Residential Lot Values and the Capital-Land Substitution Parameter – Some Recent Results from the Portland Metro Area

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Abstract: The market value of residential lot size and market response to increasing housing prices have become increasingly important as regional policy makers have sought to limit the size of urban areas. Using sales data on recently constructed homes in the Portland Metro area for the years 1996-97, we have examined the effect of lot size on the sales price of detached and attached single family homes. In addition we have used the hedonic equations to construct an estimate of land value from which we were able to calculate a value of the elasticity of capital-land substitution. Results point to a very low elasticity of home price with respect to lot size of roughly .05 - .15. Correspondingly, the elasticity of capital-land substitution compared to several values reported in the literature is relatively high; from .6 - .8.

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Introduction

Within the Pacific Northwest and to some degree elsewhere state and local governments have adopted policies of limiting urban growth within defined areas. Implemented as "urban growth boundaries" or "growth management areas" such policies seek implicitly and explicitly to increase urban densities; thereby reversing a trend of gradually decreasing urban densities established at the onset of the automobile age and encouraged by government transportation and housing policies after WWII.

Limiting urban expansion and increasing urban densities has generated much policy debate of interest to urban economic researchers. Some policy makers and many in the real estate industry raise concerns about the impacts on real estate prices and ultimately on the practicality of achieving higher densities given what many perceive as a strong consumer preference for large lot, detached single family homes. From an applied urban research perspective these concerns can be distilled into two questions presently answerable with available data and appropriate measurement techniques. These questions are:

1. Measured in terms of "willingness to pay" how much do consumers value increasing lot size?
2. Given changes in real estate prices how much will producers vary the quantity of land used in housing production in order to maximize homes sales profits?

Answers to these questions can be found in the "capital-land substitution parameter" literature. The capital – land substitution parameter denoted as σ can have a value of between 0 and 1. A value of 0 means that lot size does not change regardless of change in house and land prices. A value of 1 implies complete substitution between land and capital. Chart 1 (attached in the Appendix) depicts the relationship of the capital-land substitution parameter to land value per sq. ft and change in lot size as a function of change in home price holding capital costs constant. As home sales prices increase lot size decreases but price per sq. ft. increases. The amount of the change in quantity and prices depends on the size of the capital-land substitution parameter. By the same token decreasing home prices result in increasing lot sizes and decreasing land prices per sq. ft.

Literature

Model Specifications:

McDonald (McDonald 1982) provides the most comprehensive survey of the capital-land substitution literature. Jackson, Johnson and Kaserman (Jackson, Johnson, Kaserman 1984) and Stover (Stover 1990) have done subsequent work. McDonald presents several models directly derivable from the theoretical equation:

$$\sigma = d\ln(K/L)/d\ln(R/r), \qquad 1.$$

Where σ is the capital-land substitution parameter, K is the quantity of capital, L is the quantity of land, R is the unit price of land and r is the price of capital. Assuming a CES production function we can rewrite equation 1 in estimable form as:

$$\ln(rK/L) = a + \sigma \ln(R/r) \qquad 2.$$

If we assume that r, the price of capital, is a constant over one region in one time period, the model simplifies to what we call our Model One.

$$\ln(K/L) = a + \sigma \ln(R) \qquad 3.$$

For most regressions McDonald and Jackson, *et.al.* favor a specification also derivable from a CES production function, which is well suited to one time period cross sectional data for one region. This specification which we refer to as our Model Two is a follows:

$$\ln\left[\frac{pH - RL}{L}\right] = a + \sigma \ln R \qquad 4.$$

Where pH is the selling price of housing. This specification requires no information on capital per se and makes no explicit assumptions about the price of capital.

Jackson, *et. al.* following McDonald assume a CES production function to also derive from equation 2 an estimable equation we call our Model Three.

$$\ln\left[\frac{pH - RL}{L}\right] = a + \sigma \ln R + \sigma\rho \ln r \qquad 5.$$

The latter specification presumes a CES production function and constant returns to scale. Important here is that price of capital is allowed to vary spatially over the region. As we shall see, it becomes important when r is interpreted as the cost per sq. ft. of housing production and allowed to vary spatially as a function of vacant land parcel size. The reality is particularly in the Portland Metro Region that much available land is highly parcelized and inherently expensive to build on independent of land price. The specification in Model 3 allows for that factor.

Literature Results and Major Issues

McDonald estimated σ at .77 and adjusted for possible measurement error very close to 1.0. McDonald's literature review of 13 studies revealed a range of .08 to 1.13. Apparent in the review was that in addition to different equation specifications the databases varied widely. Some consisted of Census Tract means for one region while others consisted of cross sections of a number of different regions. Jackson, *et. al.* estimated σ at .5 for homes less than 5 years old constructed in the City of Knoxville 1973 – 1978.

Apart from appropriate equation specification and measurement error two issues seem unresolved in the literature. These are:

1. Finding an unbiased measurement of land value.
2. Using a sample set that reflects the response of the market to land and housing prices unconstrained by past history and restrictive land use regulations.

The first issue reflects the concern that we seldom observe the "market value" of land. There is a general concern that assessor data do not accurately reflect market land prices and should be avoided. The second concern acknowledges that the conditions of the underlying model are rarely met. Government regulations on minimum lot sizes may restrict market response. Data using sales prices and real estate characteristics of vintage homes will reflect the prices of land and capital when they were built; rather than present prices.

To address the above issues researchers have adopted hedonic approaches to estimating land value (Clapp 1980) (Jackson, *et.al.* 1984). Hedonic price estimates allow us to account for the factors of home sales price that owe to land (location rent) and those that owe to the housing structure. Similarly researchers seek to limit their sales data to newly constructed homes within areas without severe regulatory restrictions on lot size.

Metro Modeling Effort

Cognizant of the issues arising in the literature Metro staff elected to estimate σ fitting models one, two and three as outline above. Moreover, we chose to estimate land prices using the hedonic pricing model. In addition, we limited our sample to homes that were built after 1/1/96 and sold by 6/30/97. Below we describe our procedures and results in more detail.

The Data

As part of Portland Metro's performance measures monitoring effort conducted as part of the 2040 Plan, we have been collecting sales price and related data on all home sales in the 3 County area for the fiscal years 1995-96 and 1996-97. Chart 2 presents summary data. Significant is that median lot sizes are below 7,000 sq. ft. and average lot sizes at 7,300 sq. ft. In the mid and late 80's when home prices were low sales data

indicate lot sizes averaged just under 10,000 sq. ft. In the late 60's and early 70's lot sizes were even larger averaging close to 13,000 sq. ft.

Our sample size was about 5,500 records for Clackamas, Multnomah and Washington Counties. In addition we had another 2,200 records for Clark County but were unable to attach neighborhood data to them in time for the paper presentation.

Before and during this time period the jurisdictions throughout the Metro Region and in Clark County were actively involved in removing restrictive land use regulations thereby allowing the market to respond to higher home prices. Similarly, home prices were rapidly changing with owner occupied housing increasing at roughly 10% per year for the period 1990 – 96. As Chart 2 indicates price increases slowed slightly in 97 though home sizes continued to increase.

The table shown 3 below details the selection and computation of the independent variables used in the hedonic price model. The hedonic price model was specified as a log-log model. Variables coefficients and "goodness of fit" statistics are contained in Appendix One attached.

Neighborhood Assignments

Each property was assigned a value for twelve neighborhood variables using RLIS, Metro's geographic information system. These twelve values were: acsutility, centralcitymainstr, centralcityresidsubdiv, city, exurbcty, innercityold, oldsubsubdiv, oldsubtownctr, prestige, ruralresid, and view. To perform these assignments, the sales data were first joined to the centroids of the appropriate taxlots in Arc/Info[1]. This resulted in a point file of all sales, which were then evaluated as described below, using ESRI's Arc/Info and ArcView software.

Neighborhood	Criteria	Process
acsutility	Data for 1990 Census Tracts. Computed from mode choice utilities of transportation model	A spatial join was performed in ArcView[2] with the census tract polygons. The accessibility data was then transferred to each property based upon the census tract in which it was located.
centralcitymainstr	Within 400' (2 city blocks of a main street)	Properties with 400' of a major or minor arterial street were selected.
centralcityresidsubdiv	Residential subdivisions in the central city portion of the City of Portland	The central city portion of the City of Portland was generally defined as downtown and inner Northwest Portland on the west side of the Willamette River, and the part of the city west of 82nd Ave., east of I-5, north of Powell Blvd. and south of Lombard on the east side of the Willamette River. A visual assessment was performed in Arc/Info to identify properties which

[1] Arc/Info is a Geographic Information System package sold by Environmental Systems Research Institute, Inc. of Redlands, CA.

[2] ArcView is a desktop Geographic Information System package sold by Environmental Systems Research Institute, Inc. of Redlands, CA.

		fell inside this area/
city	Inside the city limits of an incorporated city.	A spatial join was performed in ArcView[3] with the city limits polygons. Properties, which fell inside the city limits of an incorporated city, were coded with the name of that city.
exurbcty	Located outside an urban growth boundary.	A spatial join was performed in ArcView with the Urban Growth Boundary polygons. Properties, which were outside of the UGB, were coded as 'exurbcty'.
innercityold	Located in specific neighborhoods inside the City of Portland.	A spatial join was performed in ArcView with the neighborhood boundary polygons. Properties, which fell inside the following neighborhoods, were coded as 'innercityold': Buckman, Kerns, Eliot, Hosford-Abernethy, Boise, King, Humboldt and Sabin.
oldsubsubdiv	Suburban subdivisions built prior to 1975.	A visual assessment was performed in Arc/Info to identify suburban neighborhoods where the majority of the houses were built between 1945 and 1975.
oldsubtownctr	The old downtown area of suburban cities.	A visual assessment was perfumed in Arc/Info to identify any properties, which were located in the old downtown areas of suburban cities. These were identified as areas showing a traditional grid street pattern, with yearbuilt dates older than the surrounding neighborhoods.
prestige	Neighborhoods which are generally considered prestigious or exclusive.	A visual assessment was performed in Arc/Info to identify any properties which were located in prestige neighborhoods. Examples of prestige neighborhoods would include lakeside properties in Lake Oswego, portions of Northwest Portland, areas of the West Hills in Portland and the Dunthorpe neighborhood in unincorporated Multnomah/Clackamas counties.
ruralresid	Zoned for rural residential[4] use.	A spatial join was performed in ArcView with the zoning polygons. Any property which was zoned for rural residential use was coded as 'ruralresid'
view	Elevation relative to surrounding area, slope	The base level at which a property could have a view was generally determined to be 300 feet. Properties which were at least 300 feet elevation and/or at the edge of a slope were considered to have a view.

Maps One through Four (attached in the Appendix) detail the location of the 5500 new home sales and provide some spatial perspective regarding the classification system of neighborhood variables used in the hedonic model. As part of the neighborhood and access variables we included a large number of label variables for each jurisdiction in the study areas. Finally, we included variables on home size, lot size, sale month, and housing type. Unfortunately, the data set does not include detailed structure characteristics such as no. of baths, bedrooms, stories, construction type, etc. We

[3] ArcView is a desktop Geographic Information System package sold by Environmental Systems Research Institute, Inc. of Redlands, CA.

[4] Rural residential use is defined as: residential uses permitted in rural sizes of one acre or more.

presume lack of these attributes constitutes an error term which after correction with jurisdiction label variables can be considered random.

Significant in the hedonic model was the low elasticity of lot size with respect to home price. Earlier regressions were suggesting .1 - .15. The coefficient calculated on the 96-97 sales data came in at .07; dropping from .1 calculated on similar data one year earlier. Erosion of the preference for lot size may be embedded in the aging of the population, the decrease in household size and increase in percentage of household members holding jobs and indeed multiple jobs outside the home. Taken by itself, reduced preference for lot size will act to increase the size of the capital-land substitution parameter.

Somewhat innovative in our approach was our measure of capital cost variation over the Metro area as function of parcelization. Lacking detailed data on short notice, we elected to construct a capital cost index by using the logsum access index which is very high in land scare, heavily parcelized areas and quite low in more remote areas where economies of scale in housing construction remain possible.

The Results

Using the method described by Jackson, *et. al.* we calculated land values for each of our 5500 observations and fitted the results to models one, two and three. All models presume a CES production function. Results are depicted in the table below.

Model Number	Coefficient Estimate	T Value	R SQ.
Model One			
a	-2.440	-159.17	
σ	.642	81.21	.547
Model Two			
a	1.575	99.49	
σ	.800	98.02	.638
Model Three			
a	1.433	47.88	
σ	.788	93.55	
$\sigma\rho$	.037	5.57	.640

Conclusion Summary

Though the models differ in specification and variables, the results do not differ substantially given the range of values for the capital-land substitution parameter reported in the literature. Model three with an admittedly crude proxy measure of spatial capital

cost variation suggests that neglecting to account for economies of scale on larger parcels may at least slightly bias estimates of the capital-land substitution parameter. In addition, the assumption of spatially varying land and capital costs suggests that we use an equation specification which does not assume a CES production function such as a translog model (Stover, 1990).

Doubts aside, the data point to a fairly large value for the capital-land substitution parameter. From a regional planning perspective such a result implies that fairly compact urban areas are achievable provided available land supply and economic growth favor increasing land and home prices. Conversely, a high value for σ also implies that a regime of readily available land and low home prices will result in very large lots and relatively low urban densities.

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