Property Taxation and Residential Density:

Theory and Empirics

Richard W. England and Ju-Chin Huang

Lincoln Institute of Land Policy

Working Paper

Lincoln Institute Product Code: WP08RE1

Abstract

In this paper, we first theorize about the size of a house constructed on a residential lot, measured by height and footprint area. We hypothesize that the property tax rate will have a negative impact on the density of residential construction projects. Using physical descriptions for more than 50 thousand single family homes built in New Hampshire between 1972 and 2006, we find empirical evidence that higher property taxes are associated with both smaller lots and smaller houses. On balance, higher property tax rates are associated with lower residential density.

About the Authors

Richard W. England is professor of economics and natural resources at the University of New Hampshire. He is also a visiting fellow with the Department of Taxation and Valuation at the Lincoln Institute.

rwe@unh.edu

Ju-Chin Huang is associate professor of economics at the Whittemore School of Business and Economics, University of New Hampshire.

jchuang@unh.edu

ACKNOWLEDGEMENTS

We would like to thank the Lincoln Institute of Land Policy for its financial support. Gregory Ingram provided the impetus for this project and has offered valuable comments and suggestions along the way. Byron F. Lutz was an extremely helpful and gracious discussant when we presented this paper at the 2008 National Tax Association meetings. Suwen Duan has put in long hours, often on short notice, as project research assistant.

Table of Contents

Property Taxation and Residential Density: Theory and Empirics

INTRODUCTION

During recent decades, rapid population growth and land development have been observed in various parts of the United States. Although much of that growth has been in southern and western metropolitan regions, New Hampshire stands out as a high-growth state in the northeastern quadrant of the nation. As Table 1 points out, rapid population growth in New Hampshire has been associated with a substantial decline in population density of developed areas during the past quarter century.

Some observers point to declining population densities as *per se* evidence of an undesirable phenomenon called urban "sprawl." We prefer the approach of Brueckner [2000], who defines sprawl as *excessive* growth of the area of a metropolitan region resulting from failure to account for open-space benefits, congestion externalities and incremental infrastructure costs. However one might choose to define sprawl, an important scientific and policy question is what variables drive the rapid geographic expansion of many metropolitan regions in the United States.

In this paper, our purpose is to see whether the reliance of municipal governments on the property tax might be one of those drivers. Theoretical papers by Capozza and Li [1994], Brueckner and Kim [2003], and Arnott and Petrova [2006] have already shown that higher property tax rates could indeed lower the density of metropolitan regions. In the remainder of this paper, we first derive our own theoretical model of property taxation and residential density choices and then test several hypotheses derived from that model using single-family home construction data for 1972 – 2006 for a sample of 41 New Hampshire towns and cities.

Table 1

Population Growth and Land Development in New Hampshire, 1982-1997

	1982	**1987**	**1992**	**1997**
Total population	951,000	1,057,000	1,111,000	1,173,000
Developed acres	379,000	468,900	526,000	588,600
Average density	2.51	2.25	2.11	1.99

Sources: N.H. Office of Energy and Planning for population estimates. U.S. Natural Resources Conservation Service for developed areas.

THEORETICAL MODEL AND HYPOTHESES

Our theoretical model of property taxation and land development differs from earlier contributions in several respects. One is that the rents accruing to the owner of a developed parcel derive not just from its location within the metropolitan region and the physical capital constructed on the site but also from the amenities provided by the undeveloped portion of the parcel itself. Second, structures on developed parcels are three-dimensional and hence both the footprint of a building and its height need to be modeled explicitly as development decisions. Third, the ease of substituting physical capital for undeveloped land in the production of "parcel services" needs to be modeled explicitly. Fourth, the effect that building height has on construction cost per square foot should be acknowledged. Fifth, we allow partial tax capitalization in the model with full capitalization as a special case.

A final consideration is that analysis of the impact of property taxation needs to recognize that the conventional property tax is actually two taxes bundled together at the same *ad valorem* rate, one on building value and the other on land value. In this section, we introduce these considerations into a model of the decision to develop a vacant parcel of land within a metropolitan region. An important implication of our model is that it is unambiguous that the portion of the property tax levied on building values affects density of development projects. If the property tax is fully capitalized, the portion of the tax levied on land values reduces the land price paid by developers and is theorized to have little or no effect on density. However, if the property tax is only partially capitalized into land price, then the tax levied on land values could have an effect on density.

Let us suppose that land within a metropolitan region has already been subdivided into parcels and that there are numerous municipalities of roughly equal size within the region. We assume that no additional subdivision or consolidation of parcels is feasible and that municipal boundaries are fixed. A parcel with area A_0 square feet comes onto the market for development or redevelopment at time $t = 0$. There are no municipal zoning regulations that might constrain the private developer of the parcel[1] so she or he is free to choose the size of the building footprint (F) by selecting the proportion of the parcel (φ) to develop:

[1] $$F = \varphi \ A_0, \text{ where } 0 < \varphi < \text{or} = 1.$$

This choice of footprint ratio (probably) leaves some of the parcel undeveloped:

[2] $$U = (1 - \varphi) \ A_0 .$$

---

[1] Of course, land use regulations do pertain in many localities. Ihlanfeld [2007] has found empirical evidence that restrictive land use rules affect house and vacant land prices as well as the size of newly constructed homes. We will take local zoning rules into account in the empirical section of our paper.

If construction is profitable, a structure of infinite life[2] is built on the footprint at time $t = 0$. The floor space of that structure (K) is approximated by

$$[3] \qquad K = h\ F,$$

where $h > 0$ is the height of the structure, measured in number of stories. There are no zoning limits on height. By substitution, the size of the structure depends on the parcel size, the proportion of the lot occupied by the footprint and structural height:

$$[3'] \qquad K = h\ \varphi\ A_0\ .$$

At $t = 0$, the developer incurs a construction cost (C) that depends upon the square footage of the structure as well as its height:

$$[4] \qquad C = c(h)\ K = c_0\ (1 + c_1)^h\ K\ ,$$

where c_0, $c_1 > 0$. This specification implies that capital cost per square foot tends to rise with building height, at least modestly.

The annual service flow provided by the developed parcel (s) to its occupants, whether tenants or owners, depends on the size of the structure (K) and the on-site amenities generated by the undeveloped portion of the parcel (U), call it the "yard":

$$[5] \qquad s = B\ (\ bK^\rho + (1\text{-}b)U^\rho\ )^{1/\rho}\ ,$$

where ρ is greater than or equal to negative infinity but less than or equal to one. In this CES production function, the parameter ρ governs the elasticity of substitution (σ) between structure size and the yard area of the parcel in the production of parcel services.[3] To be specific, $\sigma = 1/(1 - \rho)$. The service flow produced by the developed parcel presumably depends upon not only engineering and design technologies but also the subjective preferences of potential occupants.[4]

An alternative specification of [5] points out how the service flow from a developed property depends upon lot size as well as building footprint and height. Substituting [2] and [3'] into [5], one finds that

$$[5'] \qquad s = B\ [\ b(\varphi h)^\rho + (1\text{-}b)(1\text{-}\varphi)^\rho\ ]^{1/\rho}\ A_0.$$

This formulation reveals that, once subdivision of the metropolitan terrain has occurred, the service flow from any particular parcel depends upon developer choices about footprint ratio and building height.

---

[2] This is a bit of an exaggeration, of course. Harding, Rosenthal and Sirmans [2007] estimate that, net of maintenance, the typical single family home depreciates at almost two percent per year.

[3] In their survey of hedonic pricing models Sirmans, Macpherson and Zietz [2005] report that swimming pools, immediate access to a golf course and pleasant views add value to residential parcels.

[4] A service level of $s = 1$ could be interpreted, for example, as the use of one standard dwelling unit and its adjoining yard for a year.

Once developed, the parcel yields an annual gross rent (r) per unit of parcel service. This could be a cash rent paid by a tenant or an implicit rent paid by an owner-occupant who bought the property from the developer. The annual rent has two components:

[6] $$r = r_0 + (R\,A_0/s),$$

where r_0 is the rent *per service unit* for the structure and amenities provided by the parcel itself. This rent level is assumed to be uniform across the metropolitan region and constant over time. E.g., there are no neighborhood externalities, either positive or negative.

The other component of annual rent depends upon R = agricultural rent *per square foot* on farms adjoining the metropolitan region and urban location rent *per square foot* at the parcel's specific location within the region.[5] Agents in the land market expect this rent component to vary over time because of economic and population growth or decline within the region:

[7] $$R_t = R_0\, e^{gt}.$$

Before development can proceed, the developer has to purchase the parcel on which construction takes place. Land price per square foot (p) at $t = 0$ equals the present value of expected after-tax agricultural and urban location rents:

[8] $$p = \int [R_t - \delta LT]\, e^{-it}\, dt,$$

where i is the positive and fixed interest rate; LT is the annual land tax payment per square foot; and δ is the rate of tax capitalization that equals one if full capitalization occurs.[6] This specification assumes that the developer forecasts the region's growth prospects accurately and that future land tax payments can be fully or partially capitalized into land price.

The annual property tax payment (PT) on the developed parcel has two components, the tax paid on structure value and the tax paid on land value. These components depend upon the assessed values of the structure and its site and upon the constant tax rates (τ_1, τ_2) levied each year on those assessed values. For all years, present and future, we assume that the assessed value of the structure is set at construction cost and the land value assessment is set at acquisition cost:

[9] $$PT = \tau_1 cK + \tau_2 pA_0 .$$

Note that $LT = \tau_2 p$ and that τ_1 and τ_2 are typically equal to one another. (However, under a split-rate property tax system like that levied in some Pennsylvania cities, τ_1 is less than τ_2.) From [8] and [9], it follows that land price at $t = 0$ equals

[5] For a similar discussion of the rents accruing to a landowner, see Capozza and Helsley [1989]. Note that our model analyzes any arbitrarily chosen parcel within the region but does not theorize behavior of the rent gradient across the region.

[6] If the parcel has been previously developed and is being redeveloped, the price might also include some demolition costs. See Dye and McMillen [2007] on teardowns and redevelopment of parcels.

[8’] $p = [R_0 \ i] / [(i + \delta\tau_2) (i - g)]$

and that i must be greater than g if the price of land is to be positive. It is noteworthy that land price is influenced by the tax rate on land value but not by the rate levied on building value.[7]

At any particular moment, the instantaneous profit of the developer can be calculated as the difference between revenues and costs associated with ownership of the parcel:

[10] $\Pi_t = r_0 s + R_t A_0 - oK - (i + \tau_1) C - (i + \tau_2) p A_0,$

where o equals the annual operating cost of the structure (climate control, lighting, repairs, etc.) per unit of physical capital. Substituting from [4], [7] and [8’] into [10], one obtains

[10’] $$\Pi_t = r_0 s + R_0 e^{gt} A_0 - [o + (i + \tau_1) c_0 (1 + c_1)^h] h \varphi A_0 - [(i + \tau_2)R_0 i A_0 / [(i + \delta\tau_2) (i-g)]].$$

If property tax is fully capitalized into the land price (δ=1), then the tax levied on land, τ_2, drops out and has no effect on the profit.

Unless the developer is myopic, he or she will presumably wish to maximize the present discounted value of current and anticipated future profit (Π) resulting from parcel development, where

[11] $$\Pi = (r_0 s / i) - [o + (i + \tau_1) c_0 (1 + c_1)^h] h \varphi A_0 / i - R_0 A_0 [(i + \tau_2) / (i + \delta\tau_2) - 1] / (i - g) .$$

The first term on the right side represents the present value of the rents paid for enjoyment of the structure and on-site amenities provided by a parcel. The second term is the present value of the annual user cost of physical capital sited on the parcel. If we assume that the current and future land taxes are fully capitalized into land price at t = 0 (i.e., δ=1), the tax rate levied on land value (τ_2) does not appear in the profit equation. Consequently the growth rate of location rents (g) does not appear in this profit equation because any future escalation in annual location rents is offset by a higher annual user cost associated with a higher land price at the moment of parcel development. These results are consistent with the traditional view of property taxation, an approach that emphasizes mobility of capital among competing localities.[8]

---

7 For more on the theory and practice of land value taxation, see Dye and England (2009).

8 See Zodrow and Mieszkowski [1986] for an extended discussion of property tax incidence.

Assuming that economic conditions do permit a positive profit, what choices of footprint ratio and building height (φ^* and h^*) would maximize long-term profit (Π) for the developer? Under the assumption of $\delta=1$, analysis of [5'] and [11] reveals that a global maximum could be found by solving the following pair of nonlinear first-order conditions:

$$[12] \quad r_0 B\, [b\, \varphi^{\rho} h^{\rho} + (1\text{-}b)\ (1\text{-}\varphi)^{\rho}]^{1/\rho - 1}\, [b\, \varphi^{\rho\text{-}1} h^{\rho} - (1\text{-}b)\ (1\text{-}\varphi)^{\rho\text{-}1}]$$

$$-\ oh - (i + \tau_1)\ c_0\, (1 + c_1)^{h}\, h = 0 \ \text{ and}$$

$$[13] \quad r_0 B\, [b\, \varphi^{\rho} h^{\rho} + (1\text{-}b)\ (1\text{-}\varphi)^{\rho}]^{1/\rho - 1}\, [b\, \varphi^{\rho} h^{\rho\text{-}1} - (1\text{-}b)\ (1\text{-}\varphi)^{\rho}] - o\varphi$$

$$-\ (i + \tau_1)\ c_0\, (1 + c_1)^{h}\, [1 + h \log(1 + c_1)]\ \varphi = 0.$$

Because equations [12] and [13] do not have a closed form solution, we cannot derive general expressions for φ^* and h^*. However, as shown in England and Ravichandran (2008), numerical simulation methods can be used to discover the likely signs of the partial derivatives of φ^* and h^* with respect to the property tax rate, real interest rate and other determinants of residential density. In the case of full capitalization of land tax, their findings are summarized in Table 2.

Table 2

Predicted Impact
(England and Ravichandran, 2008)

Impact of:	**On optimal footprint:**	**On optimal height:**
Interest rate	-	-
Energy price	-	-
Construction cost	-	-
Building tax rate	-	-
Elasticity of substitution between structure and yard	-	?

What these simulations of the special case of $\delta=1$ of our theoretical model suggest is that, in the absence of constraints imposed by zoning regulations, a higher property tax rate levied on building values will tend to result in shorter residential buildings that have footprints covering smaller proportions of their respective lot areas. The result is that there tends to be less additional living space constructed on each newly developed acre of the metropolitan region.

EMPIRICAL DATA

The starting point for our empirical analysis was collection of property tax rates for all towns and cities in New Hampshire, 1972-2006.[9] These local rates, expressed as dollars owed annually per thousand dollars of assessed value, have been adjusted to 100 percent of estimated market value by the N.H. Department of Revenue Administration. As Table 3 reveals, property tax rates varied during the study period by a factor of more than nine. This substantial variation in tax rates among towns and through the years gave us hope that we would be able to detect an effect of property taxation on residential construction choices.

Our next step in data collection was to gather data on the physical characteristics and construction years for newly built single-family homes, 1972-2006. Because property assessments in New Hampshire are conducted by the towns and cities, not by county or state assessors, we solicited the cooperation of 234 local assessors. Because many could not provide data in electronic form or could offer only incomplete information, we ultimately accumulated a complete set of parcel-level data for 41 towns and cities. These data included lot size, gross area of structure, living area of structure, number of stories, access to water, and year of original construction. After surveying several local assessors to learn what percentage of gross area is typically on the ground floor for residences of various heights, we were also able to estimate the footprint area of the houses in our sample from actual gross area and building height data.

Full disclosure requires us to point out that our lot size and building square footage data are for 2007 or 2008 and not for the original year of construction. Hence, we do not know how many properties in our sample have seen further subdivision of lots or structural additions to the house since the original construction took place. For some observations, then, it is conceivable that the house was originally on a larger (or even smaller) lot with less floor space.

Per capita personal income data at the town level are available from the U.S. Census Bureau for 1979, 1989 and 1999. We have estimated per capita income (PCI) for other years of our study period by assuming that the growth rate of town PCI was a constant proportion of the actual growth rate of county PCI for inter-census years. Because college towns contain numerous low-income singles and because homebuyers in college towns are often higher-income families, we have adjusted actual and estimated town PCI by including a dummy for the three college towns in our sample.

Although our theoretical model ignores the impact of zoning regulations on residential density, our empirical analysis cannot do the same. We thus included two dummies to capture the effects of zoning on residential construction decisions. One simply measures

---

[9] See England (2008) for a fiscal history of New Hampshire during the late 20th century based on those tax rate data.

whether a town had adopted zoning regulations before or during the year of construction. The other dummy interacts the zoning-in-effect dummy with minimum residential lot size. Our expectation was that large minimum lot sizes forced some developers to build on larger lots than they would have if there had been no local zoning rules.

Our theoretical model predicts that real interest rates, real operating costs and real construction costs should correlate with footprint areas and building heights. We have been unable to find annual residential construction cost data for the period of our study. We were, however, able to acquire annual data for national mortgage rates and New Hampshire residential fuel oil prices. Because so many homes in New England heat with fuel oil, we expected that the inflation-adjusted price of heating oil could serve as a measure of operating cost – one component of the user cost of home ownership.

Because decisions about lot size depend partly on land price per acre, we have also included three measures of a town's accessibility to the regional economy and one measure of a parcel's access to water. Manchester is the state's largest city and a destination for employment, shopping and entertainment. Hence, we use road distance from a town to Manchester as an explanatory variable. Many towns in southern New Hampshire have become exurbs of metropolitan Boston during the past thirty years. Thus, if a town has easy access to one of the region's interstate highways, we interact that access with mileage to Boston.

Finally, we use year of construction in our regression models to see whether there are vintage effects that cannot be explained by the other time-series variables: per capita income, tax rates, interest rates and fuel oil prices. Except for four town dummies to capture high-growth communities and thirteen MLS region dummies to capture town fixed effects, the variables in our regression models are described in Table 3.

Table 3 Variable Definition and Descriptive Statistics					
Variable	**Definition**	**Mean**	**Std Dev**	**Minimum**	**Maximum**
Lot_Size	Lot size in square feet, 2007	79952.35	74329.551	2178	435600
Living_Area	Living area of structure in square feet, 2007	2047.815	819.159	400.231	15000
Gross_Area	Gross area of structure in square feet, 2007	4195.062	1766.162	512	23427
FPA_pred	Predicted footprint area of structure in square feet, 2007	2937.954	1174.115	418.146	17550
Log_LS	Log of lot size	10.878	0.966	7.686	12.984
Log_LA	Log of living area of structure	7.55	0.389	5.992	9.616
Log_GA	Log of gross area of structure	8.26	0.407	6.238	10.062
Log_FPA_pred	Log of predicted footprint area of structure	7.916	0.368	6.036	9.773
Height	Building height (number of stories), 2007	1.655	0.437	0.5	4
Tax_rate	Property tax rate with market value assessment, $ per $1000 of assessed valuation, 1972 – 2006	20.282	6.486	5.89	53.76
PCI_real	Real per capita income of town, 1972 – 2006 (actual or predicted, hundreds of 1983 dollars)	131.6	34.26	66.418	276.955
College_town	College town dummy (1=yes, 0=no)	0.042	0.202	0	1

Zoning_in_Effect	Zoning in effect during construction year (1=yes, 0=no)	0.965	0.185	0	1
Zon*LSmin	Zoning dummy * minimum residential lot size in square feet (2000)	57143.744	29828.832	0	130680
Real_Mortgage_Rate	Freddie Mac 30-year fixed-rate APR including points deflated by Northeast urban CPI, 1972-2006	5.017	2.821	-2.17	12.51
Real_Res_Fuel_Oil_Price	Residential fuel oil price ($ per million Btu) deflated by GDP deflator of same year, 1972-2006	8.847	2.437	5.35	15.3
DTB*NearExit	Distance of town to Boston in miles * close to interstate exit (1 if five miles or less, 0 otherwise)	31.802	32.1	0	136
Miles_to_Interstate_Exit	Distance of town to nearest interstate exit	6.502	9.871	0	46
Waterfront	Single-family residence fronting on water (ocean, lake or river) 1=yes, 0=no	0.045	0.208	0	1
Construction_year	Year of original construction on lot	1989.74	9.391	1972	2006
N = 50,774					

EMPIRICAL RESULTS

Table 4 reports preliminary results for five OLS regression models, one predicting lot size, three predicting building square footage measures and one predicting building height. All dependent variables, except for the building height, are in logarithms. The use of log-transformations is suggested by the estimation results from the Box-Cox models. Due to heteroskedasticity, the White-corrected standard errors are reported in the parentheses.[10]

Model 1 suggests that lot sizes tend to be larger in towns with higher per capita incomes, an unsurprising result. Less expected is our finding that the mere presence of local zoning during the year of construction is associated with smaller lot sizes, perhaps because land use protections result in higher land prices within a town. If, however, a town has enacted zoning AND enforces large minimum lot size rules, those specific minima appear to be binding and associated with larger actual lot sizes. Waterfront lots tend to be smaller because of higher land prices required to gain access to visual and recreational amenities. Access to the regional interstate network and proximity to the city of Manchester are associated with smaller lot sizes, as expected, because of higher land prices required to gain that access.

Interestingly Model 1 implies that higher property tax rates levied on land and building values are associated with smaller lot sizes. The significant and negative coefficient on the tax rate variable implies that an annual tax hike of ten dollars per thousand dollars of market value would reduce the lot size by 6 percent. Our preliminary interpretation of this finding is that there was incomplete capitalization of the land value component of the property tax in the New Hampshire market for residential lots during the study period. It appears that the tax rate on land value can affect the profitability of land development and can potentially impact the density of residential development in New Hampshire. However, the overall impact of property taxes on density cannot be concluded based solely on Model 1. The relationship between property tax rate and the size of living space must also be examined.

Of the three regressions (Models 2, 3, and 4) that seek to explain square footage of newly constructed single family homes, results are similar. The adjusted R^2 is relatively lower for the living area equation. We find that all three models do a good job of providing empirical support for our priors about what determines square footage of new homes. Larger homes tend to be built on larger lots. Higher real mortgage rates and energy prices during the construction year are associated with smaller gross and footprint areas. Reflecting a decision to substitute floor space for expensive land, waterfront homes have larger gross and footprint areas for their lot sizes.

---

[10] We are aware that decisions about lot size, floor space and height may have been taken simultaneously. The 2SLS and 3SLS estimates were derived for comparison. The Hausman specification tests of OLS against the instrumental variable approaches suggest that 2SLS is preferred to OLS but OLS is preferred to 3SLS. The qualitative results are the same regardless of model choices. We plan to continue to investigate the endogeneity issues. The estimation and test results of the 2SLS and 3SLS models are available upon request.

For the purposes of this paper, our most important finding is that a higher property tax rate in the year of construction is associated with smaller gross and footprint areas. *Ceteris paribus*, a ten-dollar per thousand dollar rate increase (a one percentage point hike) is associated with 11 percent reduction in gross area and 8 percent reduction in footprint area. Hence, higher property tax rates do seem to result in less newly constructed residential space per newly developed acre.

Model 5 implies somewhat less clear results for the height of newly constructed houses. Building height is seen to increase with lot size and mortgage rate and decrease with fuel oil price. It is as expected that building height decreases with the distance from the interstate highway exit. The significant and positive coefficient estimate of construction year implies that over the years, residential buildings have increased in height. Finally, a higher tax rate on single family homes is associated with the construction of some houses with fewer stories. To be specific, a ten-dollar per thousand increase in the property tax rate is associated with an *average* decline of 0.07 story in the height of new homes. The effect of property tax on building height is significant, although the magnitude is relatively small.

CONCLUSION

Various theoretical models of the decision to develop vacant lots by placing structural capital on those land parcels have implied that higher property tax rates might reduce the amount of capital investment, thereby reducing the densities of newly developed properties. Our empirical results suggest that although lot size is reduced by higher property tax rates, the impact magnitude is smaller than on building size. We believe that we have found preliminary empirical evidence that our theoretical predictions have merit: Higher property tax rates tend to result in less residential capital per newly developed acre.

Table 4 Regression Results					
Variable	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**
	Log_LS	**Log_LA**	**Log_GA**	**Log_FPA**	**HEIGHT**
Intercept	26.349*** (1.1129)	-15.396*** (0.3219)	-14.178*** (0.3385)	-1.049*** (0.3383)	-25.108*** (0.3972)
Tax_rate	-0.006*** (0.000727)	-0.009*** (0.000271)	-0.011*** (0.000288)	-0.008*** (0.000282)	-0.007*** (0.000340)
Log_LS		0.129*** (0.00170)	0.157*** (0.00179)	0.128*** (0.00177)	0.056*** (0.00204)
PCI_real	0.008*** (0.000191)				
College_town	-0.174 *** (0.0289)				
Zoning_in_Effect	-0.648*** (0.0287)				
Zon*LSmin	0.00001*** (2.306E-7)				
Real_Mortgage_Rate		-0.003*** (0.000518)	-0.004*** (0.000535)	-0.006*** (0.000523)	0.002*** (0.000674)
Real_Res_Fuel_Oil_Price		-0.001*** (0.000634)	-0.009*** (0.000662)	-0.003*** (0.000651)	-0.011*** (0.000781)
Distance_to_Manchester	0.023*** (0.00105)	0.007*** (0.000324)	0.006*** (0.000348)	0.006*** (0.000340)	0.000522 (0.000378)
DTB*NearExit	0.006 (0.000297)	0.000299*** (0.000106)	0.000171 (0.000120)	0.000403*** (0.000116)	-0.00038*** (0.000121)
Miles_to_Interstate_Exit	0.021*** (0.00128)	-0.009*** (0.000511)	-0.009*** (0.000562)	-0.007*** (0.000534)	-0.004*** (0.000559)
Waterfront	-0.698*** (0.0223)	0.161*** (0.00995)	0.230*** (0.0102)	0.191*** (0.00984)	0.071*** (0.00960)
Construction_year	-0.009*** (0.000570)	0.011*** (0.000160)	0.011*** (0.000169)	0.004*** (0.000169)	0.013*** (0.000198)
Adjusted R squared	0.2796	0.3108	0.3096	0.1812	0.1718

Note: All models also include dummy variables of Multiple Listing service areas to capture regional fixed effects. Additional dummy variables for four towns that experienced rapid growth after year 2000 are included in the log_LS equation. Standard errors adjusted for heteroskedasticity are in parentheses. * denotes statistical significance at the 0.01 level.**

REFERENCES

R.J. Arnott, P. Petrova, "The property tax as a tax on value: Deadweight loss," *International Tax and Public Finance* 13 (2006): 241-266.

Jan K. Brueckner, "Urban sprawl: Diagnosis and remedies," *International Regional Science Review* 23 (2000): 160-171.

J.K. Brueckner and H. Kim, "Urban sprawl and the property tax," *International Tax and Public Finance* 10 (2003): 5-23.

D.R. Capozza and R.W. Helsley, "The fundamentals of land prices and urban growth," *Journal of Urban Economics* 29 (1989): 295-306.

D.R. Capozza and Y. Li, "The intensity and timing of investment: The case of land," *American Economic Review* 84 (1994): 889-904.

R. Dye and R. England, eds., *Land Value Taxation: Theory, Evidence and Practice* (Cambridge, MA: Lincoln Institute of Land Policy), forthcoming in 2009.

R. Dye and D. McMillen, "Teardowns and land values in the Chicago metropolitan area," *Journal of Urban Economics* 61 (2007): 45-63.

R.W. England, "Population growth, local government budgets, and the property tax in New Hampshire," *State Tax Notes*, January 1, 2008 issue, 193-205.

R. England and M. Ravichandran, "Property taxation and density of land development: A simple model with numerical simulations," revise and resubmit to *Eastern Economic Journal*, 2008.

J. Harding, S. Rosenthal, and C. Sirmans, "Depreciation of housing capital, maintenance and house price inflation: Estimates from a repeat sales model," *Journal of Urban Economics* 61 (2007): 193-217.

K.R. Ihlandfeldt, "The effect of land use regulation on housing and land prices," *Journal of Urban Economics* 61 (2007): 420-435.

G. Sirmans, D. Macpherson, and E. Zietz, "The composition of hedonic pricing models," *Journal of Real Estate Literature* 13 (2005): 3-43.

G. Zodrow and P. Mieszkowski, "The new view of the property tax: A reformulation," *Regional Science and Urban Economics* 16 (1986): 309-327.