AN ABSTRACT OF THE DISSERTATION OF

Jiayin Lai for the degree of Doctor of Philosophy in Agricultural and Resource Economics presented on June 12, 2008.

Title: Essays on the Economics of Land Use Regulation.

Abstract approved: ____

Andrew Plantinga

This dissertation consists of three papers on land use economics and regulation. The first paper reviews numerous past literatures on how land-use regulation, agricultural subsidies, and use-value assessment method affect land values. The second paper uses a theoretical model to analyze how imposing minimum-lot-size zoning and different designs of minimum-lot-size zoning policies affects land value. The third papers use land data from Oregon to investigate the price effect of minimum-lot-size zoning and potential impact of Measure 37 and 49.

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The first essay reviews an extensive collection of literature from most major applied economics journals in recent years. These past studies attempted to investigate the impacts of various land use policies, including minimum-lot-size zoning, open space protection, wetland conservation, etc. These studies demonstrate how land use policies might affect residents' land consumption, social welfare, land markets, local government finance, and urban development patterns. Various econometric and mathematical models have been used to overcome problems related to modeling and data, such as spatial correlation.

The objective of the second essay is to investigate the effect of the minimum-lot-size zoning on land values versus the value of individual exemptions from the regulations. The study first assumes all residents live in a monocentric city and have the same income constraints, and then assumes that there are two income groups living in the monocentric city. Minimum-lot-size zoning is applied to the periphery of the city. As

stated in the study by Jaeger and Plantinga (special report, June 2007), distinguishing between two concepts - the change in property value due to regulation and the value to a landowner of an individual exemption to a regulation – is important to estimate the potential impact of Measure 37 and 49. Therefore, this study will explore both cases: 1) the removal of minimum-lot-size zoning from all parcels, and 2) having a single parcel exempted from zoning. Both open-city and closed-city scenarios will be considered. The comparative statics will show how the zoning policy influences urban land values. In addition, a simulation will help to demonstrate the impact of policy changes.

The third essay uses the two-stage hedonic model to estimate the demand for lot size. The first stage estimation allows us to estimate the marginal impact of zoning policies, while the second stage estimation is used to investigate how land values are affected by the non-marginal change in zoning policies, such as the elimination of zoning or changes related to Measure 37. In the first stage estimation, the zoning policy is assumed to have two conflicting impacts on the land value; the regulation reduces development opportunities while it also may provide more environmental benefits. In the empirical model, four Oregon counties are considered as separate land markets, and the distribution of consumers' tastes are assumed to be the same across the counties. This provides a tool for solving the identification problem in the second stage estimation.

Essays on the Economics of Land Use Regulation

by

Jiayin Lai

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APPROVED:

Major Professor, representing Agricultural and Resource Economics

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Head of the Department of Agricultural and Resource Economics

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Dean of the Graduate School

I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

Jiayin Lai, Author

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CHAPTER 1

INTRODUCTION

I. Minimum-Lot-Size Zoning and Land Use Policies

Zoning policies were originally designed to reduce negative spillover effects of urban development. The first zoning law was passed in New York City in reaction to the construction of a building towering over neighboring residences, completely covering all available land area within the property boundary and obstructing window views. Nowadays, governing bodies use zoning policies to promote health, safety, morals, and the general welfare of the community.

Minimum-lot-size zoning requires each parcel to be equal to or greater than a prescribed minimum lot size. There are several reasons for using minimum-lot-size zoning. In many rural areas, minimum-lot-size zoning is used for sanitary reasons. Sewer systems are usually not provided by local government for the parcels located outside city boundaries. In order to keep enough area for providing adequate treatment and disposal of the sewage generated and preventing groundwater degradation, a local government may use minimum-lot-size zoning to control housing density. Minimum-lot-size zoning is also used to ensure all parcels have enough physical space to accommodate buildings, driveways, other paved surfaces, and development. In such cases, the minimum-lot-size zoning policies are often combined with other restrictions, such as limiting the number of houses on each parcel. Local governments also use minimum lot size to preserve rural characteristics in a community. Therefore, minimum lot size is often restricted to be as large as 10 to 15 acres.

Although most zoning ordinances are designed to eliminate or minimize negative externalities of land development, minimum-lot-size zoning policies may also be used to serve other purposes or generate unexpected results. First, minimum-lot-size zoning may increase average housing price in a zoned area because smaller parcels with low price are not available. Second, land is different from many other consumer products because a big portion of its value comes from the surrounding area. Therefore, the spillover of the condition on one parcel may largely affect all of its neighbors. Burstein (1980) explained that fiscal zoning would be unnecessary if tastes for local public goods were sufficiently correlated with tastes for the residential property. Therefore, if land use zoning create amenities for the residents living in the zoned area, residents who prefer these amenities will move in. Since such tastes are often related to income, some land use zoning policy, such as minimum-lot-size zoning, may achieve the purpose of fiscal zoning as well. "The Fair Housing Act prohibits discrimination in the sale, rental and financing of dwellings and other housing-related transactions based on race, color, national origin, religion, gender, familial status, handicap or disability" (Glaeser and Ward, 2006). However, there are lawsuits filed in many states alleging that some zoning policies do not meet those guidelines. Through land use zoning policies, local governments may drive home prices beyond the reach of certain segments of the population (Shlay and Rossi 1981). The reason is that usually there are observed relations between income and race, national origin, gender, handicap or disability (Schill and Wachter 1995, Maantay 2001, Bajari and Kahn 2003, and Hamilton 1995). A study by Glaeser and Ward (2006) showed that minimum-lot-size zoning along with other land-use regulations (such as wetland protection policies) were blamed for affecting the affordability in the Boston area.

II. Measure 37 and Measure 49

Oregon has been attempting to use comprehensive land-use policy to achieve a balance between development and other objectives, such as farmland preservation. Such policies have been greatly influencing land values. In 2004, Oregon voters approved Measure 37, under which the landowner will receive compensation that "equals the reduction in the fair market value of the affected property interest resulting from enactment or enforcement of the land-use regulation." The measure also provides that the government responsible for the regulation may choose to "remove, modify or not apply" the regulation. Measure 37 passed partially because land-use regulations, such as minimum-lot-size zoning, prevent high-density residential development in rural areas, which some property owners believe has reduced their land values. However, Measure 37 has failed to clarify many details about compensations. In order to solve these issues raised by Measure 37, Oregon passed Measure 49 on November 6, 2007. Measure 49 provides that "if a public entity enacts one or more land use regulations that restrict the residential use of private real property, or a farming or forest practice, and that reduce the fair market value of the property, then the owner of the property shall be entitled to just compensation from the public entity that enacted the land use regulation or regulations" (Measure 49 Instruction Packet, Oregon.gov). Measure 49 intends to clarify the ambiguous issues in Measure 37, stop large developments protecting property rights, and put a stop to the abuses filed under Measure 37 by large land-holding companies. Once claims are approved, Measure 49 automatically allows up to 3 houses for landholders wanting to expand and up to 10 houses if the property holder proves market value loss. Measure 49 also guarantees these development rights are automatically passed on to family, a privilege that was overlooked by Measure 37.

According to the Measure 37 database maintained by Portland State University, as of December 12, 2007, 7717 claims for Measure 37 had been forwarded to Oregon Land Conservation and Development and County offices requesting at least $12.7 billion in compensation, encompassing an area greater than 792,000 acres. This accounts for approximately 95% of total claims filed in Oregon. There are about 4411 claims filed for subdivision and partition, and at least 4000 claims were filed for residential development. Land owners with pending or approved Measure 37 claims have options to proceed under Measure 49. As of January 22, 2008, 6400 Measure 49 election notice packets have been mailed out. Furthermore, Measure 49 still involves the calculation for the reduction of land's fair market value. Measure 49 explicitly states that "subdivisions are not allowed on high-value farmlands, forestlands and groundwater-restricted lands." (Voters' Pamphlet, Text of Measure 49) Therefore, increasing residential development density on lands zoned for residential uses will be a more important part of Measure 49 claims. Furthermore, following the pass of Measure 37 in Oregon, voter in six other states (California, Nevada, Arizona, Idaho, Montana, and Washington) considered similar ballot initiatives in 2006. Only in Arizona were the initiatives rejected. Therefore, to understand how land use policy affects residential land prices is still an important issue.

Since Measure 49 still allows mortification or waivers of existing land use policies and compensation, this policy's ultimate effect on Oregon landowners and on government cost is uncertain. If claims are approved, the costs of Measure 49 may ultimately depend on how the compensation is calculated and the costs that will be measured in changes in property values, landscape features, and the provision of public services.

III. Structure of the dissertation

The first essay reviews an extensive collection of literature from most major applied economics journals in recent years. These past studies attempted to investigate the impacts of various land use policies (including minimum-lot-size zoning, open space protection, wetland conservation, etc), agricultural subsidy programs, and use-value assessment. These studies demonstrate how these policies and programs might affect residents' land consumption, social welfare, land markets, local government finance, and urban development patterns. Various econometric and mathematical models have been used to overcome problems related to modeling and data, such as spatial correlation.

The objective of the second essay is to investigate the effect of the minimum-lot-size zoning on land values versus the value of individual exemptions from the regulations. The study first assumes all residents live in a monocentric city and have the same income constraints, and then assumes that there are two income groups living in the monocentric city. Minimum-lot-size zoning is applied to the periphery of the city. As stated in the study by Jaeger and Plantinga (2007), distinguishing between two concepts

- the change in property value due to regulation and the value to a landowner of an individual exemption to a regulation – is important to estimate the potential impact of Measure 37 and 49. Therefore, this study will explore both cases: 1) the removal of minimum-lot-size zoning from all parcels, and 2) having a single parcel exempted from zoning. Both open-city and closed-city scenarios will be considered. The comparative statics will show how the zoning policy influences urban land values. In addition, a simulation will help to demonstrate the impact of policy changes.

The third essay uses the two-stage hedonic model to estimate the demand for lot size. The first stage estimation allows us to estimate the marginal impact of zoning policies, while the second stage estimation is used to investigate how land values are affected by the non-marginal change in zoning policies, such as the elimination of zoning or changes related to Measure 37. In the first stage estimation, the zoning policy is assumed to have two conflicting impacts on the land value; the regulation reduces development opportunities while it also may provide more environmental benefits. In the empirical model, four Oregon counties are considered as separate land markets, and the distribution of consumers' tastes are assumed to be the same across the counties. This provides a tool for solving the identification problem in the second stage estimation.

IV. Literature Review

There have been studies using theoretical or empirical models to investigate the impact of minimum-lot-size zoning. Theoretical analysis usually uses a monocentric city model. Pasha used a city model with two income groups to investigate how a minimum-lot-size zoning policy might change city residents' utility levels. The model assumes that the poor live in the downtown while the rich live farther away from the city center and are subject to a binding minimum-lot-size zoning requirement. He concluded that minimum-lot-size zoning increases the utility of the poor and decreases the utility of the rich. Moss (1977) used a city model with two sectors (housing and agriculture) and assumed that total land supply is finite. He found that minimum-lot-size zoning increases land prices and extends the urban area. In the study by Grieson and White (1981), they found minimum-lot-size zoning has ambiguous impact on land prices by using a close city model. Mills (2005) used a city model with uniform density control policy applied to all parcels. He concluded that uniform density control in a metropolitan area makes all residents uniformly worse off. However, such uniform land use policy is not popular in reality.

Empirical analysis on minimum-lot-size zoning has been widely used to identify the impact of minimum-lot-size on land market, local government finance, and development patterns. In the study by Peiser (1989), he pointed out that large lot zoning might encourage urban sprawl. If large lot zoning is combined with other zoning policies that control urban area expansion, prices of all urban lands may increase and city residents are worse off. In their empirical study, Spalatro and Provencher (2001) found that, in Wisconsin, applying minimum-frontage zoning to lakefront properties increases those properties' values. Hamilton (1978) conjectures that density controls in urban development may have increased housing prices by 50% in Baltimore. He concludes that governments should abandon the policies that favor low-density development in some areas. McConnell et al. (2006) used an empirical model to compare the development patterns under the influence of zoning that controls development density versus market forces. They found that zoning policies do contribute to low density development. In an empirical study, Lichtenberg et al. (2007) used data from the Washington-Baltimore area and found statistical evidence that minimum-lot-size zoning reduces development opportunities. The magnitude of such land value deduction is smaller when minimum-lot-size zoning is applied to parcels with existing public sewer access than those without public sewer access.

Several studies have discussed how to estimate the impact of Measure 37. Jaeger and Plantinga (2007) explained that it is important to distinguish policy exemption and removing land use policy from all parcels when estimating the impact of Measure 37. Jaeger (2007) evaluated three methods: the “with or without” method, the “single exemption” method, and the “before and after” method. The study shows that the “before and after” method, which compares the land value before land use policy and after, produces the most accurate estimates. Hascic (2006) used an empirical model and spatial simulation to investigate the potential impact of Measure 37 on land values and urban development in the Eugene-Springfield area.

In theoretical analysis, the standard monocentric city has been widely used to analyze the dynamics of urban landscape features and urban amenities. Wheaton (1977) discussed the relation between income and location choice in a monocentric city. Brueckner, Thisse, and Zenou (1999) showed that urban amenities influence the relative locations of different income groups. Wu and Plantinga (2003) analyzed the influence of public open space on the urban development patterns. Wu (2006) examined how environmental amenities affect development patterns and the community characteristics.

In an empirical analysis, a two-stage hedonic model has been used to estimate the marginal willingness to pay for various characteristics of residential lands, such as tree canopy coverage (Netusil and Chattopadhyay 2006), lake-water clarity (Boyle, Poor, and Taylor 1999, Lawson 1997), air quality (Chattopadhyay 1999, Zabel and Kiel 2000), parcel size (Witte, Sumka, and Erekson 1979, Cheshire and Sheppard 1998), open space (Irwin 2002), and housing quality (Witte, Sumka, and Erekson 1979, Parsons 1986). In recent years, researchers have been attempting to improve the efficiency of estimators for hedonic regressions by controlling spatial correlation. Data associated with land often have spatial spillover characteristics that may not be captured by any variables. Therefore, the OLS estimators are not efficient, but still unbiased.

Different studies treated the spatial correlation problem in various ways. Bell and Bockstael (2000) illustrated the importance of controlling for spatial error autocorrelation in a model of residential land values. There are studies that discuss how to correct spatial correlation problem. Dubin (1998) and Anselin (1988 and 2003) outlined several model specifications to incorporate spatial externalities. In their study, Bell and Bockstael (2000) proposed an estimation method using Generalized Moments Method (GMM) while assuming a spatial autoregressive process. Numerous studies used these techniques to improve the estimation in hedonic model. For example, Dubin (1992) used data from Baltimore to show how neighborhood quality affects housing prices. Kim, Phipps, and Anselin (2003) combined the spatial-lag and spatial error model to investigate the relation between housing price and urban air quality in Seoul.

CHAPTER 2

THE EFFECTS OF LAND-USE REGULATIONS, AGRICULTURAL SUBSIDY PROGRAMS, AND USE-VALUE ASSESSMENT ON PRIVATE PROPERTY VALUES: LITERATURE REVIEW

Introduction

A list of the studies reviewed is provided, below, in table 2.1. The first set of studies (section I) considers the effects of land-use regulations on property values. Studies in sub-section I.A. examine the effect of regulations on the value of the property to which the regulation is applied. The regulations include restrictions on the development of agricultural and forest land, as well as restrictions on the type of urban development allowed (e.g., zoning that prohibits commericial development). In general, land-use regulations reduce a property's value because they prohibit what might otherwise be profitable uses of the property. However, regulations also increase property values through the provision of amenities—either amenities generated on the property itself or from neighboring properties that are also regulated, or both. These studies try to measure the net effect of these regulations. Overall, the studies reviewed find that land-use regulations have significant effects on property values. It is found that in many cases the net effects of regulations are positive. In the other instances, there are no effects or negative effects.

The studies in sub-section I.B. examine how property values are affected by amenities and disamenities generated on neighboring properties. I focuses on studies that evaluate amenities typically provided as the result of land-use regulations—farmland, open space, and wetlands. Relative to the studies in I.A., the studies in I.B. measure the benefits (or costs) of regulations that spill over to neighboring properties, but do not measure costs imposed on regulated properties. In the large majority of cases, the studies reviewed indicate positive effects of land-use regulations on neighboring properties.

Studies in section II examine how agricultural rents and land values are affected by farm subsidies. As expected, subsidies raise rents and land values, though the effects are found to vary by crop and region. As well, there is evidence presented that government payments are not fully reflected in land rents, possibly because they induce changes in farm practices that in the aggregate affect input and output prices.

A number of studies, reviewed in section III, examine the effects of use-value assessment on property values. Under use-value assessment, property tax assessment for farmland is based on the value of land in its current agricultural use, rather than on the land's market value, which may be considerably greater if more profitable future development opportunities exist. Several studies find evidence that the tax advantages of use-value assessment are reflected in property values. Other find that, in theory, use-value assessment should delay development of farmland, but the empirical evidence for this effect is mixed. Overall, the studies conclude that the incentives provided by use-value assessment are insufficient to prevent the development of farmland.

In the final section, I review several other studies that examine the determinants of property values, but do not directly consider effects of regulations, subsidies, or use-value assessment. One study considers how farmland values are affected by the residential housing market. Two others examine effects of property taxes and fiscal policies on property values.

Table 2.1. Studies of the Effects of Land-Use Regulations, Agricultural Subsidy Programs, and Use-Value Assessment on Private Property Values

I. THE EFFECTS OF LAND-USE REGULATIONS ON PRIVATE PROPERTY VALUES

I.A. *Net Effects of Land-Use Regulations on Property Values*

The Effect of Farmland Preservation Programs on Farmland Prices
Nickerson, Cynthia J., and Lynch, Lori, American Journal of Agricultural Economics, May 2001, 83(2): 341-351.

An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities
Spalatro, Fiorenza, and Provencher, Bill, Land Economics, November 2001, 77(4): 469-481.

Implicit Prices of Wetland Easements in Areas of Production Agriculture
Shultz, Steven D., and Taff, Steven J., Land Economics v80, n4 (November 2004): 501-512.

Capitalization of Exclusive Agricultural Zoning into Farmland Prices
Henneberry, David M., and Barrows, Richard L. Land Economics v66, n3 (August 1990): 249-258.

Housing Prices, Externalities, and Regulation in U.S. Metropolitan Areas
Malpezzi, Stephen, Journal of Housing Research, 7:2, 1996, 209-241.

The Effect of Environmental Zoning and Amenities on Property Values: Portland, Oregon
Netusil, Noelwah R., Land Economics Vol 81, No. 2, May 2005, 227-246.

Growth Management and Housing Prices: The Case of Portland, Oregon
Phillips, Justin, and Goodstein, Eban, Contemporary Economic Policy, Vol. 18, No. 3, July 2000, 334-344.

Neighborhood Composition and Residential Land Prices: Does Exclusion Raise or Lower Values?
Cervero, Robert, and Duncan, Michael, Urban Studies v41, n2 (Special Issue Feb. 2004): 299-315.

Could Zoning have increased Land Values in Chicago?
McMillen, Daniel P., and McDonald, John F., Journal of Urban Economics, 1993, 33, 197-188.

Land Values in a Newly Zoned City
McMillen, Daniel P., and McDonald, John F., The Review of Economics and Statistics, February 2002, 84(1):62-72.

Growth Controls and Land Values in an Open City

Brueckner, Jan K. Land Economics, Vol. 66, n3, 1990, 237-248.

Effects of an Urban Growth Management System on Land Values
Gleeson, Michael E., Land Economics, Vol. 55, No. 3, August 1979: 350-365.

The Effect of Land Use Regulation on Housing and Land Prices
Gleeson, Michael E., Land Economics, Vol. 55, No. 3, August 1979: 350-365.

The Effects of Zoning on Single-Family Residential Property Values: Charlotte, North Carolina
Judd, Donald G., Land Economics, Vol. 56, No. 2, May 1980: 142-154.

I.B. Positive Effects of Land-Use Regulations on Neighboring Properties

The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model
Ready, Richard C., and Abdalla, Charles W., American Journal of Agricultural Economics, May 2005, 87(2):214-326.

Measuring Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation
Ready, R. C., M. C. Berger, and G. Blomquist, Growth and Change, 1997, fall, 28,438-458.

Environmental Amenities and Agricultural Land Values: A Hedonic Model Using Geographic Information Systems Data
Bastian, Chris T., et al. Ecological Economics v40, n3 (March 2002): 337-349

The Problem of Identifying Land Use Spillovers: Measuring the Effects of Open Space on Residential Property Values
Irwin, Elena G., and Bockstael, Nancy E., American Journal of Agricultural Economics, Vol. 83, August 2001, pp 698-704.

Capitalization of Open Spaces into Housing Values and the Residential Property Tax Revenue Impacts of Agricultural Easement Programs
Geoghegan, Jacqueline, Agricultural and Resource Economics Review v32, n1 (April 2003): 33-45.

Treating Open Spaces as an Urban Amenity
Smith, V. Kerry, C. Poulus, and H. Kim, Resource and Energy Economics, 2002, 24(1-2): 107-129.

Using Contingent-Pricing Analysis to Value Open Space and Its Duration at Residential Locations
Earnhart, Dietrich, Land Economics v82, n1 (February 2006): 17-35.

Combining Revealed and Stated Preference Methods to Value Environmental Amenities at Residential Locations
Earnhart, Dietrich, Land Economics, 77 (Feb. 2001): 12-30.

Valuing Open Space and Land-Use Patterns in Urban Watersheds
Acharya, G., and L. L. Bennett, Journal of Real Estate Finance and Economics, 2001, 22(2/3), 221-238.

The Value of a Suburban Forest Preserve: Estimates from Sales of Vacant Residential Building Lots
Thorsnes, Paul, Land Economics v78, n3 (August 2002): 426-441.

The Influence of Wetland Type and Wetland Proximity on Residential Property Values
Doss, Cheryl R., and Taff, Steven J. Journal of Agricultural and Resource Economics v21, n1 (July 1996): 120-129.

Valuing Urban Wetlands: A Property Price Approach
Mahan, Brent L., Polasky, Stephen, and Adams, Richard M., Land Economics, February 2000, 76 (1): 100-113.

The Effects of Greenbelts on Residential Property Values: Some Findings on the Political Economy of Open Space
Correll, Mark R., Lillydahl, Jane H., and Singell, Larry D., Land Economics, Vol. 54, No. 2, May 1978: 207:217.

The Price Effects of Urban Growth Boundaries in Metropolitan Portland, Oregon
Knaap, Gerrit J., Land Economics, Vol. 61, No. 1, February 1985: 26-35.

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The Impacts of Different Farm Programs on Cash Rents
Lence, Sergio H., and Mishra, Ashok K., American Journal of Agricultural Economics, August 2003, 85(3):753-761.

The Incidence of Government Program Payments on Agricultural Land Rents: The Challenges of Identification
Roberts, Michael J., Kirwan, Barrett, and Hopkins, Jefferey American Journal of Agricultural Economics, August 2003, 85(3):762-769.

Noncash Income Transfers and Agricultural Land Values
Taylor, Mykel R., and Brester, Gary W. Review of Agricultural Economics v27, n4 (Winter 2005): 526-541.

The Effect of Agricultural Policy on Farmland Values
Weersink, Alfond, Clark, Steve, Turvey, Calum G., and Sarker, Rakhal, Land Economics, August 1999, 75(3):425-439.

Evidence of Capitalization of Direct Government Payments into U.S. Cropland Values

Barnard, C. H., G. Whittaker, D. Westernbarger, and M. Ahearn. American Journal of Agricultural Economics 1997, 79 (5): 1642-1650.

III. THE EFFECTS OF USE-VALUE ASSESSMENT ON PRIVATE PROPERTY VALUES

Agricultural Property Tax Relief: Tax Credits, Tax Rates, and Land Values
Anderson, John E., and Bunch, Howard C. Land Economics v65, n1 (February 1989): 13-22.

Effectiveness of Use-Value Assessment in Preserving Farmland: A Search-Theoretic Approach
Tavernier, Edmund M, and Li, Farong, Journal of Agricultural and Applied Economics v27, n2 (December 1995): 626-635.

Land Taxes in Agriculture: Preferential Rate and Assessment Effects
Wunderlich, Gene, American Journal of Economics and Sociology, Vol. 56, No.2 (April 1997): 215-228.

Use-Value Property Tax Assessment: Effects on Land Development
Anderson, John E., Land Economics, Vol. 69, No. 3 (August 1993): 263-269.

Use-Value Assessment Tax Expenditures in Urban Areas
Anderson, John E., and Griffing, Marlon F., Journal of Urban Economics, Vol. 48 (2002), 443-452.

Evaluating the Effectiveness of Use-Value Programs
Ferguson, Jerry T., Property Tax Journal (June 1988): 157-164.

Development Rights and the Differential Assessment of Agricultural Land: Fractional Valuation of Farmland is Ineffective for Preserving Open Space and Subsidizes Speculation
Blewett, Robert A., and Lane, Julia I., American Journal of Economics and Sociology, Vol. 17, No2, (1988): 197-205.

The Effect of Far Property Tax Relief Programs on Farm Financial Conditions
Chicoine, David L., Sonka, Steven T., and Doty, Robert D., Land Economics, Vol. 58, No. 4, (November 1982): 516-523.

IV. OTHER STUDIES

The Joint Influence of Agricultural and Non-farm Factors on Real Estate Values: An Application to the Mid-Atlantic Region
Hardie, I.W., Narayan, T.A., and Gardner, B.L., American Journal of Agricultural Economics 83 (2001) 120–132.

New Evidence on Property Tax Capitalization
Palmon, Oded, and Smith, Barton A. Journal of Political Economy v106, n5 (October 1998): 1099-1111.

Property Tax Limits, Local Fiscal Behavior, and Property Values: Evidence from Massachusetts under Proposition 2½

Bradbury, Katharine L., Mayer, Christopher J., and Case, Karl E., Journal of Public Economics, 80(2001) 287-311.

I. The Effects Of Land-Use Regulations On Private Property Values

I.A. Net Effects of Land-Use Regulations on Property Values

The Effect of Farmland Preservation Programs on Farmland Prices
Nickerson, Cynthia J., and Lynch, Lori, American Journal of Agricultural Economics, May 2001, 83(2): 341-351.

This study tests how the price of a farmland parcel is affected when a permanent easement is applied to the property. The study focuses on the voluntary farmland preservation program in Maryland which involves the purchase of development rights on agricultural land. The objective of the study is to determine how easements affect the property values.

The authors present a standard theoretical argument that easements should reduce farmland prices. The price of farmland, or any asset, in a competitive market equals the present discounted value of the stream of rents accruing to the asset. A profit-maximizing owner will always choose the highest possible rent stream. In the case of farmland, the owner will keep the land in its current agricultural use until the time when development becomes more profitable. Thus, the farmland price will reflect near-term rents from agriculture and future rents from development. Since these future development rents exceed future agricultural rents (by construction), it follows that an easement prohibiting future development must reduce the parcel's price.

The authors examine a data set on sales of 224 farmland parcels, 24 of which have permanent easements applied to them. These parcels were sold between 1994 and 1997 and are found in three Maryland counties (Calvert, Carroll, Howard). Summary statistics reveal that the price per acre for preserved parcels is $3,761, on average, and $8,998, on average, for unpreserved parcels. These prices are adjusted by net of the assessed value of structures (e.g., a house) on the property. The authors estimate a hedonic equation that controls for size, soil quality, distance to cities, and other factors. The authors also control for selection bias—namely, there may be a systematic tendency for some parcels to be enrolled in the voluntary easement program. Despite the large difference in the mean values reported above, the authors find no significant effects of preservation status on sales prices in the basic model. With an alternative specficiation that includes the preservation status variable interacted with other explanatory variables, some coefficients are significantly different from zero. However, the authors test and fail to reject the hypothesis that all of these coefficients are jointly equal to zero.

The authors offer two explanations for the lack of a significant effect of easments on farmland prices. First, they suggest that buyers may not expect the preservation program to last forever, implying that development will be permitted at some future time. Second, some buyers may not be primarily interested in the rent stream from agriculture, but rather value the opportunity to own a farm near an urban area.

The significance of this study is that it suggests that development restrictions may not reduce farmland prices if buyers place sufficiently high value on farmland amenities. It is likely that the enjoyment of these amenities will be greater if the owner is also allowed to live on the property. This study does not control for the presence or absence of a house.

An Analysis of Minimum Frontage Zoning to Preserve Lakefront Amenities
Spalatro, Fiorenza, and Provencher, Bill, Land Economics, November 2001, 77(4): 469-481.

This paper analyzes two competing effects from minimum frontage zoning. If lakefront owners prefer low-density development, then minimum frontage zoning will increase the associated amenities for existing residents. On the other hand, if lakefront development is relatively insensitive to frontage, minimum frontage zoning will restrict the subdivision of property, limiting potentially valuable development opportunities. A theoretical model is presented and data from Wisconsin lakes is used to estimate these competing effects.

The theoretical model demonstrates the development and amenities effects of minimum frontage zoning. First, assuming no amenity effects and no zoning, the authors argue that the price per unit of lakefront rises initially as frontage increases (when frontage is very small, an additional unit of frontage is highly valued) and then falls for high frontage values, as the marginal value of frontage decreases. When zoning is introduced (with no amenity effects), the price schedule is shifted down relative to the no-zoning case. This is the effect of restricting the division of properties. The price schedule with zoning is discontinuous with price jumps at points where sub-division of the property becomes possible (e.g., at 200 feet of frontage with 100-foot minimum frontage zoning). Zoning, however, creates amenities that shift up the price schedule. Which of these effects dominates is tested empirically.

The empirical model used arms-length property sales data from Vilas County and several adjacent towns in Oneida County, Wisconsin, from 1986 to 1995. All observations in the data set are of undeveloped properties. The unit price of frontage is specified as a function of the amount of frontage, property size, current state of development, location, and regulation. The model assumes 200-foot minimum frontage zoning on all properties. As such, dummy variables for properties with frontage greater than 200 feet or 400 feet are included to capture jumps in the price function.

The model was estimated separately with data for each year and the average of the results are presented. In most years, frontage has a positive and significant effect on property values. It is found that owners prefer properties near public rather than private lakeshore. Lakeshore in small tracts is generally preferred to lakeshore in large tracts when there is no 200-foot rule. This result is surprising as owners are expected to place value on the absence of development around them. The authors suspect that this result may due to omitted variable bias. A lake may be heavily developed because of features not captured by the model. As expected, the authors find a price jump at 400 feet when 200-foot rule is imposed. As well, both negative development effects and positive amenity effects of minimum frontage zoning are confirmed for propertys with lakefront between 200 feet and 400 feet. On average, the model predicted prices under the 200-foot rule to be 21.5% greater than what they observed price under less stringent state frontage standards.

This study examines the competing development and amenity effects of zoning in a relatively simple setting. It finds evidence that positive amenity effects outweigh losses from restrictions on development.

Implicit Prices of Wetland Easements in Areas of Production Agriculture
Shultz, Steven D., and Taff, Steven J., Land Economics v80, n4 (November 2004): 501-512.

The study investigates the effect of wetland easements on agricultural land values in North Dakota. The implicit prices of wetlands and wetland easements have proved difficult to quantify in previous hedonic studies in North Dakota and other areas with production agriculture. The authors suggest that problems with the data may be the obstacle.

This research presents a hedonic model of agricultural land prices. It uses data on 236 agricultural land sales between 1995 and 2002 in North Dakota, as well as data on site-specific land use, soil productivity, and hydrologic condition data. Three counties in North Dakota are represented that contain some of the highest concentrations of wetlands and waterfowl breeding habitat in the Unites States. The gross revenue was used as an indicator of the parcel's productivity, and is expected to have a positive effect on the sale price. The option value for future non-agricultural development was not considered because the probability of such conversion is extremely low. The parcels were distinguished by the presence or absence of wetlands easements and whether the wetlands are permanent or temporary (a temporary wetland is dry part of the year). (Note that parcels with wetlands also have land used for agricultural production). Wetlands and easements are expected to have negative effect on price. The authors also estimate two alternative models: one that does not distinguish between wetlands with and without easements and one that does not distinguish between permanent and temporary wetlands.

The results show that permanent wetlands (with and without easements) have negative and statistically significant effects on price. Permanent wetland acreage is worth 60% of the value of agricultural land in the same area. Easements reduce the agricultural land value by 39%. This effect is much smaller than the results from previous studies suggest (60%). However, temporary wetlands, with or without easements, have a positive, though statistically insignificant, effect on prices. To explain these results, the authors suggest that temporary wetlands may still be suitable for agricultural production and not visible during the dry season. As well, they point out that sellers are not legally required to disclose to the buyer the existence of an easement applied on the parcel. This may explain the insignificant effect of easements in the case of temporary wetlands.

The key finding in this study is that wetlands easements reduce agricultural land values when the wetlands are permanent but not when they are temporary. A potential weakness of the study is that it does not account for the proportion of a land parcel occupied by wetlands, which is surely an important factor affecting price.

Capitalization of Exclusive Agricultural Zoning into Farmland Prices

Henneberry, David M., and Barrows, Richard L. Land Economics v66, n3 (August 1990): 249-258.

Previous studies on agricultural zoning suggest that zoning decreases land values due to the loss of development opportunities. The authors argue that whether zoning has a positive or a negative effect should depend on the characteristics of parcels. Four price effects of zoning are identified: 1) development – zoning may reduce land values by restricting development opportunities, 2) externality – zoning may increase land values by limiting negative externalities from farm operators from nearby non-agricultural land, 3) neighborhood certainty – zoning may insure that future land-use patterns are compatible with agricultural production, thereby raising land values if farm operators tend to be risk averse, and 4) tax – the effects of zoning on property taxes is unclear since it depends on how land values are affected. This paper seeks to identify which of these effects dominates.

For a hedonic price analysis, the records of 140 farmland parcels sold in either 1980 or 1981 in Rock County, Wisconsin are chosen. Twenty of the parcels were developed after the transactions. These parcels are used in a discriminant analysis to identify which of the remaining 120 parcels have high development potential. Hedonic price models are then estimated with observations of 89 parcels with high agricultural potential, among which 60 are zoned and 29 are non-zoned. The independent variables include the productivity of the land, accessibility, and neighborhood characteristics.

The results indicate that the net price effect of zoning depends on the zoning classification, parcel size, and distance to the urban area, taken together. To illustrate this, the authors report that a 100-acre parcel 11 miles from the nearest city would sell for $25.62 more per acre as zoned land than as non-zoned land. A 160-acre parcel 9 miles from the nearest city would sell for $43.44 more per acre as zoned land. And, when a parcel is 260 acres and 5 miles away from the nearest city, the value of a zoned parcel is $6.88 per acre more than a non-zoned. Alternatively, a 40-acre parcel located 6 miles from the nearest city would sell for $687 more per acre if not zoned for agricultural use.

This study attempts to sort out different effects of agricultural zoning. It reveals that, depending on the characteristics of parcels, the net effects of zoning may be positive. This effect was found, in particular, for large farmland parcels somewhat removed from urban areas.

Housing Prices, Externalities, and Regulation in U.S. Metropolitan Areas
Malpezzi, Stephen, Journal of Housing Research, 7:2, 1996, 209-241.

In this study, the authors attempts to measure the costs and benefits of housing market regulations. Several questions are investigated: 1) does more stringent regulation raise housing prices?, 2) are more stringent regulations associated with lower external costs or higher benefits?, and 3) are there cities that have excessively stringent regulations?

In a simple demand and supply framework, the author shows that regulations are expected to raise housing prices because they restrict the number of housing units in order to diminish associated externalities. Using Population Census data on a large cross-section of cities, an empirical investigation is conducted to measure these effects on housing and rental prices. As well, the effects of regulations on tenure choice (own v. rent), commuting times, segregation, and neighborhood quality are also estimated.

The equilibrium prices of rental or owner-occupied housing are specified as functions of income, demographic characteristics, topographical characteristics, and regulations. Prices are measured as median house values and contract rents in each city, reported in the 1990 Census. The regulations include measures of rent controls, land-use restrictions and zoning, infrastructure policies, and building and subdivision codes. The author argues that since the model controls for inter-city differences in demand (e.g,.

with the income variable), the regulations variables should measure supply-side effects on prices. In the other models, the dependent variables (tenure choice , commuting time, segregation, and neighborhood quality) are specified as functions of rental price, housing price, income, demographic and topographic characteristics, and regulations.

In the rental price model, population change and the level and change in income have significant effects. None of the regulations variables are significant. In the housing price model, income growth has a positive and significant effect. As well, regulations are found to raise house prices in two of three cases. An index of state regulations and a rent control dummy variable have positive and significant effects, while a second regulatory index has a negative and significant effect. Heavily regulated cities were found to have less homeownership. Regulations were not found to significantly affect segregation or neighbhorhood quality and, finally, state regulations would found to shorten commuting times, though the effects were small.

This paper examines effects of regulations on housing and rental prices as well as potential benefits of regulations. The key finding is that regulations tend to increase housing price and lower homeownership rates, while having small or no effects on commuting times, neighborhood quality, and segregation. The major challenge with studies of this type is that they involve highly aggregated data. As a result, it is difficult to explain the variation in the cross-section and to interpret the results.

The Effect of Environmental Zoning and Amenities on Property Values: Portland, Oregon

Netusil, Noelwah R., Land Economics Vol 81, No. 2, May 2005: 227-246.

The author examines the effects of environmental zoning on the housing prices in Portland, Oregon. There are two levels of environmental zoning in Portland: environmental protection zoning (p-zone) and environmental conservation zoning (c-zone). P-zone allows current structures and development to be maintained but prohibits increasing the footprint of a house, adding decks, or changing vegetation. C-zone is less stringent as it allows development if alternatives have been considered. The effect of either type of zoning on housing prices is uncertain since environmental zoning both limits development opportunities but increases environmental amenities in a neighborhood.

In a hedonic model, the sale price of a property is specified as a function of structural, neighborhood, environmental and regulatory attributes. The study use the arms-length transactions prices of single-family residential properties sold between 1999 and 2001 in Multnomah County. Undeveloped parcels were not included. The study area was divided into quadrants by location. Two ways of entering the zoning variables were considered. One model includes interaction variables to reflect the environmental zoning effects, including combined effects of p-zone and c-zone, in each quadrant. The other replaces environmental zoning dummy variables with variables that interact lot size with environmental zoning in each quadrant and variables that capture the effect of environmental zoning on oversized lots.

For the first model version, p-zone has a negative effect in the Northwest quadrant and a positive effect in the Northeast, but has no statistically significant effects in other quadrants. A combination of p-zone and c-zone has significant and positive effects in the Northeast and Southeast. C-zone has statistically significant and positive effects in the North and negative effects in the Southwest. The results also show that only in Southeast are sale prices affected by the amount of the property with an environmental zone, and that environmental zoning effects are not equal across quadrants. More tree canopy has a positive effect on house prices and other neighborhood amenities (golf courses, trails, etc.) had statistically significant effects on sale prices. For the second model version, it was found that increasing lot size increases housing prices more if there is environmental zoning.

This is a very detailed hedonic study of the effects of zoning in the Portland metropolitan area. The significance of the study is that it measures the net effects of regulations—both the negative effect from restricting development and the positive effect from generating neighborhood amenities. It finds that the net effect can be positive or negative.

Growth Management and Housing Prices: The Case of Portland, Oregon
Phillips, Justin, and Goodstein, Eban, Contemporary Economic Policy, Vol. 18, No. 3, July 2000, 334-344.

This paper investigates the impact of the Portland, Oregon's, urban growth boundary (UGB) on housing affordability. In theory, since the UGB constrains the amount of land available for urban growth and, thus, promotes infill development, it raises land prices and population density. But its effect on housing prices is ambiguous. Higher land prices induce housing developers to substitute capital for land, which mitigates increases in the price of housing. Based on data from the 1990s and earlier studies on the Portland housing market, the authors conclude that the UGB has increased land prices and housing densities. The effect on the house prices, however, is less clear. Although data show that the median housing price in Portland increased by 69% from 1991 to 1996, the price level in 1996 was still lower than that in similarly sized western cities. This study examines if rising house prices are due to the UGB or a growing regional and national economy.

A hedonic model is estimated with data on 1996 median housing prices in Portland and 36 other major western cities. The authors control for factors affecting housing demand and supply, including population, income, climate, construction costs, and the rate of recent price appreciation as a proxy for speculation. To measure the effects of regulations, the authors include a variable for the number of municipalities within the city, with the expectation being that more municipalities imply less stringent regulations. The argument is that when there are many municipalities, each will assume it cannot influence the price of land and, therefore, will not restrict development in order to convey rents to current owners of land. The authors also include the regulation index developed by Malpezzi (1996). The index is measured in 1990, before the time period in this study. To reflect strong effects from the UGB, the authors increase Portland's value of the index from its 1990 value of 19 to the highest possible value of 30, while keeping the index for other cities unchanged.

Two versions of the model were estimated—one included a variable for speculative effects and one omitted this variable. In the two models, median income and construction costs have positive and significant effects on housing prices. In the model without a speculative effect, regulations are found to have a positive and significant effect on prices. To simulate the effects of removing the UGB, the authors lower the regulation index for Portland from 30 to its original value of 19. The predicted median housing price falls between \$15,246 and \$21,503 depending on the version of the model used. The implication is that the UGB has increased housing prices by between 10% and 15%, which the authors view as a relatively small change.

This paper tries to measure the effects of Portland's UGB on housing prices using a cross-sectional data set of western cities. The UGB is crudely represented in the hedonic model. As well, the analysis does not account for the fact that if the UGB encourages the substitution of capital for land, the median house in Portland may be a very different commodity compared to median houses in other western cities.

Neighborhood Composition and Residential Land Prices: Does Exclusion Raise or Lower Values?

Cervero, Robert, and Duncan, Michael, Urban Studies v41, n2 (Special Issue Feb. 2004): 299-315.

This paper argues that zoning and fiscal policies have led to exclusion in urban land markets. The authors use land-use and racial composition as outcome proxies for local zoning policies and test their effects on residential land values in a hedonic regression.

The study area is Santa Clara County, California. The county has a lack of affordable housing, a long average commute time, and low-density development. The authors obtain property sales data for in 1999 and impute unit land prices associated with single-family and multi-family residential parcels. In the hedonic price model, explanatory variables are included for neighborhood land-use characteristics reflecting zoning outcomes; neighborhood socio-demographic characteristics, which are partly a product of zoning; accessibility; and municipality and time effects. The neighborhood and household characteristics might be endogenous and instrumental variable regression was used to address this problem.

Measures of neighborhood land-use attributes are included to proxy for zoning policies. The land-use mix is measured with an index based on shares of land in different activites within a 1-mile buffer around the parcel. These activities include single-family housing, multi-family housing, retail, services, and so forth. Additional measures are included for retail and single-family residential uses and for the jobs-housing balance. Neighborhood socio-demographic attributes are assumed to proxy in part for zoning policy outcomes. Variables are included for racial mix and income in the neighborhood surrounding a parcel.

Most of the coefficient estimates are statistically significant and consistent with expectations. The results indicate that the land-use mix and the jobs-housing balance have significant effects on land values. A single-family house in a neighborhood with the greatest diversity of land uses sells for $8.70 more per square foot than a house in a single-use neighborhood. In contrast, a single-family house in a neighborhood with the greatest racial diversity sells for $5.14 less per square foot than a house in a racially uniform neighborhood.

This paper examines how land-use and racial attributes of neighborhoods, taken to be indicators of zoning policies, influence land values. The authors find evidence that land-use and racial diversity have significant effects on land prices.

Could Zoning have increased Land Values in Chicago?
McMillen, Daniel P., and McDonald, John F., Journal of Urban Economics, 1993, 33, 197-188.

This paper examines the effects of zoning on land values in 1920s Chicago. At the time, Chicago's Zoning Commission claimed that zoning will improve welfare by separating incompatible land uses. This paper derives a necessary condition for zoning (of the type used in Chicago) to increase land values and then conducts an empirical analysis to find if this condition was satisfied. The authors find that it was not satisfied and conclude that zoning—of the type practiced in 1923—could not have increased land values.

The theoretical model assumes that there are two types of land use: residential and nonresidential. Due to high commuting costs, nonresidential land (include work and commercial locations) may have positive effects on nearby housing prices. It may also generate negative externalities due to incompatible uses. Nonresidential values may be similarly affected by proximity to residential uses. The objective for the social planner is to maximize the value of land by choosing the proportions of a street block to put into residential and non-residential uses. The authors also solve for the competitive market solution and show that it may not correspond to the social optimum if private owners ignore externalites. They then ask whether block-level zoning, under which a block could be entirely assigned to residential use (the type of zoning used in Chicago), could increase land values relative to the competitive solution. They show that for block-level zoning to increase land values, the residential land value when all land on a block is residential must be higher than the existing land value.

To test whether this condition is satisfied, the authors assemble data for 1921, prior to the enactment of zoning. They regress the log of front-foot land value for each land use (residential, non-residential) on explanatory variables (distance to CBD, transportation access, etc.) and the proportion of residential land in a block. The authors control for a selection problem arising from the relatively higher value of land for residential uses and for the endogeneity of the proportion of residential land in a block.

The results indicates that increasing the proportion of residential land in a block does not affect residential land values on the south side of Chicago. As well, on the north side, there is a premium associated with being the first resident of a block. Neither of these results are consistent with the condition that converting a block entirely to residential use results in higher land values than those of non-residential or mixed uses.

The main implication of these results is that the type of zoning used in Chicago in 1923—block-zoning, which the authors refer to as a "blunt instrument"—could not have increased land values. However, this does not imply that the land-use patterns generated by the competitive market were optimal. Moreover, they suggest that mixed uses were preferred—in particular, the disamenities of living near businesses were outweighed by access to employment and shopping.

Land Values in a Newly Zoned City

McMillen, Daniel P., and McDonald, John F., The Review of Economics and Statistics, February 2002, 84(1):62-72.

This paper examines the impact of zoning on land prices. The introduction of zoning in Chicago in 1923 offers a natural experiment to identify how zoning affects the relative growth rates in values for residential and commercial land.

The experiment is described by the authors as follows:

> Suppose we were to observe a sample of otherwise identical parcels of land, all of which are initially unzoned. A new ordinance is adopted under which some parcels are zoned residential and others are zoned commercial. If we know land values before and after the new ordinance, then the difference in the land-value growth rate between residential and commercial parcels provides a clean measure of residential zoning's effect relative to commercial zoning. Of course, if no parcels remain unzoned, we cannot determine whether growth rates are higher overall after the zoning ordinance than would have purveyed under the new law. But if the zoning ordinance is necessary to eliminate unwanted intrusions of commercial land into residential areas, we should find that land-value growth rates are relatively high in areas that are zoned exclusively residential.

The authors use data on land values in Chicago in 1921 (before zoning) and 1924 (after zoning), along with information on initial land use, zoning, and accessibility. The authors control for selection bias—in particular, the possibility that blocks with high land-value growth rates are more likely to be zoned residential—and then compared changes in land values across zoning classifications.

The results indicate that residential zoning increased relative land values (residential minus commercial land-value growth rates) by 19.5%. As well, residential zoning increased relative land values by 18.4% in mixed-use blocks and 47.7% in commercial blocks. In sum, residential zoning led to higher land values than did commercial zoning.

The authors find that the Chicago zoning policy raised the growth rate of relative land values. However, since the authors cannot observe the 1924 land value without zoning, changes in the price level attributable to zoning cannot be estimated.

Growth Controls and Land Values in an Open City
Brueckner, Jan K. Land Economics, Vol. 66, n3, 1990, 237-248.

Previous studies have found that growth control raises housing prices in the communities where they are imposed and lower the value of undeveloped land near the city. This paper develops a formal dynamic model based on the framework of Capozza and Helsley (1989) to illustrate the effects of urban growth control.

The author effectively summarizes the analysis and key results in the introduction to the paper:

> Building on the framework of Capozza and Helsley (1989), the model focuses on the land development decision (conversion from rural to urban use) of a landowner operating with perfect foresight in a dynamic open-city environment. The time path of urban land rents in the model in part reflects the presence of a negative population externality (a large population lowers the city's quality of life and reduces the rent that urban land commands). After deriving the optimal date of rural-urban conversion (the date that maximizes land value), the analysis considers the effect of an unanticipated growth control regulation, which delays conversion at each location. The model's population externality is, of course, the key factor in the analysis. Given the externality, a slowing of population growth due to the control

> raises land's rent in urban use at every date and location as consumers pay a premium to live in a smaller city. For land that is already devleoped, imposition of the control raises all future rents and therefore increases the value of the land. This corresponds to the amenity effect of growth controls that has been identified in the literature.
>
> The control's impact on the value of undeveloped land is, however, not as straightforward as the literature would suggest. The impact is the net effect of two changes: first, the control delays the date at which urban rents can be earned, which lowers value; second, the control raises urban rents by lowering the city's population growth path, which raises value. Since the second of these effects may dominate, growth controls can raises the value of undeveloped land in some locations, in contrast to the literature's implicit assumption to the contrary. The analysis attempts to pinpoint the locations of undeveloped land that benefit from the imposition of a control.

The key finding is that growth controls may raise the value of undeveloped land by reducing the population externality and, thereby, raising future development rents which are capitalized into the value. The paper also considers efficient growth controls and concludes that mild controls are likely to raise total land values, but stringent ones may reduce total land values relative to the unregulated case.

Effects of an Urban Growth Management System on Land Values
Gleeson, Michael E., Land Economics, Vol. 55, No. 3, August 1979: 350-365.

In this study, the author attempted to investigate how urban growth management policies influence land values in Minnesota. The author expected that urban growth management policies will divide the land market into two submarkets: developable and undevelopable. When an urban growth management system is creditable, value of undevelopable land may be the same as the value of unusable land. Value of developable land will be the same as the value of land in comparable uses elsewhere in the market. Since urban growth management policies may reduce land supply, the author also expected that the value of developable land would increase. However, the magnitude of such an increase depends on the degree of restriction and whether the whole market is under restriction.

In order to make land values comparable, there are several control variables: accessibility, feasibility of future development, soil type, nearby amenities, segment of land market, and land use zoning. Accessibility was measured by traveling time to the nearest business center. Feasibility of future development was determined by parcel slope, whether it was located in a flood plain, and water table on a parcel. An OLS regression was conducted in this study.

The sample for this study was randomly drawn from all unimproved or un-subdivided parcels in Brooklyn Park, Minnesota – a second tier suburb of Minneapolis - in 1972. An urban growth management system was first instituted in this area in 1963. The sample includes 131 farmed parcels and 247 urban parcels. The author used assessed market value per acre in 1960, 1964, 1968, and 1976.

Comparing the trend of developable and undevelopable land value, the author found that there is an observable divergence in value between these two submarkets. For farmland, the value of developable land rose more than twice the value of undevelopable land in 1968, and such divergence grew over time. Similar results were also found for urban vacant parcels only with a smaller divergence in values of developable and undevelopable land.

This study shows that an urban growth management system separates a local land market into developable and undevelopable submarkets. However, such price effects of urban growth management system are only significant when the parcel is small and growth control policies are binding. The author also addressed that the results of this study do not necessarily indicate that urban growth management limits land supply significantly. Unlike numerous recent studies, land owners' characteristics were not included in the regression. Since land owners' characteristics have been proved to be related to the variations in land values, excluding them in the regression may lead to biased results.

The Effect of Land Use Regulation on Housing and Land Prices
Gleeson, Michael E., Land Economics, Vol. 55, No. 3, August 1979: 350-365.

In this paper, the author attempted to investigate how the stringiness of land use regulation affects price of single-family housing and vacant land. Unlike abundant previous literatures on this topic, this study considered land use regulation as an endogenous variable. The study used separate empirical models for single-family housing and vacant land with a cross section data from Florida.

The theoretical model assumes that the restrictiveness of land use regulation is endogenous. The author argued that land use regulations often have various effects on land or housing values. Price effect is only one of them. Local amenities may also be results of land use regulations. Therefore, land owners with certain demographic characteristics may offer a higher price to a parcel with the regulations that match their tastes. The author also expected that housing or land demand elasticity may also vary across communities with different land use restrictions. Since land use regulation restrictiveness was treated as an endogenous variable, a two-stage least square estimation method was used in the regression.

The data used in this study were collected from several agencies. The variables used in the regressions include sales prices for single-family housing and vacant parcels, demographic characteristics, the land use regulation restrictiveness index, location, jurisdiction control variables, and sales year. The dataset covers 25 counties in Florida and sales occurring between 2000 and 2002. Jurisdiction control variables include the form of local government and the degree of school crowding. The degree of school crowding is based on a survey of a local chief planner's perception. The land use regulation restrictiveness index was constructed by summing up the number of land use regulations. Some regulations were given more weight considering their impact on the housing and land market, but most were not.

The regression results show that land use regulation restrictiveness is positively related to housing prices and developer's costs. However, such relationship is weaker in those counties with more cities. Therefore, the author concluded that when land owners have a higher taste for strict land use regulation, the elasticity of their demand for housing or land is smaller. The author also found that there is no relationship between a good housing/land market and having a professional manager in local government. The regression results also show that crowded schools reduce property values.

There are several potential issues in this study. First, as the author addressed in the article, the method used for constructing the regulation strictness index might be too simple, since the regulation strictness mainly reflects the number of regulations. Second, more information should be included in the regression for vacant land. In the regression, the only variable that reflects a parcel's feature is lot size. Several past studies have shown that parcel slope and soil quality might affect the cost of housing construction. Therefore, these factors might be related to vacant land prices as well. Third, the degree of school crowding was based on the local chief planner's opinion. This indicator might be biased in some cases. Other indicators that might be more neutral should be considered, such as the ratio of teacher to students.

The Effects of Zoning on Single-Family Residential Property Values: Charlotte, North Carolina

Judd, Donald G., Land Economics, Vol. 56, No. 2, May 1980: 142-154.

This study attempted to investigate how zoning affects the value of single-family parcels in Charlotte, North Carolina. The study included both residential zoning and minimum-lot-size zoning.

In this study, the author used a hedonic model. The dependent variable is sale price of a property per square foot of structure. Independent variables include housing characteristics, land-use patterns of a neighborhood, demographic features, zoning policies, and lot size. The use of price per square foot of structure may be arguable because a property size includes more than the size of the housing structure. The size of the front and back yard is also important to many consumers. And zoning policies often place restrictions directly on parcel size, instead of structure size. Therefore, using parcel size might be a better choice for this research because minimum-lot-size zoning is one of the zoning variables in the regression. The author showed the regression results of using total market price of a property and market price per square feet of lot area. He concluded that there is no significant difference in results when using alternative variable specifications for price. The zoning policies used in this research include exclusive single-family residential zoning (which has no lot size restriction) and a minimum-lot-size zoning policy. The percentages of different land uses (industrial, commercial, and vacant) in a neighborhood were used to represent land-use patterns. A distance variable was constructed by combining weighted distances between a property and nearby major employment centers.

The regression model was estimated with two function forms: quadratic and semi-log. The dataset was split into two if a parcel was located in ghetto (area with high percentage of black residents). The regression was estimated with the full set of data and the subset samples from outside the ghetto area. The author suspected that housing market inside and outside the ghetto might be different.

The dataset is consisted of 3513 samples that were randomly drawn from 1976 tax appraisal records for one county in Charlotte area. All parcels in the sample had been sold in 1970. All sale prices and census data were collected from 1970 records, while all other variables were collected from the records of 1976. The dataset includes both new and existing residential properties. 3149 parcels were considered being located outside the ghetto.

Most estimated coefficients are consistent with the author's expectation. The constructed distance variable has an unexpected sign in three out of four regressions. The author suspected that the method of weighted average is not appropriate for the urban development patterns in the Charlotte area. Regression results show significant statistical evidence for the positive effect of exclusive single-family zoning on the value of residential properties. The semi-log model shows that exclusive single-family zoning may increase property value by 11%. However, minimum-lot-size zoning has a statistically significant negative effect on property values. Such negative impact might be 8% to 10% of property value. The author also concluded that land-use patterns might also affect residential property values. However, the statistical evidence for this result is not very strong.

I.B. Positive Effects of Land-Use Regulations on Neighboring Properties

The Amenity and Disamenity Impacts of Agriculture: Estimates from a Hedonic Pricing Model

Ready, Richard C., and Abdalla, Charles W., American Journal of Agricultural Economics, May 2005, 87(2):214-326.

This paper examines the effect of local amenities and disamenities of agricultural land. Agricultural land provides positive amenities in the form of open space, but may also generate negative effects if associated with animal operations. Because intensive animal production tends to be associated with large farms, hedonic studies need to account for positive and negative impacts of agricultural land to avoid biased results. This model also controls for the effects of zoning on house prices.

The study uses data on single-family home sales in Berks County, Pennsylvania, between 1998 and 2000. Housing prices are assumed to be related to housing structural characteristics, zoning, and neighborhood features. The zoning variables indicate whether the parcel is zoned for residential, agriculture, commercial/industrial, multiple use/village, or conservation. Measures of surrounding land uses are included. These include the acres of different types of open space and residential land within 400 meters of the house and between 400 and 1600 meters from the house. Disamenity effects are captured by measures of proximity to animal production, mushroom production, landfills, sewage treatment plants, roads and airports. The proximity measures were constructed in a way that allows the disamenity to decrease with distance to the house. Other measures were developed to test whether the disamenity effects from agriculture vary with the scale of the operation, the species housed in the facility, and whether the farm has a detailed conservation management.

Most of the estimated coefficients for housing and location characteristics are significantly different from zero and have signs consistent with expectations. Publicly-owned forested open space has the highest amenity effect of all land uses within 400 meters. Between 400 and 1600 meters, large-lot residential properties and commercial sites have the highest positive impact on house prices. Open space with easements provides a positive amenity to the neighborhood, however, its effect is smaller than that of open space without easements. All of the local disamenities have negative effects on house prices, with the exception of sewage treatment plants. High traffic roads are found to have the smallest negative impact, perhaps because accessibility provided by the road partially offsets its disamenity. Animal production operations have negative and statistically significant effects on house prices. For instance, the value of a residential house declines by 5.8% when a poultry operation is located within 800 meters. Among the zoning variables, only the coefficient on multiple use/village is significantly different from zero. The result indicates that houses with this zoning have higher prices than land zoned for residential. Other types of zoning do not produce significant price differences.

This paper uses a very detailed data set to quantify the effects of surrounding land uses on housing prices, and demonstrates that effects can be positive or negative. It also quantifies effects of zoning on housing values.

Measuring Benefits from Farmland: Hedonic Pricing vs. Contingent Valuation
Ready, R. C., M. C. Berger, and G. Blomquist, Growth and Change, 1997, fall, 28: 438-458.

This study investigates the amenity effect of farmland. Farmland may provide use values for non-farm residents, such as scenic views, wildlife habitat, and outdoor recreation, as well as non-use existence values from knowing that farm families can continue in their chosen profession. The existence value cannot be estimated by the hedonic price method but can be measured using stated preference techniques. This paper uses both contingent valuation and hedonic analysis to evaluate amenity value of horse farms for Kentucky residents.

In the theoretical model, the authors assume that households maximize their utility by choosing housing location and firms minimize costs by choosing a location for their business. Individuals and firms are free to move across markets. Household utility is a function of wage, housing price, and amenities. A firm’s cost is affected by wage, population, and amenities. Equilibrium is achieved when no individual and firm wants to move. By jointly solving the utility function and the cost function, the implicit price of farmland amenities can be expressed as a function of population, the marginal effect of farmland amenity on equilibrium rent, and marginal effect of farmland amenity on equilibrium wage.

For the hedonic model, household-level data was obtained from the 1980 Population Census for over 253 counties in Kentucky. Hedonic housing and wage equations were estimated separately, and used to calculate the implicit prices of amenities related to horse farms. The housing equation includes variables measuring reported house values, structural and location features, climate conditions, and amenity levels. The wage equation includes variables measuring reported income, household characteristics, climate conditions, and amenity levels. Most estimates in the two equations are statistically significant. The result suggests that people would be willing to accept a lower wage, but not pay a higher housing price, to have horse farms in their county. The estimated implicit price of one horse farm for the average Kentucky resident is $0.43.

The contingent valuation survey, conducted in Kentucky, was designed to ask non-farm dwellers that if they would accept a government program with different levels of funding to support horse farms. Under the program, money paid to farm owners would come from gamblers at racetracks instead of from households directly. The dependent variable is willingness to pay for the program. The independent variables include the number of farms lost without the program in the county and the funding level. Based on the current average level of 142.3 farms in a Kentucky county, WTP to avoid one lost farm is $0.49, for 25% lost is $24.84, and $681 for 75% lost.

This paper shows that horse farms in Kentucky generate positive externalities for local residents, which justifies the farmland preservation program in the state.

Environmental Amenities and Agricultural Land Values: A Hedonic Model Using Geographic Information Systems Data
Bastian, Chris T., et al. Ecological Economics v40, n3 (March 2002): 337-349.

This study estimated the impact of amenities provided by agricultural lands on agricultural land prices in Wyoming. Farmland prices could rise when the land provides recreational opportunities, wildlife, and open space, reflecting a household's demand for homes with rural amenities.

The authors use appraisal data for land sales transacted between 1989 and 1995 in Wyoming. GIS data is used to specify the detailed characteristics of each parcel. The explanatory variables for the hedonic analysis include parcel size, agricultural productivity, elk and fish habitat as indicators of amenities, distance to the nearest town, a time trend, and a view diversity index calculated as the proportion of the view area occupied by different land types that can be seen from the property. All the variables except the parcel size are expected to have a positive impact on farmland value. The hedonic model is estimated with alternative functional specifications.

The regression results show that most estimates are consistent with the expectations. The presence of elk habitat has a positive effect on land values statewide. However, elk habitat may decrease land values in some regions. A possible explanation is that elk may damage crops and fences, while in some areas generating little in hunting fees due to elk habitat on public lands. The presence of trout is a statistically significant factor contributing to a higher land price. View diversity is highly valued. The results suggest that people prefer a diverse landscape, which may indicate diversity of wildlife habitat in the area. As expected, the land value per acre decreases when being further away from a town, or having low agricultural productivity.

This paper uses GIS data to quantify the amenity attributes of farmland and finds that the presence of outdoor recreation opportunities and open spaces increases agricultural land prices. The significance of this study is that it shows how private amenities are capitalized into farmland prices.

The Problem of Identifying Land Use Spillovers: Measuring the Effects of Open Space on Residential Property Values
Irwin, Elena G., and Bockstael, Nancy E., American Journal of Agricultural Economics, Vol. 83, August 2001: 698-704.

This paper proposes an empirical model to examine the effects of private open space on residential housing prices. It confronts two identification problems. First, it recognizes that the residential value of parcel *i* depends on the development status of its neighbors. Whether the neighbors are developed depends on their residential value which is determined, in part, by the development status of parcel *i*. This implies that open space on neighboring parcels is endogenous. The second problem is related to spatial correlation. The factors that cause parcels to be more or less valuable will often be spatially correlated. If some of these factors are omitted from the model, and are correlated with open space variables, there will be omitted relevant variables. Both identification problems result in biased coefficient estimates.

The hedonic study used arms-length single transactions of owner-occupied residential properties data from 1995 through 1999 in Maryland. The authors estimate the model ignoring the endogeneity problem and then re-estimate it using instrumental variable regression to eliminate the endogeneity. The explanatory variables include structural, location and neighborhood characteristics. In order to measure the impact of open space, the authors used the percentage of open space in the area surrounding the parcel. Three types of open space are considered in the empirical model: privately-owned developable, privately-owned protected, and public open space. The first type is assumed to endogenous and the third type is exogenous. Since privately-owned protected open space may be endogenous, the authors estimate two separate models, one treating it as a separate exogenous variable and another including it with the privately-owned developable open space and treating it as endogenous.

In the basic model, most estimates are significant differently from zero and consistent with expectations, with the exception of privately-owned developable open space. Its coefficient is negative and not significantly different from zero. The model is re-estimated using instrumental variables to eliminate the endogeneity of the private open space variables. The results show, as expected, that private open space has positive and significant effects on housing prices. A test is also done that reveals evidence of spatial autocorrelation in the model's error terms.

This paper shows that the estimates in the hedonic model examining the effect of open space on housing values may be biased if the model ignores endogeneity problems. They find that open space is important for homeowners in the study area and that the amenity effects of open space varies by the type of open space.

A related paper is Irwin, E.G. 2002. The Effects of Open Space on Residential Property Values. *Land Economics* 78(4): 465-480. This paper presents estimates of the value of preserving open space.

Capitalization of Open Spaces into Housing Values and the Residential Property Tax Revenue Impacts of Agricultural Easement Programs
Geoghegan, Jacqueline, Agricultural and Resource Economics Review v32, n1 (April 2003): 33-45.

This study develops a hedonic model to estimate the capitalization of nearby open space into the sale prices of residential properties purchased through an agricultural preservation program in Maryland. Open space is expected to increase neighboring values of residential parcels, and permanent open space is expected to have a larger effect on housing prices than private open space which may be developed at some future time.

The data consists of arms-length transactions that occurred between 1993 and 1996 in three Maryland counties. In the hedonic model, the sale prices are specified as a function of structural housing and neighborhood characteristics, location, and indices constructed to measure the amount of preserved and developable agricultural, forest, and recreational open space. The indices were calculated for open space within 100-meter and 1600-meter buffers to capture the different types of benefits provided by open space (e.g., views v. recreational opportunities). The author controlled for the potential endogeneity of the open space measures. This arises from the fact that development decisions on a given property affect the value of the property as well as the value and development of the surrounding properties contained within the 100-meter and 1600-meter buffers. Instrumental variables are to control for this endogeneity.

Permanent open space within the larger buffer is found to raise sale prices in Calvert County This effect is found for the small and large buffers in the case of Howard County, while no significant effects are found in Carroll County. In all three counties, there is no evidence that having private forest or agricultural land in the neighborhood increases land values. The reason for this result could be the uncertainty related to the future development of the land and negative externalities from the agricultural production.

This key result from this study is evidence of positive amenity effects on neighboring properties from an agricultural preservation program in Maryland.

Treating Open Spaces as an Urban Amenity

Smith, V. Kerry, C. Poulus, and H. Kim, Resource and Energy Economics, 2002, 24(1-2): 107-129.

This paper estimates the different effects of permanent and developable open space on housing values in the surrounding area. In the case of developable open space, potential home buyers may have different expectations regarding the nature of future development. For instance, some buyers may expect the open space to be developed into a way that generates negative externalities. As such, the price effect of developable open space should be lower than that of permanent open space.

The study area is northern Wake County, North Carolina. Residential property transactions (exclusive of undeveloped land sales) from 1980 to 1998 were used in a hedonic price study. House prices were adjusted to account for appreciation over time. There are two reasons for focusing on this study area. First, there is a newly built "loop roadway". It was under discussion in the late 60s, designated in the early 70s and partially completed by 1998. This area has also experienced rapid population growth. These changes may alter residents' expectations regarding the future landscape and help to explain the effect of land use on house prices.

The independent variables include the usual measures of housing and neighborhood characteristics. Variables for distance to and adjacency to open space are developed. Permanent open space includes publicly-owned open space and private golf courses. Developable open space includes vacant land, and agricultural and forest land.

Most the estimates are consistent with expectations. There is statistical evidence for the negative effect of distance to vacant land and golf courses, as well as positive effects of being adjacent to them. Comparing the two, golf courses were found to provide higher amenity values than vacant land at all distances. The results also indicate that people do not want to live close to I-540, and the further away the better. This reflects the disamenity of construction and noise. Some estimates have counterintuitive signs. Proximity to public open space does not add value to houses. Since public open space is permanent during the study period and it provides apparent amenities, this result is counter to expectations and results from other studies.

This study shows that most open space is important for local residents and that is raises house prices to a greater degree when future development is less likely.

Using Contingent-Pricing Analysis to Value Open Space and Its Duration at Residential Locations
Earnhart, Dietrich, Land Economics v82, n1 (February 2006): 17-35.

This paper estimates the value of open space for nearby residents using contingent valuation and conjoint analysis. A survey is designed to mimic hedonic-pricing analysis. Respondents who are recent home buyers are asked to state their willingness to pay (WTP) for each of two identical houses with different levels of adjacent open space, and then to give WTP for each of two identical houses with different probabilities that the open space would be developed. The paper used the difference between the two values to measure the marginal WTP for open space and its expected duration.

The survey respondents were residents of Lawrence, Kansas in 1999. The simulated housing market included only privately-owned single-family dwellings within the city limit. The adjacent open space amenity is land in prairie. Along with WTP for different houses, information on the respondents' socioeconomic characteristics was collected.

The results show that if prairie is adjacent to a house and has no chance of being developed, the house value is higher by $8,700, on average, relative to the case in which development has already occurred. If the prairie has a 50% chance of being developed, the house value increases by only $3000 on average. In relative terms, the increases are 7% and 3%, respectively. The results indicate that not everyone is willing to pay for open space. One hundred out of 189 respondents have zero marginal WTP in the 50% development case, and 47 have zero marginal WTP in the no development case.

The author considers the possibility that some people may negative marginal WTP for open space, indicating that they would pay a positive amount to have development rather than prairie adjacent to their house. The analysis is repeated using a Tobit model of WTP that accounts for censoring at zero. The average WTP figures drop to $5,066 in the no development case and $118 in the 50% developent case.

This paper provides evidence of positive amenity effects from restricting development.

Combining Revealed and Stated Preference Methods to Value Environmental Amenities at Residential Locations
Earnhart, Dietrich, Land Economics, 77 (Feb. 2001): 12-30.

Using a combination of hedonic and conjoint methods, this study tries to answer the following questions: what is the value of a natural feature associated with a housing location?, and what is the value of marsh restoration? The assumption for both analyses is that house owners choose their housing location to maximize utility.

To obtain stated preference data, the author conducted a survey in Connecticut in 1996. This produced 105 complete responses. The respondents live close to coastal marshes (Pine Creek Marsh and Ash Creek Marsh), and were surveyed within months of an actual house purchase. The hypothetical survey asked homeowners to choose from a set of housing alternatives. Each choice set included three housing alternatives, each distinguished by an associated environmental amenity: a land-based amenity, a water-based amenity, or no amenity.

In the hedonic analysis of housing prices, the explanatory variables include structural, neighborhood, household, and environmental features. The information about house sales transactions is obtained from tax assessors, and used as the revealed preference data.

Models were estimated with the revealed preference data, the stated preference data, and a combination of the two. The estimation with the revealed preference data shows that a water-based amenity is preferred to no feature, while people are indifferent between the land-based feature and no feature. Marsh restoration increases local residents' utility. The results using stated preference data only indicate that water-based and land-based features are preferred to no feature. Although both disturbed and restored marsh lower residents' utility, only the negative effect of disturbed marsh is statistically significant. Therefore, the author concludes that the results still indicate the utility improvement with restored marsh.

Likelihood ratio tests reveal that the revealed and stated preference datasets are not compatible, but the effects of some parameters may be comparable. Results from the estimation with the combined data suggest that both natural features are preferred to no feature, forest is better than open space, and the marsh restoration increases local residents' utility.

The conclusion of this study is that natural features and marsh restoration increase utility, and the inclusion of the revealed preference data improves the estimation. Based on the revealed preference data, the benefits from water-based amenities are between $6,137 and $7,924, representing between 2.5% and 3.2% of the average house price. Restored marshes generate benefits equivalent to 16.6% of the average price. Benefits estimates using the stated preference data are even higher.

Valuing Open Space and Land-Use Patterns in Urban Watersheds
Acharya, G., and L. L. Bennett, Journal of Real Estate Finance and Economics, 2001, 22(2/3), 221-238.

The paper investigates the effects of environmental amenities on housing prices. The main objective of thise paper is to determine if precisely-measured environmental variables better represent amenity effects than aggregate measures.

The study area is New Haven County Connecticut, which covers a range of rural, suburban, and urban development patterns.. The data set includes house sales between 1995 and 1997 from the Multiple Listing Service and data from the 1990 Population Census. To represent spatial properties of the landscape, the authors develop measures of the diversity and richness of land uses, development levels, and open space. Twenty-six distinct land uses are represented. Open space variables measure the percentage of the area surrounding a property—alternatively within a radius of ¼ mile or 1 mile—in land uses classified as open space. The diversity index measures whether the surrounding area is dominated by a few or many land uses and how evenly the uses are distributed. The relative richness variable measures the percentage of the total number of land uses represented in the area. The richness variable is also interacted with population density to indicate the level of development. Other variables include location and neighborhood demographic characteristics, travel time to work, and a dummy variable for view.

Two models were estimated. The first only used aggregate indicators of whether the house is located in a rural, suburban, or urban area. The second model used the more detailed set of variables to describe land-use patterns in the surrounding area. The results of first model indicate that broad categories cannot adequately describe the price effects of surrounding land uses. In the second model, statistical results suggest that percentage of open space in the neighborhood significantly and positively influences house values. Similar coefficients on the alternative open space measures were estimated. The coefficient on the diversity measures has a negative sign and is statistically significant. This result indicates that people prefer a more homogeneous pattern of land use around their residence; this result does not give information about the specific kind of land use preferred. The effects of richness vary depending on population density. The estimated elasticity effect of richness is 0.0045 in a densely populated area and -0.0008 in a low population area.

The average housing price is $127,681 in the study area. The results indicate that a 1% increase in open space adds $75 to the house price, and a one unit increase in richness lowers the house value by $85. The authors conclude that people generally dislike heterogeneous landscapes surrounding their residences, they prefer open space, and people may like some types of land use more than others.

This paper provides evidence that housing values are influenced by the mix of land uses surrounding the property.

The Value of a Suburban Forest Preserve: Estimates from Sales of Vacant Residential Building Lots
Thorsnes, Paul, Land Economics v78, n3 (August 2002): 426-441.

This paper used hedonic price analysis to estimate the market value of proximity to forest preserves. The data include sale prices of vacant building lots and houses.

The study area consists of three single-family developments in the Grand Rapids, Michigan, metropolitan area. This area has several permanent forest preserves. Building lots and houses vary in terms of their view of and access to the preserves. Separate models are estimated for lot and house prices. Data on these dependent variables are obtained from the tax assessor’s office. Independent variables include house or lot characteristics and neighborhood attributes. Variables are included to measure whether houses or lots are adjacent to or near a forest preserve.

Hedonic models were estimated separately for each subdivision with either housing sale price or vacant lot sale price as the dependent variable. Bordering a forest preserve was found to have a positive and significant effect on lot prices in all three subdivisions. The premium in this case ranged from $5800 to $7000 per lot. Being across the street from a preserve has a negative effect on lot sizes in one of the subdivisions. Bordering a preserve positively influenced house prices in two of the three subdivisions, and being across the street from a preserve had a positive and significant effect in one case. For houses, the premium associated with bordering a preserve ranged from $7900 to $8900.

This paper quantifies the effects of preserved forest on lot and house prices.

The Influence of Wetland Type and Wetland Proximity on Residential Property Values

Doss, Cheryl R., and Taff, Steven J. Journal of Agricultural and Resource Economics v21, n1 (July 1996): 120-129.

This paper examines how different types of wetlands affect housing values in the surrounding neighborhood. The effects may vary because different types of wetlands support different kinds of wildlife, have different visual properties, and provide different amounts of flood control.

The authors evaluate assessed values (as opposed to sales prices) of single-family houses in Ramsey County, Minnesota, which includes the city of St. Paul and its surrounding area. Only houses within 1000 meters of a wetland are included. Wetlands are divided into four categories: forested, scrub-shrub, open water, and emergent vegetation. Proximity to the wetland is measured as the straight-line distance from each house to the nearest wetland type. The square of the distance to each wetland type was also included.

A hedonic price model was estimated by regressing house values on structural and location characteristics, and the wetlands distance variables. Except for the squared distance to a forested wetland, all the other estimates are statistically significant. The results indicate that people prefer to live close to all types of wetlands except for forested ones. Price declines diminish as distance increases. Tests show that all the wetlands variables have different coefficients. Among all wetlands types, emergent vegetation adds the most value to houses when it is located within 300 meters of the property. Using the mean house value in the study area ($104,956), moving 10 meters towards emergent vegetation increases a house value by $136. The figures for open water, scrub-shrub, and forested are $99, $145, and -$145, respectively.

Other versions of the model were estimated, including ones that included houses with wetlands located beyond 1000 meters. In these cases, scrub-shrub and open water are preferred to forested and emergent vegetation wetlands. The authors emphasize their marginal willingness to pay estimates do not capture the total value to society of wetlands

Wetlands are often protected by land-use regulations. This study shows that in most cases they raise the value of surrounding properties.

Valuing Urban Wetlands: A Property Price Approach

Mahan, Brent L., Polasky, Stephen, and Adams, Richard M., Land Economics, February 2000, 76 (1): 100-113.

This paper uses hedonic price analysis to estimate the amenity value of different types of wetlands in Portland, Oregon. The authors also attempt to recover the willingness-to-pay function of residents using second-stage hedonic analysis.

The study area is the portion of Multnomah County within the Portland urban growth boundary. Residential property sales data are obtained for the period 1992 to 1994. Wetlands were divided into 8 categories according to visual aesthetics and shapes. To measure the effects of wetlands on house prices, the authors measured the size of, distance to, and type of the nearest wetland and distances to wetlands of all other types. Besides wetlands variables, the authors measured structural, neighborhood, and other environmental characteristics of properties. No regulatory variables were included.

Two versions of the model were estimated. Model I assumes that prices are affected by the characteristics of the nearest wetland, whereas model II assumes prices depend on the distance wetlands of any type. For model I, all structural and neighborhood variables are statistically significant. As expected, wetland size has positive effect on house prices, and distance has a negative effect. The coefficients for wetland types are not all statistically significant, suggesting that wetland types may not be important to local residents. Use the mean house value ($122,570) and initial distance of one mile as the base, increasing the nearest wetland of any type by one acre adds $24.39 to the house value. Moving 1000 feet closer to a wetland of any type increases house prices by $436.17.

With model II, the size of the nearest wetland has a positive and significant effect. Relative to the base, moving 1000 feet closer to an open water areal wetland increases house values by $991. Moving 1000 feet closer to an open water linear wetland, an emergent vegetation linear wetland , and a scrub-shrub areal wetland reduces house values by $1250, $823, and $217, respectively. The other four types of wetlands have no significant effect in the second model. In both models, the distance to a lake and stream has a significant and negative effect on house price, but the coefficients on distance to park and river are not significant. In general, people like to live closer to wetlands, but the wetland type does not seem to matter.

The second-stage hedonic analysis used segmented market to overcome the identification problem, and estimate the willingness-to-pay function for the size of the nearest wetland to a resident. Independent variables include household income and other characteristics, number of occupants per residence, and dummy variables for market segments. The results are counter-intuitive, suggesting a positive slope for the demand curve. These results point to the inherent difficulties of second-stage estimation.

The significance of this study is that it demonstrates that wetlands, which are often preserved through land-use regulations, increase the value of houses in the surrounding area.

The Effects of Greenbelts on Residential Property Values: Some Findings on the Political Economy of Open Space
Correll, Mark R., Lillydahl, Jane H., and Singell, Larry D., Land Economics, Vol. 54, No. 2, May 1978: 207-217.

In this study, the authors attempted to analyze how a greenbelt project in Boulder, Colorado affects the value of its neighboring parcels. They argued that a greenbelt offers quasi-public good to nearby residential properties. Therefore, the greenbelt project that is funded by tax revenue could provide additional tax revenue to the local government. However, for local residents, not everybody would enjoy the benefit of purchasing land for building a greenbelt equally and such benefit decreases by distance.

In the theoretical model, the authors assume that the local land market is competitive in the long run. The model assumes that land value represents the values of a bundle of land features, including neighborhood characteristics, land features, local services, and other amenities. If the values of two parcels have identical features except the distance to the greenbelt, the externality of this amenity should be capitalized into land values. In the empirical model, the heteroscedasticity problem was dismissed because the authors did not assume that land value would vary across different neighborhoods. However, this might be arguable since there was no test conducted to verify the assumption. The empirical model was estimated with a hedonic function.

The data used in this study samples 85 single-family parcels randomly drawn from three areas that are adjacent to the greenbelt. These parcels were sold in 1975 and located within a reasonable walking distance to the greenbelt. The variables used in the regression include sales price, walking distance to the greenbelt, characteristics of housing structures, lot sizes, distance to urban area, and demographic features. The OLS regressions were first estimated using aggregated samples and then separately for each of the three neighborhoods.

Most estimation results are consistent with priori expectations. The results indicate that distance to the greenbelt significantly affects property value in the neighborhood negatively. This result confirms that the greenbelt provided quasi-public good to its neighboring properties. Properties located outside a reasonable walking distance to the green belt could be worth up to 32% less than those near the greenbelt.

Although there were people opposed to using a portion of tax revenue to purchase land for constructing greenbelt, this study shows that the greenbelt may actually bring in more tax revenue by increasing nearby property value. The authors also showed the estimated potential tax gain from increased property due to the greenbelt project. They also pointed out that preserving open space in an urban area may contribute to urban expansion because future residential development will spread out around the greenbelt.

The Price Effects of Urban Growth Boundaries in Metropolitan Portland, Oregon
Knaap, Gerrit J., Land Economics, Vol. 61, No. 1, February 1985: 26-35.

In this study, the author investigated how the urban growth boundary (UGB) affected urban land values in Portland, Oregon. He used a cross-section data for single-family vacant parcels in an urban area. The author intended to test the price effect of the UGB and if this urban development policy was binding.

In the theoretical model, the author explained that when the UGB is permanent, urban land value decreases with distance to the city center while nonurban land value does not. Land value is the present value of all future rents to the land. When the UGB policy is not permanent, value of nonurban land may include the present value of future urban land rents, which decreases with distance to the city center. Therefore, since urban land value always varies with distance to the city center, the UGB will only change nonurban land rents but not the value of land that is currently designated for urban use.

The empirical model used a hedonic function with sale price per acre of a land as the dependent variable and the UGB dummy variables, parcel features, neighborhood and demographic characteristics as independent variables. 455 single-family parcels that were sold between 1979 and 1980 were included in the dataset. These parcels are located in Washington and Clackamas County. When the UGB was originally drawn in 1975, there were parcels already in urban use outside the UGB and parcels in nonurban use inside the UGB. The model was estimated using OLS method with log-log form for each county separately.

In Washington County, most estimated coefficients are statistically significant and consistent with the author's expectation. If a parcel is in nonurban use, it is worth more when it is located inside the UGB than outside the UGB. However, such price difference is not significant for parcels in urban use. No matter being inside or outside the UGB, parcels in urban use are worth more than parcels in nonurban use. In Clackamas County, the regression results are mixed. A parcel in nonurban use would have a higher value if it is located inside the UGB. If a parcel is in urban use, there is no significant price difference if it is inside or outside the UGB. However, the author did not find statistical evidence for two expected results, 1) urban land would be worth more than nonurban land no matter where it is located; 2) nonurban land inside the UGB would be worth more than nonurban land outside UGB. The author explained the reason for mixed results in Clackamas County: unlike Washington County, Clackamas County chose to keep flexible land-use control inside the UGB.

In this study, the author found statistical evidence for the price effect of the UGB in Portland, and he concluded that the UGB as a land-use control instrument was not redundant. However, the price effect of the UGB might not be significant if the restriction was not strictly enforced. The author also pointed out that he could not draw a conclusion on how the UGB affects price of urban land inside the UGB because time series data in these study areas was not available.

II. The Effects Of Agricultural Subsidies On Private Property Values

The Impacts of Different Farm Programs on Cash Rents

Lence, Sergio H., and Mishra, Ashok K., American Journal of Agricultural Economics, August 2003, 85(3):753-761.

This study develops theoretical and empirical models to investigate how different types of government payments affect farmland rents.

The theoretical model assumes that all farmers face the same input and output prices and have identical production functions. Assuming that profits depend on crop prices, environmental conditions, government payments, and costs, and that the farmer’s objective is to maximize profits, the authors show that the equilibrium farmland rent depends on the acres planted by the farmer, the total number of acres planted in the county, crop prices, output levels, and government payments. The rent equals the annual net value of farmland to its owner.

The empirical model is based on the equilibrium land rent function derived in the theoretical model. The authors use data for three counties in Iowa during the period 1996-2000. Government payments are disaggregated into four categories: deficiency payments (DEF), payments associated with market losses (MLA), production flexibility contract payments (PFC), and Conservation Reserve Program (CRP) payments. Other variables used to explain land rents are acreage-weighted corn and soybean crop revenues.

Crop revenues have a positive and statistically significant effect on land rents. The MLA and PFC payments have positive impacts on land rents, increasing rents by approximately 85 cents for each dollar in payments. The coefficient on the CRP payment is economically and statistically insignificant. The surprising result is that the DEF payment has a negative effect and is statistically significant. The authors could not explain the reason for the counterintuitive result. The empirical model is also estimated without disaggregating government payments. The results indicate that in total government payments increase the farmland rent by 13 cents per dollar in payments.

This study finds that different types of government payments affect farmland rents differently. Overall, government payments increase farmland values.

The Incidence of Government Program Payments on Agricultural Land Rents: The Challenges of Identification

Roberts, Michael J., Kirwan, Barrett, and Hopkins, Jefferey American Journal of Agricultural Economics, August 2003, 85(3):762-769.

This paper examines the extent to which government payments are capitalized into (or the incidence of government payments on) farmland rents. Prior to the 1996 Farm Bill, direct government payments to farmers were linked to commodity prices and involved certain restrictions that often limited flexibility in terms of crops planted. In 1996, the new program used lump-sum Production Flexibility Contract (PFC) payments. Thus, after 1996 government payments had two components: payments coupled with commodity prices and decoupled PFC payments. The rent on an acre of farmland equals revenues net of variable costs. Only under restrictive conditions will coupled payments be fully capitalized into farmland rents. Otherwise, these payments will alter production decisions and affect commodity prices, offsetting to some extent the effects of the government payments on rents. Since decoupled payments are not tied to current production decision, they will tend to be fully reflected in rents.

The authors use a hedonic price model to quantify the incidence of government payments. Data on cash rents are taken from the 1992 and 1997 Agricultural Censuses. In the basic specification, rents are a function of the net return from agriculture production and government payments. The error term measures expectation errors (for agricultural returns and payments) and unobserved factors. The authors estimate a large number of models, which varying according to the independent variables included and the data sample used.

The results show that the incidence estimates are not stable across regions, suggesting that unobserved heterogeneity may still affect the estimation results. The estimates with the 1997 data show that the land rents increase by $0.33 to $1.55 for each dollar in government payments. This is a smaller effect than estimated with the 1992 data. The authors conclude that their strongest estimates imply an incidence of between $0.34 and $0.41 per dollar of payments.

This study finds that farm payments significantly influence farmland rents in the U.S. However, because the payments can influence production decisions and alter commodity prices, there a not a one-to-relationship between payments and rents.

Noncash Income Transfers and Agricultural Land Values
Taylor, Mykel R., and Brester, Gary W. Review of Agricultural Economics v27, n4 (Winter 2005): 526-541.

This paper studies the effect of U.S. sugar policy on land values in Montana. To increase the return to agricultural production, governments usually either use direct cash transfers or increases in the price of agricultural products. Due to the U.S. sugar policy, the U.S. sugar price has been kept above world prices since 1982.

The study uses a hedonic land price model. The factors considered to affect land price include parcel size, sugar beet price, expected cash receipts from crop sales, soil quality, parcel location, and population density. The land value data was obtained from appraisers during the 1986 to 1999 period in 15 counties. Proximity to a sugar beet processing facility is expected to have a positive effect on land value because there are 12 counties producing sugar beets while there are only two sugar beet processing plants. Expected sugar beet prices and expected per acre cash receipts from crop sales are expected to increase land value.

Most coefficient estimates have signs consistent with expectations and are statistically significant. For a $1 per ton sugar beet price increase, the value of sugar producing land rises by $7.58, and the value of non-sugar producing cropland rises by $3.85. In the latter case, the effect represents an increase in the option to produce sugar beets. If cash receipts increase by $10, the per-acre land value would increase by $7.60. Without domestic price supports, the price received by the producer would drop from the current level of $23.34 per ton to $14.95 per ton (the world price of sugar). This will reduce the value of sugar producing and non-sugar producing cropland by 9.1% and 4.6%, respectively. If the sugar producing industry ceased to exist in this region, land values could be reduced by 32%.

Land values are re-estimated using an asset pricing model without sugar beet production. The authors suppose the production will exist to perpetuity and compare two scenarios: 1) sugar beets/malting barley rotation, 2) feed barley/malting barley rotation. In the study region, without sugar beets production, land value could decrease by $529 per acre, a larger reduction than the $220.58 per acre decline predicted by the hedonic model.

This study investigates the effect of U.S. sugar policy on the value of land in Montana's sugar production region. Both the asset pricing model and hedonic analysis indicate declines in land values without price supports.

The Effect of Agricultural Policy on Farmland Values

Weersink, Alfond, Clark, Steve, Turvey, Calum G., and Sarker, Rakhal, Land Economics, August 1999, 75(3):425-439.

The authors estimate the separate effects of government payment and market returns on farmland prices. They also investigate if these two income sources are discounted by farmland owners at the same rate. For farmland owners, one income source may be more stable than the other one, implying their effects on farmland prices may not be the same. If government payments are discounted more than market returns, the capitalization of government payment would be less than the capitalization of market returns.

In theory, the asset pricing model indicates that the current nominal land value equals the present value of total future returns to the land net of costs. Suppose the only components of farmland income are market returns and government payments. The current nominal land value is the sum of expected government payments and expected market returns discounted with (in general) different factors. Each discount factor is equal to the nominal interest rate plus a risk premium minus the income growth rate.

The authors test whether these discount factors are the same using annual observations of direct government subsidies, income from farm operations, and land values in Ontario, Canada for the period 1947 to 1993. The data show that government payments have been relatively stable over most of the study period, and land values changed dramatically during the 1970s and 1980s.

The hypothesis that government payments and market return are discounted at the same rate is rejected. The results show that the discount rate for government payments is 0.986, which is greater than that for market returns (0.857). This finding suggests that government payments are viewed as a more stable source of income by farmland owners in Ontario. Land values are relatively unresponsive to changes in both income sources. A 1% increase in government subsidies, for instance, increases land values by 0.63%.

Evidence of Capitalization of Direct Government Payments into U.S. Cropland Values

Barnard, C. H., G. Whittaker, D. Westernbarger, and M. Ahearn. American Journal of Agricultural Economics 1997, 79 (5): 1642-1650.

The paper examines the effect of government payments on farmland prices, under the assumption that landowners expect government payments to continue. The dataset used in the study includes per-acre tract-level cropland values for 1994, 1995, and 1996.

In a hedonic model of cropland values, the explanatory variables include the average county-level annual direct government payment, an index reflecting development pressures and accessibility, agricultural productivity, average farm size, per capita payroll for recreation industries in the county, and state-level regulations. The dependent variable is the value of cropland per acre. The model was estimated separately for each of 20 Land Resource Regions covering the contiguous U.S.

The results show that the development index and the presence of intensive crops have positive and significant effects on farmland values in all regions. In some cases, the signs of the coefficients on farmland size, soil, and climate variables are not consistent with expectations. In many regions, government payments have a positive and significant effect on farmland values. In the Corn Belt, the elimination of government payments is estimated to reduce cropland values by 30% (a $445 per acre reduction from the mean cropland value of $1,480). In other regions, the percentage reduction in cropland value from elimination of government payments ranges from 12% to 69% (in the region including western Oregon, the effect is 16%).

A second (nonparametric) model was estimated that included variables for longitude, latitude, population density, and the ratio of direct government payment to gross cash farm income. Population density is divided into two levels to differentiate influences from urban and rural populations. The ratio of government payment to gross income is also divided into two levels to distinguish lands that are highly dependent on government programs.

The nonparametric estimation showed that the highest degree of capitalization of government payments is 50%, but most areas of farmland in the U.S. have low levels of capitalization.

The results of the two models indicate that there is wide variation across the U.S. in the degree of capitalization of government payments into cropland values.

III. The Effects Of Use-Value Assessment On Private Property Values

Agricultural Property Tax Relief: Tax Credits, Tax Rates, and Land Values
Anderson, John E., and Bunch, Howard C. Land Economics v65, n1 (February 1989): 13-22.

This study investigates how tax credits and tax rates affect farmland values in Michigan. To reduce taxes on farmland, Michigan uses a "circuit-breaker" program. To qualify for the program, a farmer's income must exceed a certain threshold level. Eligible farmers may either claim the general homestead property tax credit on their state income taxes, or enroll their land into a farmland preservation program and forego development opportunities in order to receive property tax reductions.

The theoretical model assumes that current farmland value equals the present value of the farm's income stream added to its potential housing income stream after the development. The model indicates that for a given level of the housing income stream, the higher the farm income stream, the lower the capitalization effect of the property tax reducation program. And, holding the farm income stream constant, the capitalization effect will be higher with greater development potential for farmland. The authors expect that when the future income stream does not change, the capitalization effect would be greater with a higher tax rate, lower interest rate, lower income threshold level, and higher percentage of non-farm income to the land.

A county-level empirical model is estimated to capture the interaction between land values, tax rates, and tax credits. The model is a system of three simultaneous equations. Besides the three variables of interest, other explanatory variables include land value, farm income, urbanization pressure, program participation rate in the county, and agricultural intensity. Urbanization pressure was calculated as "the real value of new construction as a percentage of property value in the county." County-level data is collected from 82 Michigan counties for the years from 1980 to 1983.

Most estimates are statistically significant and consistent with theory. Tax credits and tax rates are positively related to each other and to land value. When urbanization pressure gets higher, tax credits decrease while tax rates increase. Tax credit rises with higher farm income. Land value has a positive relationship with tax credit and urbanization pressure. On average, property tax credits account for 8.33% of farmland value. Combined tax reductions pay for 80 to 90% of the farmers' property tax liability, increasing the land's value by nearly 10%.

This study finds that the tax reductions provided by the "circuit-breaker" program are capitalized into farmland values. On the other hand, farmland values are found to be relatively insensitive to property tax rates, suggesting offsetting effects of the services provided by higher tax revenues and the higher tax payments by landowners.

Effectiveness of Use-Value Assessment in Preserving Farmland: A Search-Theoretic Approach

Tavernier, Edmund M, and Li, Farong, Journal of Agricultural and Applied Economics v27, n2 (December 1995): 626-635.

This paper develops a model to analyze the effectiveness of use-value assessment in preserving farmland. Under use-value assessment, farmland is assessed for property tax purposes according to its use in agricultural production, instead of its highest and best use as would be determined by the market. Because of development pressures, the market value of farmland at the urban fringe is likely to be higher than its current use value. Use-value assessment is used to reduce property taxes on farmland and provide incentives for farmland preservation. This study finds that use-value assessment does not have simple effects on a landowner's incentive to preserve farmland.

The theoretical model assumes that farmers are risk neutral and seek to maximize the present value of expected income. When the offer price from a potential developer equals the landowner's reservation price, the parcel is converted. However, it is assumed that not all offer prices are observed by farmers. Rather, each offer price is a random draw from a known distribution.

The model shows that use-value assessment delays conversion. The reason is that a lower tax raises farm income, which increases the reservation price. As a result, the average waiting period before conversion will be longer. Clearly, use-value assessment is more effective for farmland preservation when the conversion delay is longer. The difference between the average waiting periods with and without use-value assessment is determined by three elements: 1) tax rate, 2) the difference between market value and use value of farmland, and 3) the distribution of the offer price. The authors show that the effects of tax rates and differences in value (1 and 2) on the effectiveness of use-value assessment cannot be determined in general. That is, whether changes in these factors make farmland preservation more likely depends on the underlying conditions. Although the effectiveness of use-value assessment will increase with a higher average offer price, the impact of increasing the variance of the offer price distribution—which increases the chance of a high offer price—on the effectiveness of use-value assessment is indeterminate.

To further analyze the effectiveness of use-value assessment, the authors use a numerical example with farmland value data from New Jersey. They used the average farmland value as the mean offer price. In order to investigate the effectiveness of use-value assessment under different conditions, they estimated mean waiting periods with different levels of the tax rate and standard deviations for the offer price distribution. The results indicate that with use-value assessment, the reservation price is higher at all tax rate levels than the reservation price without. There is an optimal tax rate that maximizes the mean waiting period. Thus, at this tax rate use-value assessment is the most effective.

The analysis identifies farm income and the distribution of the offer price as important factors that affect the effectiveness of use-value assessment. The effectiveness varies with differences in the tax rate and the uncertainty of offer prices.

Land Taxes in Agriculture: Preferential Rate and Assessment Effects
Wunderlich, Gene, American Journal of Economics and Sociology, Vol. 56, No.2 (April 1997): 215-228.

This paper considers how changes in the property taxes influence the value of agricultural land. The real property tax is a substantial portion of the total return to agricultural land, especially for the land subject to high development pressure. In order to prevent the development of agricultural lands, preferential tax assessment is often used. In this case, property taxes are assessed on the value of the parcel in its current agricultural use rather than on its market value, which will reflect future returns to development. The author reviews national surveys by the USDA in 1992 and 1993 that show that there is a relatively large tax reduction when a parcel changes to preferential status ($2.72 per acre in 1992, $5.17 in 1993). However, in the aggregate, the differences between taxes paid on preferential and non-preferential parcels (between $0.65 to $0.81 per acre) are small.

When a parcel with preferential assessment is developed into a non-farm use, the change in the property tax is large. However, previous studies have shown that property tax incentives are small compared to the revenue from development and that preferential tax assessment has no significant effect in preventing farmland conversion. The authors suggests that tax preference programs are likely to be effective only when there are long-term contracts between landowners and local governments with severe penalties attached to developing land.

In most cases, preferential tax assessment applies to land, but not to buildings and improvements. On the other hand, property taxes are applied to all of these assets. The author suggests that this may limit the effectiveness of preferential tax assessment in terms of preventing development. Were the preferential assessment to also apply to buildings and improvements, there would be additional incentives to retain land in agriculture.

This paper discusses the effect of preferential tax assessment on the agricultural land values. The author shows that use-value assessment can affect agricultural land values but argues that it may do little to prevent the development of farmland. To improve the effectiveness of preferential tax assessment programs, the government should try to establish long-term contracts with severe penalties and use a less complicated administrative procedure.

Use-Value Property Tax Assessment: Effects on Land Development
Anderson, John E., Land Economics, Vol. 69, No. 3 (August 1993): 263-269.

This paper develops a theoretical model to investigate the effect of the use-value assessment on the timing of development, which fundamentally affects the value of property. The author also examines how use-value assessment affects the development decision when there is uncertainty and development is irreversible.

The model assumes that the value of agricultural land has two components: the discounted net income stream from agricultural production prior to development, and the discounted net income stream after development. The discount rate is the sum of the interest rate and the tax rate. The landowner is assumed to maximize the value of the land by choosing the time of development. The results indicate that at the optimum the marginal benefit of waiting one more period (the growth rate in the value of developed property) equals the opportunity cost of waiting (foregone interest plus an expression for the value of the farming use relative to the developed use).

With the use-value assessment, the property tax is based on the discounted net income stream from agricultural production (the first component), instead of the market value of the land. As a result, use-value assessment reduces the total property tax on agricultural land. It is shown that under land value maximization, use-value assessment causes development to be delayed. This delay effect is greater when the divergence between use-value and developed value is larger and when the level of property taxation is higher. The author also proves that when the difference between the values of the developed and undeveloped land is small, a higher tax rate would delay development and a smaller tax rate speeds development. It is also proved that an increase in farm income delays development holding other factors constant. How the change in the income stream from the developed land affects the timing of development depends on the tax and interest rates.

Following Capozza and Sick (1990), the author incorporates uncertainty and irreversibility (of development) into the model by adding a term representing the uncertainty premium into the farming income stream. The premium reflects the fact that where the income stream from developed land to be low in the future, the landowner cannot return the developed land back to agricultural production. Although the option value for the undeveloped land increases the farmland value, the author's results indicate that development will still be delayed by use-value assessment.

The author proves that the use-value assessment lowers the property tax on agricultural land at the urban fringe and delays land development. The effectiveness of use-value assessment in preventing development depends on the property tax rate and the difference between the use value and the market value of the land.

Use-Value Assessment Tax Expenditures in Urban Areas

Anderson, John E., and Griffing, Marlon F., Journal of Urban Economics, Vol. 48 (2002), 443-452.

The authors of this paper examine spatial variation in the difference between the market value and use value of agricultural land. They provide a basis for estimating the foregone tax revenues (or expenditures) from use-value assessment of farmland.

In theory, the value of agricultural land has four components: the value of accessibility, the cost of conversion, the expected future rent increase, and the agricultural land rent. Conversion costs and agricultural rents are assumed to be invariant with respect to location. However, the value of accessibility and the expected future rent increase should decline with distance to the CBD. As such, the difference between the market value and use value of the land should decline as one moves further away from the CBD and eventually approach zero.

In an empirical analysis, the authors regress the logarithm of the difference between the market value and use value of the land on a constant and the distance between the agricultural land and a nearby metropolitan area. The estimation is conducted separately for two study areas in Nebraska: Lancaster County and Sarpy County, which are part of the Lincoln and Omaha metropolitan areas, respectively. The market and use values of agricultural land were obtained from the local tax assessor's office. In Lancaster County, the assessor capitalizes the net income from crops and livestock to estimate the use value. In Sarpy County, the assessor uses the sale prices of agricultural land in adjoining counties to estimated use value.

The results show that the coefficient estimates are statistically significant. In Lancaster County, the difference between the market value and use value is $987.69 per acre for a parcel 3 miles from the CBD, $444.48 at 10 miles, $140.93 at 20 miles, and $89.01 at 24 miles. In Sarpy County, the difference is $6385.70 per acre at 6 miles, $4343.44 at 10 miles, $1657.28 at 20 miles, and $1023.71 at 25 miles. The greater difference between the two values in Sarpy County reflects the fact that Omaha is a larger city than Lincoln.

Evaluating the Effectiveness of Use-Value Programs
Ferguson, Jerry T., Property Tax Journal (June 1988): 157-164.

This paper evaluates the effectiveness of use-value assessment, which lowers property taxes for agricultural land, in preserving farmland. In an empirical analysis, the author uses time-series data on farmland acreage to test if the conversion of agricultural land changes after the implementation of use-value assessment.

Data are obtained for four counties in Virginia between 1920 and 1980. The dependent variable is the percentage of total land in a county occupied by farms, and it is regressed against a time trend (the number of five-year intervals since 1920) and the square of this variable. Models are estimated separately for each county. In 1974, the use-value assessment program was implemented in Virginia. The author argues that if use-value assessment is effective, the trend should be different in the five-year interval after 1974. Thus, the data for the period between 1920 and 1970 is used in the estimation. The author estimates the farm acreage in 1980 (with the model) and compares it with the actual percentage.

The results show that there is no significant change in the time trend of farm acreage in three counties, but there is a change in the trend in one county. The author concludes that use-value assessment, by itself, cannot lower the development pressure on agricultural land.

In order for the results of this study to be valid, one has to believe that the factors determining farm acreage over time can be adequately represented with a simple time trend model. It is likely, however, that this relationship is much more complex and changing through time in fundamental ways. If so, this study is of limited value.

Development Rights and the Differential Assessment of Agricultural Land: Fractional Valuation of Farmland is Ineffective for Preserving Open Space and Subsidizes Speculation

Blewett, Robert A., and Lane, Julia I., American Journal of Economics and Sociology, Vol. 17, No2, (1988): 197-205.

This paper investigates the effectiveness of differential tax assessment at preserving farmland. Under differential assessment, property taxes are assessesed on the value of land in agricultural production and, thus, lower property taxes on farmland at the urban fringe. The reduced tax burden is a form of compensation for farmland owners and can provide an incentive for delaying development of farmland.

In a theoretical model, the authors assume that land rent is independent of the land uses of surrounding parcels and that income from agricultural production on farmland is constant over time. The value of farmland equals the sum of the discounted rural use-value and discounted urban use-value. The discounted net benefit of urban use is the difference between the two use-values. With growing development pressures, the discounted net benefit of urban use increases through time with the rising urban use-value, and farmland is converted once the discounted net benefit of urban use is positive. With differential assessment, the rural use-value increases due to the lower property tax, but the development is not prevented as long as the urban use-value grows.

An empirical analysis is used to test if use-value assessment slows down farmland conversion. Data are obtained on farmland in 92 Indiana counties for the periods 1954-59 and 1964-69. Use-value assessment was implemented in 1963. Empirical models are estimated for the two time periods separately. The percentage decline in farmland acreage in a county is regressed on percentage changes in population, property taxes per acre, and the number of farmers over 65 years of age. The authors expect the percentage change in the property tax to have a positive effect on the dependent variable before the implementation of use-value assessment, and a negative effect afterwards (note: it makes sense that the effect will be lessened with use-value assessment, but the authors do not explain clearly why it should be negative).

Holding other factors constant, the results show that use-value assessment may slow down the conversion of farmland in Indiana. The percentage change in property taxes has a positive and significant effect before the implementation of preferential assessment, while its effect is negative and statistically insignificant after implementation.

The Effect of Far Property Tax Relief Programs on Farm Financial Conditions
Chicoine, David L., Sonka, Steven T., and Doty, Robert D., Land Economics, Vol. 58, No. 4, (November 1982): 516-523.

This paper analyzes the impact of tax relief programs (use-value assessment and circuit-breaker programs) on the financial conditions of farmers and landlords. Both programs are designed to reduce property taxes to provide incentives for the preservation of agricultural land. Use-value assessment involves assessment for property taxes based on value in current farmland use rather than market value. Circuit-breaker programs provide for state income tax credits or refunds for property taxes in excess of a given percentage of total farm household income.

The authors use a simulation approach to investigate how different tax relief programs affect the financial condition of a hypothetical farm over a ten-year period. The hypothetical farm is assumed to have a cash grain operation in east central Illinois with one-half of the 600 acres of agricultural land farmed and the other one-half leased. The initial financial condition of the farmers and landlords is based on commercial farm data for east central Illinois. Crop yield variability is derived from 13 years of individual farm data for a sample of east central Illinois farms. Price variability is based on 1973-1978 crop prices. The average yields and prices are initially set at the 1978 level and the initial farmland value is assumed to be $3,300 per acre. The annual crop price and input cost inflation are assumed to be 7% and 14%, respectively, and the tax rate is assumed to be constant during the simulation.

The results show that the circuit-breaker program is not effective for the farmer because property taxes as a percentage of farming income never exceeded the qualification level for joining the program. Compared to a property tax of $34.22 per acre with the market-value assessment, the use-value assessment lowered the property tax to $21 per acre and the annual tax relief was $3,913. Since the use-value assessment improves the financial condition of the farmers, the agricultural land value rises. The capitalized net rents with the market-based assessment and use-value assessment are $10,731 per acre and $11,773 per acre respectively. For the landlord, with no non-farm income, the circuit-breaker program reduces the property tax by 50%, and provides 33% more tax relief than the use-value assessment does. The tax relief programs increase the average after-tax income by $2,000 to $3,000.

The authors also apply the simulation model with double the initial land value to study the effect of the tax relief programs on agricultural land at the urban fringe. They find that although the tax relief programs have a positive effect on the farmer's and landlord's financial situation, the effects are too small to prevent the conversion of agricultural land.

IV. Other Studies

The Joint Influence of Agricultural and Non-farm Factors on Real Estate Values: An Application to the Mid-Atlantic Region

Hardie, I.W., Narayan, T.A., and Gardner, B.L., American Journal of Agricultural Economics 83 (2001) 120–132.

The purpose of this paper is to explain farm values in terms of both agricultural returns and non-farm values (residential use of the land in this study). The authors extend existing models by considering the simultaneity in the determination of prices for farmland and housing. The results quantify how higher housing prices affect farmland values, and vice-versa.

The underlying theory for the paper derives from the Capozza-Helsley model. The current agricultural land value is the discounted present value of future rents for farm use plus future rents for non-farm use after conversion net of conversion cost. This establishes the dependence of agricultural land prices on the value of land in non-farm use. The optimal time to develop land is when the development rent equals the sum of the agricultural rent and annualized conversion cost. As such, the agricultural rent will be an implicit component of the developed land value. The theory establishes that the prices for agricultural and developed land are determined jointly. The implication is that factors (like population density or regulations) that have direct impacts on developed land values will affect agricultural land values indirectly (and vice-versa).

The empirical model consists of simultaneous equations for farmland and residential land prices. In the theoretical model, agricultural rent and household income were assumed constant over time and space, and housing was homogenous. The empirical model relaxes these assumptions. The empirical model also replaces developed land prices with housing prices. The theoretical model also assumes perfect foresight in terms of future rents, taxes, and conversions costs. The regression model uses only current values, and thus does not attempt to explain changes in land prices over time.

Data was assembled for 230 counties in the mid-Atlantic region for the years 1982, 1987, and 1992. Variables to explain farmland and housing prices were measured as county medians or averages (examples include farm production expenses, median income, and the average age of houses) or were entered as dummy variables (in the case of state dummies). An index of distance to major cities weighted by the city's population is used to capture development pressure. Since the effect of population on housing price will be larger when income is higher, the authors also interacted income and population.

Most of the coefficient estimates are statistically significant and consistent with expectations. Increases in output prices and machinery value and decreases in input prices raise farmland value. However, farmland price is much more sensitive to residential housing values than to farm income factors. Results indicate that the median housing value is significantly affected by population and income, but not by farmland price.

This study quantifies how factors affecting residential housing values are transmitted to farmland values. Conversely, it shows that farmland values have little influence on housing values.

New Evidence on Property Tax Capitalization

Palmon, Oded, and Smith, Barton A. Journal of Political Economy v106, n5 (October 1998): 1099-1111.

The authors examine the capitalization of property taxes into property values in Texas. In theory, the current property value equals the present value of net benefits generated to home owners. The discount factor equals the net user cost of housing (the appropriate real, net of expenses, after-income tax discount rate) plus a term for property taxes. If taxes are fully capitalized into property values, the property tax term should simply equal the property tax rate (assuming it is expected to remain constant over time). In effect, property taxes increase the rate at which future net benefits are discounted. If property taxes are not fully capitalized, then the property tax rate will have a partial impact on the discount factor. This provides the basis for the empirical test in this paper.

The empirical model consists of two functions: 1) a hedonic function with the market price of the house as the dependent variable, and structural and location characteristics as independent variables; 2) a function for the discount factor as described above. The second model is estimated under the assumption that net user cost (the first component of the discount factor) equals 3%.

The authors use housing market data in 1989 for properties from 50 subdivisions in Houston, Texas. Although, all subdivisions have similar demographics and identical public services, the tax rate used by municipal utility districts (MUD) to finance public service varies substantially. The reason for using this dataset is that the variations in tax rates and public services are likely to be correlated. To avoid potential bias in the parameter estimates, the capitalization effect of the tax rate must be isolated from the public service effect. The authors also suspect possible correlation between the tax rate and neighborhood quality. Therefore, separately, they estimate another model which includes three additional variables indicating neighborhood quality.

The result shows that about 60% of the property tax is capitalized. This is not full capitalization, but it is much higher than what Yinger et al. (1988) predicted (15%-30%) with similar assumptions regarding net user cost. As the authors suspect, the tax rate is correlated with neighborhood characteristics. The coefficients of tax rate are 0.617 and 0.639, respectively, in the models with and without neighborhood characteristics (the estimates are statistically significant).

To investigate the capitalization effect of property taxes, this paper uses a dataset in which the study area has subdivisions with the same public service but different tax rates. The empirical results indicate that property taxes are not fully capitalized into property values.

Property Tax Limits, Local Fiscal Behavior, and Property Values: Evidence from Massachusetts under Proposition 2½
Bradbury, Katharine L., Mayer, Christopher J., and Case, Karl E., Journal of Public Economics, 80(2001): 287-311.

This paper uses models of public spending and house prices to investigate the capitalization of Proposition 2½, passed in Massachusetts in 1980, into property values. Proposition 2½ places a cap on the effective property tax rate and the nominal annual growth rate in the tax, as well as allows residents to vote to override the Proposition. Lower taxes may raise property values, but a town with barriers to raising taxes may provide lower level public services, therefore becoming less attractive for potential home buyers. The paper explores how tighter local government budgets under Proposition 2½ reduce public expenditures. Then, the paper investigates how house prices are affected by the reduction in public expenditures.

The house price model assumes that households choose house locations by comparing local amenities, public services, and tax rates. Thus, the house price is a function of these factors and the housing stock. There are three endogenous variables in house price model: changes in school spending, changes in non-school spending, and single-family housing permits.

In the public spending model, public expenditures are explained by residents' preferences, costs of public services, and local government budgets. Since education is a major part of public spending in a community, the spending model is estimated separately for school spending and non-school spending. There are two endogenous variables in public spending model: change in number of students and change in population. The constraints of Proposition 2½ did not bind in all communities. To reflect the extent to which the Proposition 2½ restricted community's public spending, the authors use dummy variables to divide communities into three groups: constrained, unconstrained, and constrained with override. A community is constrained if it reached the levy limit without passing overrides in 1989. The authors suspect that the dummy variables measuring the constraint could be endogenous, because whether Proposition 2½ binds in a community may reflect the voters' choice of public spending before Proposition 2½. However, excluding these dummy variables does not significantly change the estimation.

The model is estimated with community level data from 1990-1994. The results of the spending model indicate that Proposition 2½ significantly constrained local spending in some communities, with most of its impact on school spending. School spending experienced the slowest growth in constrained communities. The results from the housing price model suggest that school spending had a significant impact on house prices, while non-school spending did not. In general, the communities constrained by Proposition 2½ increased their school spending less than did unconstrained communities, and reducing school spending significantly affected house prices in a negative way.

CHAPTER 3

THE EXEMPTION OF MINIMUM-LOT-SIZE ZONING AND URBAN LAND VALUES

I. Introduction

After Measure 37 came into effect, claims have typically been resolved by waiving land-use regulations that applied to the land. In 2007 November, Measure 49, which modified Measure 37, was passed and came into effect. Measure 49 will allow the development started or completed under Measure 37 if it meets the definition of a "vested right." Having some lands exempted from minimum-lot-size zoning may cause changes in equilibrium land prices and landscape features in a city. Minimum-lot-size zoning reduces development density. As a result, the neighborhood under the zoning policy may have more open spaces between houses, giving residents more privacy and better view for landscape. As a result, the spillover amenity effect of large lots may increase the value of all lands in the same neighborhood. This is environmental effect. However, the land-use policy often limits the choices of land development. As a result, the land governed by such policy may have a lower price. This is the development effect of zoning policies. Minimum-lot-size requirement may lower the land value when the development effect outweighs the environmental effect. However, a single parcel that is exempted from the zoning regulation has all the benefits created by the policy with more development choices than other zoned parcels in the same neighborhood. Therefore, for the same land, the value may increase more when the land is exempt from the policy than when the policy is removed from all lands in the same area. However, when more and more parcels in the same neighborhood get the policy exemption, the price increase due to the exemption may get smaller. When all lands are exempted, the zoning requirement will have no effect.

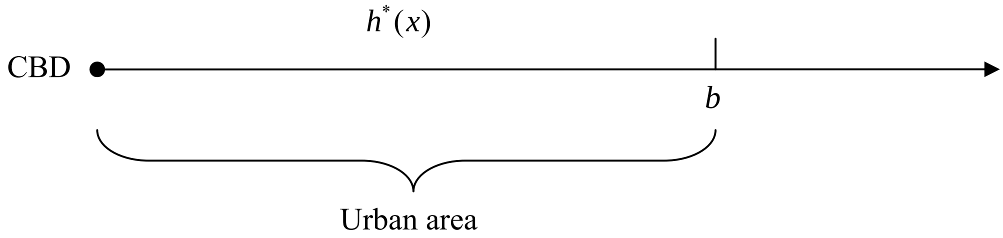
In theoretical analysis, the standard monocentric city has been widely used to analyze the dynamics of urban landscape features. Wu (2006) examined how environmental amenities affect development patterns and the community characteristics. Wu and Plantinga (2003) analyzed the influence of public open space on the urban development. In the context of minimum-lot-size zoning, Pasha (1996) set up a model with a monocentric semi-closed city and residents from two income groups. In the model, the poor live in the downtown while the rich live farther away from the city center and are subject to minimum-lot-size zoning. He showed that the zoning policy increases the utility level of the poor, while reducing the utility level of the rich because the land price in the suburb is increased by the policy, and the land price at the city center is decreased. He also found that urban sprawl may be the result of this policy.

This study addresses two main issues: First, I use an urban spatial model to analyze how minimum-lot-size zoning affects land values, urban population, residential land development, and social welfare. Second, I use this model to distinguish between two concepts: the change in property value due to regulation and the value to a landowner of an individual exemption to a regulation. This issue is directly relevant to the current policies. This is because as stated in measure 37 and 49, if a land is eligible for compensation, the land policy that depreciates land values may be removed from the parcel. Therefore, it is important to understand that removing some land use policies from a single parcel in a neighborhood may have different consequences than removing the policy from all parcels.

The model used in this study is different from a previous study by Pasha (1996). First, this study took consumer's preference for the low-density development into account. For urban residents, low density development has both benefits and shortcomings. Regarding the benefits, low-density development often provides more open spaces between neighboring housing structures, better privacy for the house occupants, and less health issues related to sanitary. However, low-density development is not a perfect solution for urban housing planning. Long distance commuting is a predominant issue for the residents living in low-housing-density communities. The consequences of long distance commuting (such as pollution from cars and transportation system congestions) are attracting more attention. In Pasha's study, the benefit of minimum-lot-size zoning was not reflected in consumer's utility maximization problem. In this study, both the advantage and disadvantage of low-density development created by enforcing minimum-lot-size zoning are incorporated into the models. Second, I used both open city and closed city models to explore the impact of minimum-lot-size zoning. In reality, urban development in any metropolitan area does not resemble either open city or closed city models completely. A closed city model may be a better choice for investigating urban development changes in the short term. Because of the inconvenience of relocations, urban residents are not likely to reconsider their residency locations when a land use policy comes into effect. However, when a land use policy has impact on urban development or the provision of local amenities, people will eventually move to the location where their utility will be maximized. Therefore, an open city model should be better at explaining the effect of land use policies than a closed city model in the long run. In Pasha's study, he used a semi-close city model, where the total population is fixed, but the neighborhood boundary between high-income and low-income residents is endogenous. As explained above, Pasha's model only explained the effect of minimum-lot-size zoning policy in one situation. Third, in his paper, Pasha assumes that minimum-lot-size zoning policy was applied to all parcels in the wealthier neighborhood. In this study, I assume that minimum-lot-size zoning starts from an arbitrary point in the wealthier neighborhood. The reason is that the starting point of minimum-lot-size zoning might not be the boundary of different income groups. Where the starting point of minimum-lot-size zoning is may depend on the development density that the local government wants to have. Furthermore, where to impose minimum-lot-size zoning may affect the zoning policy impact on land values. Therefore having a flexible starting point for minimum-lot-size zoning in the model enables us to further explore the impact of this policy. I will also present how the impact of minimum-lot-size zoning on land values changes with different minimum-lot-size requirements and residents' preference for the amenities provided by minimum-lot-size zoning. Because of the differences between my model and Pahsa's, the results of this study are expected to be different.

II. The Model

Figure 3.1



The monocentric urban spatial model assumes that the household resides at distance x from the central business district (CBD) where they work (figure 3.1).

$$U(h,q)=h^{\alpha}q^{1-\alpha} \quad (3.1)$$

$$Y=hp+q+tx \quad (3.2)$$

The model also assumes the Cobb-Douglas utility function when there is no zoning policy applied for all city residents and that the city residents maximize their utility subject to a fixed income constraint. The residents spend all income on the land with size h at the price of p, numeraire goods q, and the cost of traveling between home and work tx (where t is the unit transportation cost). The solution of a household's utility maximization problem yields the optimal consumption of land and other goods. A household would change the choice of location (as well as the parcel size) as long as this increases their utility. Therefore, in equilibrium, the utility levels of all households are same. Because of the travel cost, the land price declines with distance to the CBD and eventually equals the price of agricultural land at the urban fringe. Therefore, at the boundary of the city (b), price of agricultural land ($\overline{p}$) equals urban land price ($p^{*}(b)$):

In order to simplify the model, unlike the circular city used in the standard model, I assume a linear city in this study.

The solution to the maximization problem yields:

$$h^*(x) = \frac{\alpha(Y - tx)}{p^*(x)}\ ^1 \quad (3.3)$$

$$q^*(x) = (1-\alpha)(Y - tx) \quad (3.4)$$

Further results will depend on different model set-ups. There are two scenarios: a closed city model and an open city model. In the closed city model, the city population is constant, and minimum-lot-size zoning policy only changes the utility level at equilibrium. In the open city model, residents are free to move into or out of the city, and utility level is always at the original equilibrium level. I will first investigate the effect of minimum-lot-size zoning on land prices in a closed city model. A simulation with a closed city model will be conducted in assisted to the analytical model. Since the simulations in the closed city model involves much more challenging computations than in the open city model, I will use an open city model with simulations to further explore the impact of the zoning policy under different scenarios (such as different starting points for minimum-lot-size zoning, different minimum-lot-size requirements, and different residents' preference for low density development.)

II.A. Simple Closed City Model

In the closed city model, V^* represents equilibrium utility level, which is endogenous. When there is no land-use policy, the optimal solutions for the land price is:

$$p^*(x) = [\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(Y - tx)}{V^*}]^{\frac{1}{\alpha}} \quad (3.5)$$

Using the city boundary condition (at the boundary of the city (b), price of agricultural land ($\overline{p}$) equals urban land price ($p^*(b)$)), city boundary can be solved as in the following equation:

$$\overline{p} = [\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(Y - tb)}{V^*}]^{\frac{1}{\alpha}} \quad (3.6)$$

[1] In this chapter, all variables with "*" represent equilibrium levels.

Solve equation 3.6, the boundary of the city (b) is

$$b = \frac{1}{t}[y - \frac{V^* \overline{p}^{\alpha}}{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}] \quad (3.7)$$

By substituting equation 3.5 into equation 3.3, the equilibrium land demand is:

$$h^*(x) = [(1-\alpha)(Y-tx)]^{\frac{\alpha-1}{\alpha}} V^{*\frac{1}{\alpha}} \quad (3.8)$$

Since parameter α has a value between 0 and 1, the equilibrium land consumption is an increasing function of the distance between the land and CBD. The reason is that the land located further away from CBD has to be cheaper to compensate for the high commuting cost.

Because $h^*(x)$ is the amount of land consumed for housing by each household, the inverse gives the number of household per unit of land at the distance x. Thus, the integration over the housing density from the CBD $(x = 0)$ to the city boundary $(x = b)$ gives the total number of households (N) living in the city:

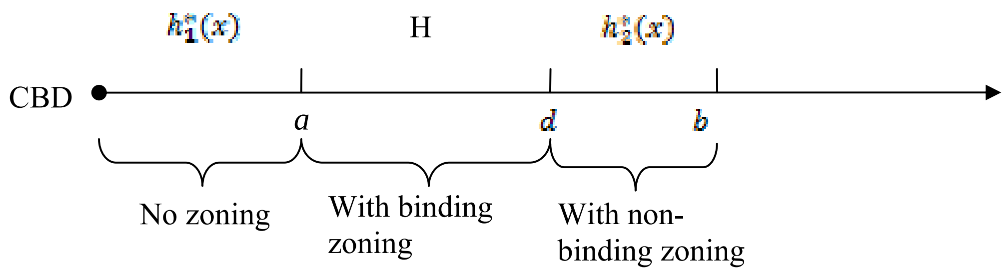
$$N = \int_0^b \frac{1}{h^*(x)} dx \quad (3.9)$$

Substitute the result of b (equation 3.7) and equation 3.8 into equation 3.9 to derive the equilibrium population:

$$N = \frac{1}{t}[Y^{\frac{1}{\alpha}} \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}} V^{*-\frac{1}{\alpha}} - \overline{p}] \quad (3.10)$$

In order to show how minimum lot-size zoning influences land values, I examine two effects of this policy: an environmental effect and a development effect (as discussed in the introduction). In the model, I assume that everybody living in the city values the environmental benefit offered by low-density housing development. All residents living in the area with the minimum lot-size zoning enjoy the same level of the environmental benefit, which depends on the size of the zoned region. For city residents who live outside the zoned region, the environmental benefit of minimum lot-size zoning is discounted according to the distance between their residence and the edge of zoned region. The residents living in the zoned area experience the development effect of the minimum lot-size zoning policy more directly than those residents living outside the zoned area. The reason is that some residents in the zoned area have to buy a larger lot than what they would otherwise want to. The residents living outside the zoned area are indirectly affected by the development effect. When the minimum lot-size zoning is in effect, land prices in the zoned area will change. This may lower utility levels and induce residents to move outside the zoned area, bidding up the land price elsewhere.

Figure 3.2



As illustrated in the figure above, the zoning policy is assumed to be applied to all lots located beyond point a. I do not assume that the zoning policy is binding on all lots. Therefore, at point d, the lot size is larger than the minimum-lot-size requirement even when the zoning requirement is not applied to this parcel. All lots between point d and city limit b are at least as big as the minimum-lot-size requirement and the lot size is increasing as the location is farther away from CBD. Therefore, the land demand function between d and b is $h_2^*(x)$. Notice that the land demand function $h_1^*(x)$ outside the area with zoning policy (between a and b) and the demand function $h_2^*(x)$ should be different because only the lots in the zoned region fully enjoy the environmental benefit of minimum-lot-zoning policy without distance discount

To incorporate the environmental effect of minimum-lot-size zoning policy, I assume consumer's utility function as:

$$
U(h,q) = \begin{cases} = h^{\alpha} q^{1-\alpha} (\frac{b-a}{a-x+1})^{\beta} \forall x \in [0,a) \\ = H^{\alpha} q^{1-\alpha} (b-a)^{\beta} \forall x \in [a,d) \\ = h^{\alpha} q^{1-\alpha} (b-a)^{\beta} \forall x \in [d,b] \end{cases} \quad (3.11)
$$

Equation 3.11 shows that if a resident lives outside zoned area, his/her utility depends on the land consumption, numeraire goods, and the benefit of low-density development that is discounted by the distance to the zoned area. If a resident resides in the zoned area, his/her utility depends on the lot size, numeraire goods, and the direct benefit of low-density development. In the area where the minimum-lot-size zoning is binding, all residents' land consumptions are the same.

Consumers maximize their utility by choosing their residence location and quantity of numeraire goods subject to an income constraint ($Y = hp + q + tx$). $b-a$ (the size of zoned area) represents the benefits from low-density residential development that is protected by the minimum-lot-size zoning. The reason for using the size of zoned area as the indicator for low-density development amenities is that the level of such amenities often depends on the size of area with low-density development. The benefits of low-density development, such as scenic view, will not show when there are only very few large parcels. When there are many large residential parcels connecting with each other and these parcels cover a large enough area together, low-density development will create a better view to local residents than high-density development does. $a-x+1$ is the distance discount factor for the benefit of minimum-lot-size zoning. When a lot is located outside the zoned area, the low-density development benefit diminishes as the distance to the zoned area gets bigger. Therefore, the benefit for the parcels located outside the zoned area is $\frac{b-a}{a-x+1}$. Therefore, when the location of a parcel is in the zoned area, the distance discount factor is 1. Since x represents resident's chosen location to live, when the location gets really close to the starting point of zoned area, the distance discount factor gets close to 1. Therefore, when the housing location is at the point where minimum-lot-size zoning policy starts ($x = a$), the resident living at this location will enjoy the same amenity as those living in the zoned area because the distance discount factor on the numerator becomes 1 ($a-x+1=1$). Here, I use subscript 1 representing the functions and variables for the parcels located outside the zoned area, subscript 2 for the parcels in the zoned area, and subscript H for the parcels with binding zoning policy. With only two unknown variables - the utility level when the city land market reaches equilibrium and city boundary - the optimal solution for the price function of land located outside the zoned area becomes:

$$p_1^*(x)=\left[\frac{\alpha^\alpha(1-\alpha)^{1-\alpha}(Y-tx)\left(\frac{b-a}{a-x+1}\right)^\beta}{V^*}\right]^{\frac{1}{\alpha}} \quad (3.12)$$

The price function of land located inside the zoned area becomes:

$$p_2^*(x)=\left[\frac{\alpha^\alpha(1-\alpha)^{1-\alpha}(Y-tx)(b-a)^\beta}{V^*}\right]^{\frac{1}{\alpha}} \quad (3.13)$$

If the minimum-lot-size zoning policy is removed from a single parcel and there is no policy change on any other parcels, the price of this parcel will be

$$p_2^*(\hat{x})=\left[\frac{\alpha^\alpha(1-\alpha)^{1-\alpha}(Y-t\hat{x})(b-a)^\beta}{V^*}\right]^{\frac{1}{\alpha}} \quad (3.14)$$

In equation 3.14, $\hat{x}$ is the distance between the parcel with removed zoning policy and the CBD.

In the open city model, equilibrium utility level is usually assumed to be constant because city residents are free to move in and out. If any policy changes because equilibrium utility level goes up, there will be people moving in. On the other hand, people will move out when equilibrium utility level goes down. Land prices will fluctuate accordingly with urban population. Since the equilibrium utility level does not change as zoning policy changes in the closed city model, the land price function with binding minimum-lot-size zoning (parcels located between point a and d in figure 3.2) can be derived by using the utility function and budget constraint. In order to do so, the demand function for numeraire goods needs to be solved first:

$$q_H^*(x)=\left(\frac{V^*}{H^\alpha (b-a)^\beta}\right)^{\frac{1}{1-\alpha}} \quad (3.15)$$

Substitute equation 3.15 into the budget constraint, the solution for the price function of land with binding zoning policy is:

$$p_H^*(x)=\frac{Y-tx-\left(\frac{V^*}{H^\alpha (b-a)^\beta}\right)^{\frac{1}{1-\alpha}}}{H} \quad (3.16)$$

The boundary of binding zoning (d) can be solved with the following function:

$$H=h_2^*(x)\Rightarrow H=\left(\frac{(1-\alpha)^{1-\alpha}(Y-tx)^{1-\alpha}}{V^*}\right)^{\frac{1}{\alpha}} \quad (3.17)$$

The solutions for demand functions of the lands inside and outsides the zoned area are:

$$h_2^*(x)=\left(\frac{(1-\alpha)^{1-\alpha}(Y-tx)^{1-\alpha}(b-a)^\beta}{V^*}\right)^{\frac{1}{\alpha}} \quad (3.18)$$

$$h_1^*(x)=\left(\frac{(1-\alpha)^{1-\alpha}(Y-tx)^{1-\alpha}\left(\frac{b-a}{a-x+1}\right)^\beta}{V^*}\right)^{\frac{1}{\alpha}} \quad (3.19)$$

Therefore, the total population in the city can be written as:

$$N=\int_0^a \frac{1}{h_1^*(x)}dx+\int_a^d \frac{1}{H}dx+\int_d^b \frac{1}{h_2^*(x)}dx$$

$$N=\int_0^a \left(\frac{(1-\alpha)^{1-\alpha}(Y-tx)^{1-\alpha}\left(\frac{b-a}{a-x+1}\right)^\beta}{V^*}\right)^{-\frac{1}{\alpha}} dx+\int_a^d \frac{1}{H}dx+\int_d^b \left(\frac{(1-\alpha)^{1-\alpha}(Y-tx)^{1-\alpha}(b-a)^\beta}{V^*}\right)^{-\frac{1}{\alpha}} dx$$

(3.20)

In addition, since urban land price equals agricultural land price at the city boundary, we can use the following equation to solve for city boundary

$$\bar{p} = [\frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}(Y-tb)(b-a)^{\beta}}{V^{*}}]^{\frac{1}{\alpha}} \quad (3.21)$$

The equilibrium utility level and b can be solved by equation 3.20 and 3.21 simultaneously. Substitute these two results into equation 3.12-3.19, all other unknown variables (price functions and demand functions for numeraire goods and lands, total population, and city boundary) can be solved. Since equation 3.20 and 3.21 cannot be solved analytically, further results and analysis will be shown with simulations.

The setup for the simulation is as described in the following table:

Table 3.1

Variable		***Quantity***	***Unit***
Household income	Y	35000	Dollar
Transportation cost	t	2000	Dollar/mile
Total population	N	2000	
Agricultural land price	$\bar{p}$	10000	Dollar/mile
Utility function parameter	α	1/3	
Utility function parameter	β	1/3	
Minimum-lot-size zoning starting point	a	8	Mile
Minimum-lot-size requirement	H	0.05	Mile

The solutions for unknown variables are shown in table 3.2. The cases with and without minimum-lot-size zoning are listed side by side for comparison:

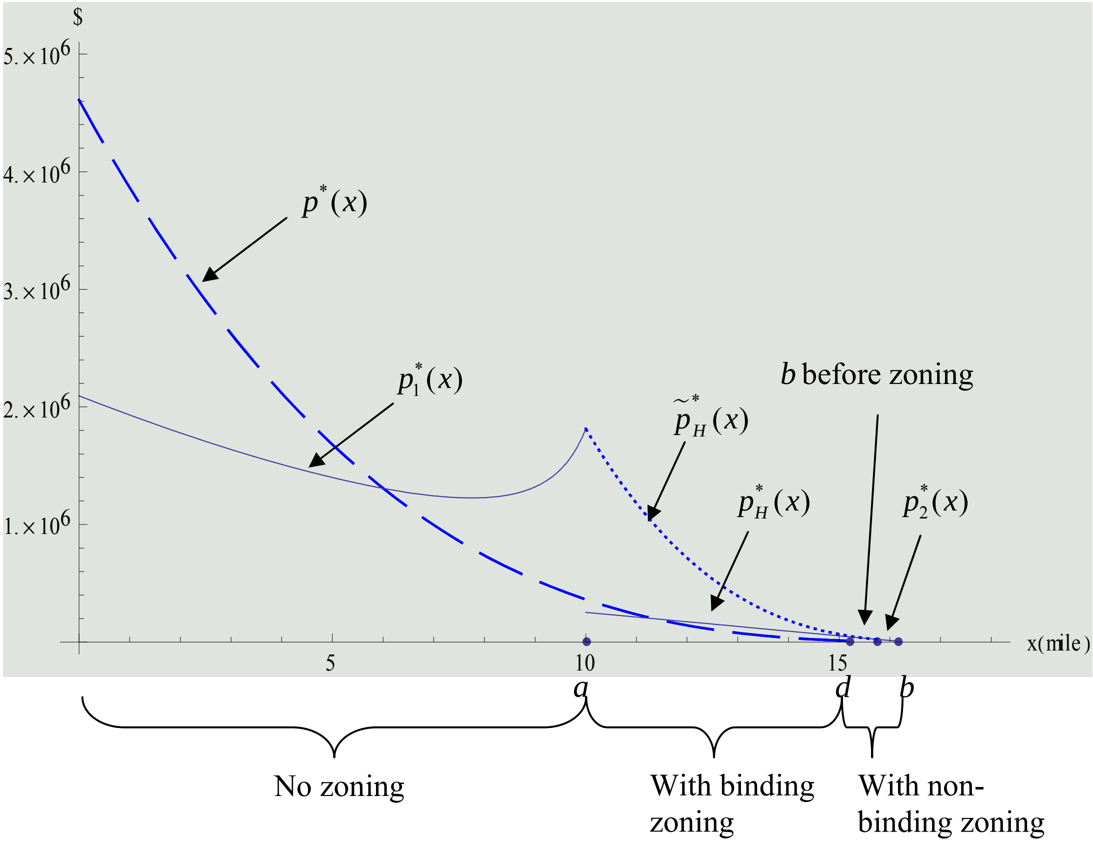
Table 3.2

Variable		***Quantity***		***Unit***
		Without zoning	***With zoning***	
Equilibrium utility	V^*	116.57	137.86	
City boundary	b	15.13	16.10	Mile
Binding zoning boundary	d	N/A	15.59	Mile
Demand function for the land in the area without zoning	$h_1^*(x)$	3.56(35-2x)$^{-2}$	0.13(13-x)(17.5-x)$^{-2}$	
Demand function for the land in the area with zoning that is not binding	$h_2^*(x)$		0.13(17.5-x)$^{-2}$	
Price function for the land in the area without zoning	$p_1^*(x)$	93.52(35-2x)^3	3665.29 (17.5-x)^3(9-x)$^{-1}$	
Price function for the land in the area with zoning that is not binding	$p_2^*(x)$		3665.29(17.5-x)^3	
Price function for the land with binding zoning	$p(H)$		649139-40000x	
Total population outside zoned area	N_1	1943	1816	
Total population inside zoned area	N_2	57	184	
Land price at CBD	$p_1^*(0)$	4010000	1510249	Dollar/Mile
Lot size at CBD	$h_1^*(0)$	0.0029	0.0057	Mile
Lot size at city boundary	$h_1^*(b)$	0.16	0.084	Mile

The above table shows that minimum-lot-size zoning improves the equilibrium utility level, even though there were large parcels when minimum-lot-size requirement is not enforced. There are several reasons that minimum-lot-size zoning becomes a popular tool to control development density, such as scenery view and environmental protection. Such benefits can only be provided when the development density is low enough and the area with low-density development is large enough. Since landowners can always have a free ride for these benefits while their neighbors keep large parcels, some benefits of low density development are often under-supplied. There might not be enough parcels with large size to provide those benefits when there is no minimum-lot-size zoning, or some parcels might not be large enough. Therefore, we observe that minimum-lot-size zoning policy increases equilibrium utility level even when the policy is not binding on all parcels.

Figure 3.3 shows the price functions for land before and after minimum-lot-size zoning is applied. The dashed line represents the price function curve for land when there is no minimum-lot-size requirement throughout the city ($p^*(x)$). The solid line represents the price function curves for land after the minimum-lot-size requirement comes into effect. There are three sections on the solid line: 1) the price function of land located outside the zoned area ($p_1^*(x)$), 2) the price function of land with binding zoning policy ($p_H^*(x)$), and 3) the price function of land with zoning policy that is not binding ($p_2^*(x)$). The dotted line ($\tilde{p}_H^*(x)$) represents the prices of one single piece of land when the minimum-lot-size policy is removed only from this land in the zoned area.

Figure 3.3



The simulation results show that after the minimum-lot-size zoning is applied, the equilibrium utility level increases. This is due to the fact that 1) benefits related to low-density residential development are created or preserved by minimum-lot-size zoning, 2) city residents value these benefits (as shown in the utility function).

In the area that is not restricted by minimum-lot-size zoning, the price of some parcels decreases when the zoning policy is applied. These parcels are located close to the CBD. This is because being very close to CBD is not as desirable as before the zoning policy. CBD is not the only place providing location-based benefit (the convenience to work) for city residents and the amenities related to low-density development are provided by the zoned area that are closer to city boundary. This can be easily seen in figure 3.3. Most of the land price function $p_1^*(x)$ is flatter than $p^*(x)$. When parcels are located closer to where minimum-lot-size zoning starts but not restricted by the zoning, their prices inflate above the price level when the policy is not applied. In addition, unlike the relation between distance to the CBD and land prices in the rest of the city, land price goes up as the distance to CBD gets bigger. The reason is that these parcels enjoy low-density development amenities with a very small distance discount and the development on these lands is not restricted by the minimum-lot-size requirement. Compared to the situation before minimum-lot-size zoning policy, the residents living close to the edge of a zoned area only gain more benefit from the zoning policy but do not lose any development options. As indicated in equation 3.3, land price and lot size have an inverse relationship. Therefore, the density of residential development goes down as one moves away from the CBD and then goes up as one gets closer to the edge of zoning area.

The situation is very different at the location just within the zoned area: once minimum-lot-size zoning is applied, the land price drops significantly to a level that is lower than the price of their neighboring parcels that are not governed by the zoning policy. Although the residents in the zoned area enjoy the low-density development benefit directly, the development opportunity is largely limited, especially where the minimum-lot-size requirement is binding. Land price drops more rapidly as the distance to CBD increases when the zoning policy is binding. The reason is that all parcels have the same size wherever the zoning policy is binding, but the transportation cost increases with distance to CBD. In the area with binding zoning policy, the minimum-lot-size requirement decreases the values of lands located closer to where the zoning policy starts ($p_H^*(x) < p^*(x)$.) However, as one moves away from the zoning policy starting point, the difference between the land values before the zoning policy and after gets smaller and eventually the land values increase after the zoning policy is implied. This is the result of two competing effects that work against each other. Limited development options decrease land price. However, the environmental effect brings benefits to these parcels with restricted size, which causes the land price $p_H^*(x)$ to decrease slower over the distance to CBD than $p^*(x)$ does. As shown in figure 3.3, point d is where minimum-lot-size zoning is no longer binding. Beyond this point, all parcels are larger than the minimum-lot-size requirement even when there is no zoning policy to prevent high-density development. In this region, land price decreases with distance to CBD at a slower rate than in the area between point a and d because the parcel size can vary by location. Comparing to the land price function without the zoning policy ($p^*(x)$), in the zoned area, the land price function with the zoning policy ($p_2^*(x)$) is always located higher. This is the result that all residents in this area directly enjoy the benefit of low-density development, and minimum-lot-size zoning has restrictive development effect here. Even when the zoning is binding, such benefit still over-powers the loss on development flexibility.

Once minimum-lot-size zoning policy is removed from a single piece of land and there is no policy change on its surrounding parcels, the price of this parcel will increase. If this parcel is located at the point where the zoning policy starts, its price equals the price of land that is located outside the zoning area. If this parcel is located right on the edge where the minimum-lot-size requirement is no longer binding, the price of this parcel will be on the price function curve of the land with non-binding zoning ($p_2^*(x)$). As explained in the introduction, minimum-lot-size zoning policy is used to prevent high-density development. Therefore, the policy created amenities associating with low-density development. However, most of these amenities (such as scenic view and better air quality) can only be provided when the minimum-lot-size requirement is applied to many parcels or an area that is big enough. When a land owner is the only one who has the exemption of minimum-lot-size zoning in the neighborhood, he/she will still enjoy the benefit of low-density development as a free ride. This is because removing the minimum-lot-size requirement from a single parcel will not change the development density in this area significantly. Therefore, the benefit of low-density development will stay at almost the same level. When a piece of land is located in the area with a minimum-lot-size requirement, the price difference between the cases of having or not having the zoning policy removed may be very significant. Notice that when a parcel is located close to where minimum-lot-size zoning starts, the zoning policy decreases land price. However, once the policy is removed from only one of these parcels, the policy may contribute to a dramatic increase in land price. However, such price difference varies by location. If the minimum-lot-size requirement is removed from a parcel close to point d , the price difference may be very small.

II.B. Simple Open City Model

In the open city model, residents are free to move into and out of the city, and the utility level is always at the equilibrium level. When there is higher amenity to increase the utility of city residents, the city will attract more people to move in. Higher housing demand will raise land prices and lower the utility level to its original equilibrium level. I used the same setup for the city and minimum-lot-size zoning policy as in the closed city model.

In the open city model, the unknown variables cannot be solved analytically. Therefore, simulation was used to demonstrate how minimum-lot-size zoning affects land prices. The equations for binding zoning boundary, city boundary, land price, and land demand are the same as described in the closed city model.

When there is no minimum-lot-size zoning policy, as in the closed city model, the solution to consumers' maximization problem are equation 3.3 and 3.4. There is no resident moving within, into, or out of the city when all city residents have the same utility level. Therefore, the land price function can be written as equation 3.5. The city boundary, equilibrium land demand, and city population can be solved by using equation 3.6, 3.7, and 3.10 respectively. I assume that a minimum-lot-size zoning policy is applied in the same way as described in the close city model (figure 3.2). All parcels located beyond point a have to be bigger than H . All residents enjoy the full amenities associated with low-density development and this amenity is determined by the size of zoned area ($b-a$). Residents who live outside the area with minimum-lot-size zoning also benefit from the low-density development related amenity but with a distance discount $(a-x+1)^{-1}$. Therefore, all unknown variables - except the city boundary - can be solved using equation 3.12-3.21. The steps are a little bit different from how I solved unknown variables in the closed city model. In the open city model, since equilibrium utility is known, solve for b in equation 3.21 first. Substituting the result of city boundary in equation 3.12-3.20, we will have the results for all other unknown variables. Since it is hard to solve equation 3.21 without assuming the value of parameters, further analysis will be shown with simulation results.

The setup for the simulation is as described in table 3.3:

Table 3.3

Variable		***Quantity***	***Unit***
Household income	Y	35000	Dollar
Transportation cost	t	2000	Dollar/mile
Utility	V^*	8	
Agricultural land price	$\overline{p}$	10000	Dollar/mile
Utility function parameter	α	0.5	
Utility function parameter	β	0.2	
Minimum-lot-size zoning starting point	a	10	Mile
Minimum-lot-size requirement	H	0.01	Mile

The solutions for unknown variables are shown in table 3.4. The results with and without minimum-lot-size zoning are listed side by side for comparison:

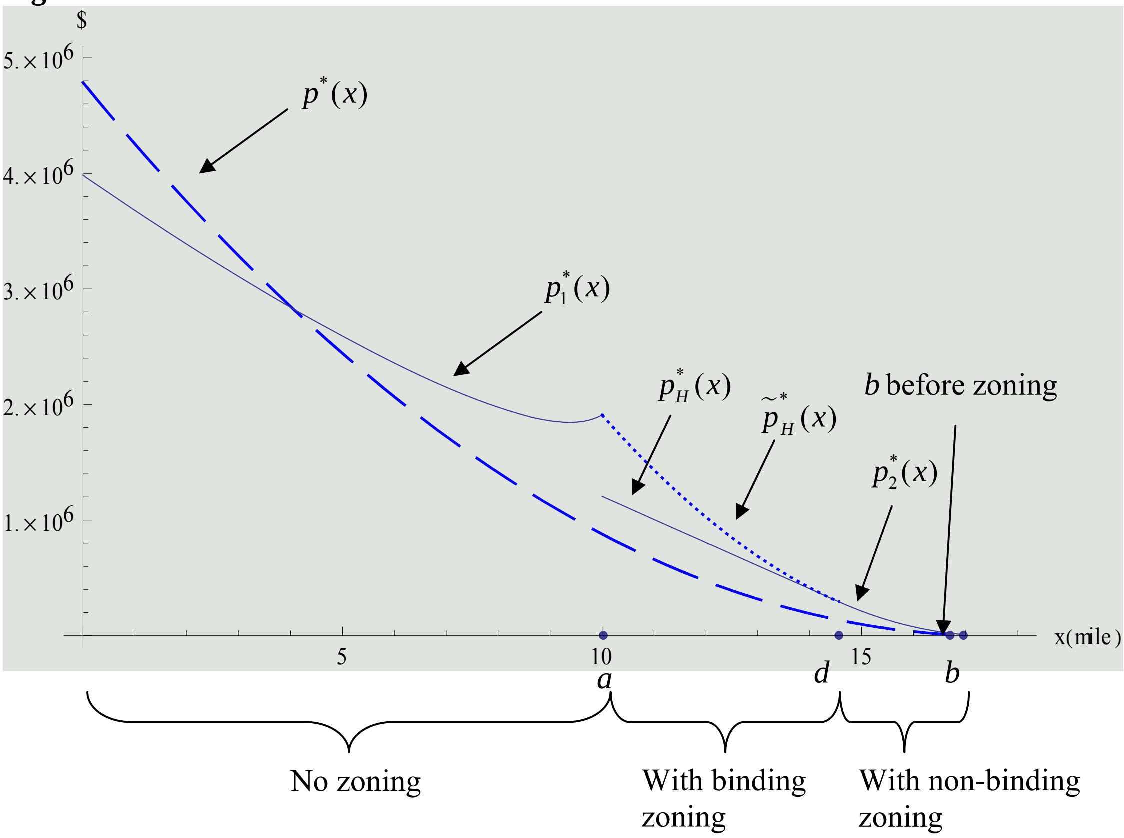
Table 3.4

<table>
<tr><th rowspan="2">Variable</th><th rowspan="2"></th><th colspan="2">Quantity</th><th rowspan="2">Unit</th></tr>
<tr><th>Without zoning</th><th>With zoning</th></tr>
<tr><td>Total population</td><td>N</td><td>2387</td><td>2743</td><td></td></tr>
<tr><td>City boundary</td><td>b</td><td>16.7</td><td>16.96</td><td>Mile</td></tr>
<tr><td>Binding zoning boundary</td><td>d</td><td>N/A</td><td>14.55</td><td>Mile</td></tr>
<tr><td>Demand function for the land in the area without zoning</td><td>$h_1^*(x)$</td><td rowspan="2">$0.13(35\text{-}2x)^{-1}$</td><td>$(2.06\text{-}0.12x)(35\text{-}2x)^{-2}(11\text{-}x)^{0.4}$</td><td></td></tr>
<tr><td>Demand function for the land in the area with zoning that is not binding</td><td>$h_2^*(x)$</td><td>$0.06(35\text{-}2x)^{-1}$</td><td></td></tr>
<tr><td>Price function for the land in the area without zoning</td><td>$p_1^*(x)$</td><td rowspan="3">$3906.25(35\text{-}2x)^{2}$</td><td>$8486.62(35\text{-}2x)^{3}(11\text{-}x)^{-0.4}$</td><td></td></tr>
<tr><td>Price function for the land in the area with zoning that is not binding</td><td>$p_2^*(x)$</td><td>$8486.62(35\text{-}2x)^{2}$</td><td></td></tr>
<tr><td>Price function for the land with binding zoning</td><td>$p(H)$</td><td>3205419-200000x</td><td></td></tr>
<tr><td>Land price at zoning starting point outside zoned area</td><td>$p_1^*(a)$</td><td></td><td>1909491</td><td>Dollar/Mile</td></tr>
</table>

Table 3.4 Continued

Variable		***Quantity***		***Unit***
		Without zoning	***With zoning***	
Land price at zoning starting point inside zoned area	$p_H^*(a)$		1205419	Dollar/Mile
Total population outside zoned area	N_1	1953	2145	
Total population inside zoned area	N_2	434	598	
Land price at CBD	$p_1^*(0)$	4785156	3983951	Dollar/Mile
Lot size at CBD	$h_1^*(0)$	0.0037	0.0044	Mile
Lot size at city boundary	$h_2^*(b)$	0.08	0.054	Mile

Figure 3.4



As shown in figure 3.4, amenities provided by the minimum-lot-size zoning increase the price of land that is outside but close to the zoned area. Since some residents are attracted to relocate closer to the zoned area, the price of parcels that are closer to the CBD drops after the minimum-lot-size zoning is applied. The price of land still decreases with distance to CBD because of transportation cost, with one exception. The parcel located closer to the zoned area enjoys more amenities provided by minimum-lot-size zoning than the parcel located closer to CBD. Therefore, the land price goes up slightly as the boundary of the zoned area is approached. This indicates that the increase in benefit of low-density development exceeds the loss on transportation costs.

Same as in the closed city model, at the starting point of the zoned area, the parcel governed by the minimum-lot-size zoning policy has a lower price than its neighbor does where the minimum lot size is unrestricted, but it is still higher than the land price before the zoning policy is in effect. Since all parcels governed by the minimum-lot-size zoning have the same benefits of low-density development, parcels would be worth more if they are located closer to the CBD.

The lot size at the edge of city is smaller than before the zoning policy (0.08 mile with no zoning and 0.054 mile with zoning). At locations close to point a in the zoned area, when the minimum-lot-size policy comes into effect, parcel sizes are bigger because the zoning policy is binding here. Since parcel sizes increase in the distance to the CBD and zoning is binding in part of the zoned area, minimum-lot-size zoning policy changed the zoned area into a region with less variation in parcel sizes across the region and higher average development density.

As shown in the figure 3.4, if minimum-lot-size zoning is removed from a single property in the zoned area, the price of this property will go up. The further the parcel is located from the CBD, the less the price difference will be. For the parcels governed by minimum-lot-size zoning, the price difference between the cases with and without minimum-lot-size zoning is relatively smaller than the price gain from individual policy exemption. This is also true in different situations that I will discuss.

Population in the city increases after the minimum-lot-site zoning is applied and more agricultural lands are developed into residential lots. This is similar to the results in the closed city model where imposing minimum-lot-size zoning increases residents' utility. The result in the open city model indicates that when the zoning policy is applied to control the development density, most city residents benefit from the policy. Therefore, the city residents' utility might initially go up. It attracts more people to move in and bid up land prices. Consequentially, equilibrium utility level goes back to its original level.

How minimum-lot-size zoning affects land price functions depends on several factors: 1) what is the minimum-lot-size requirement, 2) where the policy is applied, and 3) what are residents' preferences for low-density development. Changing one of them or several of them at the same time may generate different results. Since graphs 3 and 5 show very similar results, closed city model and open city model might yield similar results in most cases. The closed city model is more complicated when deriving equations or calculating results for simulations. Therefore, I will use the open city model to demonstrate the effects of minimum-lot-size zoning under different scenarios.

Table 3.5 and graphs 3.5-3.8 show the simulation results with alternatives for the starting points of minimum-lot-size zoning. I compared different results when zoning starts from 12, 10, 8, 2, and 0 miles while keeping other known variables unchanged.

Table 3.5

Variable		***Quantity***					***Unit***
		a=12	a=10	a=8	a=2	a=0	
Total population	N	2287	2743	3037	2728	1642	
City boundary	b	16.92	16.96	16.98	17.03	17.05	Mile
Binding zoning boundary	d	14.12	14.55	14.84	15.34	15.44	Mile
Land price at zoning starting point outside zoned area	$p_1^*(a)$	893861	1909491	3936029	11099978	N/A	Dollar/Mile
Land price at zoning starting point inside zoned area	$p_H^*(a)$	761581	1205419	1634058	1206722	N/A	Dollar/Mile
Price difference at the zoning starting point	$p_1^*(a) - p_H^*(a)$	132280	704072	2301971	9893258	N/A	Dollar/Mile
Total population outside zoned area	N_1	1911	2145	2225	1180	N/A	
Total population inside zoned area	N_2	376	598	812	1547	1642	
Land price at CBD	$p_1^*(0)$	32437216	3983951	4781817	9117721	14878126	Dollar/Mile
Lot size at CBD	$h_1^*(0)$	0.0054	0.0044	0.0037	0.0019	0.0012	Mile
Lot size at city boundary	$h_2^*(b)$	0.058	0.054	0.052	0.0047	0.045	Mile

Figure 3.5: *a* =0

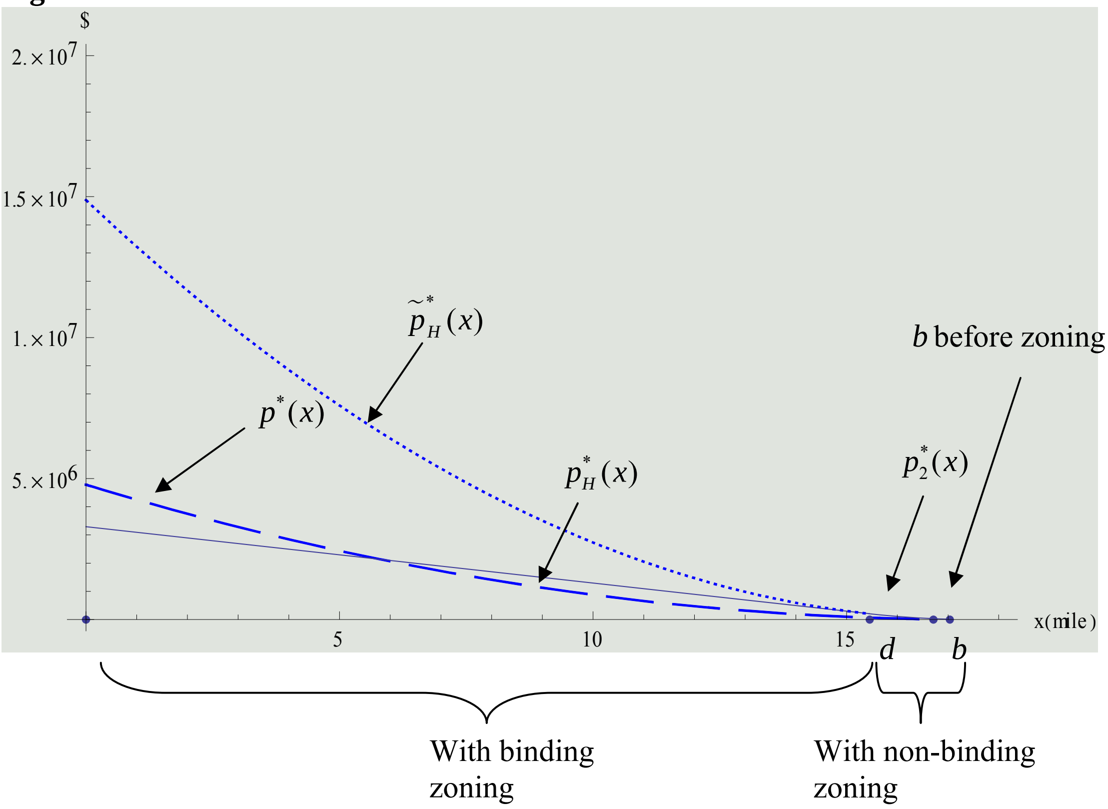

$
2.×10^7
1.5×10^7
1.×10^7
5.×10^6
5
10
15
x(mile)
$\tilde{p}^*_H(x)$
$p^*(x)$
$p^*_H(x)$
$p^*_2(x)$
b before zoning
d
b
With binding zoning
With non-binding zoning

Figure 3.6: a=2

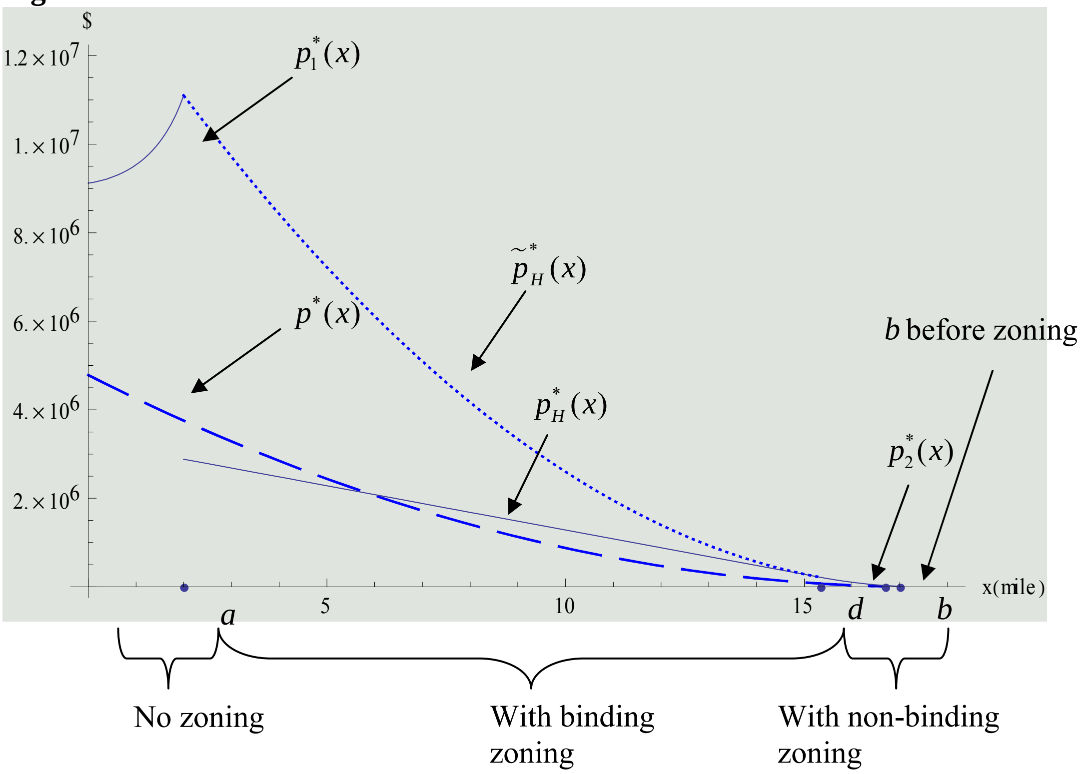

$
1.2×10^7
1.×10^7
8.×10^6
6.×10^6
4.×10^6
2.×10^6
$p_1^*(x)$
$\tilde{p}_H^*(x)$
$p^*(x)$
$p_H^*(x)$
b before zoning
$p_2^*(x)$
x(mile)
5
10
15
a
d
b
No zoning
With binding zoning
With non-binding zoning

Figure 3.7: ***a*** **=8**

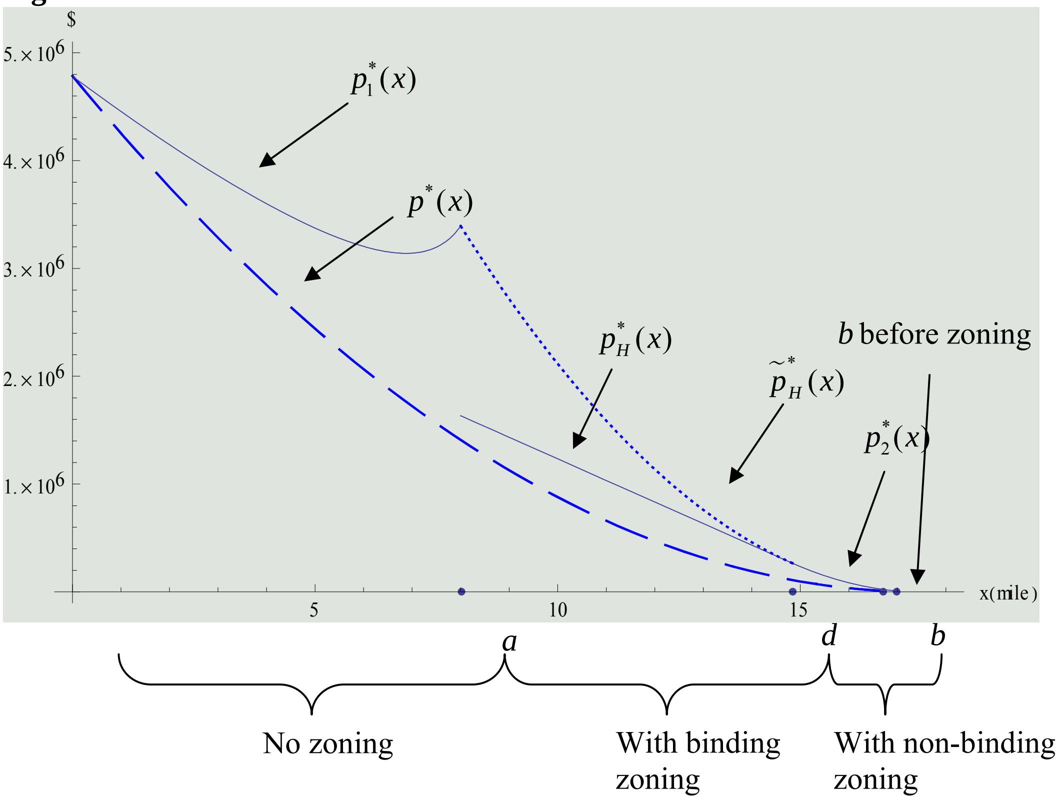
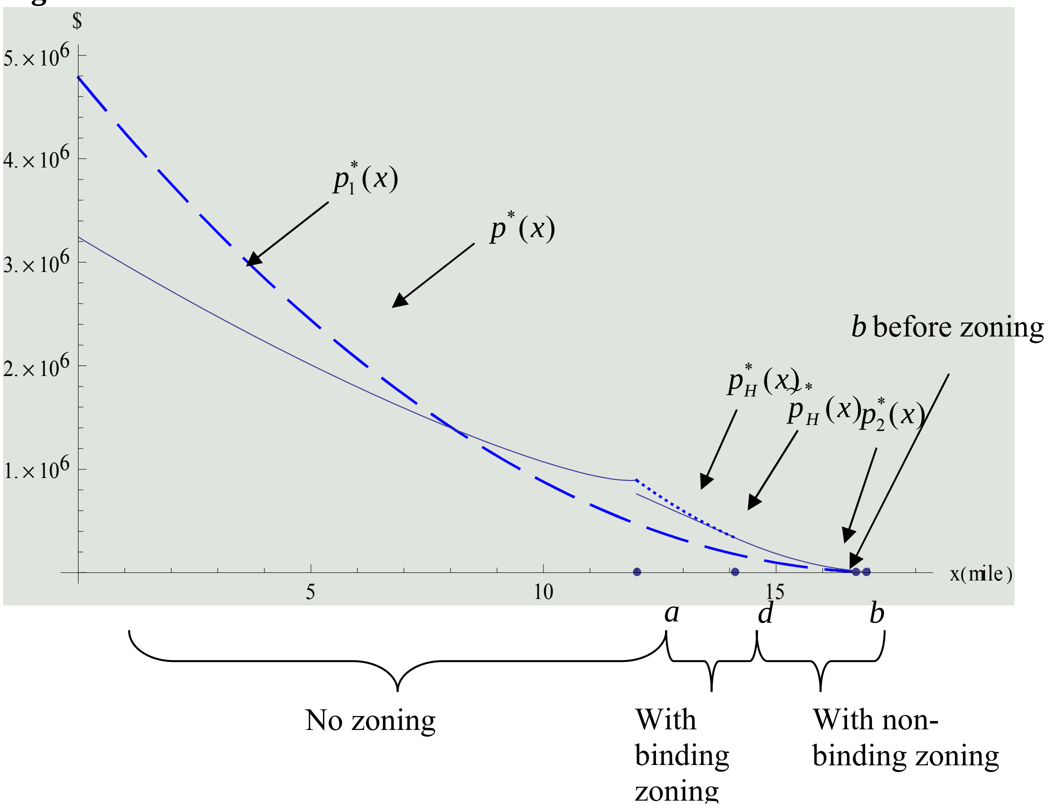

$
5.×10^6
4.×10^6
3.×10^6
2.×10^6
1.×10^6
5
10
15
x(mile)
$p_1^*(x)$
$p^*(x)$
$p_H^*(x)$
$\tilde{p}_H^*(x)$
$p_2^*(x)$
b before zoning
a
d
b
No zoning
With binding zoning
With non-binding zoning

Figure 3.8: $a = 12$



When minimum-lot-size zoning starts from a further location, a smaller area will be governed by the zoning policy. Since the size of zoned area directly affects residents' utility positively, when a is large, all city residents benefit less from the policy. As shown in graphs 3.5-3.8, when minimum-lot-size zoning starts farther away from the CBD, the price drop at the point where zoning begins is smaller. Therefore, the increase in land price due to the removal of minimum-lot-size zoning from a single parcel is smaller. In other words, when zoning starts far enough away from the CBD, having minimum-lot-size zoning removed from a single parcel will not benefit the land owner significantly. Evidence that a large a decreases zoning benefits is also reflected in the change in the city boundary. When there are more parcels restricted by the zoning policies, the city gets larger.

When minimum-lot-size zoning is applied, the parcels in the zoned area do not always have a higher price than before. Whether a parcel is worth less or more depends on the parcel's location and where minimum-lot-size zoning starts. Only when a=8, minimum-lot-size zoning increases land prices everywhere in the city. When the zoned area is small, only a few parcels can benefit from low-density development directly. Therefore, the price of land that is far away from the zoned area (but close to the CBD) decreases. When the zoned area is large, the minimum-lot-size requirement is imposed on the originally much smaller parcels. Thus, land owners at these locations are forced to live on a large lot. Usually these parcels are more expensive because the convenience of being close to the CBD. After the minimum-lot-size comes into effect, the unit price of land has to drop to a level that is affordable. Notice that when a=2, the price of land outside the zoned area is much higher than before. This is because these parcels outside the zoned area are close to both CBD and the zoned area, but they have much more flexible development options.

For policy makers, if they want to use minimum-lot-size zoning to inflate land prices so that property tax will be higher, they have to choose a certain level of a. Otherwise, imposing minimum-lot-size requirement may always decrease land prices somewhere in the city. On the other hand, even though minimum-lot-size zoning policy is designed to control the development density, it may lead to a landscape with higher development density than what policy makers might intend to have. As shown in table 3.5, lot size at city boundary gets smaller when the zoning starting point moves closer to CBD. Since land prices and parcel size have an inverse relation, higher land values are associated with higher development density. As shown in graphs 3.5-3.8, minimum-lot-size zoning may increase development density in the zoned area and decrease development density outside the zoned area and the area close to CBD. Therefore, minimum-lot-size zoning policy may not only attract more people to move in, but also attract people to move farther away from CBD. In reality, this may lead to undesirable results. For example, there might be more people living farther away from work and transportation systems will have to deal with increasing pressure during rush hour. Consequentially, air and noise pollution will create more problems related to urban development.

The table 3.6 and graphs 3.9-3.12 show the results with different minimum-lot-size requirement H .

Table 3.6

Variable		***Quantity***					***Unit***
		H =0.06	H =0.02	H =0.01	H =0.006	H =0.0035	
Total population	N	2260	2478	2743	2981	3095	
City boundary	b	16.96	16.96	16.96	16.96	16.96	Mile
Binding zoning boundary	d	16.96	16.03	14.55	12.59	10	Mile
Land price at zoning starting point outside zoned area	$p_1^*(a)$	1909491	1909491	1909491	1909491	1909491	Dollar/Mile
Land price at zoning starting point inside zoned area	$p_H^*(a)$	241817	676355	1205419	1681719	1909491	Dollar/Mile
Price difference at the zoning starting point	$p_1^*(a) - p_H^*(a)$	1667674	1233136	704072	227772	0	Dollar/Mile
Total population outside zoned area	N_1	2145	2145	2145	2145	2145	
Total population inside zoned area	N_2	115	333	598	836	950	
Land price at CBD	$p_1^*(0)$	3983951	3983951	3983951	3983921	3983921	Dollar/Mile
Lot size at CBD	$h_1^*(0)$	0.0044	0.0044	0.0044	0.0044	0.0044	Mile
Lot size at city boundary	$h_2^*(b)$	0.054	0.054	0.054	0.054	0.054	Mile

Figure 3.9: *H* **=0.06**

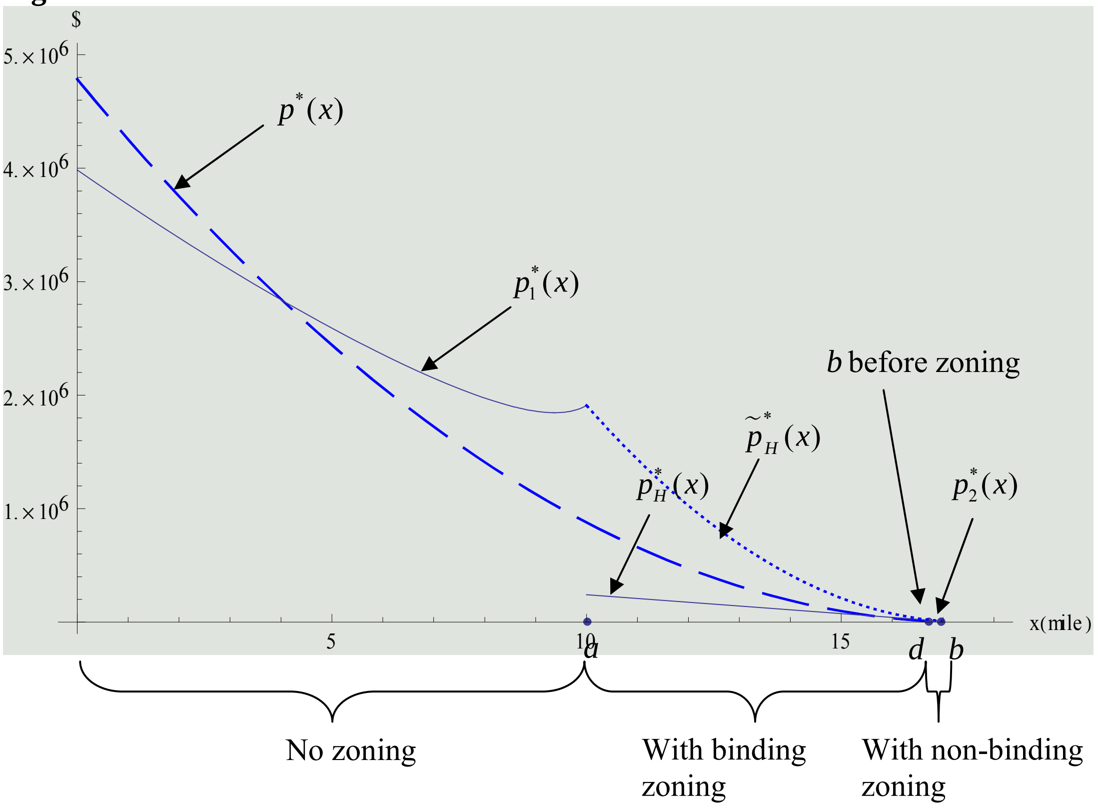


Figure 3.10: H **=0.02**

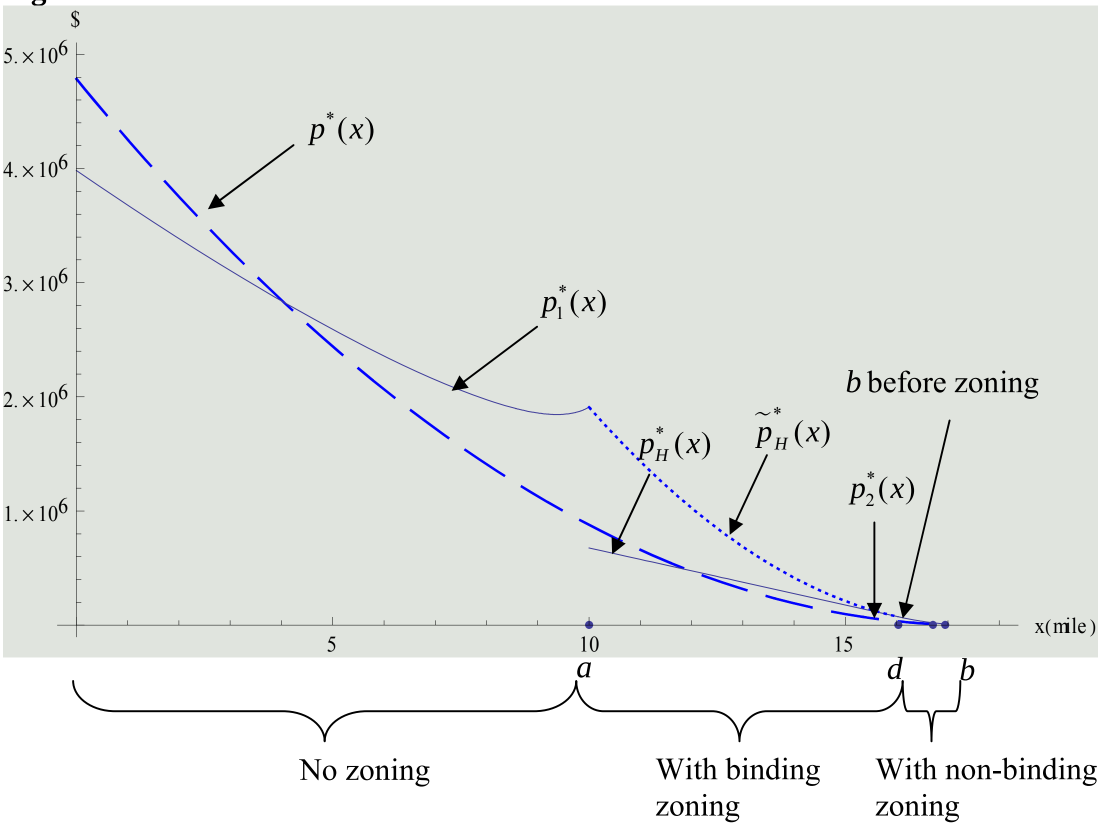


Figure 3.11: ***H* =0.006**

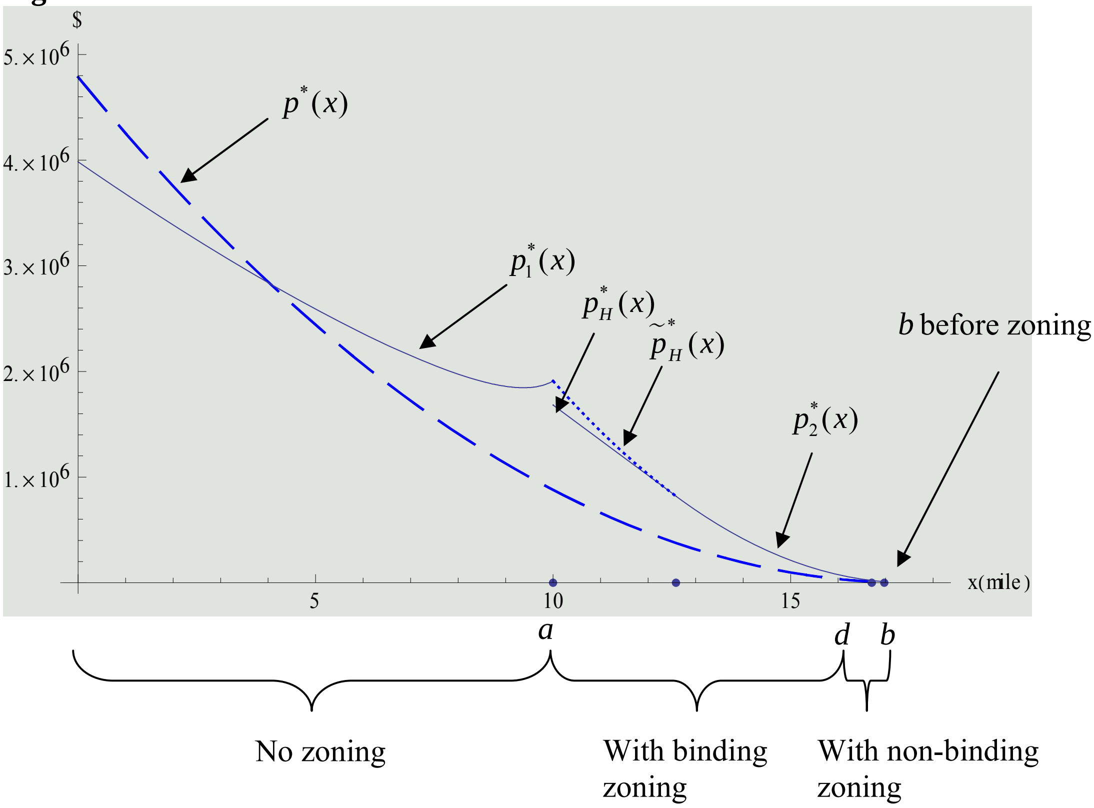
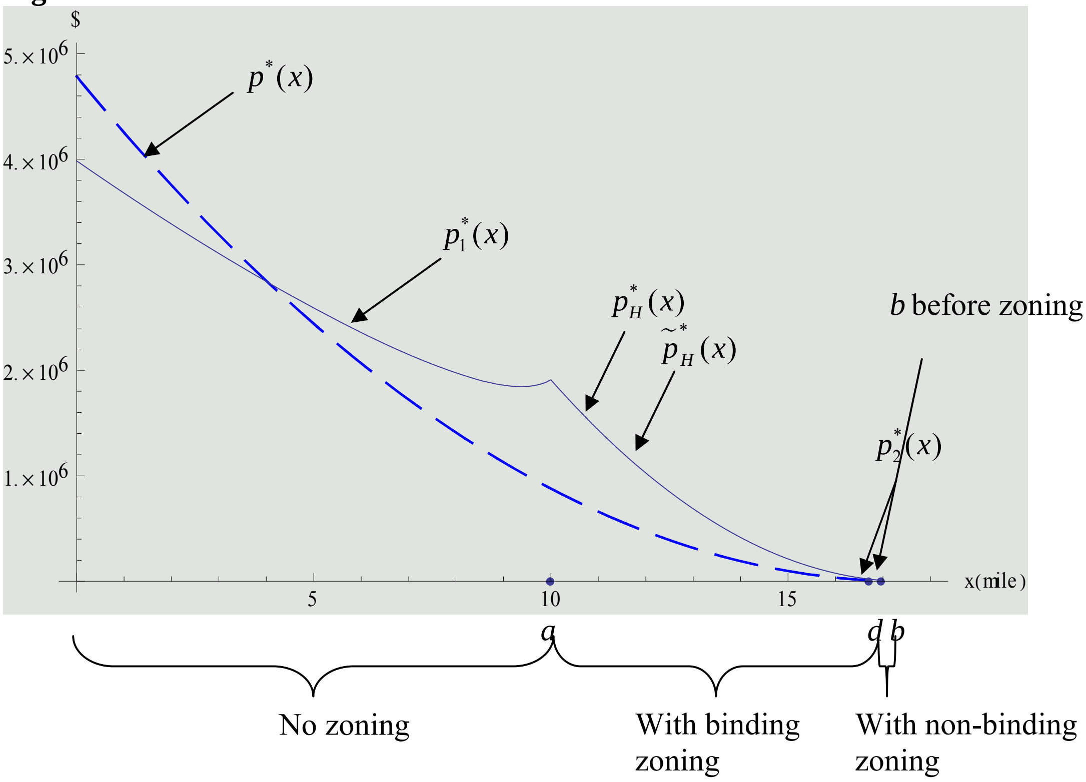


Figure 3.12: H **=0.0035**



I did not find a value for H so that minimum-lot-size zoning policy would increase all parcels' value while holding other variables constant. Figure 3.12 is the case when zoning is not binding at all in the zoned area. However, land price still increases in some part of the city. This may be because that imposing minimum-lot-size zoning provides a guarantee for the cap of development density in the zoned area. When there is no policy to regulate land development, residents may speculate development density will increase when the desirability of urban lands increases. Therefore, although a minimum-lot-size zoning policy may not be binding, city residents may still prefer to have a policy that guarantee the impossibility of high density development at certain locations. As we might see in reality, having open space next to a house may increase the house value. However, if the open space is protected by certain regulations in the long run, the house value may be enhanced more by its adjacency to open space. Therefore, it should still have impact on resident's utility. Figures 3.9-3.11 show that, for all parcels that are not governed by minimum-lot-size zoning and parcels with non-binding zoning policy, changing the minimum-lot-size requirement will not lead to different results of how a parcel's value will be affected by minimum-lot-size zoning. In the open city model, since the equilibrium utility level is fixed, b, $p_1^*(x)$, and $p_2^*(x)$ are not functions of the minimum-lot-size requirement (H). Therefore, these variable and functions are not affected when H changes. This result would be different in the closed city model because the equilibrium utility level appears in the functions of all unknown variables. The equilibrium utility level must be solved as a function of total population, which is a function of the minimum-lot-size requirement. Therefore, the minimum-lot-size requirement is a factor in the equation of equilibrium utility level.

Large minimum-lot-size requirement causes the price of parcels with a binding zoning policy to decrease. Therefore, when minimum-lot-size zoning is removed from only one of those parcels, the price gain on the parcel is greater with a larger minimum-lot-size requirement. It indicates that the development effect of this restrictive zoning policy is greater than its environmental effect, since the environmental benefit, which depends on the size of zoned area, does not change with H. If the size of minimum-lot-size requirement was considered as one of the factors affecting the environment benefit of minimum-lot-size zoning directly, the environmental effect would be stronger than the one in my model. A possible setup for such a model would be assuming that minimum-lot-size requirement is a factor in the environmental amenities that directly affect residents' utility level. Equilibrium utility level should increase with minimum-lot-size requirement at a decreasing rate. Such a setup will increase the environmental effect of minimum-lot-size zoning. However, if the environmental effect out-powers the development effect also depends on other aspects of the model, such as resident's preference and the design of minimum-lot-size zoning policy.

Next, we will see how different consumer's preferences influence the results of the simulation. When β is bigger, the change in $b-a$ contributes more to the change in the equilibrium utility. Thus, the β parameter affects how much a consumer values the benefit from low-density development. The following table and graphs show the results with three different values of β.

Table 3.7

Variable		***Quantity***			***Unit***
		β=0.3	β=0.2	β=0.1	
Total population	N	2964	2743	2552	
City boundary	b	17.05	16.96	16.84	Mile
Binding zoning boundary	d	15.52	14.55	13.14	Mile
Land price at zoning starting point outside zoned area	$p_1^*(a)$	2838140	1909491	1291079	Dollar/Mile
Land price at zoning starting point inside zoned area	$p_H^*(a)$	1301807	1205419	1064318	Dollar/Mile
Price difference at the zoning starting point	$p_1^*(a) - p_H^*(a)$	1536333	704072	226761	Dollar/Mile
Total population outside zoned area	N_1	2318	2145	2026	
Total population inside zoned area	N_2	646	598	526	
Land price at CBD	$p_1^*(0)$	3665656	3983951	4351390	Dollar/Mile
Lot size at CBD	$h_1^*(0)$	0.0048	0.0044	0.0040	Mile
Lot size at city boundary	$h_2^*(b)$	0.045	0.054	0.066	Mile

Figure 3.13: β =0.3

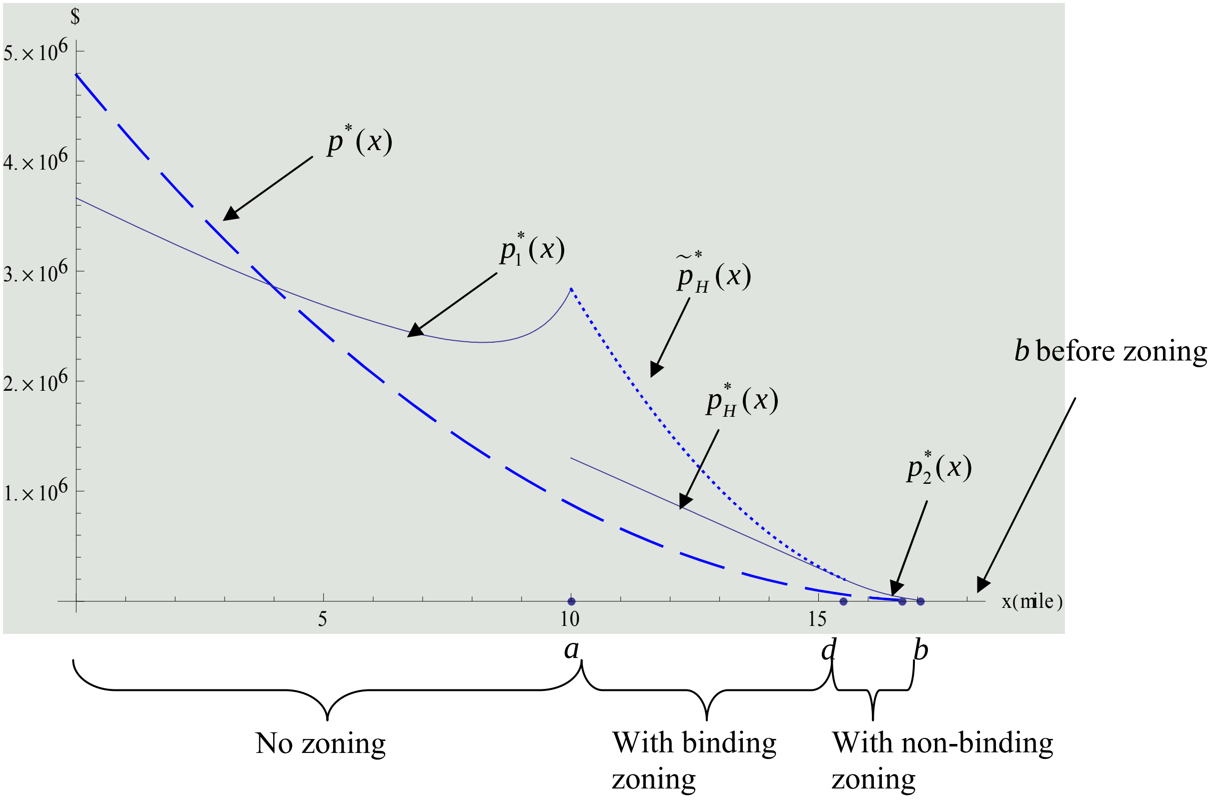
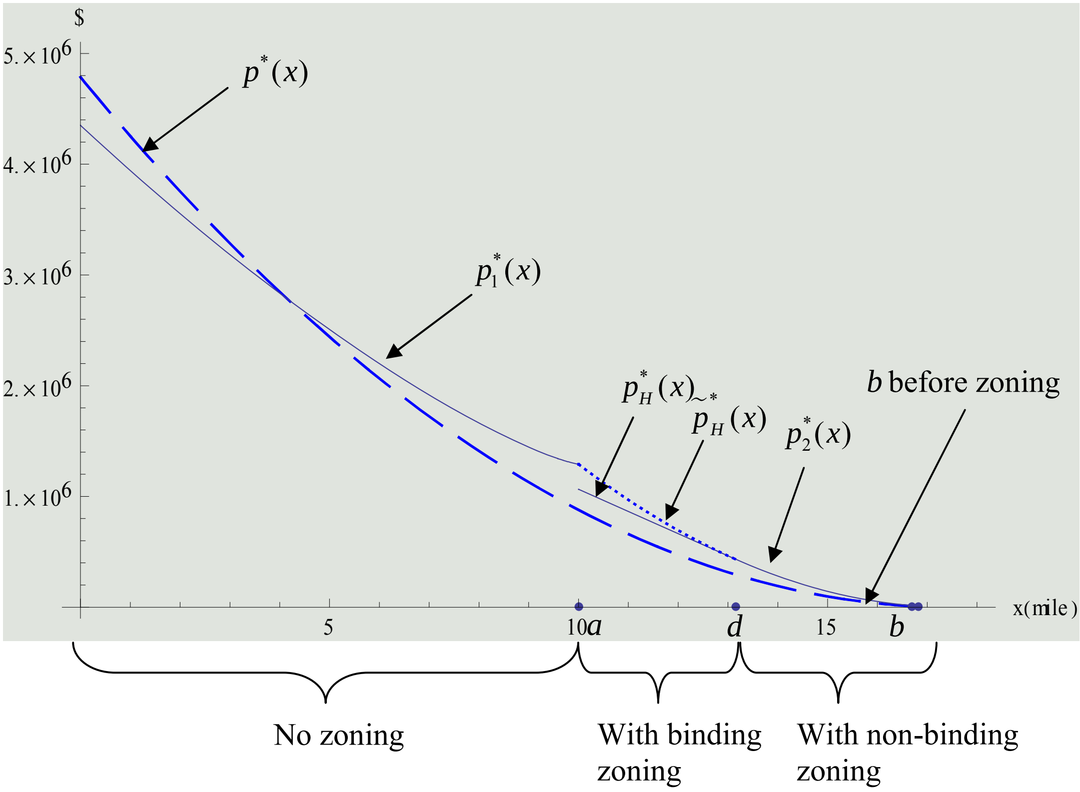


Figure 3.14: β=**0.1**



When residents value the benefit of low-density development more, the price function becomes flatter. This is because the amenities provided by the zoned area attract some residents away from the CBD. The price drop at the point where minimum-lot-size zoning starts is greater because having the amenities of low-density development but not losing the development flexibility is much more appealing when the value of β is high. Intuitively, removing the zoning restriction from only one parcel is more beneficial to the landowner.

II.C. Closed City Model and Open City Model with Two Income Groups

Residents in a city are often different from each other in many different ways. Income level is one of those characteristics that often affect the willingness-to-pay for land. In this section, I use city models with two income groups. The simulation results within an open city model and closed city model will be shown.

Figure 3.15

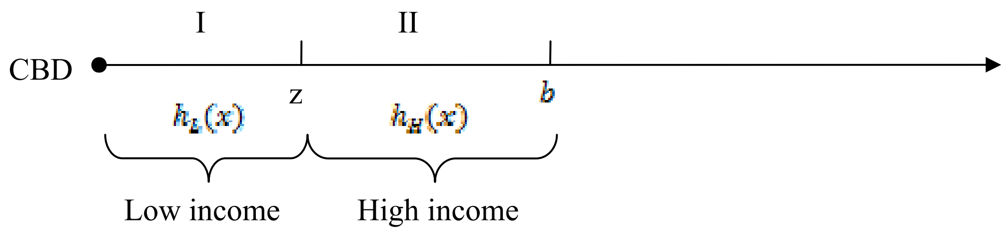
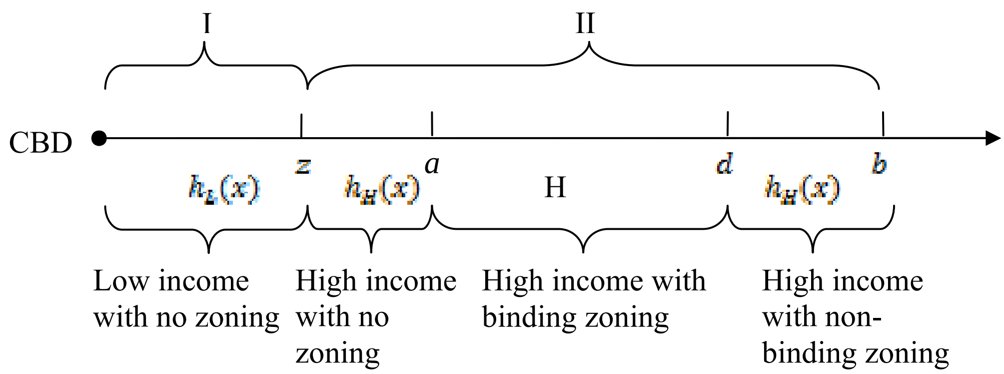


Figure 3.16



As in the simple city model, the city is linear and has a single center. All residents commute to the CBD for work. In this model, there are two income groups- high and low. Since the high-income group can spend more on land consumption while still being able to afford the transportation cost, they are able to live in the outer part of the city with larger properties (region II in figure 3.15 and 3.16). Therefore, residents with low income live closer to the CBD (region I in figure 3.15 and 3.16). I assume that a minimum-lot-size zoning policy is applied to all lots located beyond point a in the rich neighborhood. Minimum-lot-size zoning policy is not binding on all lots. Therefore, there is a point d at which the lot size is not smaller than the minimum-lot-size requirement even when such zoning policy is not applied to the property (figure 3.16).

All lots between point d and city limit b are at least as big as the minimum-lot-size requirement and the lot size increases as the location is farther away from CBD. Therefore, the land demand function between d and b is $h_H(x)$. In this section, I use subscript 0 for all variables in the case when minimum-lot-size zoning is not applied, h for all variables related to high-income group, and l for variables related to low-income group.

II.C.1 Closed city model

Low-income consumer's problem is

$$Max\ U_l(h,q) = h_l^{\alpha} q_l^{1-\alpha} \left(\frac{b-a}{a-x+1}\right)^{\beta} \quad (3.22)$$

$$s.t.\ Y_l = ph_l + q_l + tx \qquad (3.23)$$

High-income consumer's problem is

$$Max\ U_h(h,q) = \begin{cases} h_h^{\alpha} q_h^{1-\alpha} \left(\frac{b-a}{a-x+1}\right)^{\beta} \forall x \in [z,a) \\ H^{\alpha} q_{hH}^{1-\alpha} (b-a)^{\beta} \forall x \in [a,d) \\ h_h^{\alpha} q_h^{1-\alpha} (b-a)^{\beta} \forall x \in [d,b] \end{cases} \quad (3.24)$$

$$s.t.\ Y_h = ph_h + q_h + tx \quad (3.25)$$

Using the equations above, the demand functions for numeraire good and land for both high-income and low-income groups are the same as equation 3.3 and 3.4. Using the utility functions 3.22 and 3.24, the land price functions can be derived and they have the same functional form as equations 3.12, 3.13 and 3.16 only with different income and equilibrium utility levels.

Variables with subscript 0 represent the functions or values of variables before minimum-lot-size zoning is applied. Variables with subscript 1 represent the function or values of variables after minimum-lot-size zoning outside the zoned area, and variables with subscript 2 are variables inside the zoned area with a minimum-lot-size requirement. To solve the consumer's problem, I need to solve the equilibrium utility levels for both income groups (V_l^* and V_h^*) by using population in each group.

$$N_l = \int_0^z \frac{1}{h_l^*(x)} dx \quad (3.26)$$

$$N_h = \int_z^a \frac{1}{h_{h1}^*(x)} dx + \int_a^d \frac{1}{H} dx + \int_d^b \frac{1}{h_{h2}^*(x)} dx \quad (3.27)$$

Since, most boundary variables (z , d , and b) in equations 3.26 and 3.27 are unknown, I first used the city boundary condition – the price of land at the city boundary equals the price of agricultural land (as shown below) – to solve for the boundary of city b:

$$\bar{p} = \left(\frac{\alpha^\alpha (1-\alpha)^{1-\alpha} (Y_h - tx)(b-a)^\beta}{V_h^*}\right)^{\frac{1}{\alpha}}$$

Then using the neighborhood boundary condition, I solve for the boundary (z) between where residents with high income and low income live:

$$p_l^*(x) = p_{h1}^*(x) \Rightarrow \left(\frac{\alpha^\alpha (1-\alpha)^{1-\alpha} (Y_l - tx)(\frac{b-a}{a-x+1})^\beta}{V_l^*}\right)^{\frac{1}{\alpha}} = \left(\frac{\alpha^\alpha (1-\alpha)^{1-\alpha} (Y_h - tx)(\frac{b-a}{a-x+1})^\beta}{V_h^*}\right)^{\frac{1}{\alpha}}$$

Therefore, the boundary of neighborhood z is

$$z = \frac{Y_l V_h^* - Y_h V_l^*}{t(V_h^* - V_l^*)} \quad (3.28)$$

Variable d is solved by using the following equation:

$$H = h_{h2}^*(x) \Rightarrow H = \left(\frac{(1-\alpha)^{1-\alpha} (Y_h - tx)^{1-\alpha}}{V_h^*}\right)^{\frac{1}{\alpha}}$$

Substitute the solution of z , d , and b back into equations 3.26 and 3.27 to solve for V_l^* and V_h^*. All other unknown variables can be solved by using V_l^* and V_h^*.

A simulation was conducted to show how the minimum lot size requirement changes the land prices and utility levels. The known variables are listed in table 3.8 and the simulation results of unknown variables are listed in table 3.9.

Table 3.8

Variables	***Symbol***	***Value***	***Unit***
Income of the poor	Y_l	18000	Dollar
Income of the rich	Y_h	36000	Dollar
Travel cost	t	2000	Dollar/mile
Utility function parameter	α	1/3	
Utility function parameter	β	1/3	
Agricultural land price	$\overline{p}$	10000	Dollar/mile
Population in zone I	N_l	1200	
Population in zone II	N_h	800	
Minimum-lot-size zoning starting point	a	10	Mile
Minimum-lot-size requirement	H	0.02	Mile

Table 3.9

<table>
<tr><th rowspan="2">Variable</th><th rowspan="2">Symbol</th><th colspan="2">Quantity</th><th rowspan="2">Unit</th></tr>
<tr><th>Without zoning</th><th>With zoning</th></tr>
<tr><td>Equilibrium utility level for high-income residents</td><td>V_l^*</td><td>61.27</td><td>66.72</td><td></td></tr>
<tr><td>Equilibrium utility level for high-income residents</td><td>V_h^*</td><td>142.53</td><td>158.98</td><td></td></tr>
<tr><td>City boundary</td><td>b</td><td>15.09</td><td>16.24</td><td>Mile</td></tr>
<tr><td>Binding zoning boundary</td><td>d</td><td>N/A</td><td>13.75</td><td>Mile</td></tr>
<tr><td>Boundary of neighborhood</td><td>z</td><td>2.21</td><td>2.49</td><td></td></tr>
<tr><td>Demand function for the land in the poor neighborhood</td><td>$h_l^*(x)$</td><td>$0.13(9\text{-}x)^2$</td><td>$(0.29\text{-}0.027x)(9\text{-}x)^2$</td><td></td></tr>
<tr><td>Demand function for the land in the rich neighborhood that is not zoned</td><td>$h_{h1}^*(x)$</td><td rowspan="2">$1.63(18\text{-}x)^{-2}$</td><td>$(3.98\text{-}0.36x)(18\text{-}x)^2$</td><td></td></tr>
<tr><td>Demand function for the land in the rich neighborhood with non-binding zoning</td><td>$h_{h2}^*(x)$</td><td>$0.36(18\text{-}x)^2$</td><td></td></tr>
<tr><td>Price function for the land in the poor neighborhood</td><td>$p_l^*(x)$</td><td>$5152.67(9\text{-}x)^3$</td><td>$39301.1(9\text{-}x)^3(11\text{-}x)^{-1}$</td><td></td></tr>
<tr><td>Price function for the land in the rich neighborhood that is not zoned</td><td>$p_{h1}^*(x)$</td><td>$409.289(35\text{-}2x)^3$</td><td>$2063.38(18\text{-}x)^3(11\text{-}x)^{-1}$</td><td></td></tr>
</table>

Table 3.9 Continued

Variable	***Symbol***	***Quantity***		***Unit***
		Without zoning	***With zoning***	
Price function for the land in the rich neighborhood with zoning that is not binding	$p_{h2}^{*}(x)$	$409.289(35\text{-}2x)^{3}$	$2063.38(18\text{-}x)^{3}$	
Price function for the land with binding zoning	$p_{hH}^{*}(x)$		1532047-100000x	
Land price at zoning starting point outside zoned area	$p_{h1}^{*}(a)$	209556	1056451	Dollar/Mile
Land price at zoning starting point inside zoned area	$p_{hH}^{*}(a)$		532047	Dollar/Mile
Land price at CBD	$p_{l}^{*}(0)$	3756298	2604591	Dollar/Mile
Lot size at CBD	$h_{l}^{*}(0)$	0.0050	0.0036	Mile
Lot size at city boundary	$h_{h2}^{*}(b)$	0.19	0.12	Mile

Figure 3.17

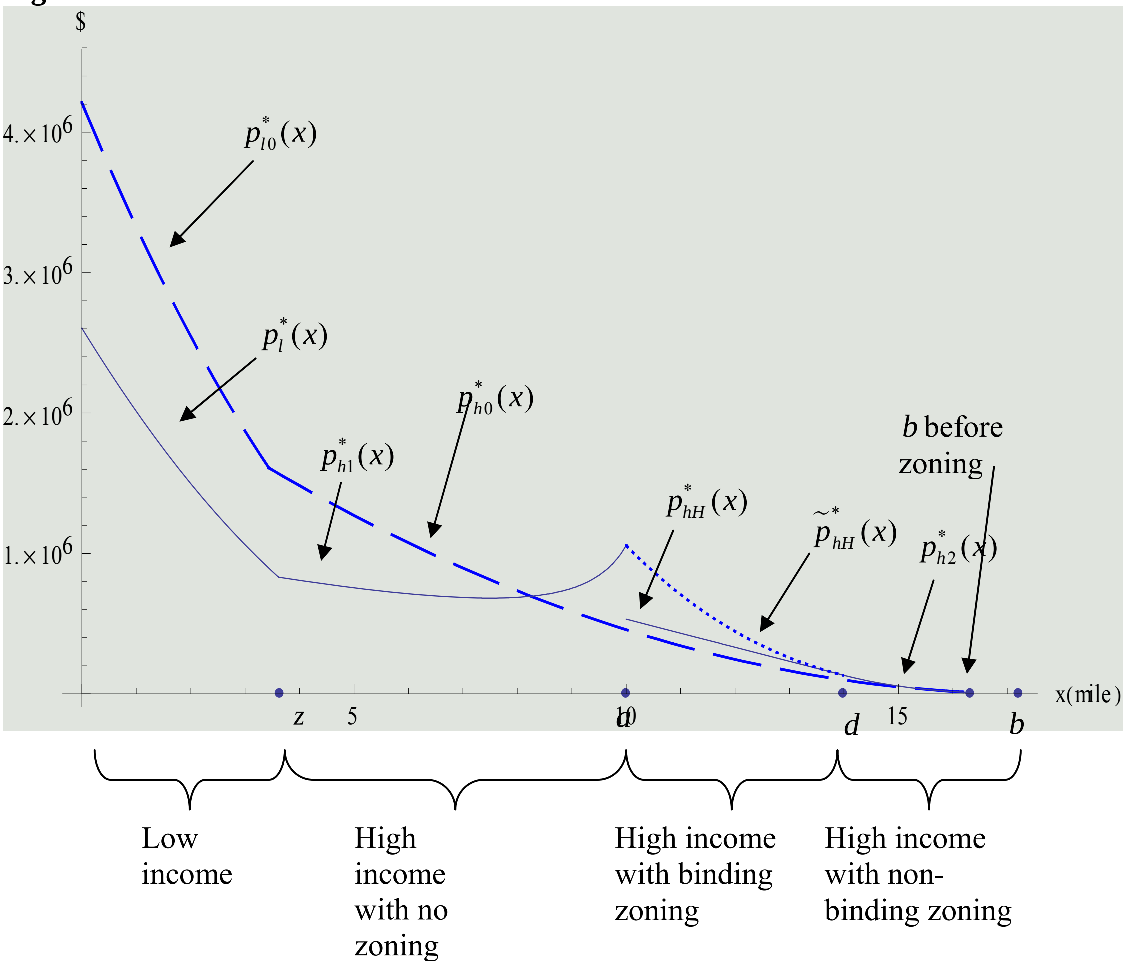


Figure 3.17 shows the land demand functions before and after a minimum-lot-size requirement is applied to outer part of the city. In the neighborhood with low-income residents, the land price function with the minimum-lot-size policy ($p^*_l(x)$) lies below the previous price function curve ($p^*_{l0}(x)$). Because of the attraction of low-density amenity that is located closer to the city boundary, $p^*_l(x)$ is also slightly flatter than $p^*_{l0}(x)$. For those parcels governed by minimum-lot-size zoning, whether the policy increases land prices depends on location. Moving away from the CBD, land price initially drops after the zoning policy is applied, and then goes above the previous land

price as the distance to the CBD increases. The price increases with distance because low-density development amenities over-power the convenience of being close to work.

The boundary (z) between the areas occupied by high-income and low-income residents moves a little bit farther away from the CBD after minimum-lot-size zoning is applied. When minimum-lot-size zoning is imposed, some people (including both the rich and poor) choose to move closer to the zoned area. Therefore, the housing density in the central city decreases and land price falls accordingly. The city expands as minimum-lot-size zoning comes into effect.

In the model of this study, low-income residents do not benefit as much as high-income residents from the zoning policy. However, decreased housing density, lower land prices, and discounted low-density development benefits from minimum-lot-size zoning policy make low-income residents better off after the policy is applied. Although some wealthier residents have to pay more for land, the amenities of low-density development are high enough to increase the utility level in the rich neighborhood as well. The results show that imposing minimum lot size requirement in the rich neighborhood increases the utility levels of both income groups. This result is different from previous research by Pasha: minimum-lot-size zoning increases the utility of low-income residents and decreases the utility of high-income residents. Pasha‘s model assumed that all parcels in the rich neighborhood are subjected to minimum-lot-size zoning and the minimum-lot-size requirement is large enough to be the constraint for all residents with high income. This assumption is more restrictive than the simulation model in this study. Pasha did not assume that the benefit from low-density development would have an impact on consumer’s utility function directly. Such benefit was not a component in resident’s utility function in his model. This may lead to an underestimate of the positive impact of minimum-lot-size zoning and an over-estimate of the restrictive impact of the zoning policy.

II.C.2 Open city model

The method to solve for unknown variables in an open city model with two income groups are the same as was used in the open city model with no income differences among residents.

The setup for the simulation is as described in table 3.10:

Table 3.10

Variable		***Quantity***	***Unit***
Low income	Y_h	18000	Dollar
High income	Y_h	36000	Dollar
Transportation cost	t	2000	Dollar/mile
Utility level of low income residents	V_l^*	2	
Utility level of high income residents	V_h^*	8	
Agricultural land price	$\overline{p}$	10000	Dollar/mile
Utility function parameter	α	0.5	
Utility function parameter	β	0.2	
Minimum-lot-size zoning starting point	a	10	Mile
Minimum-lot-size requirement	H	0.01	Mile

The solutions for unknown variables are shown in table 3.11. The cases with and without minimum-lot-size zoning are listed side by side for comparison:

Table 3.11

Variable		***Quantity***		***Unit***
		Without zoning	***With zoning***	
Total population	N	10120	10225	
City boundary	b	17.2	17.46	Mile
Binding zoning boundary	d	N/A	15.14	Mile
Boundary of neighborhood	z	6	6	
Demand function for the land in the poor neighborhood	$h_l^*(x)$	$0.004(9\text{-}x)^{-1}$	$(0.016\text{-}0.0018x)\,(9\text{-}x)^{-2}(11\text{-}x)^{0.4}$	
Demand function for the land in the rich neighborhood that is not zoned	$h_{h1}^*(x)$	$0.064(18\text{-}x)^{-1}$	$(0.52\text{-}0.029x)\,(18\text{-}x)^{-2}(11\text{-}x)^{0.4}$	
Demand function for the land in the rich neighborhood with non-binding zoning	$h_{h2}^*(x)$		$0.029((18\text{-}x)^{-1}$	
Price function for the land in the poor neighborhood	$p_l^*(x)$	$250000(9\text{-}x)^2$	$558661(9\text{-}x)^2(11\text{-}x)^{-0.4}$	

Table 3.11 Continued

Variable		***Quantity***		***Unit***
		Without zoning	***With zoning***	
Price function for the land in the rich neighborhood with zoning that is not binding	$p^*_{h2}(x)$	15625(18-x)^2	3313601-200000x	
Price function for the land with binding zoning	$p^*_{hH}(x)$		34916.3(18-x)^2	
Land price at zoning starting point outside zoned area	$p^*_{h1}(a)$	1000000	2234649	Dollar/Mile
Land price at zoning starting point inside zoned area	$p^*_{hH}(a)$		1313601	Dollar/Mile
Total population of low income	N_l	9000	8646	
Total population of high income	N_h	1120	1579	
Land price at CBD	$p^*_l(0)$	20250000	1734108	Dollar/Mile
Lot size at CBD	$h^*_l(0)$	0.00044	0.00052	Mile
Lot size at city boundary	$h^*_{h2}(b)$	0.12	0.054	Mile

Figure 3.18

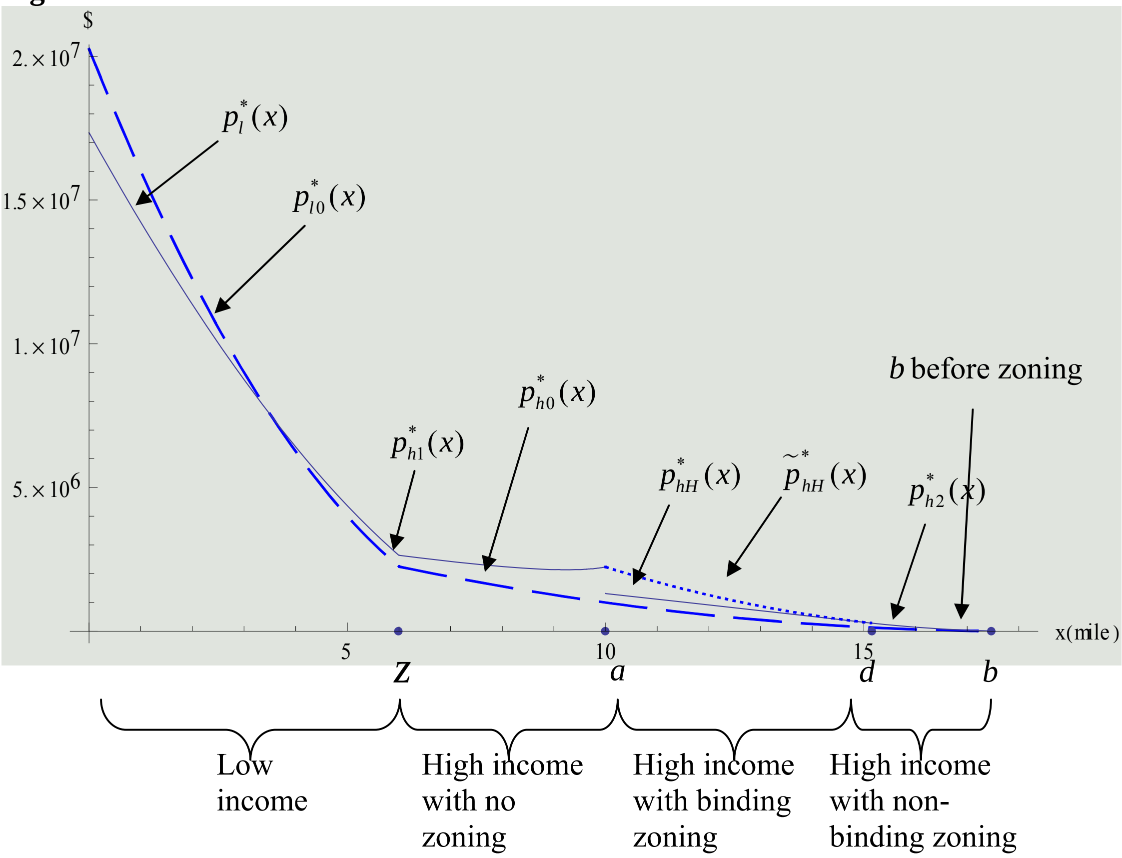


Figure 3.18 and table 3.11 show similar results as in the closed city model with a few differences. Not all parcels in the low-income neighborhood have a lower price when minimum-lot-size zoning comes into effect. Once minimum-lot-size zoning is applied, there are more people who want to live closer to the zoned area to benefit from low-density development. These people include both high-income and low-income residents. The distance between $p_{h1}^{*}(x)$ and $p_{h}^{*}(x)$ is bigger when moving closer to the starting point of minimum-lot-size zoning. This indicates that there are more people with high incomes willing to move closer to the zoned area. Since living close to the CBD is not as important as before the zoning policy, the parcels located near the city center are valued less.

Land prices suddenly drop once the parcel is zoned with a minimum-lot-size requirement. However, the price of these parcels is still higher than the price before the policy is applied. This is because low-density development provides amenities that are valued by city residents. A better living environment attracts people to move in, land prices increase, and the city boundary expands until utility goes back to the equilibrium level.

When minimum-lot-size zoning is imposed, people choose to move into the city. There is a population increase in both the rich neighborhood and poor neighborhood. Throughout the city, more rich people move in than poor people. This is because the low-density development is more appealing to the residents with high income. Some high-income residents live right in the zoned area and directly enjoy the benefit from minimum-lot-size zoning, while all low-income residents live outside the zoned area and enjoy the benefit with a distance discount. The boundary between the high-income and low-income groups does not change when the minimum-lot-size comes into effect. This is because there is no utility change in the open city model (equation 3.28).

Although minimum-lot-size zoning policy is designed to prevent high-density development, average development density in the zoned area is higher than the density before the policy. When there is no minimum-lot-size requirement, the lot size at the city boundary is 0.12. However, the lot size is as small as 0.054 after the policy is applied. This difference is much larger than what we see in the previous case that assumes no income difference among city residents (0.08 before the policy versus 0.054 after the policy). As shown in equation 3, land price and lot size have an inverse relationship, which means that the parcel with a higher price has a smaller size than the parcel with a lower price at the same location. In figure 18, $p^*_{hH}(x)$ and $p^*_{h2}(x)$ are above $p^*_{h0}(x)$ everywhere in the rich neighborhood. Therefore, at the same location, the parcel size is smaller when minimum-lot-size zoning policy is applied, except for parcels with the binding zoning policy. This also can be proven directly:

$$\because h_{h2}^{*}(x) = f(Y_h, b, x) \text{ and } b = f(Y_h)$$

$$\therefore \frac{\partial h_{h2}^{*}(x)}{\partial Y_l} = \frac{\partial h_{h2}^{*}(x)}{\partial Y_l} + \frac{\partial h_{h2}^{*}(x)}{\partial b} \bullet \frac{\partial b}{\partial Y_l}$$

$$\therefore \frac{\partial h_{h2}^{*}(x)}{\partial Y_l} = \{\frac{\alpha\beta(Y_h - tx)^2}{a-b} + (\alpha-1)[\frac{(b-a)^{\beta}(1-\alpha)^{1-\alpha}\alpha^{\alpha}(Y_h - tx)}{V_h^{*}}]^{-\frac{2}{\alpha}}\}[\frac{(b-a)^{\beta}(1-\alpha)^{1-\alpha}\alpha^{\alpha}(Y_h - tx)}{V_h^{*}}]^{-\frac{2}{\alpha}}$$

$$\because 0 < \alpha < 1 \text{ and } 0 < a < b$$

$$\therefore \frac{\partial h_{h2}^{*}(x)}{\partial Y_l} < 0$$

Therefore, when minimum-lot-size zoning is designed to prevent over-crowed residential development, it only increases the lot size wherever the policy is binding. In the area that zoning is not binding, the lot size tends to be even smaller especially when the income level is high.

III. Conclusion

Minimum-lot-size zoning changes the city's development pattern, residents' location choices, and land prices. This policy is typically used to prevent a city from becoming over-crowded and to preserve the amenities of low-density development. If the benefit of low-density development is a normal good for all residents, minimum-lot-size zoning increases utility level when the city population is constant or increases city population when all residents are free to move in and out of the city. Since minimum-lot-size zoning policy promotes low-density development in the outer city, the amenities of low-density development draw people away from the CBD. However, transportation costs are unavoidable for commuting between residence and work, and are still an important factor when people choose residential locations. Therefore, in most parts of the city, land price still goes down with increasing distance between the parcel and CBD even when minimum-lot-size zoning is in effect. Only when parcels are located very close to the starting point of minimum-lot-size zoning, land price may go up slightly with increasing distance to CBD. This is because of the attraction of low-density development and the flexibility of development. For the parcels with non-binding minimum-lot-size requirement, imposing the zoning policy always increases land price. For the rest of the parcels, the impact of minimum-lot-size zoning on land prices depends on several factors: the minimum-lot-size requirement, where the zoning policy starts, and how much people value the benefit of low-density development.

The amenities of low-density development can only be provided when minimum-lot-size zoning is applied to a large enough area. Such amenities also have a spillover effect. Thus, when minimum-lot-size zoning is removed from one single parcel and there is no policy change on other parcels, the price of the parcel with policy exemption jumps up. This price gain gets smaller when the parcel is located closer to where the minimum-lot-size requirement is no longer binding. When minimum-lot-size zoning is removed from only one parcel, the price of parcel goes up dramatically (unless minimum-lot-size zoning is not binding). In reality, such price increase may still happen when the zoning policy removal is applied on more than one parcel in a neighborhood. There are two conditions under which removing minimum-lot-size zoning from one or more parcels will increase the values of these parcels: 1) the zoning removal on several parcels doesn't change the neighborhood characteristics that were created by minimum-lot-size zoning policy, 2) minimum-lot-size zoning was binding on these parcels before it was removed. The reason for the first condition is that many amenities that are related to low-density development must be provided only when minimum-lot-size zoning policy is applied to large enough neighborhoods. Therefore, if remove minimum-lot-size requirement on several parcels will not affect urban development patter in the zoned area, the amenities are most likely not affected. On the other hand, if a local government removed minimum-lot-size zoning on all parcels, the amenity associated with minimum-lot-zoning will disappear and the value of parcels that were previously zoned with minimum-lot-size requirement may decrease.

The results from this theoretical model may also be applied to other types of land development regulations. For example, how the construction codes on controlling building structure heights and density affect housing values can also be analyzed using this model. This model can be combined with other methods to further explore the effect of Measure 37 and 49. Using game theory and this city model, a simulation can show that how Measure 37 may eliminate minimum-lot-size zoning policy and its benefits altogether. If having minimum-lot-size zoning requirement removed becomes an option for all land owners, a land owner may speculate more than one of his/her neighbors will file for the zoning policy removal. Therefore he/she may anticipate the amenities protected by enforcing minimum-lot-size zoning will diminish.

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CHAPTER 4

THE EFFECT OF MINIMUM-LOT-SIZE ZONING ON LAND VALUES IN OREGON

I. Introduction

To investigate the relationship between the lot size and the willingness to pay for land, a two-stage estimation using the hedonic price method proposed by Rosen (1974) is used to estimate an inverse demand function for lot size. The model permits an evaluation of non-marginal changes in the marginal implicit price of size. Empirical analysis can directly compare land values with and without land-use policy only when the policy could be the only difference between two parcels' values. However, such data are not available. First, the land market is highly differentiated: it is difficult to find two pieces of land with identical characteristics except for the land-use policy to which they are subjected. Second, policy may have indirect as well as direct (development and amenity effects) impacts on land value. Once a land-use regulation is imposed, neighborhood infrastructure (such as road layout and public service locations) and landscape features change as well, which in turn affects land value. However, it is hard to predict how the landscape features and public services in a neighborhood develop over time under different circumstances. As a result, we may not be able to estimate the current value of the land with different land-use policies or no policy imposed in the past. Therefore, the difference between the values of the same parcel before and after the regulation may not correctly reflect the "reduction in the fair market value of the affected property interest resulting from enactment or enforcement of the land-use regulation". Even though, we were able to estimate the land values before and after a land use policy correctly, the difference between these two values might not coincide with the gain in land value when the land use policy is removed from a property – another option in Measure 37. The reason is that neighborhood features might be changed by land use policies. As explained in the previous chapter, minimum-lot-size zoning creates low-density development with many local amenities, such as better scenic views and better air quality. These features are often created when low residential development covers a sufficiently large area. When minimum-lot-size zoning policy is removed from a single property, average development density in the neighborhood might be the same.

Therefore, the property will gain more in value than when the zoning policy is removed from the whole neighborhood. This is because the property with policy exemption has a privilege in development opportunities while the neighborhood amenities stay unchanged.

An appropriate method is instead to estimate the demand function for the lot size itself, permitting estimates of the benefits of non-marginal lot-size changes. The parameters of the hedonic price function give the relationship between the price of a commodity and its characteristics. However, it only explains how the marginal change in the characteristics affects the commodity price. The second stage estimation estimates the demand curve for the commodity's characteristics, which provides the tool for estimating the benefit of non-marginal changes. This study will use the two-stage hedonic estimation to estimate consumers' underlying preference for the lot size of residential lands in Oregon and investigate the impact of non-marginal changes caused by minimum-lot-size zoning on the land value.

II. Theoretical Model

The hedonic price model assumes that there is a sufficiently large number of combinations of the parcel characteristics offered, and consumers as price-takers are free to choose any combinations. Each consumer selects the combination of land features that maximizes his utility subject to an income constraint. The consumer's utility depends on a composite commodity *x* and land with characteristics of $z = (z_1 ... z_n)$ (such as size, neighborhood and environmental amenities, etc.). At the equilibrium, given the prices of all alternative consumption choices and a land market that clears, all consumers choose the bundle of parcel characteristics that maximizes their utility subject to their budget. Assume that the consumer's budget constraint is $y = x + P(z)$, where the price of composite commodity *x* is 1. The price of land can be expressed as a function of its characteristics $z_1 ... z_n$:

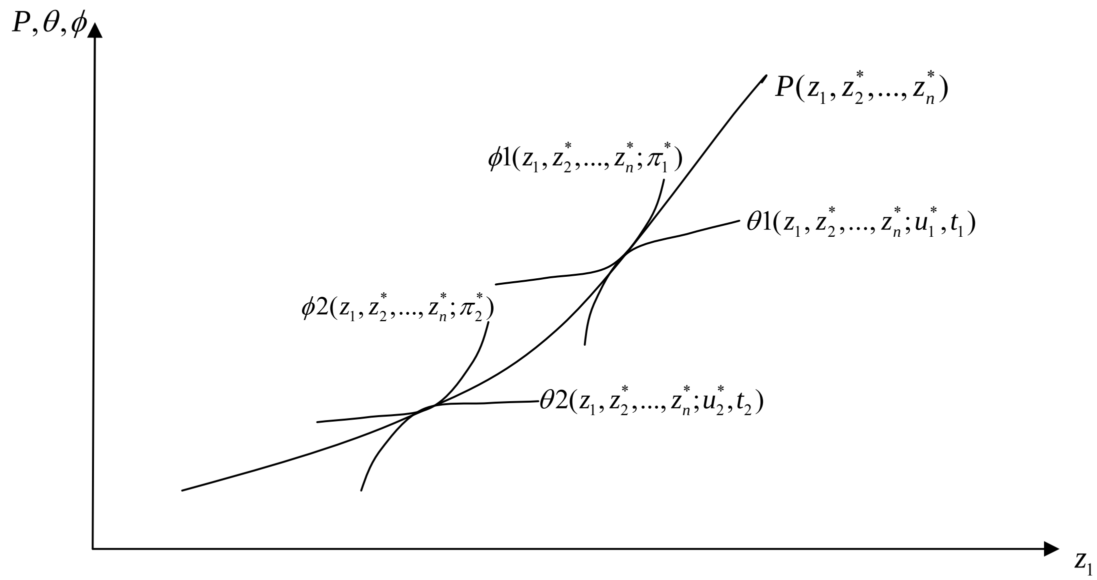
$$P = P(z) = P(z_1 ... z_n) \quad (4.1)$$

Let t be a parameter representing taste that differs from person to person. The consumer's utility function is given by:

$$U = U(x, z_1 ... z_n; t) \quad (4.2)$$

Suppose that the price that consumer is willing to pay for z at a fixed utility level and income is $\theta(z; u, y, t)$, so $\theta(z^*; u^*, y, t) = P(z^*)$ at the equilibrium. Holding other characteristics and the utility level constant, and allowing a consumer to choose his bid price for the land at the different level of characteristic $z_i (i \in 1,..., n)$, we will be able to get the bid curve $\theta(z_i, z_{-i}^*; u^*, t)$ (figure 1). $\phi(z_1, z_2^*, ..., z_n^*; \pi_1^*)$ in figure 1 is the supplier's offer curve. At the equilibrium, the bid curve and the offer curve are tangent to each other, and both are tangent to the hedonic price function curve. Figure 1 shows two bid curves for two consumers who may have different tastes (t) or incomes (y). Because the interest of this paper is on how consumers value land characteristics, there is no need to formally estimate the production function on the supply side of the market.

Figure 4.1



Suppose each consumer selects only one parcel of land. The first-order condition of the consumer's utility-maximization problem is:

$$\frac{\partial P}{\partial z_i} = \frac{U_{z_i}}{U_x}, \forall i = 1...n \quad (4.3)$$

Equation 4.3 shows that the partial derivative of the hedonic price function with respect to any characteristic gives the implicit marginal price of that characteristic. If the form of utility function and income constraint is specified, the demand for one characteristic can be derived directly. However, this involves many restrictions and we have limited knowledge about the form of consumers' preferences. As a result, this study uses an empirical model to estimate the demand for lot size.

III. Data

The data is collected from five Oregon counties: Lane, Benton, Jackson, and Marion. Several urban areas are located in this study region, and minimum-lot-size zoning is widely used to prevent high-density development on the urban fringe. These cities also face pressure from urban expansion and from increasing housing demand. Minimum-lot-size zoning thus may have a significant impact on land values in these areas. Data employed include assessed property value in 2005 and features of vacant residential lands, zoning regulation, neighborhood features, and demographic characteristics. The definition and source of data are listed in the appendix. The parcels are selected first by the property class, which categorizes parcels by use, zoning, or assessment program, which describes the primary use of a parcel at the time of assessment. Then the parcels recorded with zero assessed value or zero acreage are excluded from the dataset.

There are several reasons why the recorded sales prices may not always reflect the market value of properties: (1) buyers or sellers may not act with full knowledge of the market; (2) buyers or sellers may make a decision in a hurry; (3) buyers may have unusual favorable or unfavorable terms of financing. In addition, for empirical estimation, there may not be enough sales records in a year to provide enough variation in minimum-lot-size zoning. As a result, this study uses the real market value obtained from the county assessor's office. The Real Market Value (RMV) is typically the price a property would sell for in a transaction between a willing buyer and a willing seller.

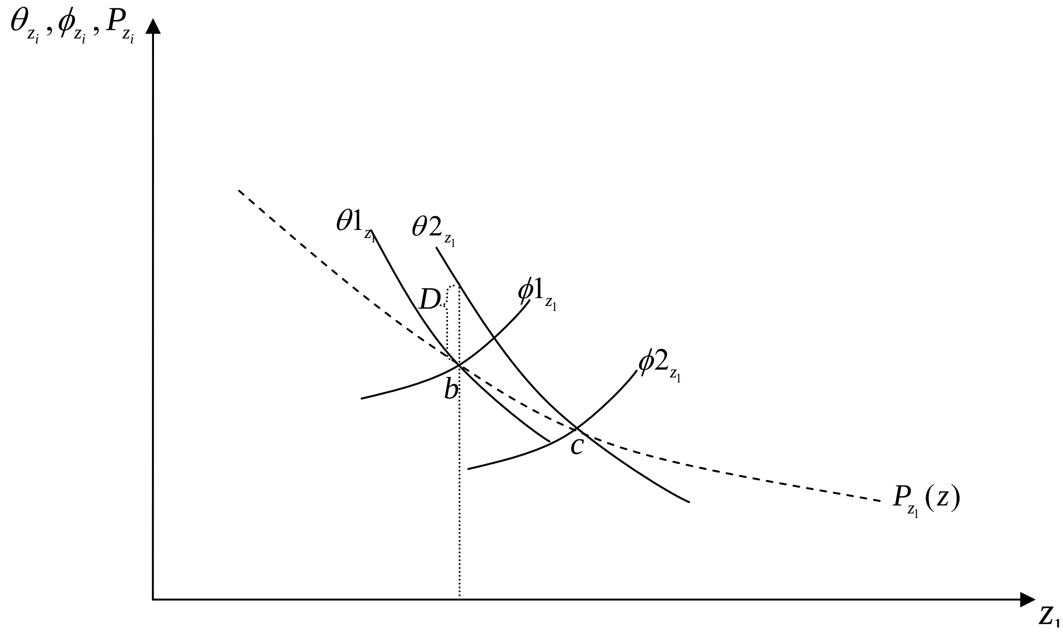
The dataset used in this study only includes the records of vacant residential land. Although using only vacant land may involve sample selection problems (some lands may be vacant for a specific reason, such as that the shape of the parcel is not suitable for any residential structure), this choice avoids the problem of separating the values of structures and land.

IV. Empirical Model

As mentioned in the theoretical section, without assuming the form of the utility function form, the second stage hedonic model has two identification problems when estimating the demand for a parcel feature. First, since the first stage hedonic price function is nonlinear, the marginal willingness to pay varies by the lot size. In other words, the implicit price of lot size and lot size are determined simultaneously when the minimum-lot-size zoning is not binding or not applied to the land. To solve this problem, instrumental variables that are uncorrelated with the error term in the second stage estimation can be used to solve the simultaneity problem.

Second, the implicit price function of lot size (which is the first-order derivative of the hedonic function with respect to the lot size) only shows the price and lot size at the equilibrium. However, the supply and demand curves are not identified. Figure 4.2 shows the challenge of identifying the demand curve for a land characteristic in the second stage estimation.

Figure 4.2



The dashed curve labeled as $P_{z_i}(z)$ is the first order derivative of $P(Z)$ with respect to a land characteristic z_i, which only reflects the MWTP and quantity of z_i at the equilibrium. The solid curves labeled as $\theta 1_{z_i}$ and $\theta 2_{z_i}$ are the compensated demand functions of z_i for two consumers with different unobserved tastes. The intersections of the demand curves and the implicit price function curve (point b and c) represent the consumers' choices, and they are the only observed points on the demand curves. In figure 4.2, consumer 2 prefers z_1 more than consumer 1 does, so for the same amount of z_1, he is willing to pay more. As a result, the unobserved taste is correlated with the independent variable z_1. If this correlation is ignored in the second stage estimation, the regression results will be biased. In figure 4.2, this bias is D.

To solve the second identification problem, Brown and Rosen (1982) showed that with a single hedonic price function, specifying the functional form of consumer's utility function is the only way to solve the identification problem in the second-stage estimation. However, if there are many hedonic price functions with the same structural parameters to provide enough “in-between” variation, the identification can be achieved. Following Bartik (1987), a dummy variable for county (as well as the interaction terms of county dummy variables and demand shifters) can be used as an instrumental variable if we can assume that the distribution of tastes among property owners has no correlation with the county of their residence. Land owners’ tastes to land are often related to their demographic characteristics. For example, a family with more family members living together would prefer a larger land than a family with few people. People who grew up in rural areas may want to have a large lot so that they can have a garden or rural features in the neighborhood. Such relationships between a land owner’s taste and demographic features are not likely to vary by counties. However, demographic characteristics like these are not included in the data used in this study. Therefore, missed information about certain demographic characteristics may be the source of “unobserved taste”, as Bartik mentioned. Furthermore, such unobserved taste is not related to which county a land owner resides. Therefore, county dummy variables should be a good candidate for instrument variables in the second stage estimation. In general, the most appropriate way to solve the second identification problem is to find cases where consumers with the same income and tastes face different marginal implicit prices. Such a case can correspond to similar consumers in different housing markets. With the market segmentation method, we need to assume that the structure of the supply and demand functions is the same across the markets, even though the hedonic price function of each market can be different.

IV.A. First Stage Estimation

For most parcels, the hedonic price function is concave because of the diminishing marginal utility of lot size to landowners. However, when the lot is too small, the developer has either very few choices or no choice in terms of the type of housing structure to build. As a result, the marginal willingness to pay for lot size could be increasing until the size reaches a certain point (e.g., point a in figure 4.3 and 4.4).

Figure 4.3

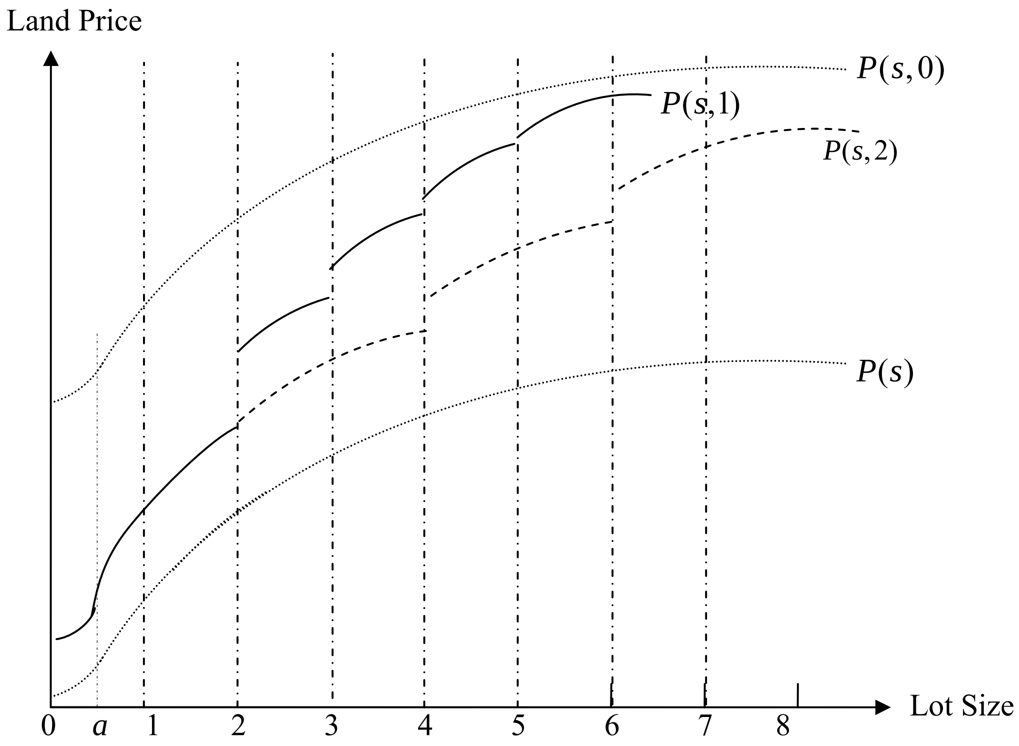
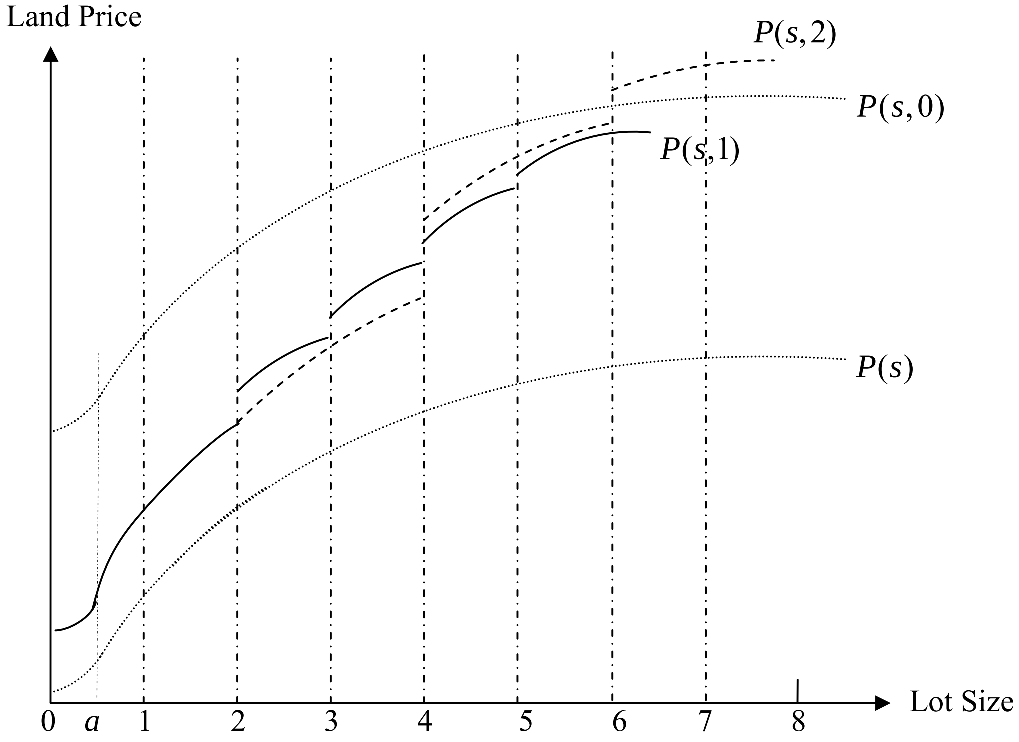


Figure 4.4



As stated in the first essay, minimum-lot-size zoning may have two effects: the development effect and the environmental effect. Suppose only the development effect is considered. Let $P(s,0)$ be the equilibrium price for residential vacant land when there is no zoning restriction. With the freedom of dividing or combining parcels in the future, the price is higher than when any zoning restriction is applied. Let $P(s)$ be the hedonic price function when there is no change on the existing lot size allowed. The landowners cannot combine or divide their lands. With very limited development possibilities, the price is the lowest among all the cases with and without zoning restrictions.

Let the solid curve $P(s,1)$ be the hedonic price function of the land zoned for residential use with a minimum lot size of 1 acre (Res-1). The hedonic price function before the first price jump indicates the equilibrium price of land that was already smaller than 1 acre before the zoning policy is imposed. Any lot that is smaller than 2 acres cannot be divided into two. Assuming that the marginal implicit price of lot size declines as the land gets larger, it is profitable to divide a large parcel into smaller ones. As a result, when the lot size reaches another integer multiple level of the zoning restriction, there is a jump in the land price, because the lot can be further divided. This is the development effect. Notice that the price jump gets smaller as the size of land increases. The reason is that landowners may not divide their land even when it is possible under the minimum-lot-size zoning, and the marginal willingness to pay for the lot size is decreasing. As a result, the development effect declines as the lot size increases.

Let the dotted curve $P(s,2)$ be the implicit price function for the land zoned for Res-2. The price jump is smaller than the one in Res-1, because for Res-1, a 4-acre land parcel can be divided into four 1-acre parcels, however under Res-2 zoning, it can only be divided into two 2-acre parcels. In other words, the larger the minimum-lot-size requirement, the more restrictive the policy is. The more restrictive land-use policy makes the lot less desirable. So the hedonic function of Res-2 is located below the one for Res-1. As the policy gets tighter, the hedonic function curve gets closer to the lower bound. The minimum lot size can be so large that there is no jump in price at all because there is little development opportunity. For example, suppose the minimum-lot-size requirement is 50 acres. Once the land size is as large as 50 acres, the marginal price of land size could be approaching zero. As a result, dividing a 100-acre parcel into two won't be more profitable than selling the whole parcel. In this case, there is no development effect, so there is no jump at the integer multiple level of the zoning requirement. On the other hand, if the minimum lot size is very small, there are more and larger price jumps, and the implicit price curve will be very close to p(s, 0) when lot size gets larger.

Notice that the hedonic price curves for the lands governed by minimum-lot-size zoning start between the upper ($P(s,0)$) and lower ($P(s)$) boundaries. Although some parcels are already smaller than the minimum-lot-size requirement and it seems that the zoning policy will not affect the land price when it is first imposed, the development on those small parcels is still limited. First, they cannot be further divided when there is demand for very small lots (such as in a crowded downtown areas). Second, once the landowner combines the small zoned parcel with the neighboring land (zoned or not zoned), he cannot make the small parcel go back to its original size. As a result, the limited development opportunities make the hedonic price curve for the zoned land lower than the curve for land without zoning.

When only considering the development effect, the hedonic price function curve of larger zoning sites is always placed lower than the one for smaller zoning sites because of fewer development choices available. However, if both development and environmental effects are considered, the hedonic price function curve for larger zoned lots may be pushed to be higher than the curve for smaller zoning lots or even higher than the price function for lots without zoning (figure 4.4).

The first-stage estimation (estimating the hedonic price function for vacant lands) uses a Box-Cox transformation, which allows a flexible functional form for non-linear regression. The dependent variable is the real market value of land, and the independent variables include the acreage, neighborhood features, and demographic characteristics. When the omitted variables are potential problems in the regression, Cropper, Deck, and McConnell (1988) showed that the linear function of Box-Cox transformed estimates outperforms the quadratic Box-Cox function. Since the variable selection in this study is limited to the geographic and demographic information provided by the county offices and Federal Census Bureau, some variables might be omitted. Therefore, this study uses the linear form Box-Cox transformation. The transformations on the dependent and continuous independent variables are allowed to vary differently. However, except for the lot size, the transformations on the independent variables are the same. The Box-Cox transformation on the dependent and independent variables is defined as:

$$P(Z)^{(\lambda)} = \begin{cases} \dfrac{P(Z)^{\lambda}-1}{\lambda}, \forall \lambda \neq 0 \\ \log[P(Z)], \lambda = 0 \end{cases} \quad \text{and} \quad z_i^{(\alpha)} = \begin{cases} \dfrac{z_i^{\alpha}-1}{\alpha}, \forall \alpha \neq 0 \\ \log(z_i), \alpha = 0 \end{cases}$$

Where $P(Z)$ is the assessed RMV of parcels, and Z_i represents a vector of factors that affects land value.

$$\begin{aligned}[P(Z)]^{(\lambda)} &= \beta_0 + \beta_1 highway^{(\alpha)} + \beta_2 railroad^{(\alpha)} + \beta_3 water^{(\alpha)} + \beta_4 wetland^{(\alpha)} \\ &+\beta_5 city\_center + \beta_6 city\_boundary + \beta_7 UGB...\end{aligned} \qquad (4.4)$$

Equation 4.4 is the first set of terms, which describe the neighborhood features, including distance to the nearest highway, distance to the nearest railroad, distance to the nearest water body, distance to the nearest wetland, distance to the nearest city center, and variables indicating if a parcel is located inside the city boundary or Urban Growth Boundary (UGB). The distance to the nearest highway, railroad, water, wetland and city center are calculated in ArcGIS. The city centers were located by using Google Earth. The dummy variable $city\_boundary$ indicates if a parcel is located within the city limits. The coefficient is expected to be positive, because a city provides important public services (such as garbage services, water and sewer access, and public transportation). In addition, if a parcel is located within the city limit, it may be close to a business center, public transportation routes, and entertainment facilities. Therefore, the parcels located inside a city limit are expected to be more expensive than the parcels outside the city limit. A city center often is the center of business and services. Although some parcels may not be inside the city limit, they may not be far from all services and convenience provided by the city center. There are two possible reasons: 1) a parcel may be located just outside the city limit, 2) a city center may not be located at the geographic center of city, so some parcels may be outside the city limit but closer to the city center than many parcels inside the city center. Therefore, land prices are expected to drop as the distance to city center increases. The dummy variable *UGB* indicates if a parcel is located within the Urban Growth Boundary (UGB). The UGB is a boundary that is decided by a local government to control urban expansion. It separates urban land from rural land. Therefore, if vacant lands are located within the UGB, they will have more possibilities for development into residential parcels. As a result, these lands may be priced higher than those lands located outside the UGB. Since water and wetlands improve the environmental quality of a neighborhood (such as scenic views, open space, and higher air quality), the parcels located close to these features are expected to have higher value. Both railroads and highways generate noise problems for neighboring residential areas. The coefficient on distance to railroad is expected to be negative. However, the effect of highway distance on residential parcels in the neighborhood is unclear because highways also provide accessibility, which may increase the land value.

$$[P(Z)]^{(\lambda)} = ... + \beta_8 pop^{(\alpha)} + \beta_9 year^{(\alpha)} + \beta_{10} price^{(\alpha)} + \beta_{11} white^{(\alpha)} + \beta_{12} income^{(\alpha)} + ... \quad (4.5)$$

The value of land can also be affected by the demographic features in a parcel's neighborhood. Equation 4.5 includes the census data at tract level for total population (*pop*), the median year the structure was built (*year*), the median value of properties (*price*), the percentage of white residents (*white*), and the median household income (*income*). The parcel located in an area with high population density is expected to have a higher value. If a parcel is located in a neighborhood with high housing value (high median house value), the value of a vacant parcel might be higher. However, a vacant land might be cheaper if it is located in a neighborhood with older and more expensive houses. High housing value indicates higher housing demand. In a long established residential neighborhood with high housing demand, the low values of vacant land might suggest that those lots are not usable. For example, some lots may have a shape that is not feasible to construct a building on it. Therefore, median housing value in a neighborhood does not always have a positive correlation with RMV of vacant parcels. The land located in a wealthy neighborhood tends to be more expensive. However, there might be exceptions because some vacant parcels might not be usable for housing construction. Several studies have shown the positive relationship between a high percentage of white residents and high land value, so the parameter on *white* is expected to be positive.

$$[P(Z)]^{(\lambda)} = ... + \beta_{13} small \bullet A^{(\upsilon)} + \beta_{14} large + \beta_{15} large \bullet A^{(\zeta)} + ... \quad (4.6)$$

Equation 4.6 is the set of variables that captures the structural change in the hedonic price function. *small* indicates the parcels that are smaller than b acres, and *large* indicates the parcels that are larger than a acres. As shown in graphs 4.3 and 4.4, the hedonic price curve is concave before point b and convex after point a, so the transformations on the lot size are different. Point b can be found by using CUSUM test[2]. CUSUM test is a statistical test used to find the observation from which the structural break of regression function happens. The null hypothesis is that the estimated coefficients are stable through whole dataset. Assuming there are T observations in the dataset, the calculation of the statistic uses first t (1<t<T) observations, "one step ahead prediction error" and forecast variance.

$$\begin{aligned} [P(Z)]^{(\lambda)} = & ... + \beta_{aj} MLZ_{a_j} + \beta_{a1j} MLZ_{a_j} \bullet D_{3\bullet a_j > A \geq 2 \bullet a_j} + \beta_{a2j} MLZ_{a_j} \bullet D_{4\bullet a_j > A \geq 3 \bullet a_j} \\ & + ... + \beta_{aij} MLZ_{a_j} \bullet D_{A \geq i \bullet a_j} + \varepsilon \end{aligned} \quad (4.7)$$

Equation 4.7 includes variables that capture the development and environmental effects of different minimum-lot-size restrictions. β_{ai} and β_{aij} are the parameters related to the

[2] The CUSUM test is based on the cumulated sum of the residuals:

$$W_t = \sum_{r=K+1}^{r=t} \frac{w_r}{\hat{\delta}}$$

Where $\hat{\delta}^2 = (T-K-1)^{-1} \sum_{r=K+1}^{T} (w_r - \overline{w})^2$ and $\overline{w} = (T-K)^{-1} \sum_{r=K+1}^{T} w_r$. Under the null hypothesis, W_t has a mean of zero and a variance approximately equal to the number of residuals being summed. The test is performed by plotting W_t against t. The hypothesis is rejected if, W_t goes outside the boundaries.

minimum-lot-size zoning. The subscript i on β represents different price jumps and the subscript j represents different minimum-lot-size requirements. In equation 4.7, MLZ_{aj} is the dummy variable indicating if the minimum lot size of a_j acres is applied to the parcel. The dummy variable $D_{3\bullet a_j > A \geq 2\bullet a_j}$ equals 1 if a parcel is larger than or equal to two times the minimum-lot-size requirement (a_j acres) but smaller than three times the minimum-lot-size requirement. The term $MLZ_{aj} \bullet D_{3\bullet a_j > A \geq 2\bullet a_j}$ captures the price jump at the $2a_j$ acres.

IV.B. Second Stage Estimation

The second stage model estimates an inverse demand curve for lot size. I assumed that minimum-lot-zoning restrictions may change both the intercept and slope of the inverse demand curve, and then tested this hypothesis.

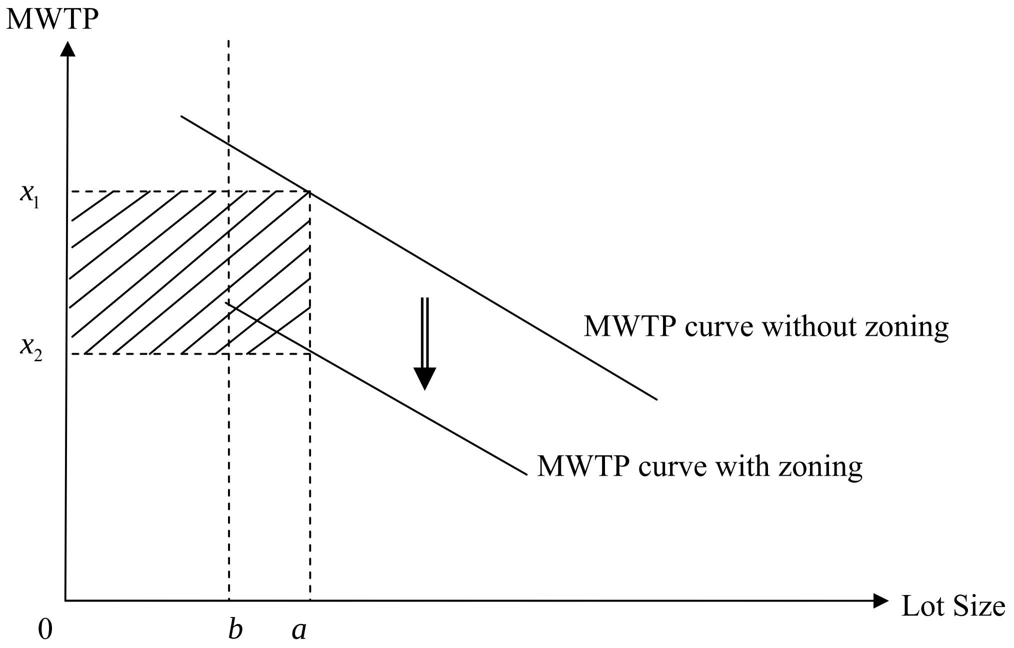
The empirical model for the second stage estimation is as follows:

$$MWTP^{(\gamma)} = \eta_0 + \eta_1 A^{(\theta)} + \eta_2 white^{(\theta)} + \eta_3 income^{(\theta)} + \eta_{a1} MLZ_{a_1} + ... + \eta_{aj} MLZ_{a_j} + \varepsilon \quad (4.8)$$

The marginal willingness to pay is the first order derivative of the hedonic function with respect to lot size. The marginal willingness to pay is not constant, which means that the unit price that consumers are willing to pay for a certain lot size depends on the total lot size. Since the lot size and the marginal willingness to pay are determined simultaneously, the second-stage hedonic estimation is subject to endogeneity problems. Therefore, the OLS estimator is biased. I make use of instrumental variables that are assumed to be uncorrelated with the error term. The instrumental variables are chosen to be the demand shifters (the census tract level percentage of white residents and median household income), the dummy variables for counties, and the interaction terms of them. By doing so, I assume that the distribution of consumers' tastes in the error term does not vary by county but varies by individuals. As a result, the interaction term of the demand shifters and the county dummy variable is not correlated with the error term, but correlated with the choice of lot size. The independent variables in the second stage estimation include lot size, percentage of white residents, median household income, and zoning policies. As in the first stage estimation, the Box-Cox transformation is also applied on both sides of the function.

The second stage estimation will show how minimum-lot-size zoning shifts the demand curve for lot size, as shown in figure 4.5. If the net effect of the minimum-lot-size zoning is negative (the development effect is stronger than the environmental effect), the zoning policy makes the land less attractive to buyers. As a result, the demand curve for lot size shifts downward. If a parcel has a acres, when the minimum-lot-size requirement is b acres, the MWTP for lot size decreases from x_1 dollars to x_2 dollars. The shaded area in figure 4.5 is the difference of TWTP for lot size between the values with and without the zoning policy.

Figure 4.5



IV.C. Spatial Correlation and Other Statistical Problems

The Moran's I test suggests the existence of positive spatial correlation. The existence of spatial autocorrelation is predictable because the value of land is significantly influenced by environmental and demographic characteristics, and these features are closely related to locations. As stated in the first essay, the lots with larger size (which may be created by the minimum-lot-size zoning) may have spillover effects on neighboring properties. This effect may not be captured by the independent variables and can result in spatial correlation in the error term. Another reason for the existence of spatial autocorrelation is that the data on demographic characteristics were collected at census tract level. Therefore, these variables are commonly used for the parcels in the same tract, and they become the source of spatial autocorrelation. When data indicate spatial correlation, the OLS estimation is unbiased but inefficient. To solve this problem, I used a GMM approach proposed by Bell and Bockstael (2000). Both stage estimations may have a heteroscedasticity problem, in which case, this may be another source of inefficiency. In this dataset, most parcels are located in or close to cities. In addition, different cities may have a different distribution of income levels. As a result, it is possible that the parcels located in one area may have greater variation in the land values than the parcels located in other areas.

V. Results

The first stage hedonic model regression used 1244 observations from Benton County, 1798 observations from Jackson County, 2733 observations from Lane County, and 1650 observations from Marion County. The distribution of observations across counties and minimum-lot-size zoning policies is shown in table 4.1.

Table 4.1

	Number of Observations in Benton	***Number of Observations in Jackson***	***Number of Observations in Lane***	***Number of Observations in Marion***
1-acre-minimum	*N/A*	*26*	*124*	*50*
2-acre-minimum	*20*	*N/A*	*196*	*4*
2.5-acre-minimum	*N/A*	*88*	*N/A*	*N/A*
3-acre-minimum	*N/A*	*N/A*	*N/A*	*4*
Small minimum-lot-size zoning	**20**	**114**	**320**	**58**
5-acre-minimum	**50**	**126**	**44**	**63**
10-acre-minimum	*2*	*N/A*	*3*	*7*
20-acre-minimum	*N/A*	*N/A*	*N/A*	*1*
Large minimum-lot-size zoning	**2**	**N/A**	**3**	**8**
No Minimum-lot-size zoning	**1164**	**217**	**1**	**98**
Total Observations	**1244**	**1798**	**2733**	**1650**

V.A. First Stage Estimation Results

As shown in table 4.2, minimum-lot-size zoning policies affect land prices negatively in most counties. However, 1-acre-minimum zoning in Jackson and Marion County, 2-acre-minimum zoning in Marion County, and 2.5-acre-minimum zoning in Jackson County have a positive impact on land prices.

Table 4.2

	Benton	*Jackson*	*Lane*	*Marion*
Box-Cox Transformation	$\lambda = 1, \upsilon = 0.8,$ $\alpha = 1.3$	$\lambda = 0.4, \upsilon = -0.3,$ $\alpha = -0.3$	$\lambda = 1, \upsilon = 0.2,$ $\alpha = 1$	$\lambda = 1, \upsilon = 0.9,$ $\varsigma = 0.8, \alpha = 0.8$
Intercept	-1152649*	28760	-1540095*	365283**
Acreage	15406*	14.93*	35353*	N/A
Small Acreage	N/A	N/A	N/A	74757*
Large Acreage	N/A	N/A	N/A	-2208.8*
Distance to the Nearest City	-0.02**	334.65*	-0.02	2.68*
Distance to the Nearest Highway	0.25*	34.24**	-0.01	-8.01*
Distance to the Nearest Railroad	-0.29*	-19.32	0.38*	1.42**
Distance to the Nearest Water	0.01	-469.57*	-0.07	1.85**
Distance to the Nearest Wetland	0.27*	15.58**	-0.05*	-2.57*
Median Household Income	0.03*	1309**	0.01	2.57**
Total Population	-0.04	274.59*	1.72*	1.33

Table 4.2 Continued

	Benton	***Jackson***	***Lane***	***Marion***
Percentage White	-242105*	-95.78**	-20586	9342.53
Median Years of Structure Built	80.11*	-10482**	810.73*	-606.77***
Median Value	-0.02	-610.11	0.19*	0.07
Inside/Outside UGB	-36576*	96.77*	13912*	40840*
Inside/Outside City Boundary	4979.37	4.21**	-2819.77	27465*
Large	N/A	N/A	N/A	6507.11*
Small Minimum-Lot-Size Zoning	-55791***	-38.25*	-36448**	-12235*
5-Acre-Minimum Zoning	-21167*	-34.63*	-29690*	-13674*
Large Minimum-Lot-Size Zoning	-48765*	N/A	-23081*	-24020*
Price Jump at 2.5 Acre under 2.5-acre-minimum zoning	N/A	18.96	N/A	N/A
Price Jump at 1 Acre under 1-acre-minimum zoning	N/A	N/A	24620*	20074
R-Squared	0.3224	0.4660	0.4609	0.3310

* Significant at 1%
** Significant at 5%
***Significant at 10%

Marion is the only county in this dataset that has a structural break on the hedonic price function curve. Only when the lot size is smaller than 0.64 acre, the hedonic price function has a positive marginal willingness to pay for lot size.

Due to the limitation of data, for most minimum-lot-size zoning policies, there are no parcels with a lot size larger than the minimum requirement. Therefore, the price jumps at integer multiples of the minimum-lot-size requirements were tested only for 2.5-acre-minimum in Jackson County and 1-acre-minimum in Lane and Marion County. The results show the statistic evidence of the price jumps at the integer multiples of the 1-acre-minimum requirement policy in Lane County. The other two parameters for price jumps are not statistically significant.

There are very few observations or no observations in zoning policy categories in some counties. In order to keep the consistency of zoning policies across counties, I separated different minimum-lot-size requirements into three groups. The small minimum-lot-size zoning group includes the zoning requirements with 1-acre minimum, 2-acre minimum, 2.5-acre minimum, and 3-acre minimum. The large minimum-lot-size zoning policy group includes the requirements with 10-acre minimum and 20-acre minimum. 5-acre-minimum zoning was singled out as a separate group because it is a popular zoning policy in all four counties with many observations. The regression results indicated that minimum-lot-size zoning decreases residential land prices in all study areas. Since there is no Box-Cox transformation applied on the dependent variable (real market value) and dummy variables in the regression functions for Benton, Lane, and Marion County, it is easy to interpret the parameters of dummy variables. On average, small minimum-lot-size zoning reduces land price by \$55791 in Benton County, \$36448 in Lane County, and \$12235 in Marion County. 5-acre minimum zoning reduces land price by \$21167 in Benton County, \$29690 in Lane County, and \$24020 in Marion County. Large minimum-lot-size zoning reduced land price by \$48765 in Benton County, \$23081 in Lane County, and \$24020 in Marion County. In

Jackson County, the effect of the minimum-lot-size zoning on land prices depends on the size of the lot. This is because the Box-Cox transformation parameter of dependent variable (RMV) does not equal 1. Suppose RMV_0 is the real market value of a parcel that is not zoned with a minimum-lot-size requirement and RMV_1 is the real market value of a zoned parcel. In Jackson County, the difference of RMV_0 and RMV_1 is $(\lambda b_{-MLZ} X_{-MLZ})^{\frac{1}{\lambda}} - (\lambda b_{MLZ} + \lambda b_{-MLZ} X_{-MLZ})^{\frac{1}{\lambda}}$. λ is the Box-Cox transformation parameter, b_{MLZ} is the estimated parameter for the dummy variable of minimum-lot-size zoning, b_{-MLZ} is the vector of estimated parameters for all other variables, and X_{-MLZ} is the matrix of all variables except the dummy variable for minimum-lot-size zoning.

Most estimated parameters of all other variables are as expected. Distance to the nearest highway has a mixed effect on land values in the neighborhood. Being close to a highway increases land values in Benton and Jackson County, but it decreases land values in Lane and Marion County. Although the estimated parameter for distance to the nearest city has negative values in Benton and Lane County, the estimated parameter is not statistically significant in Lane County and has a small value in Benton County. Land values increase with median household income in all four counties, and this result is statistically significant. When the total population in a tract is higher, the land values are higher in Jackson, Lane, and Marion County. Although the regression results indicate that total population in a tract is negatively related to land values in Benton County, this result is not statistically significant. The relation between median years of structure built and land values vary by county. In Benton and Lane County, this relation is positive and statistically significant. In Jackson and Marion County, land values are lower in a tract with older houses. Parcels located within the UGB are worth more than those outside the UGB, except in Benton County. Parcels located within the city limit have a higher RMV than those outside the city limits, except in Lane

County. In Lane County, the estimated parameter on the dummy variable for city limits is not statistically significant.

There are several estimated parameters that have unexpected signs. Distance to a railroad has a positive relation with land value in Lane and Marion County, and the estimators are statistically significant. Distance to water has a negative estimated parameter in three counties, and two of them are statistically significant. The reason for this result might be that "water" is defined to include all different types of bodies of water, including streams, rivers, reservoirs, etc. However, other detailed information about bodies of water that might affect the desirability of the body of water is not available, and some features of bodies of water might not be appealing to land owners, such as poor water quality and low water clarity. Distance to the nearest wetland is expected to be positively related to land values. However, the estimated parameter on distance to the nearest wetland is negative in Lane and Marion County, and the results are statistically significant.

V.B. Second Stage Estimation Results

All 7425 observations from four counties were used for estimating the second stage regression. There are 512 parcels governed by small minimum-lot-size zoning, 283 parcels governed by 5-acre-minimum requirement, and 13 parcels governed by large minimum-lot-size zoning. The second-stage regression was estimated with two functional forms, linear and log-transformed independent variables. The results of the second-stage hedonic estimation are presented in table 4.3. The estimation results show that consumer's MWTP for lot size decreases with increasing lot size. Most minimum-lot-size zoning policies significantly reduced consumers' MWTP for lot size.

Table 4.3

	Simple Linear Model	*Log Model*
Constant	-353871*	741156.9*
Acreage	-353454*	-69965.7*
Median Family Income	0.4	65103.3*
Percentage White	663758.2*	421001.7*
Large Minimum-Lot-Size Zoning	-75639.1	-79588.5
5-Acre-Minimum Zoning	-21197.7***	-27301.6*
Small Minimum-Lot-Size Zoning	-23464.3	-19946.7*
R-Squared	0.2	0.37

* Significant at 1%
** Significant at 5%
***Significant at 10%
Log Model:

$$MWTP = \eta_0 + \eta_1 \log(A) + \eta_2 MLZ_1 + \eta_3 MLZ_{2.5} + \eta_4 MLZ_5 + \eta_5 MLZ_{10} + \eta_6 \log(white)$$
$$+\eta_7 \log(income) + \varepsilon$$

A Hausman test was conducted to validate the usage of county dummy variables as instrument variables in the second-stage hedonic regression. The test result confirms that the choice of the instrument variables is correct.

Although large minimum-lot-size zoning reduces MWTP for lot size, the results are not statistically significant in both regressions. MWTP for lot size increases with consumers' income levels. Consumers who live in a neighborhood with a higher percentage of white residents are more likely to pay more for lot size. Large minimum-lot-size zoning reduced marginal willingness to pay for lot size is $75639.1 in simple linear model and $79588.5 in log model. 5-acre-minimum zoning reduces marginal willingness to pay for lot size by

$21197.7 in simple linear model and $27301.6 in log model. Small minimum-lot-size zoning reduces marginal willingness to pay for lot size by $23464.3 in simple linear model and $19946.7 in log model.

In order to further explain the regression results, I calculated changes in land price under different scenarios to compare the price effect of individual policy exemption and removing policies from all parcels. In the first stage hedonic model, the estimated coefficients of dummy variables for minimum-lot-size zoning policies indicate the changes in land prices when a single parcel is exempted from minimum-lot-size requirements. The reason is that the coefficients of policy dummy variables show how land price changes when minimum-lot-size zoning is removed from a parcel while holding all other variables constant. In the second stage estimation, the estimated coefficients for the minimum-lot-size zoning dummy variables represent the land price difference between the case when minimum-lot-size zoning is in effect and the case when the policy is removed from all parcels. This is because the second stage hedonic model estimates land owner's preference for lot size. Table 4.4 presents the simulation results with simple linear model and table 4.5 presents the simulation results with log model. In both tables, scenario 1 assumes that minimum-lot-size zoning is removed from all parcels and scenario 2 assumes that minimum-lot-size zoning is removed only from a single parcel. The simulation results show that minimum-lot-size zoning policy exemptions lead to a larger price increase on the parcel that has the policy removed in all counties.

Table 4.4

Simple Linear Model		***Benton***	***Jackson***	***Lane***	***Marion***
	Median lot size	0.22	0.14	0.21	0.22
Large minimum-lot-size zoning	**Price increase with scenario 1**[3]	16641	N/A	15884	16441
	Price increase with scenario 2[4]	48765	N/A	23081	24020
5-acre-minimum zoning	**Price increase with scenario 1**	4663	2968	4452	4663
	Price increase with scenario 2	21167	29644	29690	13674
Small minimum-lot-size zoning	**Price increase with scenario 1**	5162	3285	4928	5162
	Price increase with scenario 2	55791	26838	36448	12235

Table 4.5

Log Model		***Benton***	***Jackson***	***Lane***	***Marion***
	Median lot size	0.22	0.14	0.21	0.22
Large minimum-lot-size zoning	**Price increase with scenario 1**	17509	N/A	16714	17509
	Price increase with scenario 2	48765	N/A	23081	24020
5-acre-minimum zoning	**Price increase with scenario 1**	6006	3822	5733	6006
	Price increase with scenario 2	21167	29644	29690	13674
Small minimum-lot-size zoning	**Price increase with scenario 1**	4388	2793	4189	1388
	Price increase with scenario 2	55791	26838	36448	12235

[3] Scenario 1 is assuming that minimum-lot-size zoning is removed from all parcels.
[4] Scenario 2 is assuming that a single parcel is exempted from minimum-lot-size zoning policy.

VI. Conclusion

As an important policy tool to control residential development, minimum-lot-size zoning has two competing effects on land values: environmental and development. Environmental effects have a positive impact on land values because of the benefit of low-density development, while development effects have a negative impact on land values because the development options on the land governed by the minimum-lot-size zoning policy are limited. A two-stage hedonic regression was estimated to explore the net effect of minimum-lot-size zoning on land values in four Oregon counties. The results indicate that the minimum-lot-size zoning reduced TWTP for land and MWTP for lot size. However, some estimation results are different from expectation.

There are several shortcomings of this study. First, to improve the regression, future studies need to collect more data so that there are enough parcels that are zoned with each minimum-lot-size requirement. Therefore, there will be no information lost from the data due to categorizing the minimum-lot-size zoning policies into three policy groups. Second, more information about parcels and neighborhood features should be included. For example, past studies (Diamond 1980, Netusil and Chattopadhyay 2006) have showed that slope on parcels affects land value. The relation might be positive if there is a major scenic view in the distance. It also might be negative: if the parcel is very steep as the construction cost will be higher. More information collected will improve estimation results. Third, land use policies may be endogenous in some cases. Local governments often change land use policies under economic pressure (Lenon, Chattopadhyay, and heffley 1996, Lichtenberg and Hardie 2007). For example, if the location of the UGB is chosen so that it includes high-valued properties. Then, the location of the UGB is not exogenous to the land value. Minimum-lot-size zoning may be imposed on the community with highly desirable neighborhood or demographic features to enhance the high land values. With the data collected from this study, I was not able to test the endogeneity of land use policies and the model treated all land use policies as exogenous variables.

There are other options to investigate the impact of Measure 37 and 49. For example, if a complete dataset of historical land values, neighborhood features, and demographic characteristics is available, we can choose two locations, one with a land use policy applied at some point of time in history and one with free development. The hedonic model results could directly show how the change in land use policies affects land value.

VII. Appendix

Table 4.6

Variable	***Definition***	***Source***
A	Acreage	County assessor's office
$P(Z)$	Real market value	County assessor's office
$highway$	Distance to the nearest ODOT highway[5]	Map from Oregon Geospatial Data Clearinghouse, distance calculated
$railroad$	Distance to the nearest railroad	Map from Oregon Geospatial Data Clearinghouse, distance calculated
$water$	Distance to the nearest water[6]	Map from Oregon Geospatial Data Clearinghouse, distance calculated
$wetland$	Distance to the nearest wetland	Map from National Wetland Inventory, distance calculated
$city\_center$	Distance to the nearest city center	Map from Google Earth, distance calculated
$city\_boundary$	Dummy variable indicating if the land is located within the city boundary	Map from Oregon Geospatial Data Clearinghouse, distance calculated
UGB	Dummy variable indicating if the land is located within the Urban Growth Boundary (UGB)	Map from Oregon Geospatial Data Clearinghouse, distance calculated

[5] Include all state owned or maintained highways, connections, frontage roads, temporary traveled routes and located lines.

[6] Include river, pond, lake, reservoir, canal, and ocean.

Table 4.6 Continued

Variable	***Definition***	***Source***
MLZ_{a_j}	Dummy variable indicating the land zoned for a acres minimum	County GIS department and assessor's office
$D_{a_2>A\geq a_1}$	Dummy variable indicating the land that is larger or equal to a_1 acres but smaller than a_2 acres	County assessor's office
pop	Total population in a census tract	US Census 2000 Long Form
year	The median year of structure built[7] in a census tract	US Census 2000 Long Form
price	The median price of properties in a census tract	US Census 2000 Long Form
white	The percentage of white residents in a census tract	US Census 2000 Long Form
income	The median household[8] income in a census tract	US Census 2000 Long Form

[7] Data on year structure built refer to when the building was first constructed, not when it was remodeled, added to, or converted. For housing units under construction that met the housing unit definition--that is, all exterior windows, doors, and final usable floors were in place--the category "1989 or March 1990" was used. For a houseboat or a mobile home or trailer, the manufacturer's model year was assumed to be the year built. The figures shown in Census data products relate to the number of units built during the specified periods that were still in existence at the time of enumeration.

[8] A household includes all the persons who occupy a housing unit. Persons not living in Households are classified as living in-group quarters. In sample tabulations, the count of Households may differ from the count of occupied housing units as a result of the weighting process.

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CHAPTER 5

CONCLUSION

In the first paper, I showed that there have been numerous literatures contributing to the research on how land-use policies have changed land values in the United States. Through years of evolving, governments have designed and improved land-use policies in an attempt to diminish unwanted externality of land development and improve social welfare. Most academic literatures have found statistical evidence for the price effect of land-use policies. Some policies are not designed to influence property value. However, as several studies have showed, the price effect of these policies may be inevitable and may also introduce other unexpected side effects to communities in some cases. From these studies, we also can see that better technology and new estimation methods, such as the Geography Information System (GIS) and hedonic model, have improved the research on land-use policy.

In the second paper, the theoretical model shows that minimum-lot-size zoning changes urban development pattern and land prices. Since minimum-lot-size zoning may create some amenities to a community, cities will expand and land prices of some parcels may increase. After minimum-lot-size zoning comes into effect, utility level increases in a closed city model and population goes up in an open city model. The magnitude of these effects ultimately depends on the design of minimum-lot-size zoning policy and city residents' preference. Removing a minimum-lot-size requirement from one parcel may increase the value of this parcel if the amenities related to minimum-lot-size zoning remain unchanged. One of the predominant characteristics of land development is the spillover effect. As explained in the theoretical model, the implementing or removing of minimum-lot-size zoning influences more than the area that is governed by the zoning policy. Even though such spillover effect fades away as the distance to the zoned area increases, the price effect of minimum-lot-size zoning may not. The reason is that the application of minimum-lot-size zoning forces all residents to reconsider land prices, taking new neighborhood characteristics and locations into account.

In the third paper, a two-stage hedonic model was used to estimate the impact of minimum-lot-size zoning on land values in Oregon. The samples are vacant residential parcels from Lane, Marion, Benton, and Jackson County. The function form of regression models took the non-linear relationship between parcel values and related variables into consideration. The regression results from the first stage hedonic regression indicates the price effect of removing minimum-lot-size zoning from only one parcel. The regression results from the second stage hedonic regression show the price effect of removing minimum-lot-size zoning from all parcels. The empirical results confirm the results from the theoretical model: when a minimum-lot-size requirement is removed from only one parcel; parcel value will go up significantly. The results of the empirical model show that minimum-lot-size zoning reduces property values in Oregon.