] The I-1 District is established to provide for and accommodate industrial uses in the fields of repair, storage, manufacturing, processing, wholesaling and distribution.
[xi] The purpose of this District is to regulate the development and use of property in areas of the City that contain sensitive or unique environmental, historic, architectural, or other features which require additional protections