Measuring Interactions among Urbanization, Land Use Regulations, and Public Finance

Seong-Hoon Cho, JunJie Wu, and William G. Boggess

This article presents a polychotomous choice-selectivity model to estimate the interactions among urbanization, land use regulations, and public finance in five western states (California, Idaho, Nevada, Oregon, and Washington). Land use regulations in these five states reduced the total developed area by an estimated 12.2% from 1982 to 1992, but increased housing prices between 1.3% and 4.7%, depending on the intensity of land use regulations in a county. Land use regulations also reduced public expenditure and property tax in the long run by 5.6% and 8.4%, respectively, but increased public expenditure and property tax in the short run by 9.8% and 12.6%.

Key words: land development, land use regulations, housing price, public expenditure, property tax.

Local land use policies have been examined in a number of studies (e.g., Epple, Romer, and Filmore; Henderson; Levine; McDonald and McMillen; Phillips and Goodstein). However, little empirical evidence is available on which factors motivate adoption of land use regulations, nor has there been much systematic analysis of the impact of land use regulations on land development and public finance. In this article we present an empirical model to evaluate quantitatively the interactions among urbanization, land use regulations, and public finance in five western states of the United States (Oregon, California, Idaho, Nevada, and Washington). We provide estimates of both the extent to which the rate of development affects the demand for more restrictive land use regulations, as well as the subsequent impact of those regulations on land development, housing prices, public expenditure, and property tax.

Because local political processes determine land use regulations, treating regulations as exogenous may cause a selection bias when analyzing their effect on development (Pogodzinski and Sass). The endogenous nature of zoning regulation was first raised by Davis, who pointed out the difference in preferences for zoning between the existing homeowners and developers or renters. Erickson and Wollover estimated the effects of a number of demographic variables on the choice of zoning regulations, but did not account for the endogenous nature of zoning decisions. Wallace treated zoning regulations as endogenous when evaluating the impact of land use zoning. She estimated a logit model to correct for selection bias. McMillen and McDonald explored the econometric problems involving the measurement of the impact of endogenous zoning decisions. They used a two-step estimation technique to derive unbiased estimates of the zoning regulations, but excluded demographic variables from consideration. Pogodzinski and Sass modeled the political procedure of zoning by assuming that zoning regulations were established to maximize effective political support. In order to measure effective political support, they considered whether a utility-maximizing representative voter would support local land use zoning. These studies, however, have not explored the linkages among land use regulations, land development, public expenditure, and property tax. In particular, it is not clear how changes in development rates, housing prices, property taxes, and public expenditure affect support for restrictive land use regulations.

This article uses a polychotomous choice-selectivity modeling system (Lee) to measure the interactions among land development, land use regulations, and public finance (public expenditure and property tax) in the five

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western states. An advantage of the modeling system is that it captures the effect of self-selection in the choice of land use regulations. Self-selection arises when a regulation has different impacts in counties adopting it than it would have in counties that have not adopted, should they choose to adopt. This simultaneous equation system also captures the interactions among land use regulations, land development, housing price, and public finance. The results show that land use regulations are more likely to be adopted in counties facing rapid land development, high public expenditure, and high property taxes. Land use regulations, in turn, decrease land development, long-run public expenditure, and property tax, at the cost of higher housing prices and short-run increases in pubic expenditure and property tax.

Empirical Model

A polychotomous choice-selectivity modeling system (Lee) is used to estimate the interactions among land use regulations, land development, housing price, and public finance. The modeling system consists of five equations representing the choice of land use regulations, land development, housing price, property tax, and public expenditure. Each of the equations is discussed below.

The choice of land use regulations is estimated using a multinomial logit model. The independent variables in the model are chosen based on economic theory. Assuming that regulators impose land use regulations to maximize effective political support (see, e.g., Pogodzinski and Sass) or net returns from land use (see, e.g., Ding, Knapp, and Hopkins) subject to a budget constraint, the probability of land use regulation can be derived as a function of housing price, agricultural rent, property tax, and public expenditure. In addition, we assume that both the current and expected future development pressures increase the likelihood of land use regulations. To capture the effect of development pressure, we included the distance to the closest metropolitan area, population density, and average per capita income as explanatory variables in the regulation equation. Also, to test the hypothesis that rapid land development promotes county governments to impose land use regulations, the increase in development density over the past five years was included as an independent variable. More specifically, the land use regulation equation is specified as:

$$(1)\quad \mathrm{Pr}_{it}^{j} = \frac{e^{\eta_0^j+\eta_1^j(d_{it}-d_{i,t-5})+\eta_2^j r_{it}+\eta_3^j \tau_{it}+\eta_4^j g_{it}+\boldsymbol{\eta}_5^{j\prime}\mathbf{X}_{it}}}{\sum_{k=0}^{3} e^{\eta_0^k+\eta_1^k(d_{it}-d_{i,t-5})+\eta_2^k r_{it}+\eta_3^k \tau_{it}+\eta_4^k g_{it}+\boldsymbol{\eta}_5^{k\prime}\mathbf{X}_{it}}}$$

where i is an index of county; j is an indicator of land use regulation intensity (defined below), with $j = 0, 1, 2, 3$ representing minimal, low, moderate, and stringent regulations, respectively; t is 1982, 1987, 1992 (the three years for which we have both land use and land use regulation data); Pr_{it}^{j} is probability for county i to adopt regulation intensity level j in year t; d is development density, i.e., the percent of land developed; r is housing price; τ is property tax per capita; g is public expenditure per capita; and $\mathbf{X}$ is a vector of independent variables affecting land use regulations.

Previous studies on land development under uncertainty and irreversibility (see, e.g., Arrow and Fisher) suggest that development decisions depend on not only the current profit but also the expected profit and risk in the future. Following the general guidance of this literature, development density was specified as a function of the current and expected housing prices, construction costs, and the expected risk associated with land development. In addition, because developers have to compete with farmers for land, the current and expected farm profit and risks also affect land development. Expected farm profit and housing prices are difficult to measure. As in previous studies (see, e.g., Alig and Healy, Hardie and Parks), the variables that are believed to affect the expected housing prices and farm profits are included as independent variables. These include current development density, population density, per capita income, the distance to the closest metropolitan center, land quality, as well as current housing prices and farm profit. Thus, the land development equation is specified as follows:

$$(2)\quad d_{it} = \beta_0^j + \beta_1^j r_{it} + \beta_2^j \tau_{it} + \beta_3^j g_{it} + \boldsymbol{\beta}_4^{j\prime} \boldsymbol{Z}_{it}^{d} + \varepsilon_{it}^{d}$$

where $\mathbf{Z}^{d}$ is a vector of independent variables affecting land development (e.g., profit and risks associated farming and land development), and ε^{d} is an error term.

Expected risks associated with development are measured by the expected variance of housing prices, which is estimated by

$$(3) \qquad V_t[r] = \frac{1}{4}\sum_{i=0}^{3}(r_{t-i} - E[r_{t-i}])^2$$

where $E[r_t] = r_{t-1} + (1/4)[(r_{t-1} - r_{t-2}) + (r_{t-2} - r_{t-3}) + (r_{t-3} - r_{t-4}) + (r_{t-4} - r_{t-5})]$. The expected risk associated with farming was similarly estimated.

Much urban economics research has focused on households' bid prices for housing. In most recent studies (see e.g., Brueckner, Thisse, and Zenou), households are assumed to have preferences defined over residential space, environmental and neighborhood characteristics (e.g., amenities, public expenditure), and a nonhousing good. Households choose the residential locations and consumption bundle to maximize their utility subject to a budget constraint. Competition for housing will bid up housing prices at desirable locations. In equilibrium, housing prices depend on household income, the distance to the city center, environmental and neighborhood characteristics (e.g., amenities, property tax, public expenditure), farm profit, and population. All of these variables (denoted by vector $\mathbf{Z}^r$) are included in the housing price function:

$$(4) \qquad r_{it} = \gamma_0^j + \gamma_1^j d_{it} + \gamma_2^j \tau_{it} + \gamma_3^j g_{it} + \boldsymbol{\gamma}_4^{j'} \mathbf{Z}_{it}^r + \varepsilon_{it}^r.$$

Interactions between land use regulation and public finance have been analyzed both theoretically and empirically in the literature. For example, Fernandez and Rogerson showed that land use regulations tend to decrease public expenditure. Pogodzinski and Sass analyzed how local fiscal variables and zoning are simultaneously determined. They found that property tax and public expenditure are affected by the size of jurisdiction, land quality, per capita income, and population density. Leon, Chattopadhyay, and Heffley measured the interdependence of land use regulations and fiscal policies using data from 164 Connecticut townships. They included household income, distance to city center, and size of a town as independent variables in the property tax and public expenditure equations. Based on these studies, we included county size, land quality, per capita income, distance to the closest metropolitan center, population density, development density, and housing price as regressors in the property tax and public expenditure equations:

$$(5) \qquad \tau_{it} = \delta_0^j + \delta_1^j d_{it} + \delta_2^j r_{it} + \delta_3^j g_{it} + \boldsymbol{\delta}_4^{j'} \mathbf{Z}_{it}^\tau + \varepsilon_{it}^\tau$$

$$(6) \qquad g_{it} = \pi_0^j + \pi_1^j d_{it} + \pi_2^j r_{it} + \pi_3^j \tau_{it} + \boldsymbol{\pi}_4^{j'} \mathbf{Z}_{it}^g + \varepsilon_{it}^g.$$

Equations (1), (2), (4)–(6) together compose our polychotomous choice-selectivity modeling system. In the next section, we discuss the technique for estimating the system.

Estimation Method

Maddala (pp. 242–45) suggests a two-stage technique for estimating a simultaneous equation system with discrete dependent variables. In the first stage, we estimate the reduced form equations (2)–(5) using OLS. We then estimate the multinomial logit model (1) after replacing r, τ, and g with their predicted values from the reduced form equations. Finally, we calculate $\hat{\lambda}_{it}^j \equiv \phi[\Phi^{-1}(\hat{\Pr}_{it}^j)]/\hat{\Pr}_{it}^j$ using the predicted values of probabilities from the multinomial logit model $\hat{\Pr}_{it}^j$, where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability and cumulative distribution function of the standard normal.

In the second stage, the parameters in the structural equations are estimated by applying OLS to the following equations.

$$(7) \qquad d_{it} = \beta_0^j + \beta_1^j \hat{r}_{it} + \beta_2^j \hat{\tau}_{it} + \beta_3^j \hat{g}_{it} + \boldsymbol{\beta}_4^{j'} \mathbf{Z}_{it}^s - \beta_5^j \hat{\lambda}_{it}^j + u_{it}^d$$

$$(8) \qquad r_{it} = \gamma_0^j + \gamma_1^j \hat{d}_{it} + \gamma_2^j \hat{\tau}_{it} + \gamma_3^j \hat{g}_{it} + \boldsymbol{\gamma}_4^{j'} \mathbf{Z}_{it}^r - \gamma_5^j \hat{\lambda}_{it}^j + u_{it}^r$$

$$(9) \qquad \tau_{it} = \delta_0^j + \delta_1^j \hat{d}_{it} + \delta_2^j \hat{r}_{it} + \delta_3^j \hat{g}_{it} + \boldsymbol{\delta}_4^{j'} \mathbf{Z}_{it}^\tau - \delta_5^j \hat{\lambda}_{it}^j + u_{it}^\tau$$

$$(10) \qquad g_{it} = \pi_0^j + \pi_1^j \hat{d}_{it} + \pi_2^j \hat{r}_{it} + \pi_3^j \hat{\tau}_{it} + \boldsymbol{\pi}_4^{j'} \mathbf{Z}_{it}^g - \pi_5^j \hat{\lambda}_{it}^j + u_{it}^g$$

where $j = 0, 1, 2, 3$. The $\hat{\lambda}_{it}^j$ is included in each equation to account for self-selection (Lee), which arises when regulations have different impacts in counties adopting them than in a randomly selected county with the same characteristics, should the county choose to adopt. Self-selection can be tested by testing the null hypothesis that all coefficients on $\hat{\lambda}_{it}^j$ in equations (7)–(10) are zero. If the null hypothesis is rejected, we would conclude that there is self-selection in the choice of land use regulations, and the estimated coefficients for equations (7)–(10) would be biased if $\hat{\lambda}_{it}^{j}$ were not included in the equations (see Maddala, pp. 260–61).

The model can be used to estimate the effects of alternative intensities of land use regulations on land development, housing price, public expenditure, and property tax. To illustrate, consider a county with no land use regulations (i.e., $j = 0$). The expected value of public expenditure, g , for this county is

$$(11) \quad E\left(g_{it}^{0} \mid I = 0\right) = \pi_0^0 + \pi_1^0 \hat{d}_{it} + \pi_2^0 \hat{r}_{it} + \pi_3^0 \hat{\tau}_{it} + \boldsymbol{\pi_4^{0\prime}} \boldsymbol{Z_{it}^{g}} - \pi_5^0 \hat{\lambda}_{it}^{j}$$

where the last term reflects self-selection. If the county had adopted land use regulation intensity level j ($j > 0$), the expected value of g for this county in the short run would be

$$(12) \quad E\left(g_{it}^{j} \mid I = 0\right) = \pi_0^j + \pi_1^j \hat{d}_{it} + \pi_2^j \hat{r}_{it} + \pi_3^j \hat{\tau}_{it} + \boldsymbol{\pi_4^{j\prime}} \boldsymbol{Z_{it}^{g}} - \pi_5^j \hat{\lambda}_{it}^{j}.$$

It is short run in the sense that development density, housing price, and property tax are not affected by the regulations. The difference between equations (11) and (12) is the short-run effect of the land use regulations.

In the long run, land regulations would affect development density, housing price, and property tax, which may in turn affect public expenditure. The expected changes in public expenditure that account for the effect of changes in development density, housing price, and property tax is referred to as the long-run effect. To calculate the long-run effect, we first substitute the estimated coefficients into the equation system (2)–(5) and then solve for the final-form equation for the public expenditure: $g_{it} = \boldsymbol{\xi}^{j\prime} \mathbf{W}_{it}$, where $\mathbf{W}_{it}$ is a vector of exogenous variables in equations (2)–(5), and ξ is a vector of coefficients for the reduced-form equation. Each element of ξ is a function of the estimated coefficients in equations (2)–(5). Using the reduced-form equation, the long-run effect of land use regulations on public expenditures can be estimated by

$$(13) \quad \left[E\left(g_{it}^{j} \mid I = 0\right) - E\left(g_{it}^{0} \mid I = 0\right)\right]_{\text{long-run}} = (\boldsymbol{\xi}^{j} - \boldsymbol{\xi}^{0})' \mathbf{W}_{it}.$$

The short- and long-run effects of land use regulations on housing price, land development, and property taxes can be estimated in the same way.

Data

The study area includes five western states (California, Idaho, Nevada, Oregon, and Washington) of the United States. The data on land use were taken from the 1982, 1987, and 1992 Natural Resource Inventories (NRI). The NRI collected land use data at about 800,000 randomly selected sites across the continental United States and divided land use into eleven major categories (cultivated cropland, noncultivated cropland, pastureland, rangeland, forestland, urban and built-up land, and five other categories). In this study, cultivated cropland, non-cultivated cropland, pastureland, and rangeland are categorized as farmland and urban and built-up land is categorized as urban land. The NRI assigns a weight to each site to reflect the acreage each sample site represents. The sum of this value for all sites in a county equals the total land area in the county.

A comprehensive land use policy survey was conducted to collect first-hand information on county land use regulations in the five western states. The survey, conducted between August and October of 1999, was designed following the Dillman Total Design Method: (*a*) the questionnaire was designed after an extensive literature review, (*b*) the questionnaire was pre-tested by a few selected county land use planning directors, and the questionnaire was revised based on their comments, (*c*) the questionnaire was sent to all county land use planning directors in five western states, (*d*) two postcard reminders were sent to those who did not respond in two and four weeks, (*e*) telephone calls were made to those who did not respond in six weeks.

Among other questions, respondents were asked to report whether or not a particular type of regulation (29 in all) was in use by 1982, 1987, 1992, and 1997 and to evaluate the effectiveness of the regulations on a scale of 1 to 5 with 1 being not effective and 5 being most effective. The overall response rate was 69%. Counties in Washington had the highest response rate (87%), followed by Oregon (78%), Nevada (65%), California (60%), and Idaho (57%).

The survey results show that the most important goal of land use regulations in Nevada was to promote industrial and commercial investment. In contrast, counties in other states were more concerned about the conservation of farmland, forestland, and natural areas. All counties expressed a serious concern about urbanization. Almost all counties had a comprehensive land use plan when the survey was conducted; however, the timing of the initial adoption varied across counties. Extra territorial planning and zoning (state-granted power to cities to control development at the edge of cities) were popular in Idaho, urban growth boundaries were popular in Oregon and Washington. Agricultural, residential, forestry, conservation, open space, and steep slope zonings were popular throughout the states, whereas performance zoning (to regulate the impacts of development through standards on noise, view, water) was used only in a limited number of counties. Specification of minimum parcel sizes was popular in many counties, limits on maximum parcel sizes was not.

Developer exaction and dedication (to require developers to provide parks, streets, and even school space or cash in lieu of facilities return for development approval) were used in many counties. Fee- simple purchase (to acquire property for public use, e.g., parkland) was especially popular in California. Preferential property taxation for farmland and forestland was the most popular incentive-based management technique. Special assessments were popular in Oregon, Washington, and California.

Environmental impact assessments were popular in Washington and California. Regional fair sharing (to set standards to ensure that all communities get a share of regional growth and affordable housing) was especially popular in California. The planners predicted a high possibility of conversion from farmland to residential land, especially in Idaho and Nevada. Counties in California spent the largest amount of money on planning, while counties in Idaho spent the least amount. However, the average share of money spent on planning out of county general funds remained fairly close in the five states. Planners in Oregon and Washington felt that the state governments had a strong influence on land use regulations, whereas planners in California, Idaho, and Nevada felt strong influences from nongovernment organizations.

Based on the information collected from the land use policy survey, we constructed an index to measure the intensity of land use regulation in each county. Specifically, we identified the twenty most important land use regulations in the region. The sum of the effectiveness scores of these regulations is defined as the level of land regulation intensity. Because the effectiveness of each regulation is evaluated on a scale of 1–5 with 1 being not effective and 5 being most effective, the maximum score a county can receive is 100. Based on the index, we classified counties into four categories (table 1). Counties with an index greater than or equal to 60 are classified as having "stringent land use regulations," counties with an index greater than or equal to 30 but less than 60 are classified as having "moderate land use regulations," counties with an index greater than 0 but less than 30 are classified as having "low land use regulations," and counties without any land use regulations are defined as "no land use regulations." We classified counties into discrete categories rather than using the continuous index) because the effectiveness of individual land use regulations is represented by a discrete index. In addition, the classification seems to reflect well the overall intensity of land use regulations in the five western states. According to this classification, 78% of counties in Oregon and Washington had "stringent land use regulations." In contrast, 89% counties in Nevada and Idaho had "low or no land use regulations." Seventy-two percent of counties in California had "moderate land use regulations."

Table 1. The Intensity of Land Use Regulation in the Five Western U.S. States

Category	Index of Intensity of Land Use Regulations (I)	% of Counties
Stringent	$I \geq 60$	31%
Moderate	$30 \leq I < 60$	33%
Low	$0 < I < 30$	25%
No regulations	0	11%

Land quality and location variables used in the empirical models include the average land capability class and distance to the closest metropolitan center (population $\geq$ 100,000). The weighted average of land capability classes was calculated for each county using the survey records of the land capability class and the x-factor at each NRI site. The Natural Resources Conservation Service divided land capability into eight classes, with 1 being the best quality land and 8 being the worst quality land. Location was calculated as the distance from the geographical center of each county (defined as the cross point of the medium latitude and longitude) to the center of the closest metropolitan area (defined as a city with more than 100,000 people). The data on the latitude and longitude of the geographical center of each county and the closest metropolitan area were obtained from the National Association of Counties. The website, www.indo.com/distance was used to measure the distances.

Data on the average value of new housing units, construction cost, income, population, property tax, and public expenditure were obtained from "USA Counties 1996" on CD-ROM prepared by the Bureau of the Census. The demographic, economic, and governmental data are presented for 3,475 variables for the various time periods including 1982, 1987, and 1992 in the CD-ROM. Average farm profit data were obtained from the Census Bureau's "Regional Economic Information System: 1969–1997." Both the farm profit and the average value of new housing units are adjusted by the consumer price index from the Bureau of Labor Statistics. The summary of variables is shown in table 2.

Estimation Results

Factors Affecting Adoption of Land Use Regulations

Parameter estimates for the multinomial logit model of land use regulations are presented in table 3. The model correctly predicts the level of land use regulation for 61% of counties. The marginal effects of alternative variables on the intensity of land use regulations are shown in table 4. Six of eight marginal effects are statistically significant at the 1% level for counties with "stringent" land use regulations. Four of eight coefficients are statistically significant at the 1% level for counties with "moderate" land use regulations. The marginal effects of all eight variables increase with the intensity of land use regulations. Although the marginal effects are less significant for counties with a less stringent land use regulation, the signs of the marginal effects are consistent across the county groups.

For each level of regulation intensity, land use regulations are more frequently adopted in counties with high public expenditures and property taxes. This provides empirical evidence that counties with more regulations are more likely to be urban counties with higher public expenditure and property tax. Land use regulations are also more frequently adopted in counties with a larger increase in development density in the previous five years. This suggests that development pressure promotes county governments to take actions to control further land development.

Counties with higher farm profit adopted land use regulations more frequently. This

Table 2. Definition of Variables

Variables	Mean	Standard Deviation	Definition
Endogenous variables			
Development density	1.87	0.22	Percent of total land developed (%)
Housing price	159.0	91.5	Value of private new housing units ($1,000)
Property tax	436.0	67.0	Property tax per capita ($)
Public expenditure	1859.0	616.0	Public expenditure per capita ($)
Exogenous variables			
Farm profit	8.2	15.9	Farm profit per acre ($)
Population density	0.2	0.9	Population per acre
Income	15.6	4.0	Income per capita ($1,000)
Land capability class	5.2	0.9	Weighted average of land capability class with 1 being the best land and 8 being the worst land
Distance to the closest metropolitan center	80.0	52.6	Distance from the geographic center of a county to the closest metropolitan center (population ≥ 100,000) (mile)
Construction cost	75.0	28.8	Construction cost as recorded on the building permit ($1,000)
County size	1709.0	1894.0	Size of county (1,000 acres)
Expected variance of farm profit	169.3	1006.1	Expected variance of farm profit
Expected variance of housing price	353.5	1949.1	Expected variance of housing value (100)

Table 3. Parameter Estimates for the Multinomial Logit Model of Land Use Regulations

Variables		Stringent	Moderate	Low
Constant		−2.176**	1.240*	−0.619**
		(0.845)	(0.609)	(0.231)
Changes in development density in the previous five years		7.989*	5.028	4.213
		(3.655)	(2.654)	(4.735)
Housing price		0.005**	0.002*	0.001
		(0.001)	(0.001)	(0.001)
Property tax		0.004**	0.003**	0.002*
		(0.001)	(0.001)	(0.001)
Public expenditure		0.464**	0.124**	0.094*
		(0.043)	(0.017)	(0.037)
Farm profit		0.113**	0.059	0.058**
		(0.021)	(0.031)	(0.007)
Distance to the closest metropolitan center		−0.002*	−0.002*	−0.001
		(0.001)	(0.001)	(0.002)
Population density		1.022**	0.193**	0.154
		(0.132)	(0.021)	(0.738)
Income		0.107**	0.079**	0.077*
		(0.021)	(0.019)	(0.034)
Pseudo R^2:	0.65			
Likelihood ratio test statistic:	351			
Correct predictions of land use regulation:	61%			

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

suggests that farmers with high farm profit are more willing to support land use regulations preserving their farmland. High population densities increase pressure for land use regulations. Land use regulations are also more frequently adopted by counties with higher per capita income. These results of population and income are consistent with those found by Erickson and Wollover, who estimated the effects of a number of demographic variables on the adoption of zoning regulations. Counties closer to metropolitan centers are more likely to impose land use regulations. This result is expected because counties closer to metropolitan centers tend to have more land use conflicts.

Table 4. The Marginal Effects of Alternative Variables on the Probability to Adopt Different Levels of Land Use Regulation Intensity

Variables	Stringent	Moderate	Low
Changes in development density in the previous five years	0.008*	0.007*	0.001
	(0.004)	(0.003)	(0.002)
Housing price	0.475**	0.169**	0.150*
	(0.025)	(0.023)	(0.060)
Property tax	0.096**	0.087*	0.064
	(0.019)	(0.042)	(0.049)
Public expenditure	0.548**	0.226**	0.138*
	(0.021)	(0.025)	(0.055)
Farm profit	0.121**	0.049*	0.047**
	(0.045)	(0.018)	(0.009)
Distance to the closest metropolitan center	−0.064*	−0.058	−0.016
	(0.031)	(0.035)	(0.012)
Population density	0.896**	0.562**	0.431*
	(0.031)	(0.092)	(0.206)
Income	0.217**	0.043**	0.039*
	(0.024)	(0.007)	(0.018)

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Factors Affecting Land Development, Housing Price and Public Finance

Tables 5–8 present the estimated parameters for the equations of land development, housing price, public expenditure, and property tax under alternative levels of land use regulations. There is strong evidence that self-selection occurred in the adoption of land use regulations. The coefficient of λ^j is statistically significant at the 10% level or better in all equations under each level of regulation intensity. This suggests land use regulations would not have the same effects on nonadopters, should they choose to adopt, as it does on adopters. The parameter estimates for counties with stringent land use regulations are generally greater than for those with less stringent regulations in all four equations. This suggests that under stringent land use regulations, land development, housing price, public expenditure, and property tax are more sensitive to variables affecting them.

Estimated parameters for the land development equation are presented in table 5. As predicted by economic theory, higher housing prices increase development density, while higher farm profit reduces development density. The positive coefficients on the expected variance of farm profit and negative coefficients on the expected variance of housing price in counties with high degrees of land use regulations indicate that land is more likely to be developed when risks associated with development are low and risks associated with farming high. In addition, land is more likely to be developed in counties with higher land quality, higher per capita income, higher population density, and lower construction costs.

Parameter estimates for the housing price equation are shown in table 6. Seven of eight coefficients under stringent regulations are statistically significant at the 1% level. Only four of eight coefficients are statistically significant at the 1% level under no regulation. The coefficients on property taxes are not statistically significant at the 5% level under no and some regulation but are statistically significant at the 5% level under stringent and moderate regulations. Results suggest that counties with stringent and moderate regulations are likely to be

Table 5. Parameter Estimates for the Land Development Equation under Different Levels of Land Use Regulation Intensity

Variables	Stringent	Moderate	Low	None
Constant	0.522**	0.214**	0.306**	0.102*
	(0.045)	(0.058)	(0.025)	(0.049)
Housing price	0.007**	0.005*	0.002*	0.001
	(0.001)	(0.002)	(0.001)	(0.001)
Property tax	0.152**	0.147**	0.134**	0.101*
	(0.015)	(0.026)	(0.031)	(0.048)
Public expenditure	0.084**	0.062*	0.039	0.021
	(0.015)	(0.026)	(0.032)	(0.044)
Farm profit	−0.449*	−0.284**	−0.095**	−0.041**
	(0.187)	(0.032)	(0.017)	(0.007)
Expected variance of housing price	−0.025**	−0.015*	0.011*	0.003**
	(0.005)	(0.006)	(0.005)	(0.001)
Expected variance of farm profit	0.186	0.221	0.151**	0.182
	(0.098)	(0.143)	(0.019)	(0.095)
Construction cost	−0.015**	−0.012**	−0.007	0.003
	(0.004)	(0.004)	(0.005)	(0.005)
Income	0.112**	0.089**	0.057*	0.031**
	(0.020)	(0.016)	(0.022)	(0.009)
Population density	0.627**	0.415**	0.288**	0.104
	(0.035)	(0.018)	(0.045)	(0.056)
Distance to the closest metropolitan center	−0.024**	−0.015**	−0.010*	−0.005
	(0.005)	(0.004)	(0.004)	(0.004)
Land capability class	−0.210**	−0.145**	−0.149**	−0.099*
	(0.050)	(0.025)	(0.047)	(0.041)
λ^j	−0.921**	−0.913**	−0.059	0.020
	(0.204)	(0.036)	(0.031)	(0.012)
R^2	0.81	0.75	0.69	0.55

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Table 6. Parameter Estimates for the Housing Price Equation under Different Levels of Land Use Regulation Intensity

Variable	Stringent	Moderate	Some	None
Constant	18.271**	16.365*	13.224	15.820**
	(3.665)	(7.419)	(10.258)	(5.914)
Development density	0.314**	0.282**	0.132**	0.089**
	(0.045)	(0.035)	(0.017)	(0.014)
Property tax	−0.023**	−0.017**	−0.006	−0.002
	(0.005)	(0.006)	(0.004)	(0.003)
Public expenditure	0.085*	0.105*	0.097**	0.072**
	(0.037)	(0.047)	(0.015)	(0.010)
Farm profit	0.121**	0.065**	0.043**	0.029*
	(0.029)	(0.008)	(0.006)	(0.013)
Income	0.109**	0.075**	0.051*	0.028*
	(0.015)	(0.010)	(0.022)	(0.013)
Population density	0.087**	0.069**	0.029**	0.012*
	(0.006)	(0.008)	(0.010)	(0.005)
Distance to the closest metropolitan center	−0.038**	−0.024**	−0.019*	−0.008*
	(0.004)	(0.005)	(0.007)	(0.004)
λ^j	6.127**	5.910**	3.243**	2.157**
	(0.053)	(0.047)	(0.526)	(0.046)
R^2	0.61	0.56	0.55	0.48

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

located near a metropolitan center where housing prices are significantly affected by both the distance to the metropolitan center and property tax.

Housing prices are higher in counties with higher per capita income and population density. Counties with higher property tax per capita tend to have lower housing prices.

Table 7. Parameter Estimates for the Per Capita Public Expenditure Equation under Different Levels of Land Use Regulation Intensity

Variable	Stringent	Moderate	Low	None
Constant	5.581*	8.557*	4.298*	2.091*
	(2.047)	(3.442)	(1.813)	(0.787)
Development density	0.005**	0.003**	0.001*	0.001
	(0.001)	(0.001)	(0.0004)	(0.001)
Housing price	0.288**	0.301**	0.215**	0.139**
	(0.036)	(0.028)	(0.027)	(0.041)
Property tax	1.126**	1.214**	1.075**	0.854**
	(0.033)	(0.031)	(0.026)	(0.180)
County size	0.071**	0.047**	0.022*	0.013
	(0.011)	(0.008)	(0.008)	(0.015)
Land capability class	−0.216**	−0.148*	−0.109*	−0.072*
	(0.062)	(0.063)	(0.041)	(0.034)
Per capita income	0.048**	0.022*	0.015	0.006*
	(0.009)	(0.008)	(0.009)	(0.003)
Population density	0.024**	0.015*	0.004	0.002*
	(0.004)	(0.008)	(0.003)	(0.001)
Distance to the closest metropolitan center	−0.425**	−0.239**	−0.120*	−0.071
	(0.031)	(0.038)	(0.051)	(0.046)
λ^j	0.690**	0.340**	0.289**	0.129*
	(0.061)	(0.061)	(0.056)	(0.047)
R^2	0.69	0.64	0.58	0.54

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Table 8. Parameter Estimates for the Per Capita Property Tax Equation under Different Levels of Land Use Regulation Intensity

Variables	Stringent	Moderate	Low	None
Constant	8.654**	5.269*	2.290**	2.612*
	(1.064)	(2.412)	(0.783)	(1.219)
Development density	0.192**	0.104	0.061**	0.041**
	(0.031)	(0.141)	(0.013)	(0.015)
Housing price	0.063**	0.032**	0.015**	0.006*
	(0.004)	(0.005)	(0.005)	(0.003)
Public expenditure	0.312**	0.219**	0.198**	0.072*
	(0.053)	(0.025)	(0.021)	(0.029)
County size	0.029**	0.026**	0.016**	0.008*
	(0.005)	(0.009)	(0.002)	(0.003)
Land capability class	−0.649**	−0.410**	−0.381*	−0.205**
	(0.025)	(0.059)	(0.167)	(0.026)
Per capita income	0.055**	0.036**	0.038**	0.007**
	(0.006)	(0.005)	(0.004)	(0.001)
Population density	0.226**	0.185*	0.132**	0.091*
	(0.074)	(0.083)	(0.014)	(0.045)
Distance to the closest metropolitan center	−0.212*	−0.135**	−0.041	−0.040*
	(0.083)	(0.045)	(0.028)	(0.016)
λ^j	0.375**	0.210**	0.102*	0.075**
	(0.043)	(0.041)	(0.041)	(0.010)
R^2	0.77	0.65	0.58	0.54

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Housing prices tend to be higher in counties with a large per capita public expenditure. This may reflect that counties with a large public expenditure can provide better public services.

Parameter estimates for the per capita public expenditure equations are shown in table 7. Overall, the model fits the data well. Most variables are statistically significant at the 5% level or higher. Per capita public expenditure is positively correlated with income and population density. Large counties with high development densities tend to have more public expenditures. This result may reflect that large counties with high development densities require more public expenditures. As expected, the higher the property tax, the larger the public expenditure.

Parameter estimates for the per-capita property tax equations are shown in table 8. The R^2 and the magnitude of coefficients are consistently larger under the stringent regulations than under the other degrees of regulations. The coefficients of the variables in the property tax equation have the same signs and interpretations as in the public expenditure equations.

The Effects of Land Use Regulations

The effect of land use regulations on development, housing prices, public expenditure, and property tax were estimated using equations (11)–(13). The results are shown in tables 9 and 10. The effects of land use regulations increase with the degree of regulation. In counties with "stringent" land use regulations, the percent of developed area is reduced by 0.45% in the long run. This means that for a county with 100 square miles of total area, stringent regulations reduce the developed area by 0.45 square miles. The total land area in all counties with stringent regulations in the five western states is 85,560,500 acres. By 1992, 2,909,100 acres, or 3.4% were developed. If land use regulations had not been imposed in those counties, 3.85% of total land area would have been developed. Thus, regulations in those counties saved about 385,000 acres of land from development, which is 13.2% of developed area in 1992. The long run effect is larger than the short run effect because in the long run, land use regulations also reduce public expenditure and property tax, which further reduce development pressures.

In counties with "moderate" regulations, the percentage of developed area is reduced by 0.31% in the five western states in the long run. The total land area in all counties with moderate regulations in the five western states is 113,183,300 acres. By 1992, 2,829,600 acres, or 2.5% were developed. If land use regulations had not been imposed in those counties, 2.81% of total land area would have been developed.

Table 9. The Estimated Short-Run Effects of Land Use Regulations on Land Development, Housing Price, Public Expenditure, and Property Tax in Five Western U.S. States

Regulation Intensity	Percent of Total Land Developed	Housing Price ($/unit)	Public Expenditure ($/capita/year)	Property Tax ($/capita/year)
Stringent	−0.36**	6,132**	129**	39**
	(0.07)	(189.4)	(17.2)	(5.6)
Moderate	−0.28*	2,893**	74*	24**
	(0.07)	(785.2)	(32.3)	(8.3)
Low	−0.15*	858*	41**	13
	(0.06)	(396.6)	(6.0)	(13.8)

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Table 10. The Estimated Long-Run Effects of Land Use Regulations on Land Development, Housing Price, Public Expenditure, and Property Tax in Five Western U.S. States

Regulation Intensity	Percent of Total Land Developed	Housing Price ($/unit)	Public Expenditure ($/capita/year)	Property Tax ($/capita/year)
Stringent	−0.45**	6,891**	−74**	−26**
	(0.05)	(418.5)	(12.8)	(4.7)
Moderate	−0.31*	3,276**	−49**	−23**
	(0.17)	(619.9)	(9.1)	(2.6)
Low	0.21*	1,956*	−36	−7
	(0.10)	(882.4)	(25.8)	(4.6)

Note: Standard errors are in parentheses; * and ** indicate statistical significance at the 5% and 1% level, respectively.

Thus, regulations in those counties saved about 351,000 acres of land from development, which is 12.4% of developed area in 1992. Similarly, in counties with "low" regulations, the percentage of developed area is reduced by 0.21%. The total land area in all counties with low regulations in the five western states is 89,026,500 acres. By 1992, 1,826,800 acres, or 2.1% were developed. If land use regulations had not been imposed in those counties, 2.31% of total land area would have been developed. Thus, regulations in those counties save about 187,000 acres of land from development, which is 10.2% of developed area in 1992.

Land use regulations in the five western states saved an estimated 12.2% of total developed area (923,000 acres out of 7,565,500 acres of total developed area in 1992) in the long run. However, in counties with the most stringent land use regulations, average new housing price increased by $6,891 per unit in the long run. The average new housing price was $146,000 in 1982; stringent land use regulations increased new housing prices by 4.7% in the long run.

Under stringent regulations, public expenditure increased by the $129 per capita in the short run. The average public expenditure was $1,320 per capita in 1982; thus, stringent regulations increased public expenditure by 9.8% in the short run. However, in the long run, land use regulations reduced public expenditure by $74 per capita or 5.6% under stringent regulations because few acres of land are developed. Land use regulations also increased property tax in the short run ($39 per capita under the stringent regulation), but reduced property tax in the long run ($26 per capita under stringent regulation).

The difference between the short-run and long-run effects on public expenditure and property taxes suggests that in the short run, county governments may need to raise property taxes to cover the increased public expenditure needed to develop and implement land use regulations. However, in the long run land use regulations reduce developed area, which in turn reduces public expenditure and property taxes.

Conclusions

Measuring the effects of land use regulations is becoming increasingly important as more communities exercise land use regulations. Previous studies on land use regulations have tended to focus on a single land use regulation, treating all others as given and exogenously determined. They also have neglected interactions among residential development, land use regulations, and public finance. In this article a simultaneous equations system with self-selection is used to estimate adoption decisions of land use regulations and their impacts on land development, public expenditure, and property tax in five western states. The system of equations was estimated using data from our first-hand county land use regulation survey, the 1982, 1987, and 1992 National Resources Inventories, and other government publications.

The results of this study suggest that rapid conversion of farmland and open space to development along with high public expenditure and property taxes promote local governments to impose more stringent land use regulations. More stringent land use regulations, in turn, reduce land development, long-run public expenditure and property tax at the expense of higher housing prices and short-run increases in public expenditure and property tax. More specifically, in the five western states of the United States, land use regulations reduced the total developed area by an estimated 12.2% from 1982 to 1992, but increased housing prices between 1.3% and 4.7%, depending the intensity of regulations in a county. Land use regulations also reduced public expenditure and property tax in the long run by 5.6% and 8.4%, respectively, but increased public expenditure and property tax in the short run by 9.8% and 12.6%. These interactions among urbanization, land use regulations, and public finance were significantly affected by population density, geographic location, land quality, and the relative profitability and risks of farming versus development.

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