Draft: October 28, 2004

# Measuring and Modeling Local Urban Land use Regulation.

By

Bengte Evenson
Department of Economics
University of Nevada at Las Vegas

William C. Wheaton
Department of Economics
Center for Real Estate
MIT
Cambridge, Mass 02139
wheaton@mit.edu

**I. Introduction.**

Cities and town throw barriers in the way of new residential development including:

a). Requiring extensive subdivision improvements, and creating an approval process for such that is very slow and cumbersome.

b). Requiring overly large lots "by right" and then negotiating downward.

c). Restricting land to be permanently open, or agricultural through regulations rather than eminent domain.

In the long run such regulations must impact a market's supply curve, which again in the long run must be the determinant of price levels.

Why do Town's do this, and why might the practice vary?

a). They are creating true public good type benefits (open space) without paying for the full cost [Bates and Santerre, 2001].

b). They are trying to increase the asset prices of housing to existing home owners (note not land owners) by restricting the town supply of new development. [Hamilton, 1978].

In these models a single agent owns housing and is able to increase its asset value as well as obtain public benefits as open space or regulation is enacted. Hence higher housing prices are effectively a positive term in agent utility functions.

BUT, in order to get a positive relationship between asset prices and open space one needs an "urban economics" hedonic-theory type model in which housing has to be purchased in exchange for local amenities – hence housing prices are effectively a cost or negative term in the agent's utility function. How can house prices represent a "purchase" cost and a positive asset at the same time?

The objectives of this paper:

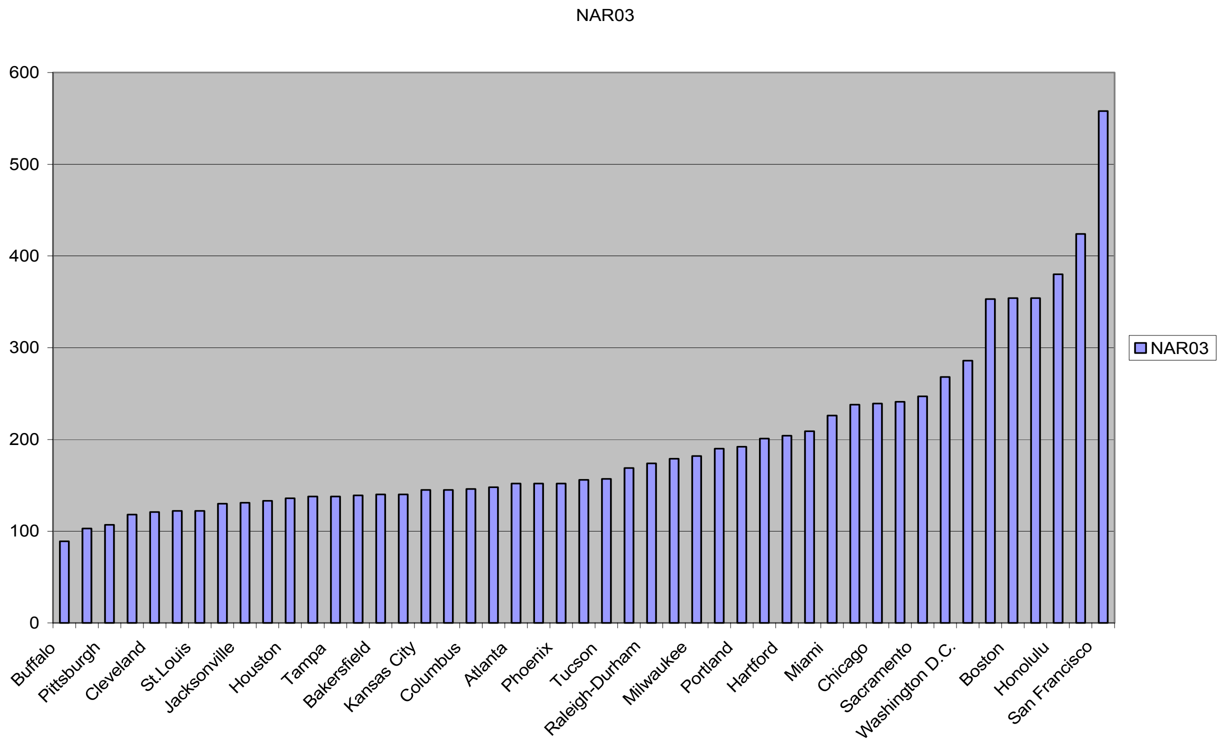
1). Review two available cross-section measures of land use regulation and show that both are plausible and significantly related to higher house prices.

2). Suggest a model in which there are 2 (in this case intergenerational) agents. For one prices are an asset, for the other they are a cost. A weighting exists between the two. This model is "well behaved" in the sense that current residents selecting a finite amount of regulation as being optimal and this choice will depend on several MSA level attributes.

3). Test the comparative statics of the model using the two metrics previously identified as plausibly representing land use regulation. Determine if cross section variation in the metrics lines up with MSA attributes as hypothesized.

## II. Cross Section variation in House prices.

**FIGURE 1**




a). Traditional "Ricardian" explanation of house price differences [Capozza and Helseley, 1999].

$$\begin{array}{llllll} \ln Price = 2.39 + .64e\text{-}7\ HH & + .0033\ Cost & + .42\ Grow & + .021\ Inc & \\ \quad (7.6) \quad (1.8) & (1.0) & (2.0) & (4.4) & R2=.62,\ N=46 \end{array}$$

b). Measures of Regulation or Supply inelasticity.

- A survey undertaken by a research project at Wharton in the early 1990s. This survey asked developer respondents about the difficulty of building houses in each of 35 Metropolitan areas. It is described in detail in Malpezzi [1996, 1998].

- Local measures of housing supply elasticity. This has been recently done for 46 MSA by Evenson (2002). Using Vector Autoregressive models, Evenson examines how each markets house prices and stock respond to demand shocks. Elasticities are measured at various time intervals as the percentage change in stock over the percentage change in price – using VAR impulse response analysis. In the sample of 46 MSA, at a 9 year interval, the elasticities vary between .2 and 10.0.

$$\ln Price = \underset{(5.1)}{2.41} + \underset{(0.5)}{18e\text{-}7\ HH} + \underset{(0.9)}{.0039\ Cost} + \underset{(3.2)}{.56\ Grow} + \underset{(3.3)}{.023\ Inc} + \underset{(1.5)}{.023\ Wharton}$$

$R2=.72$, $N=35$

$$\ln Price = \underset{(5.1)}{3.27} + \underset{(1.8)}{62e\text{-}7\ HH} + \underset{(0.5)}{.0021\ Cost} + \underset{(4.2)}{.65\ Grow} + \underset{(4.5)}{.021\ Inc} - \underset{(-2.6)}{.020\ Evenson}$$

$R2=.68$, $N=46$

**III. A Inter-generational model of local land use regulation: Variables, definitions**

Subscripts for individual towns: i,.

Two periods. Generation one lives in each, generation two arrives and lives in the second period (which is "long"). There is no repeated game.

Capital letters: first generation

$U(Y, Z_i)$: utility of generation 1 in period 1
$Z_i$ : fraction of town open land regulated.
Y: generation 1's earnings (in period 1)

Since first generation already owns housing its utility in the first period is independent of that periods house prices. It will, however, live off of the house prices that prevail in period 2 when it "retires" by selling assets.

$U(r\phi P_i, Z_i)$: utility of generation 1 in period 2.
$\phi$: fraction of house generation 1 "keeps"
r: annuity rate .

Total PDV of intergenerational utility for the first generation:

$U = U(Y, Z_i) + \beta U(r\phi P_i , Z_i) + \beta\lambda u_i$
$\beta$: inverse discount rate.
$\lambda$: probability children live in same housing market as parents.

Lower case: 2nd generation

$u_i = u(y + r(1-\phi) P_i - rP_i , Z_i )$ : utility of 2nd generation after inheritance and house purchase.
$= u_i(y - r\phi P_i , Z_i )$

y: 2nd generation earned income.

[A more complicated model has $u_i(y + r(1-\phi-\lambda) P_i ))$ ]

## IV. Town choice of Regulation.

All decisions are made by generation 1. Their total utility in Z is clearly positive considering both of their period's personal gains and the utility of their offspring.

$$\partial U/\partial Z_i = U'_{1Zi} + \beta U'_{2Zi} + \beta\lambda u'_{Zi} \quad > 0$$

Generation 1's total utility in ($2^{nd}$ period) house prices is mixed:

$$\partial U/\partial P_i = \beta r\phi[ U'_{2Y} - \lambda u'_{Y} ] \; >< 0$$

We know for sure that at P=0, $\partial U/\partial P_i$ must be positive since with no retirement wealth, the marginal utility of generation 1's own utility must be greater than that of its offspring (who would be able to buy a house for free). Diminishing marginal utility also requires that as P goes to infinity the term $\partial U/\partial P_i$ must become negative as the first generation is saturated with wealth and its offspring struggles to afford housing. Thus:

$$\partial^2 U/\partial P_i^2 < 0$$

Notice that these conclusions hold for any value of $\phi$, and that the "break even" point is independent of r or $\phi$ or $\beta$. The term is quite sensitive to the value of $\lambda$.

Generation 1's decision thus gives the utility maximizing condition:

$$\partial U/\partial Z_i = - \partial U/\partial P_i \, dP_i/dZ_i$$

The solution clearly involves selecting a level of Z such that P is high enough so that at the optimum $\partial U/\partial P_i < 0$.

Nash equilibrium is which each town choice is taken assuming other town's choices are fixed.

## V. Comparative statics.

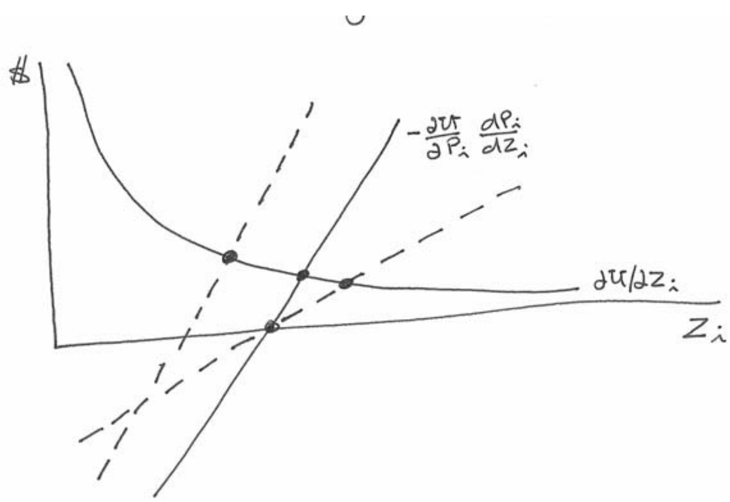
*Given* some value for $dP_i /dZ_i$ (which must be positive), the RHS of the above expression rises in P and hence $Z_i$ as well. It may even start out negative, cross the horizontal axis and then becomes positive (as a function of Z). The LHS declines steadily in Z. As the attached diagram shows, there should be a well-behaved solution.

As $\lambda$ increases $\partial U/\partial P_i$ decreases and the RHS shifts up (leftward). Hence the solution to Z is reduced. This makes sense. The more "important" the current generation regards the next, the less set aside or regulation it selects. If $\lambda$=0, then $\partial U/\partial P_i$ is always positive, the optimum is constrained, and the generation 1 selects the maximum Z, with corresponding maximum house prices. Also greater income (in both generations) reduces

As r$\phi$ decreases, then the RHS "rotates" clockwise and a higher level of Z is also chosen [Figure 2]. This makes sense. The less the current generation "keeps" of its equity and the more it transfers to the next generation, then the more Z will be selected . Higher income (of both generations) also reduces $\partial U/\partial P_i$ and rotates the schedule clockwise – hence more Z.

A decrease in $\beta$ (a higher discounting of the future by generation 1) has impacts on both the RHS and LHS of the equality. Dividing both sides by $\beta$, the net impact is equivalent to an upward shift in the LHS. From Figure 1 this will increase the chosen level of Z. This makes sense in that if future generation welfare is discounted less then the current generation acts to only maximize its own consumption benefit from Z.
Clearly it is also true that any factor which shifts $dP_i /dZ_i$ also rotates the RHS of the decision schedule. If something reduces $dP_i /dZ_i$ then the RHS rotates clockwise and the solution to Z is higher, while something that increases it, rotates the RHS counterclockwise and lowers the chosen Z.

**FIGURE 2**



## VI. Metropolitan Structure and $dP_i / dZ_i$

We can incorporate a simple monocentric model with towns as "rings" or linear zones. It is important to have a "furthermost" zone that expands indefinitely as land area in the "interior" towns is restricted. This is what drives prices higher.

As described previously, we assume that $2^{nd}$ generation residents "inherit" $Z_i$ and then determine equilibrium $P_i$.

Notation:

$a_i$ : total available land in town i=1,n-1 for $2^{nd}$ Generation use.[ $a_i$ is fixed, while $a_n$ is endogenous]
$Z_i$ : fraction that is removed from the market by $1^{st}$ generation in period 1.
$k_i$ : travel cost associated with living in zone i. (k is cost per mile)
N: $2^{nd}$ generation population

$$a_n = [N - \Sigma a_i (1- Z_i )] / (1- Z_n )$$

$u^0 = u(y-ka_n - P_n , Z_n)$ $P_n$ is exogenous (Ricardian theory) so $a_n$ determines $u^0$

$u^0 = u(y-k_i - P_i , Z_i )$ determines each $P_i$

Thus, the impacts of $Z_i$ on the $2^{nd}$ generation and on prices are:

$du^0 /dZ_i = -u'_{xn}\, da_n/dZ_i = - u'_{xi}\, dP_i/dZ_i + u'_{zi}$ , which solves to:

$$dP_i/dZ_i = (u'_{xn}/u'_{xi})da_n/dZ_i + u'_{zi}/u'_{xi} > 0$$

and:

$da_n/dZ_i = a_i (1 - Z_i)/(1- Z_n ) > 0$ *and is proportional to* $a_i$ : "larger towns have bigger impacts on prices. From the previous section this means that generation 1 will choose less Z. Furthermore in an MSA composed of many small towns, town shares will be smaller and hence the response of prices less.

## VII. Empirical test (MSA Level).

1). MSA with Fragmented jurisdictions should have more land use regulation.

2). MSAs with a larger proportion of children living where they were born should have less land use regulation.

3). Wealthier MSA should have more regulation.

4). Other covariates? Regional effects? MSA land area? Long term growth rate?.

## VIII. Empirical Results (MSA level).

$$\underset{}{\ln Wharton} = \underset{(9.7)}{2.29} \; \underset{(-1.5)}{-.038\,sameborn} \; \underset{(-1.5)}{-\,.057\,govs} \; \underset{(3.7)}{+\,.011\,Inc}$$

R2=.39, N=32

$$\ln Evenson = \underset{(3.4)}{5.81} \; \underset{(-1.1)}{-\,1.55\,sameborn} \; \underset{(-1.9)}{-\,.42\,govs} \; \underset{(-1.8\,)}{-\,.036\,Inc}$$

R2=.31, N=32

$$\ln Wharton = \underset{(8.4)}{2.36} \; \underset{(-.2)}{-.043\,sameborn} \; \underset{(-1.0)}{-\,.051\,govs} \; \underset{(3.6)}{+\,.012\,Inc} \; \underset{(-.21\,)}{-\,.0000088\,HH}$$

R2=.39, N=32

$$\ln Evenson = \underset{(3.4)}{6.48} \; \underset{(-0.9)}{-\,1.56\,sameborn} \; \underset{(-2.1)}{-.59\,govs} \; \underset{(-1.9)}{-.041\,Inc} \; \underset{(.8)}{+\,.0002\,HH}$$

R2=.33, N=32

$$\ln Wharton = \underset{(7.5)}{2.54} \; \underset{(-.5)}{-.11\,sameborn} \; \underset{(-0.7)}{-\,.048\,govs} \; \underset{(2.1)}{+\,.009\,Inc} \; \underset{(-.21)}{-\,.0000077\,HH}$$

+ Regional effects (4) R2=.45, N=32

$$\ln Evenson = \underset{(1.9)}{3.48} \; \underset{(-0.5)}{-\,.56\,sameborn} \; \underset{(-1.1)}{-.27\,govs} \; \underset{(-1.3)}{-.028\,Inc} \; \underset{(.6)}{+\,.00012\,HH}$$

+ Regional effects (4) R2=.59, N=32

## IX. Next Steps/Alternatives.

1). Better Regulation data: Joint Survey with the NAHB on residential permitting time. Larger sample of MSA.

2). More "stylized" facts and regression results to identify the direction of future modeling.

3). Alternative models. Rather than using 2 generations to get well behaved utility, consider a single generation model with renters and owners. Using the current notation, owners are generation one and renters are generation 2. Prices enter positively with diminishing marginal utility for owners, negatively with increasing marginal disutility for renters. $\lambda$ then becomes some weight that the political process assigns to each group. Presumably the comparative statics of this model would focus on the renter/owner ratio across markets [empirical work in progress].

4). Intra MSA analysis of cross section of towns. In an asymmetric Nash equilibrium, larger towns should regulate less than smaller ones.