SUBDIVISION SPECIFIC AMENITIES AND RESIDENTIAL PROPERTY VALUES

by

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Abstract

A hedonic property value model, derived from a dynamic game theoretic framework, is estimated using data obtained for 211 subdivisions including 4628 building lots in five Maryland counties. Linear Box-Cox estimation results show that variables measuring subdivision specific amenities significantly affect residential property values, and omission of such variables produces biased coefficient estimates.

Keywords: Subdivision specific amenities, hedonic property value model, linear Box-Cox estimation.

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I. Introduction

The determinants of values of residential properties have been a central concern in real estate research as it is important for the land owners, developers, demanders, and policy makers to recognize the factors that derive residential property values. In light of Lancaster's (1966) consumer behavior theory, a residential property is described as a composite good consisting of multiple attributes that vary both in quantity and quality. Accordingly, hedonic price theory has become a popular operational device that functionally relates value of residential property to some measures of the unique attributes of the property.

Hedonic property value models (Freeman, 1993) assume that the sales price of a property represents an equilibrium price for that specific property and its uniquely associated attributes. Existing hedonic studies classify the attributes of a residential property into four categories – structural characteristics of the dwelling (e.g. size of the lot, style of the house, number of rooms in the house, quality of the materials and structural integrity, etc.), location specific attributes (e.g. distance from central business district, proximity to parks, etc.), neighborhood (socio-economic) characteristics (e.g. quality of local schools, population density, crime rates, etc.), and environmental amenities (e.g. air quality). While measuring the effect of open space on residential property values in Maryland, Geoghegan, Lynch, and Bucholtz (2003), Irwin (2002), and Irwin and Bockstael (2001) identify commuting distance to the two major urban centers in the region as the location attributes of the property, and population density, median household income, the percent of population with education beyond high school, and the percent of population that is African American within a 400-meter radius of residential parcels as the neighborhood characteristics. However, none of these studies take account of the subdivision specific attributes of the property.

Following Hardie and Nickerson (2003), development of a subdivision can be defined as the process of converting a rural property into a set of building lots and parcels. Along with building lots a subdivision also includes parcels composed of open space, forests, streets, parking areas, swimming pools, playing fields and other non-house land units. While parcels are not directly purchased by homebuyers, they may affect the value that buyers are willing to pay for the residential property. For example, a homebuyer may be willing to pay more for an otherwise same house in a subdivision which has a swimming pool and/or tennis court built in it.

This study provides a test of the hypothesis that subdivision amenities significantly affect residential property values. If the hypothesis could not be rejected, omission of variables measuring subdivision amenities could produce biased marginal values for other attributes. The extent of the impact of such amenities, and of other attributes, on residential property value will also be examined. For this purpose, a hedonic property value model will be specified and estimated.

The following section of this paper specifies the hedonic property value model by employing a game theoretic framework. Section three discusses issues related to estimation of this hedonic pricing model. Section four defines the variables included in the estimated model and gives summary statistics for the data used in the empirical study. Empirical results are presented in section five. Finally, the implications of the findings and policy issues are discussed in a summary and conclusion section.

II. Theoretical Framework

Following Palmquist (1989), land conversion is assumed to occur as a result of profit maximizing behavior of agents who own undeveloped land parcels and make decisions regarding the optimal conversion of the parcels to residential use. Although separate landowners, developers, and builders are observed in the real world, this study hypothesizes an integrated landowner, developer, and builder, termed the seller hereafter, who develops a residential subdivision from agricultural or forest land and builds houses in it. The buyers or demanders of these developed residential properties are treated as renters of housing services who maximize utility given an exogenous income. Defining sellers and buyers in this fashion allows the transaction in a market for housing can be viewed a simple two-stage dynamic game of complete and perfect information.

The key features of a dynamic game of complete and perfect information are that (i) the moves occur in sequence, (ii) all previous moves are observed before the next move is chosen, and (iii) the players' payoffs from each feasible combination of moves are common knowledge (Gibbons, 1992). For analytical simplicity, we assume that the game is played between a representative seller and a representative buyer in two stages. Player one, the seller, moves first by choosing an action from her feasible set of actions. The seller makes the profit maximizing decision of building houses and other facilities in his subdivision at some specific location and asks for "rents" in exchange for housing services. In the second stage, player two (the buyer) observes the action of player one and then chooses an action from her feasible set of actions. The buyer observes the characteristics of the house (and its surroundings) and the rent offered by the seller. The buyer accepts the offer if it maximizes her utility, otherwise she rejects it. The game ends at this point. The payoffs to the seller and the buyer depend on both of their actions. The game is assumed to be played in a single period (the possibility of repeated game is excluded here). If the buyer rejects the offer, she does not have the option to make a counter offer and the case of a new offer from the seller following a rejection of a previous offer is considered as a new game.

As is true for any other dynamic game of complete and perfect information, this game can be solved by backwards induction. The seller first solves the buyer's problem in the second stage. Following the basic hedonic property value model (Freeman, 1993) we assume that the buyer's (representative individual household) utility is a function of a composite commodity X, lot size l, and a vector of all other housing attributes H. We also assume that at each time τ the household rents only one residential house of some type at some location and spends her entire income $I(\tau)$ over the composite good, the house, and transport costs. Under these assumptions, the buyer's utility maximization problem at time τ can be formulated as:

$$\underset{X,H,D}{Max} \quad U = U(l, H, X) \text{, subject to}$$

$$I(\tau) = X + R(l, H, D, \tau) + T(D, \tau) \tag{2}$$

where $U(\cdot)$ is the utility function, $R(\cdot)$ is the rent of a house with lot size l, and other housing attributes $H = (H_1, \ldots\ldots\ldots H_n)$ at distance D from the city center at time τ, $T(\cdot)$ is the transport cost per unit of time for a household at distance D at time τ, and X is the amount of composite good of which price is the numeraire. The price of the numeraire good is normalized to 1. It is assumed that preferences are weakly separable in residential property and its characteristics. The first order condition for the choice of a particular housing characteristic H_i is

$$\frac{\partial U / \partial H_i}{\partial U / \partial X} = \frac{\partial R(l, H, D, \tau)}{\partial H_i} \tag{3}$$

The right hand side of equation (3) gives the implicit marginal price for the housing characteristic at time τ. If the buyer is assumed to be a price taker in the housing market, the seller can be viewed as facing an array of implicit marginal price schedules for various housing characteristics. In equilibrium, the marginal implicit prices associated with the house actually rented must be equal to the corresponding marginal willingness to pay for those characteristics.

We assume identical buyers in the housing market (so that $U(\cdot)$ represents preferences of all buyers), denote the equilibrium utility level by $U^*(\cdot)$ at time τ $(0 \leq \tau \leq \infty)$, and solve $U = U(l, H, X)$ for X in the form of $X = X(l, H, U)$. Substituting into the budget constraint yields the equilibrium rent of the housing $R^*(\cdot)$:

$$R^*(l, H, D, \tau) = I(\tau) - D(D, \tau) - X(l, H, U^*(\tau)) \qquad (4)$$

$R^*(\cdot)$ is the buyer's best response to seller's action. That is, if the buyer is offered the price $R^*(\cdot)$ for the residential property with lot size s, and other attributes H at distance D from the city center at time τ, she would accept it.

Since the seller can solve the buyer's problem as well as the buyer, she can anticipate the buyer's reaction to her own action. Given this "perfect foresight" the buyer would accept the offer $R^*(\cdot)$ at time τ, the seller takes profit maximizing action to develop the land and build house units in it. Following Fajita (1982) we assume that, with perfect foresight about the future time paths of housing rents and agricultural land rents, the seller determines the time t when each unit of agricultural land at distance D is to be converted for residential use, the lot size l, and the characteristics of the houses to be built on the land.

From the seller's point of view, the attributes of a residential property can be classified into three major groups – building or structural attributes, subdivision specific amenities, and location or neighborhood characteristics. Building characteristics (e.g., size of building lots, number of bathrooms, etc.) and subdivision specific attributes of the residential property (e.g., entrance of the subdivision, streets, open space, swimming pool, etc.) are treated as mutable characteristics in the sense that the seller has control over the quantities supplied. Location or neighborhood attributes of the residential property are immutable as the developer/builder cannot alter those. In addition, some other attributes of a residential property may be imposed by state or regional policies or acts (such as minimum lot size zoning restriction, required forest area to be retained or provided within the subdivision). These sorts of policy attributes act as constraints on the sellers' decision making process.

It is useful to separate $H = (H_1,...........H_n)$ into four sub-vectors, including $\hat{H} = (H_1,...........H_k)$ representing structural characteristics, $\widetilde{H} = (H_{k+1},...........H_l)$ consisting of subdivision attributes, $\overline{H} = (H_{l+1},...........H_m)$ depicting location and neighborhood characteristics, and $\dot{H} = (H_{m+1},...........H_n)$ constituting policy constraint variables. While $\hat{H}$ and $\widetilde{H}$ represent mutable characteristics of a residential property, attributes represented by $\overline{H}$ and $\dot{H}$ are exogenous in nature. Assuming that the subdivision is developed and houses are built at an optimal time t, the seller's problem in the first stage of the game amounts to

$$\underset{l,\hat{H},\,\widetilde{H},\,t}{Max}\ \Pi(l,\hat{H},\widetilde{H},\overline{H},\dot{H},D,t) = \int_0^t e^{-r\tau} A(\tau,D,\overline{H})d\tau + \frac{e^{-rt}}{l}\left[\int_t^\infty e^{-r(\tau-t)} R^*(l,\hat{H},\widetilde{H},\overline{H},\dot{H},D,\tau)d\tau - \hat{C}(l,\hat{H};\overline{H},\dot{H})\right] - e^{-rt}\widetilde{C}(\widetilde{H};\overline{H},\dot{H}) \quad (5)$$

where $A(\cdot)$ = Rental value of undeveloped land at time τ and at distance D from the CBD,

$R^*(\cdot)$ = Equilibrium rental value of a house with lot size l, mutable characteristics $\hat{H}$, and $\widetilde{H}$, and immutable characteristics $\overline{H}$

and $\dot{H}$ at distance D at time τ ,

$\hat{C}(\cdot)$ = Costs of building a house with lot size l and building attributes $\hat{H}$ at time τ in a subdivision with immutable characteristics $\overline{H}$, and $\dot{H}$.

$\widetilde{C}(\cdot)$ = Costs of building other non-house facilities at time τ in a subdivision with immutable characteristics $\overline{H}$ and $\dot{H}$.

r = Discount rate for future revenues and costs,

$\Pi(l,\hat{H},\widetilde{H},\overline{H},\dot{H},D,t)$ is the discounted net profit from an acre of the residential subdivision at distance D from the CBD, when a development strategy $(l,\hat{H},\widetilde{H})$ is adopted at time $t \geq 0$.

The seller maximizes $\Pi(\cdot)$ by choosing optimal values of t , l , $\hat{H}$, and $\widetilde{H}$ for any given distance D , undeveloped land rent $A(\cdot)$, and immutable characteristics $\overline{H}$ and $\dot{H}$. The rents $R^*(\cdot)$ must be the buyer's maximum willingness to pay or "bid rent" for a house built at time t , and distance D , with lot size l and housing characteristics $\hat{H}$, in a subdivision with attributes $\widetilde{H}$ given $\overline{H}$ and $\dot{H}$. An interior solution to the problem of maximizing $\Pi(\cdot)$ with t , l , $\hat{H}$, and $\widetilde{H}$ all greater than zero, would satisfy the following conditions:

$$\Pi_t(l,\hat{H},\widetilde{H};D,\overline{H},\dot{H})=0:\ R^*(l,\ \hat{H},\widetilde{H},t;D,\overline{H},\dot{H}) = lA(\overline{H},D,t) + r\hat{C}(l,\hat{H};\overline{H},\dot{H})$$

$$\Pi_l(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H})=0:\ \overline{R}(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H}) - r\hat{C}_l(l,\hat{H};\overline{H},\dot{H}) = l\left[\overline{R}_l(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H}) - r\hat{C}_l(l,\hat{H};\overline{H},\dot{H})\right]$$

$$\Pi_i(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H})=0:\ \overline{R}_i(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H}) = r\hat{C}_i(l,\hat{H};\overline{H},\dot{H}) + rl\widetilde{C}_i(\widetilde{H};\overline{H},\dot{H})\quad for\quad i \in \hat{H},\widetilde{H}\ .$$

where $\overline{R}(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H}) \equiv r\int_0^{\infty} e^{-r(\tau-t)}R^*(l,\hat{H},\widetilde{H},t;D,\overline{H},\dot{H})d\tau$ is the average future rent from the developed lot, $\overline{R}_i(\cdot)$ is the partial derivative of that rent with respect to lot size l and $i \in \hat{H},\widetilde{H}$. The seller is assumed to take rents $A(\cdot)$ accruing to undeveloped land as exogenous.

The seller solves the above first order conditions simultaneously for optimal lot size l^*, mutable attributes $\hat{H}^*$, and $\widetilde{H}^*$. Substituting these into the buyer's best response function yields $R^*(l^*,\hat{H}^*,\widetilde{H}^*;\overline{H},\dot{H},D,\tau)$, which is the equilibrium rental value of a house built at time τ at distance D given immutable characteristics $\overline{H}$ and $\dot{H}$. This is the backwards induction outcome of the game, which is the sub-game perfect Nash equilibrium. The game does not involve noncredible threats as the seller gives no credence to threats by the buyer to respond in ways that will not be her self interest. When the second stage arrives; the seller anticipates that the buyer will respond optimally to her actions by accepting the offer.

The hedonic price of a residential property is the present value of the stream of future rents obtained from the residential use and can be expressed as

$$P^*(l^*,\hat{H}^*,\widetilde{H}^*,\overline{H},\dot{H},D,t) = \int_t^{\infty} e^{-r(\tau-t)}R^*(l^*,\hat{H}^*,\widetilde{H}^*;\overline{H},\dot{H},D,\tau)d\tau \qquad (6)$$

$P^*(\cdot)$ is the sales price of a residential property which is a function of the size of the lot, all other mutable characteristics $(\hat{H},\widetilde{H})$ supplied by the seller, distance from the CBD, time, and the immutable characteristics $(\overline{H},\dot{H})$. It describes the locus of equilibrium points between buyers and sellers in the market. The marginal implicit equilibrium price of any of the attributes can be found by differentiating the hedonic price function with respect to the attribute. Evaluated at an individual's optimal choice, this implicit price represents the individual's marginal willingness to pay for the attribute (Irwin, 2002).

While lot size and building attributes receive direct payments, subdivision specific amenities, location and neighborhood characteristics receive no direct payments. However, the consumer's willingness to pay for a house is affected by these attributes. It is to be expected that payments increase with the desired attributes of the subdivision, location and neighborhood, and decrease with undesired ones. On the other hand, it is often the case that the land developers are constrained by some state and county policies. Therefore, we include these sorts of variables in our empirical hedonic analysis. The following section discusses the issues related to the estimation of hedonic price function.

III. Estimation Issues

While hedonic pricing models offer a means to estimate the marginal implicit prices of characteristics associated with a differentiated good, such as residential property, estimation of such models is characterized by a variety of econometric issues. Irwin (2002) discussed the problems associated with endogeneity, spatial autocorrelation, and multicollinearity including the questions of appropriate functional form for hedonic pricing models and the extent of the housing market. At this moment, we will restrict our analysis of estimation issues only to the question of functional form. Potential identification problems and other issues will be taken care up in the future.

Cropper, Deck, and McConnell (1988) examined how errors in measuring marginal attribute prices vary with the form of hedonic price function. They estimated omission of attributes could seriously affect the performance of those hedonic functions. Their simulation results suggest that when all attributes are observed, linear and quadratic functions of Box-Cox transformed variables provide the most accurate estimates (i.e. produces lowest mean percentage errors) of the marginal attribute prices. They also found that, when certain variables are not observed or when a variable is replaced by proxy, a linear version of the Box-Cox transformation of the hedonic price function produces most robust estimates.

Since we are hypothesizing that our estimated hedonic property value model may be characterized by omitted variables, we will adopt a linear Box-Cox transformation of the of the hedonic price function specified in equation (6). The linear Box-Cox transformation requires the dependent variable to be scaled by a factor θ such that

$$DEPVAR^{(\theta)} = \frac{DEPVAR^{\theta} - 1}{\theta} \qquad (7)$$

The model includes both the linear (when $\theta = 1$) and semi-log (when $\theta = 0$) specifications of the model as special cases. Likelihood ratio tests can be employed to detect whether the linear Box-Cox specification is significantly different from the linear and semi-log formulations. We will proceed to report the empirical results following a descriptive summary of the variables and data summary statistics.

IV. Data

Our empirical analysis depends on data obtained for 211 subdivisions with 4628 building lots in five Maryland counties. The data were collected from plans submitted to county land planning and regulatory agencies, State-maintained GIS records of taxation and assessment, Census 2000, and from County Public School Systems.

The empirical study is restricted to subdivisions that have all single-family dwellings, all townhouses, or mixture of single family and townhouse dwellings. In order to ensure individual ownership of residential property, subdivisions with commercial or industrial sites or with lots developed for apartment buildings or condominiums are eliminated from the study. We also have limited the study to subdivisions with five or more building lots and to subdivisions for which plans were approved between 1991 and 1997.

An initial survey was conducted to identify all of the subdivisions that fit our residential use criteria. A random sample of data was collected from each county planning agency for at least 50 percent of these qualifying subdivisions. These data then were matched to lots and parcels in the Maryland Property View county databases developed and maintained by the Maryland State Department of Planning. This provided access to tax assessment, sales and Computer Assisted Mass Appraisal (CAMA) data files (which contain attributes of existing dwelling units), and to GIS data on roads, streams, and other geographical features. The planning and property view data were augmented by Census 2000 data on incomes and race for the census tract containing the subdivisions, and by school achievement scores for the schools serving the subdivision.

The study area is comprised of five Maryland counties in the DC-Baltimore metropolitan area. These counties are Carroll, Charles, Howard, Montgomery, and Prince Georges. Montgomery and Prince Georges are counties with densely populated urban areas that adjoin Washington D.C. Subdivisions in Carroll and Charles counties are further from urban centers and are dispersed throughout the countryside or clustered around a county town center. Howard county is close to Baltimor, but many homeowners in this county work in and commute to the Washington D.C. metropolitan area.

The dependent variable in the hedonic pricing model is the sales value (SALESVAL) of building lots obtained from Maryland Property View county databases. Observations are restricted to single dwelling arms length transactions of owner occupied residential properties that occurred within the included subdivisions between January 1992 and December 1999. This restriction reduces the number of observations to 4587. The independent variables used in the model are size of building lots (LOTSIZE) and four subsets of housing attributes. Table 1 provides definitions and descriptive statistics for the available observations for all of the variables included in the model.

The first subset of independent variables includes building characteristics of the residential properties. The foundation square footage of the principal structure of the building is presented by BLDAREA. Employing CAMA quality of construction codes, five dummy variables (BLDGRADE1 – BLDGRADE5) are generated, with BLDGRADE1 representing "fair" quality construction and BLDGRADE5 representing "excellent" quality construction. Number of stories in a house is illustrated by another set of dummy variables (BLDSTORY1 – BLDSTORY3), with 1 for one storied house and 3 for three-storied ones. SINGLFAM and TOWNHS indicate whether the building is a standard single family unit or a townhouse. BASEMENT indicates whether the housing unit has a basement.

Subdivision specific attributes, the primary focus of this study, are included in the second subset of independent variables. This subset included three measures of amenities that the developer/builder (the seller) can provide to enhance the profit from the subdivision. They are represented by three dummy variables, AMENITY1 – AMENITY3. AMENITY1 indicates the presence or absence of walking paths, sitting area etc., AMENITY2 shows whether there is club-house or community center in the subdivision, and AMENITY3 stands for ball field, play grounds or swimming pool. In addition to these dummy variables, other subdivision attributes such as the percentage of total acreage that is designated as open space (PCTOAREA), and total area of the subdivision (SUBAREA) are also included in the model.

Several variables are developed to measure differences in buyer bid rents caused by location and neighborhood features. Included measures are commuting distance to the nearest CBD (COMDIST), median household income (MHHINC), the percentage of African American population in the census block, and the quality of public schools represented by standardized test

Table 1. Residential Property Variables: Definitions and Summary Statistics

Variables	Definition	Obs.	Mean	Std. Dev.	Min.	Max.
Dependent Variable						
SALESVAL	Sales value of the residential property ($10,000)	4587	24.49	14.64	3.60	415.01
Independent Variables						
LOTSIZE	Size of building lot (acres)	4587	0.43	0.91	0.02	36.08
Building Characteristics						
BLDAREA	Foundation square footage (100 sq.ft.)	4587	2.36	1.00	0.92	9.64
BLDGRADE1	1 if fair quality construction	4587	0.25	0.43	0.00	1.00
BLDGRADE2	1 if average quality construction	4587	0.32	0.47	0.00	1.00
BLDGRADE3	1 if good quality conatruction	4587	0.38	0.49	0.00	1.00
BLDGRADE4	1 if very good quality construction	4587	0.04	0.19	0.00	1.00
BLDGRADE5	1 if excellent quality construction	4587	0.01	0.08	0.00	1.00
BLDSTORY1	1 if 1 storied building	4587	0.02	0.13	0.00	1.00
BLDSTORY2	1 if 2 storied building	4587	0.88	0.32	0.00	1.00
BLDSTORY2H	1 if 2 and half storied building	4587	0.01	0.09	0.00	1.00
BLDSTORY3	1 if 3 storied building	4587	0.07	0.25	0.00	1.00
FOYER	1 if foyer	4587	0.02	0.14	0.00	1.00
BASEMENT	1 if the building has basement	4587	0.89	0.32	0.00	1.00
SINGLFAM	1 if the building is a std. single family unit	4587	0.61	0.49	0.00	1.00
Subdivision Attributes						
SUBAREA	Area of the subdivision (acres)	4587	78.68	88.11	0.96	367.72
PCTOAREA	OAREA as % of total subdivision area	4587	48.20	23.70	0.00	91.32
AMENITY1	1 if sub. has paths, totlots, sitting areas	4587	0.44	0.50	0.00	1.00
AMENITY2	1 if sub. has clubhouse or community center	4587	0.02	0.12	0.00	1.00
AMENITY3	1 if sub. has ball flds, tennis ct. or swm. pool	4587	0.29	0.46	0.00	1.00
Location and Neighborhood Features						
PCTFMLND	Percent of agricultural land w/n half mile radius	4587	19.16	19.16	0.00	89.39
PCTNATLND	Percent of natural land w/n half mile radius	4587	31.13	16.99	0.00	87.86
PCTOPNURBN	Percent of open urban land w/n half mile radius	4587	2.49	5.16	0.00	33.91
COMDIST	Commuting Distance to nearest CBD (miles)	4587	21.13	13.94	5.00	92.90
MSPAP_H	High School MSPAP scores	4587	101.48	2.88	91.93	105.71
MHHINC	Med. HH income in the census block ($10,000)	4558	8.37	2.91	0.80	20.00
PCTAFRAM	Percent of African American in the cen. block	4558	31.90	33.30	0.00	100.00
Policy Variables						
PUD	1 if under Planned Unit Development	4587	0.11	0.31	0.00	1.00
TDR	1 if have Transferable Development Right	4587	0.19	0.39	0.00	1.00
ZONMIN	Min. lot size zoning requirement (acres)	4572	0.53	0.83	0.00	5.00
PCTXTREE	Acres of required forestration (%)	4587	6.45	7.77	0.00	31.50
EXEMPT	1 if subdivision is exempt from FCA	4587	0.14	0.35	0.00	1.00
COUNTY1	1 if the subdivision is in Carroll county	4587	0.05	0.21	0.00	1.00
COUNTY2	1 if the subdivision is in Charles county	4587	0.15	0.35	0.00	1.00
COUNTY3	1 if the subdivision is in Howard county	4587	0.28	0.45	0.00	1.00
COUNTY4	1 if the subdivision is in Montgomery county	4587	0.29	0.46	0.00	1.00
COUNTY5	1 if the subdivision is in Prince Georges county	4587	0.23	0.42	0.00	1.00

scores from the MSPAP tests given to high school students in Maryland (MSPAP_H). Characteristics of the land surrounding the subdivisions are represented by three location variables computed as percentage of land in designated uses within half mile radius of the subdivision centroid. These are PCTOPNURBN (area in public parks, outdoor recreation facilities, historic sites etc.), PCTNATLND (area in brush, forest, wet or bare land), and PCTFMLND (agricultural acreage). All three of these variables can represent amenity values to homebuyers. Natural and farm land can also proxy for the cost of buying land for development. In this role, these variables will indicate the supply of nearby potentially available for development.

The fourth subset of dependent variables represents some policy measures that can act as constraints to the sellers land development decision making. Lot size policies are represented by maximum density zoning restriction (ZONDENS) and minimum lot size zoning requirements (ZONMIN). Whether the subdivision is developed as a Planned Unit Development (PUD) and/or has Transferable Development Rights (TDR) may also affect supplier's decisions. These features are included in the model as dummy variables. PCTXTREE represents FCA (Forest Conservation Act) requirement of forest (as percentage of the subdivision area) to be part of the subdivision. Another dummy variable (EXEMPT) indicates whether the subdivision is exempt from FCA. Finally, five county dummy variables (COUNTY1 – COUNTY5) are included to account for other unspecified policy effects.

V. Empirical Results

Table 2 presents results from the linear Box-Cox estimation of the hedonic pricing model. Parameter estimates are listed in the second column of Table 2. Column three reports the likelihood ratio test statistics of the null hypotheses that each of the estimated coefficients is equal to zero. Corresponding P-values in the fourth column shows whether the estimated coefficients are significant or not. A P-value of 0.05 indicates that the corresponding coefficient estimate is significant at 95 percent level.

The coefficient estimate for lot size and building area are found to be highly significant and positive implying that the equilibrium price of housing is increasing with lot size and foundation area of the principal structure. All of the dummy variables representing housing attributes are significant at the 0.0001 level and are of the expected sign, except for those representing two and half storied or three storied building. Equilibrium housing price is increasing in total area of the subdivision, in percentage of subdivision area designated for open space, and in type one amenity (paths, sitting areas, etc.). Results also show that equilibrium residential housing price is unaffected by type two amenity (clubhouse or community center), but decreases with amenity type three (ball field, play ground, swimming pool).

Parameter estimates of location and neighbor features show that equilibrium housing price is decreasing in commuting distance to CBD, surrounding farm and natural land, and proportion of African-American population in the census block. However, it is increasing in median household income in the census block. All of the policy variables included in the model, except for dummies representing Carroll and Charles counties, are significant. It cumulates positive value to the residential housing if the construction is under Planned Unit Development (PUD) criteria, and also if the developer/builder has given Transferable Development Right (TDR). It is found that equilibrium price of a residential property decreases with minimum lot

Table 2. Linear Box-Cox estimates of scale variant parameters.

Variable	Coef. Estimates	L-R test Stat.	Prob > chi2(df)	df of chi2
CONSTANT	2.1294			
LOTSIZE	0.1276	187.29	0.0000	1
Building Characteristics				
BLDAREA	0.1840	1118.76	0.0000	1
BLDGRADE2	0.0923	104.08	0.0000	1
BLDGRADE3	0.3213	547.29	0.0000	1
BLDGRADE4	0.5446	759.81	0.0000	1
BLDGRADE5	0.5184	230.57	0.0000	1
BLDSTORY2	0.0395	4.74	0.0290	1
BLDSTORY2H	-0.0060	0.03	0.8540	1
BLDSTORY3	-0.0074	0.09	0.7660	1
FOYER	0.2455	81.89	0.0000	1
BASEMENT	0.0346	5.38	0.0200	1
SINGLFAM	0.1589	337.29	0.0000	1
Subdivision Attributes				
SUBAREA	0.0003	28.87	0.0000	1
PCTOAREA	0.0011	57.03	0.0000	1
AMENITY1	0.0139	2.82	0.0930	1
AMENITY2	0.0019	0.01	0.9390	1
AMENITY3	-0.0276	6.27	0.0120	1
Location and Neighborhood Features				
PCTFMLND	-0.0011	33.44	0.0000	1
PCTNATLND	-0.0004	3.29	0.0700	1
PCTOPNURBN	-0.0004	0.42	0.5180	1
COMDIST	-0.0471	23.42	0.0000	1
MSPAP_H	-0.0005	0.06	0.8140	1
MHHINC	0.0076	31.04	0.0000	1
PCTAFRAM	-0.0008	15.67	0.0000	1
Policy Variables				
PUD	0.0435	12.30	0.0000	1
TDR	0.0221	3.02	0.0820	1
ZONMIN	-0.0777	15.17	0.0000	1
PCTXTREE	0.0032	69.97	0.0000	1
EXEMPT	0.0165	4.49	0.0340	1
COUNTY1	0.0290	1.99	0.1590	1
COUNTY2	-0.0124	0.53	0.4670	1
COUNTY3	-0.0938	26.30	0.0000	1
COUNTY4	-0.1012	28.31	0.0000	1
Transformation Parameters			No. of Obs.	4543
THETA	-0.0743		Log-likelihood	-12784.256
SIGMA	0.1480		LR Chi sq. (35)	8156.62000

size zoning requirement. Surprisingly, required forestation (acres) as a percentage of the total site acreage and exemption from the FCA both show to have positive effect on equilibrium housing price.

The dependent variable (SALESVAL) is transformed following the formula in equation (7); the estimated value of the transformation parameter θ is (-0.0743). Likelihood ratio test statistics rejects the null hypotheses of $\theta = 1$ and $\theta = 0$ implying that linear and semi-log specifications would be incorrect. The mean value of the dependent variable after transformation is 2.744.

In order to capture the marginal effects of a continuous variable, corresponding elasticity are computed using the coefficient estimates, mean value of the transformed dependent variable, and the mean value of the independent variable. This gives an estimate of elasticity at the mean which is used to predict the change in the transformed dependent variable. Finally, using the formula in equation (7), the change in the transformed variable is converted in terms of original dependent variable. This measure gives the marginal change in the sales value of a residential property for a one percent change in each of the continuous dependent variables. For example, the linear Box-Cox model provides an estimated elasticity (at the mean) of -0.0003 for the change in equilibrium price of residential housing with respect to the change in the percentage of open space in the subdivision. This elasticity implies that a marginal increase in the percentage of open space would increase the average price ($215,139) of the residential properties by $15,027.

The marginal effects of the dummy variables are calculated in a similar fashion but employing the coefficient estimate instead of elasticity. It allows us to estimate the effect of the presence of certain attributes on the mean value of the residential property. For example, provision of subdivision amenity type one, paths and/or sitting areas, increases the average residential property value by $10,574

Finally, four restricted models, each excluding one subset of independent variables, are also estimated employing the same technique. Likelihood ratio tests reject the null hypotheses that any of these subsets of housing attributes is not significant as a whole. Moreover, parameter estimates show that omission of any specific subset of variables produces biases in the estimates of the rest of the coefficients. Since our primary concern is the set of subdivision specific attributes, the estimation results of the restricted model without such attributes are presented in Table 3.

While omission of subdivision specific attributes changes the magnitudes of coefficient estimates of the included variables, compared to the unrestricted model, it does not change the sign of the coefficient estimates of the retained variables. However, exclusion of such variables makes dummy variables for two-storied building, distance to CBD, and minimum lot size requirement insignificant which were significant in the unrestricted model. On the other hand, the coefficient estimates for the proportion of open urban land within half mile radius and for the dummy variable indicating Charles county become significant in the restricted model. Thus, omission of variables measuring subdivision attributes produces biased marginal values for other attributes

VI. Summary and Conclusion

This study attempts to test the hypothesis that subdivision specific amenities significantly affect residential property values. A hedonic pricing model, derived from a dynamic game theoretic setting, is employed to test the hypothesis. A linear Box-Cox specification of the hedonic housing pricing model, with housing sales price as a function of lot size and other

Table 3. Linear Box-Cox estimation results of the restricted model (without subdivision specific attributes)

Variable	Coef. Estimates	L-R test Stat.	Prob > chi2(df)	df of chi2
CONSTANT	1.8526			
LOTSIZE	0.1116	173.60	0.0000	1
Building Characteristics				
BLDAREA	0.1819	1261.31	0.0000	1
BLDGRADE2	0.0848	113.49	0.0000	1
BLDGRADE3	0.2980	559.33	0.0000	1
BLDGRADE4	0.4954	736.39	0.0000	1
BLDGRADE5	0.4819	224.60	0.0000	1
BLDSTORY2	0.0443	6.47	0.0110	1
BLDSTORY2H	-0.0044	0.02	0.8890	1
BLDSTORY3	-0.0092	0.16	0.6910	1
FOYER	0.2082	64.75	0.0000	1
BASEMENT	0.0419	8.73	0.0030	1
SINGLFAM	0.1273	248.23	0.0000	1
Location and Neighborhood Features				
PCTFMLND	-0.0009	26.52	0.0000	1
PCTNATLND	-0.0007	11.56	0.0010	1
PCTOPNURBN	-0.0012	5.44	0.0200	1
COMDIST	-0.0090	1.13	0.2880	1
MSPAP_H	0.0016	0.84	0.3580	1
MHHINC	0.0060	23.77	0.0000	1
PCTAFRAM	-0.0006	9.74	0.0020	1
Policy Variables				
PUD	0.0253	5.86	0.0160	1
TDR	-0.0196	5.01	0.0250	1
ZONMIN	-0.0059	2.18	0.1400	1
PCTXTREE	0.0023	43.80	0.0000	1
EXEMPT	0.0223	9.13	0.0030	1
COUNTY1	-0.0312	2.69	0.1010	1
COUNTY2	-0.0692	23.88	0.0000	1
COUNTY3	-0.0786	23.88	0.0000	1
COUNTY4	-0.1420	71.46	0.0000	1
Transformation Parameters				
			No. of Obs.	4543
THETA	-0.0934		Log-likelihood	-12907.404
SIGMA	0.1434		LR Chi sq. (35)	7910.32000

housing attributes, is estimated. Different housing attributes are grouped into four subsets: building characteristics, subdivision attributes, location and neighborhood features, and policy variables. The empirical analysis is carried out using data obtained for 211 subdivisions with 4628 building lots in five Maryland counties.

Empirical results show that variables measuring subdivision specific amenities significantly affect residential housing property values, and omission of such variables produces biased coefficient estimates for other measures. In particular, it is found that housing price is increasing in open space provided within the subdivision, and in amenity type one indicating whether the subdivision has walking paths and/or sitting areas. It is also increasing with the area of the subdivision.

This is a working paper that reports preliminary findings. While estimation of hedonic pricing models is characterized by econometric issues, such as endogeneity, spatial autocorrelation, and multicollinearity, and functional form, the empirical analysis take accounts of the last two of the issues. Other issues, along with potential identification problems, will be addressed with careful attention as the work progress. Also, more emphasis will be given to policy implications.

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