Property Taxes: Do They Affect Forestry and Agricultural Land Uses?

Maksym Polyakov[1] and Daowei Zhang, Auburn University Auburn

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Abstract

This study uses nested logit model to analyze changes between agricultural, forestry, and developed land uses in Louisiana during 1982-1997 using NRI point data. The model utilizes modern land use theory based on the land rent theory. In addition to the returns, we incorporated into the model property tax paid per acre of land for each of the three studied land uses. We found that property tax is significantly influencing probabilities of land use change in Louisiana.

Key words: land use change, property tax, discrete choice, nested logit, Louisiana.

[1] School of Forestry and Wildlife Sciences Building, Auburn University, AL 36849-5418.
polyama@auburn.edu (334) 844 1053 (v); (334) 844 1084 (Fax)

Introduction

Land use changes, while driven by maximization of economic benefits to the land owner, often produce negative externalities such as air and water pollution, biodiversity loss, wildlife habitat fragmentation, and increased flooding. In the conditions when majority of land base is privately owned, like in the US South, it is important to understand how economic, social, environmental factors, as well as intended or unintended consequences of public policies, affect private landowners' decisions concerning land use change.

Most of existing studies of land use in the US are based on the classic land use theory developed by David Ricardo and Johann von Thünen in the nineteenth century. This theory explains land use patterns in terms of relative rent to alternative land uses, which depends on land quality and location. Due to the data limitations, majority of econometric land use studies utilize aggregated data describing areas or proportions of certain land use categories within well defined geographic area such as a county or other region as a function of socioeconomic variables and land characteristics aggregated at the level of geographic unit of observation (Alig and Healy, 1987; Plantinga et al., 1990; Stavins and Jaffe, 1990). Some of the studies, employing aggregated data, model shares of exhaustive set of land use within specified land base using binomial or multinomial logit model of shares, which allows restricting shares to unity (Parks and Murray, 1994; Hardie and Parks, 1997; Ahn et al., 2000). A few most recent studies use parcel-based observation of land characteristics and land use transitions. Depending on the number of land use categories considered (choices) they use binominal probit (Kline et al., 2001), or nested logit (Lubowski et al, 2003) models.

There were two major applications of empirical studies of land use and land use change in the US. First, the estimates of econometric models were used to predict forest area trends and timber supply (Alig and Wear, 1992; Ahn et al., 2000) as well as potential of carbon sequestration through forest area expansion (Stavins, 1999). Second, studies had examined the effects and effectiveness of government programs such as Conservation Reserve Program (Schatzki, 2003), flood control projects (Stavins and Jaffe, 1990), programs for wetlands conservation (Parks and Kramer, 1995), zoning and urban control policies (Carrion-Flores and Irwin, 2004). However, there have been a very little research about the effect of property taxes, and in particular, preferential valuation, on the land use changes.
In this paper, we analyze the effect of property taxes on the land use change on the Louisiana private lands using USDA Natural Resource Inventory sample plots.

The Theoretical Model

Consider a risk-neutral landowner choosing to allocate a non-divisible parcel of land of uniform quality to one of several possible alternative uses. We assume that a landowner's decision is based on the maximization of net present value of future returns generated by the land. The owner's expectations concerning future returns generated by different land uses are drawn from the characteristics of the parcel and historical returns. The net present value of parcel *n* in use *i* is $\frac{R_{ni}}{r}$, where R_{ni} is the annual net returns from land uses *i* and *r* is the discount rate. Converting a parcel from use *i* to alternative use *j* also involves one time conversion cost C_{nij}. We assume that landowner's utility of new land use *j* conditional on current land use *i* could be expressed as $U_{nj|i} = \frac{R_{nj}}{r} - C_{nij}$. Neither return for each of the land uses, nor conversion costs are directly observable for individual parcels, however, there are other observable attributes of the land uses $\mathbf{x}_{nj} \forall j$, and observable attributes of plots $\mathbf{s}_n$, that are related to either returns or conversion costs, so that $U_{nj|i} = V_{nj|i} + \varepsilon_{nj}$, where $V_{nj|i} = V(\mathbf{x}_{nj}, \mathbf{s}_n)$ is the representative utility and ε_{nj} captures the factors that are affecting utility, but not included into representative utility, and assumed to be random. The probability of converting parcel *n* to land use *j* is

$$\begin{aligned} P_{nj|i} &= \text{Prob}(U_{nj|i} > U_{nk|i} \ \forall k \neq j) \\ &= \text{Prob}(V_{nj|i} + \varepsilon_{nj} > V_{nk|i} + \varepsilon_{nk} \ \forall k \neq j) \\ &= \text{Prob}(\varepsilon_{nj} - \varepsilon_{nk} > V_{nk|i} - V_{nj|i} \ \forall k \neq j) \\ &= \int I(\varepsilon_{nj} - \varepsilon_{nk} > V_{nk|i} - V_{nj|i} \ \forall k \neq j) f(\varepsilon_n) d\varepsilon_n, \end{aligned}$$

where $I(\cdot)$ is the indicator function, equaling 1 when the term in parenthesis is true and 0 otherwise, and $f(\varepsilon_n)$ is the joint density of the vector of probabilities ε_{nj}. Depending on assumptions about the density distribution of random components of utility, several different discrete choice models could be derived from this specification (Train, 2003).

Assuming random components are independent and identically distributed (iid) with a type I extreme value distribution, conditional logit model (McFadden 1974) is derived:

$$\text{Prob}(Y_n = j) = P_j = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{nj})}{\sum_{j=1}^{J} \exp(\boldsymbol{\beta}'\mathbf{x}_{nj})}$$

Conditional logit model is easy to estimate and interpret. However, the independence of irrelevant alternatives (IIA) property of the conditional logit model is unlikely to represent actual structure of choices in many real situations. Grouping alternatives into several a priory identified more homogenous nests allows partial relaxation of the requirements of identical distribution and independence among random components of alternatives. This model is referred to as nested logit model and allows for correlation of unobserved portions of utilities within a nest as well as for the different variances for the groups of alternatives among nests.

In a two-level nested logit model, we divide a set of *J* alternatives into *L* nests. The vector of observed attributes is viewed as partitioned into subset determining choice of nest $\mathbf{z}_{nl}$ and subset determining choice of alternative within nest $\mathbf{x}_{nj|l}$. The probability of individual *n* choosing alternative *j* is a product of probability of choosing nest *l* and probability of choosing alternative *j* within nest *l*:

$$P_{njl} = P_{nj|l} \times P_{nl} = \frac{\exp(\boldsymbol{\beta}'\mathbf{x}_{nj|l})}{\sum_{j=1}^{Jl} \exp(\boldsymbol{\beta}'\mathbf{x}_{nj|l})} \times \frac{\exp(\boldsymbol{\gamma}'\mathbf{z}_{nl} + \tau_l I_l)}{\sum_{l=1}^{L} \exp(\boldsymbol{\gamma}'\mathbf{z}_{nl} + \tau_l I_l)}$$

Where I_l is an inclusive value for nest *l* defined as

$$I_l = \ln\left(\sum_{j=1}^{Jl} \exp(\boldsymbol{\beta}'\mathbf{x}_{nj|l})\right),$$

and τ_l is an inclusive value parameter. Inclusive value parameter τ_l is a measure of independence among choices in the nest *l* and the statistics $1-\tau_l$ is a measure of correlation

(Train 2003). When $\tau_l = 1$, the choices within nest *l* are independent, so when $\tau_l = 1 \; \forall l$ model becomes conditional logit, which can be tested by imposing appropriate restrictions.

Data

Land use data for Louisiana are derived from the National Resources Inventory (NRI) obtained from USDA National Resources Conservation Service (NRCS 2000). The NRI is a longitudinal panel survey of the Nation's soil, water, and related resources designed to assess conditions and trends every five years. The details of NRI sampling design, data collection, and estimation procedures are discussed by Nusser and Goebel (1997). The 1997 NRI dataset provides results that are nationally consistent for all nonfederal lands for four points in time: 1982, 1987, 1992, and 1997. The NRI dataset for Louisiana contains 23679 points representing 31.4 million acres. In this study we used data for NRI plots in Louisiana which can be classified as nonfederal lands in either agricultural, forest, or developed uses at the beginning and at the end of each of the three five-year periods. This constitutes 13414 points representing 22.6 million acres (see Table 1). Other land uses, which include rangelands, other rural lands, rural transportation, small and large water bodies, federal lands, and CRP land were not included in the analysis because of small share (e.g., rangelands) or because changes in these land uses are not driven by market forces (e.g., federal lands).

Land quality is an important characteristic determining potential return from agricultural and forestry uses. There are two variables in NRI database, which characterize land quality of each sample plot (except federal lands, developed lands and waters). One variable is land capability class, which is a categorical variable taking values I to VIII and indicating existence and severity of limitations that reduce the choice of plants or require moderate conservation practices, or preclude cultivation and limit the use of plot mainly to pasture, range, forestland, or wildlife food and cover. Studies that model land use at county level utilized aggregated NRI land quality characteristics as proportion of certain land capability class (Hardie and Parks, 1997; Miller and Plantinga, 1999) or as average land capability class (Ahn et al., 2002). Lubowski et al. (2003) model land use change at the parcel level and use land capability class as a set of dummies. Another variable characterizing land quality in NRI database is a binary variable that indicates whether plot is classified a prime farmland that is a land on which crops can be produced for the least cost and with the least damage to the resource base. For this study we selected "Prime farmland" variable to represent land quality of a sample plot.

In order to quantify effect or population and proximity to populated places, we use population interaction index (PII), which is similar to a gravity index. PII is derived from Census tract population data of 1980, 1990, and 2000 and linked to the NRI plots. We used linear interpolation to obtain PII for 1982, 1987, and 1992, which are starting years of three five-year transition periods.

Table 1. Transitions between major land use categories in Louisiana (thousand acres)

Initial land use	Period	Final land use				
		Agriculture	Forestry	Developed	Other	Total
Agriculture	1982-87	8356.4	170.9	81.5	97.9	8706.7
	1987-92	8210.5	136.5	47.9	187.2	8582.1
	1992-97	7969.6	167.1	61.6	75.3	8273.6
Forestry	1982-87	202	13043.7	64.4	110.9	13421
	1987-92	48.3	13015.4	53.9	116.1	13233.7
	1992-97	29.8	13034.9	57.6	50.4	13172.7
Developed	1982-87	0.2		930.5		930.7
	1987-92		0.1	1080.5		1080.6
	1992-97			1183.4		1183.4
Other	1982-87	23.5	19.1	4.2	8271.6	8318.4
	1987-92	14.8	20.7	1.1	8443.8	8480.4
	1992-97	45.1	24.4	3.2	8674.4	8747.1
Total	1982-87	8582.1	13233.7	1080.6	8480.4	31376.8
	1987-92	8273.6	13172.7	1183.4	8747.1	31376.8
	1992-97	8044.5	13226.4	1305.8	8800.1	31376.8

We used parish level return and property tax data. Property tax per acre of agricultural, forest, and developed land for 1981, 1987, and 1992 were calculated using the data available from Biennial Reports of Louisiana Tax Commission (State of Louisiana, 1982; Louisiana Tax Commission, 1988, 1994). These reports contain data on assessed values and acreages of land and improvements for various land use categories, as well as the millage rates for various local taxes for each parish. Total amount of property tax was obtained by applying millage rates to assessed values of land in each of the land uses. Acreages of land in forest and agricultural land uses for calculation of property tax per acre were taken from the Louisiana Tax Commission Reports. Because of these reports contain number of lots rather than acreage for developed lands (country and city lots), we used acreage of urban and built-up land from NRI data to obtain per acre property tax for this land use category.
As a proxy for per acre agricultural returns we used market value of agricultural crops divided by acreage of croplands from the Census of Agriculture data available at http://agcensus.mannlib.cornell.edu/. Forestry returns were calculated as the value of stumpage sold in a parish averaged over 5 year period and divided by acreage of timberlands in a parish. The values of stumpage by parish and by year for Louisiana were derived from the severance tax data by Louisiana Forestry Commission and are available from the annual Louisiana timber and pulpwood production reports at http://www.ldaf.state.la.us/divisions/forestry/reports/timberpulpwood/. Returns of developed land were calculated from the assessed values of developed land, which are defined as 10% of fair market value, and assuming 10% capitalization rate. Table 2 presents descriptive statistics of explanatory variables.

Table 2. Descriptive statistics of explanatory variables.

Variables	N	Minimum	Maximum	Mean	Std dev
Parish level					
Return from agricultural lands, \$/ac	155	4.19	356.36	95.96	77.55
Return from forestry lands, \$/ac	155	0.00	63.87	16.24	12.13
Return from developed lands, \$/ac	155	39.30	1811.55	607.87	395.04
Property tax for agricultural land, \$/ac	155	0.43	6.39	1.81	0.89
Property tax for forestry land, \$/ac	155	0.13	2.52	0.86	0.43
Property tax for developed land, \$/ac	155	3.90	229.67	52.20	45.59
Plot level					
Population interaction index	35790	10.58	1468.78	117.77	125.13
Prime farmland	35790	0.00	1.00	0.49	0.50

Estimation Results

We model transition between three broad land uses (agriculture, forestry, and developed) over tree five-year intervals. Because transition to developed land use is practically irreversible, we consider two initial land uses (*i*) and three final land uses or alternatives (*j*). We combine parish (*p*) specific attributes of alternatives with attributes of plots (*n*) to obtain the following utility function for each alternative:

$$U_{nj|i} = \beta_{ij}^0 + \beta^1 R_{pj} + \beta^2 T_{pj} + \beta^3 PII_n^D + \beta^4 PRIME_n^A + \varepsilon_{nj},$$

where β_{ij}^0 is set of transition specific intercepts ($i \neq j$) indicating conversion costs, $\beta^1 \ldots \beta^4$ are parameters, R_{pj} is return for land use *j* in parish *p*, T_{pj} is property tax for land use *j* in parish *p*, PII_n^D is plot specific population influence index for developed land use alternative, and $PRIME_n^A$ is plot specific dummy "prime farmland" for agricultural land use alternative. It is assumed that population influence index affect the utility of the choice of developed land and "prime farmland" affects the choice between agricultural and forestry land uses being irrelevant for the choice of developed land. In order to take care of possible differences in variances and correlation between outcomes, we formulate nested logit model by grouping alternatives into two nests: (i) "rural", consisting of agricultural and forestry land uses, and (ii) "urban", consisting of developed land use. We assumed that there is a significant similarity between agricultural and forestry land uses (with possible correlation between variances of their utility functions), while choice of developed land use differs from two the choice of two former alternatives. Because of "urban" nest consist of one alternative, this model is partially degenerate, and therefore overparameterized with respect to inclusive value parameters (Hunt, 2000). Recall, that inclusive value parameter is a measure of independence between choices within nest. For identification purpose, we restrict inclusive value parameter of the "urban" nest to unity.

We estimated conditional logit and two-level nested logit models using NLOGIT 3.0 (Greene, 2002). Nested logit model was estimated using Full Information Maximum Likelihood (FIML) method. All observations were weighted using NRI expansion factors scaled so that they sum to the number of observations. The estimation results of conditional logit and nested logit models are presented in Table 3. McFadden's pseudo-R^2 indicates good fit of both models. The likelihood ratio test was carried for nested logit specification against the null hypothesis of conditional logit specification. The value of likelihood ratio statistic is 11.802 with 99% critical value of $\chi_1^2 = 6.63$, which rejects null hypothesis. The inclusive value parameter for "rural" nest is different from unity at 1% level of significance, supporting nested logit versus conditional logit once again.

Table 3. Conditional logit and nested logit estimates of land use change in Louisiana

	Coefficient Estimates			
	Conditional Logit		Nested Logit	
Conversion agriculture to forestry	–3.0524***	(0.0914)	–2.9775***	(0.0923)
Conversion forestry to agriculture	–5.4795***	(0.1018)	–5.5581***	(0.1062)
Conversion agriculture to developed	–5.3709***	(0.1871)	–6.1801***	(0.3523)
Conversion forestry to developed	–6.5210***	(0.1727)	–6.5348***	(0.1766)
Property tax	–0.0082***	(0.0031)	–0.0081***	(0.0031)
Return	0.0013***	(0.0004)	0.0013***	(0.0004)
PII for developed	0.0058***	(0.0004)	0.0056***	(0.0004)
Prime farmland for agriculture	1.0381***	(0.0960)	1.1572***	(0.1033)
Inclusive value for rural			0.1223†††	(0.2654)
Inclusive value for urban			1.0000	Fixed
McFadden R^2	0.9350		0.9351	
Log Likelihood	–3104.4		–3098.5	

Notes: *** significantly differ from 0 at 1%; ††† significantly differ from 1 at 1%.

Analyzing regression coefficients presented in table 3, we see that for both conditional logit and nested logit models the transition specific intercepts indicating conversion costs are significantly different from zero and negative, as expected. The highest are costs of transition from forestry to developed use, while the lowest are costs of transition from agriculture to forestry. Population size and proximity reflected by population influence index is a factor significantly influencing probability of conversion to developed land use, while quality of land is an important determinant of land being converted to or retained in agricultural land use. Returns to alternative land uses are significant and have positive sign. This confirms the basic assumptions of Ricardian land rent theory. Finally, the amount of property tax levied from land in particular use inversely impacts probability of conversion to this land use. While being significant and consistent with underlying theory, the coefficients of conditional and nested logit models presented in Table 3 are difficult to interpret. One of the reasons is that the same vector of coefficients is used in all utility functions, thus in our model one coefficient determines nine elasticities. Table 4 presents matrices of partial elasticities and crosselasticities of the probabilities of land use change with respect to returns and property taxes for both conditional and nested logit models.

Table 4. Land use transition probabilities and elasticities (averaged over observations) by land quality (nested logit model)

Transition	Prime	Prob.	Elasticities of transition probabilities with respect to						
			Return to			Property tax on			PII for
			Agr	For	Dev	Agr	For	Dev	Dev
Agr→Agr	0	0.950	**0.004**	–0.001	–0.007	**–0.001**	0.000	0.004	–0.007
Agr→Agr	1	0.980	**0.002**	0.000	–0.009	**0.000**	0.000	0.005	–0.015
Agr→For	0	0.045	–0.088	**0.021**	–0.007	0.013	**–0.006**	0.004	–0.007
Agr→For	1	0.014	–0.140	**0.016**	–0.009	0.014	**–0.006**	0.005	–0.015
Agr→Dev	0	0.005	–0.011	0.000	**0.810**	0.002	0.000	**–0.436**	**0.537**
Agr→Dev	1	0.006	–0.017	0.000	**0.912**	0.002	0.000	**–0.481**	**0.623**
For→Agr	0	0.004	**0.082**	–0.027	–0.004	**–0.014**	0.008	0.003	–0.005
For→Agr	1	0.013	**0.082**	–0.027	–0.005	**–0.015**	0.008	0.003	–0.005
For→For	0	0.992	0.000	**0.000**	–0.004	0.000	**0.000**	0.003	–0.005
For→For	1	0.983	–0.001	**0.000**	–0.005	0.000	**0.000**	0.003	–0.005
For→Dev	0	0.004	0.000	–0.003	**0.768**	0.000	0.001	**–0.449**	**0.510**
For→Dev	1	0.004	0.000	–0.003	**0.818**	0.000	0.001	**–0.508**	**0.513**

Conclusion

This paper analyses determinants of land use changes in Louisiana during the period 1982-1997. Land quality is an important factor determining allocation of land to agricultural land use while urbanization (proximity and concentration of population) plays an important role in conversion to developed land use. Higher return to a particular land use increases the probability of conversion to this land use and decreases the probability of converting to other land uses. This finding corresponds with results of most of the studies of land use change (e.g, Lubovski, 2003). Higher property tax to a particular land use decreases the probability of conversion to this land use and increases the probability of converting to other land uses. This result supports underlying theory, however as to our knowledge, it was not reported in empirical studies of land use. This result has an importing policy implication by allowing evaluating effect and effectiveness of particular property tax policies on land use change. The shortcomings of this study are that it does not take into account possible spatial correlation and possible temporal autocorrelation in pooled cross sectional data

References

Ahn, S., A. Plantinga, and R. Alig. 2000. Predicting future forestland area: A comparison of econometric approaches. For. Sci. 46(3): 363-376.
Ahn, S., A. J. Plantinga, and R. J. Alig. 2001. Historical Trends and Projections of Land Use for the South-Central United States. U.S. Forest Service, Pacific Northwest Research Station, Research Paper PNW-RP-530.
Alig, R. J. and R. G. Healy. 1987. Urban and built-up land area changes in the United States: An empirical investigation of determinants. Land Economics 63(3):215-226.
Alig, R. J. and D. N. Wear. 1992. Changes in private timberland in the United States: Statistics and projections for 1952-2040. J. For. 90(5):31–37.

Carrion-Flores, C. and E. G. Irwin. 2004. Determinants of Residential Land Use Conversion and Sprawl at the Rural-Urban Fringe. American Journal of Agricultural Economics, 86(4):889–904.
Greene, W. H. 2002. Nlogit Version 3.0 Reference Guide. New York: Econometric Software, Inc.
Hardie, I. W., and P. J. Parks. 1997. Land Use with Heterogeneous Land Quality: An Application of an Area-Base Model. American Journal of Agricultural Economics, 79(2):299–310.
Hunt, G. L. 2000. Alternative Nested Logit Model Structures and the Special Case of Partial Degeneracy. Journal of Regional Science, 40(1):89–113.
Kline, J. D., A. Moses, and R. J. Alig. 2001. Integrating Urbanization into Landscape-Level Ecological Assessments. Ecosystems 4(1):3-18.
Louisiana Tax Commission. 1988. Twenty-Third Biennial Report 1986-1987. Baton Rouge, LA. 196 p.
Louisiana Tax Commission. 1994. Twenty-Sixth Biennial Report 1992-1993. Baton Rouge, LA. 210 p.
Lubowski, R.N., A.J. Plantinga, and R.N. Stavins. 2003. Land Use Change and Carbon Sinks: Econometric Estimation of the Carbon Sequestration Supply Function. Working Paper. John F. Kennedy School of Government, Harvard University, Cambridge, MA.
Natural Resources Conservation Service (NRCS). 2000. 1997 national resources inventory, revised December 2000. Natural Resources Conservation Service, U.S. Department of Agriculture, Washington, D.C.
Nusser, S. M. and J. J. Goebel. 1997. The National Resources Inventory: a long-term multi-resource monitoring programme. Environmental and Ecological Statistics 4:181-204.
Parks, P. J. and R. A. Kramer. 1995. A Policy Simulation of the Wetlands Reserve Program. Journal of Environmental Economics and Management, 28(2):223-240.
Parks, P. J., and B. C. Murray. 1994. Land Attributes and Land Allocation: Nonindustrial Forest Use in the Pacific Northwest. For. Sci. 40(3):558-575.
Plantinga, A. J., J. Buongiorno, and R. J. Alig. 1990. Determinants of Changes in Non-Industrial Private Timberland Ownership in the United States. Journal of World Forest Resource Management 5:29-46.
Schatzki, T. 2003. Options, uncertainty and sunk costs:: an empirical analysis of land use change, Journal of Environmental Economics and Management, 46:86-105
State of Louisiana. 1982. Twentieth Biennial Report of the Louisiana Tax Commission for the Years 1980-1981. Baton Rouge, LA. 186 p.
Stavins, R. N. 1999. The Costs of Carbon Sequestration: A Revealed-Preference Approach. American Economic Review, 89:994-1009.
Stavins, R. N., and A. B. Jaffe. 1990. Unintended Impacts of Public Investments on Private Decisions: The Depletion of Forested Wetlands. American Economic Review 80:337-352.
Train, K. E. 2003. Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge, UK. 334 p.